

PATENT APPLICATION

MARINE FUEL COMPOSITIONS AND METHODS OF MAKING THE SAME

BACKGROUND

TECHNICAL FIELD

[0001] Described are compositions for use as fuels and methods of making the same. More specifically, described are compositions possessing lubricity useful as marine fuels.

DESCRIPTION OF THE RELATED ART

[0002] New regulations by the International Maritime Organization (IMO) requires the amount of sulfur in marine fuels to be less than 0.5 percent by weight (wt%) by January 1, 2020 (IMO 2020 Regulation).

[0003] Due to the inherent design of marine engines, there is a need for lubricity in marine fuels to maintain the balance between adequate wear protection on the engine components and thermal efficiency to maximize fuel efficiency. Sulfur, present in hydrocarbon fuels, can add the lubricity necessary for providing supplemental lubricity to marine engines. As a result of the IMO 2020 Regulation, the lubricity benefit provided by sulfur in marine fuels may be reduced significantly.

SUMMARY OF THE INVENTION

[0004] Described are compositions for use as fuels and methods of making the same. More specifically, described are compositions possessing lubricity useful as marine fuels.

[0005] In a first aspect, a marine fuel composition for use in marine engines is provided. The marine fuel composition includes a fuel component selected from the group consisting of high sulfur fuel oil (HSFO), low sulfur fuel oil (LSFO), slurry oil from a fluid catalytic cracker, heavy coker gas oil (HCGO), light cycle oil (LCO) from a fluid catalytic cracker, vacuum tower bottoms (VTB), atmospheric tower bottoms (ATB), low sulfur straight run (LSSR), high sulfur straight run (HSSR), distillate base stock (DBS), low sulfur vacuum gas oil (LSVGO), high sulfur vacuum gas oil (HSVGO), cracked or straight run fuel oil (m100), straight run gas oil (SRGO), ultra low sulfur heating oil (ULSHO), residues, and combinations of the same, the fuel component is present in an amount between 10 vol% and 99.9 vol%, and a lubricity component operable to increase the lubricity of the fuel component, the lubricity component selected from the group consisting of a base oil, an aromatic extract, and combinations of the same, where a sulfur content is between 0.101 wt % and 5 wt %.

[0006] In certain aspects, the lubricity component is present in an amount between 0.1 vol % and 90 vol %. In certain aspects, the base oil is selected from the group consisting of group II base oils, group III base oils, group IV base oils, group V base oils, and combinations of the same. In certain aspects, the marine fuel composition further includes fuel additives. In certain aspects, the residues are selected from the group consisting of straight run residue, thermal residue, cracked residue, and combinations of the same. In certain aspects, an API gravity is between 11.2 and 40. In certain aspects, a viscosity is between 3 cSt and 400 cSt at 122 deg F. In certain aspects, an amount of calcium is less than 30 mg/kg. In certain aspects, an amount of zinc is less than 15 mg/kg. In certain aspects, an amount of phosphorus is less than 15 mg/kg. In certain aspects, the lubricity component further includes a group I base oil.

[0007] In a second aspect a method of making a marine fuel composition is provided. The method includes the steps of developing a computer blend model for a fuel component and a lubricity component based on a desired value for a target property, where the computer blend model includes a volumetric ratio of the fuel component, where the computer blend model includes a volumetric ratio of the lubricity component, preparing a physical sample of the fuel component

based on the volumetric ratio of the computer blend model, mixing the lubricity component with the fuel component to produce the marine fuel composition, testing the target property of the marine fuel composition for conformance with the desired value, and preparing a commercial volume of the marine fuel composition.

[0008] In certain aspects, the method further includes the step of mixing a fuel additive into the marine fuel composition. In certain aspects, the computer blend model includes a value for each target property of the fuel component and the lubricity component. In certain aspects, the fuel component is selected from the group consisting of high sulfur fuel oil (HSFO), low sulfur fuel oil (LSFO), slurry oil from a fluid catalytic cracker, heavy coker gas oil (HCGO), light cycle oil (LCO) from a fluid catalytic cracker, vacuum tower bottoms (VTB), atmospheric tower bottoms (ATB), low sulfur straight run (LSSR), high sulfur straight run (HSSR), distillate base stock (DBS), low sulfur vacuum gas oil (LSVGO), high sulfur vacuum gas oil (HSVGO), cracked or straight run fuel oil (m100), straight run gas oil (SRGO), ultra low sulfur heating oil (ULSHO), residues, and combinations of the same. In certain aspects, the lubricity component is selected from the group consisting of a base oil, an aromatic extract, and combinations of the same. In certain aspects, the target property is selected from the group consisting of amount of sulfur, the API gravity, the kinematic viscosity, the flash point, the amount of hydrogen sulfide, the amount and types of metal components, the acid number, the total sediment by hot filtration, the oxidation stability, the amount of fatty acid methyl ester, the cloud point, the cold filter plugging point, the pour point, the lubricity, the amount of metals, and combinations of the same. In certain aspects, the target property is API gravity, and where the desired value of the API gravity is between 11.2 and 40. In certain aspects, the target property is viscosity, and where the desired value of the viscosity is between 3 cSt and 400 cSt at 122 deg F. In certain aspects, the target property is an amount of sulfur, and where the amount of sulfur is between 0.101 wt % and 5 wt %.

DETAILED DESCRIPTION OF THE INVENTION

[0009] While the scope will be described with several embodiments, it is understood that one of ordinary skill in the relevant art will appreciate that many examples, variations and alterations to the apparatus and methods described herein are within the scope and spirit. Accordingly, the exemplary embodiments described herein are set forth without any loss of generality, and without imposing limitations.

[0010] The compositions and methods described here are directed to marine fuel compositions and the methods of making the marine fuels. The marine fuel compositions are blends of fuel components. The marine fuel compositions are suitable for use in marine engines while meeting the IMO 2020 regulation and any other specifications that regulate marine fuels.

[0011] Advantageously, the marine fuel compositions comply with the IMO 2020 Regulation and inherently provide lubricity to engines. Providing lubricity to engines protects the integrity of the engines, increases thermal efficiency and contributes to engine longevity. The lubricity of the fuel can protect the interface between the piston ring and the wet cylinder in a marine engine. The lubricity of the fuel can reduce friction, heat and wear between mechanical components of the marine engine. Inherently providing lubricity means the use of lubricants can be reduced or eliminated in the marine fuel compositions. Advantageously, the lubricity components used in the marine fuel compositions can act as both a lubricant and as a fuel source. Advantageously, the marine fuel compositions containing lubricating characteristics can increase wear protection and fuel efficiency compared to fuels that meet the IMO 2020 regulation with regard to sulfur but do not contain lubricants. Advantageously, the use of the fuel component together with the lubricity component is in the absence of compatibility and stability concerns across the range of compositions described here.

[0012] As used throughout, “aromatic extract” refers to co-products developed during the base oil manufacturing process. A solvent can be used in an extraction process to extract multi-ring aromatic and high-sulfur materials from a feedstock to the base oil manufacturing process. The extracted aromatic extracts are then separated from the solvent and the solvent can be recycled as part of the extraction process. The raffinate from the extraction process can be further processed to produce base oils.

[0013] As used throughout, “base oil” refers to a base stock or lubrication grade oil with a boiling

point range between 500 degrees Fahrenheit (deg F) and 1050 deg F and includes hydrocarbons with 10 to 100 carbon atoms. The American Petroleum Institute (API) categorizes base oils into groups based on the molecular chemistry, such as the amount of paraffins (saturates), naphthenes, aromatics, oleophatics, oleophobic, esters, polyolefins, and other molecular structures, along with properties of the base oil. The base oils are grouped into group I base oils, group II base oils, group III base oils, group IV base oils, and group V base oils. Base oils are not considered a fuel component or hydrocarbon fraction for purposes of the marine fuel composition.

[0014] As used throughout, “group I base oil” refers to a base oil that contains less than 90 weight percent (wt %) saturates and/or greater than 0.03 wt % sulfur and has a viscosity index greater than or equal to 80 and less than 120. Group I base oils do not include slack waxes.

[0015] As used throughout, “group II base oil” refers to a base oil that contains greater than or equal to 90 wt % saturates and less than or equal to 0.03 wt % sulfur and has a viscosity index greater than or equal to 80 and less than 120.

[0016] As used throughout, “group III base oil” refers to a base oil that contains greater than or equal to 90 wt % saturates and less than or equal to 0.03 wt % sulfur and has a viscosity index greater than or equal to 120.

[0017] As used throughout, “group IV base oil” refers to a base oil that contains polyalphaolefins (PAO).

[0018] As used throughout, “group V base oil” refers to all other base stocks not included in group I base oils through group IV base oils. For purposes of the marine fuel compositions described herein, group V base oils do not include compounds considered fuel components.

[0019] As used throughout, “IMO 2020 Regulation” refers to the requirement by the International Maritime Organization (IMO) that all marine fuels contain 0.5 wt % or less sulfur by January 1, 2020.

[0020] As used throughout, “lubricity” refers to the ability of a lubricating compound to reduce the friction or wear on moving parts. A high lubricity fuel exhibits a reduce amount of friction compared to a low lubricity fuel. The lubricity of a fuel cannot be directly measured, so a number of test methodologies employing visual means have been developed to determine lubricity. Test methodologies for measuring lubricity include ASTM D6078 (Scuffing Load Ball-on-Cylinder

Lubricity Evaluator (SLBOCLE) test), ASTM D6079 (High Frequency Reciprocating Rig (HFRR) test), and ISO 12156-1 (HFRR test). The specific test chosen depends on the type of fuel or use of the fuel.

[0021] As used throughout, “lubricants” refers to compositions for use as friction modifiers that are not intended to be consumed during operation of an engine. Lubricants are designed to have a high survivability. Lubricants are different from marine fuels and marine fuels differ from lubricants, where lubricants alone are not suitable for use as marine fuels. Lubricants are designed for specific applications and specific engines, where additives can be used with lubricants to prolong the life of the lubricant. A composition used as a lubricant does not inherently provide the same properties as the lubricity component in the marine fuel compositions described here.

[0022] As used throughout, “marine fuels” refers to compositions that are intended to be consumed in marine engines. The composition of the marine fuel can be selected based on the desired properties and the type of marine engine in which the composition is to be used. Marine engines can include compression engines and turbine engines. The range of fuels suitable for use in a compression engine overlaps, but is different from the range of fuels suitable for use in turbine engines.

[0023] The marine fuel compositions include a fuel component and a lubricity component. The selection of the fuel component and the lubricity component can be made to produce a marine fuel composition that has the desired values of the targeted properties and the type of marine engine. The targeted properties can include the amount of sulfur, the API gravity, the kinematic viscosity, the flash point, the amount of hydrogen sulfide, the amount and types of metal components, the acid number, the total sediment by hot filtration, the oxidative stability, the amount of fatty acid methyl ester, the cloud point, the cold filter plugging point, the pour point, the lubricity, the amount of metals, and combinations of the same. In at least one embodiment, the marine fuel compositions can be formulated to meet the specifications of ISO 8217. In at least one embodiment, the marine fuel compositions can be formulated based on a desired use and such that the desired values of the targeted properties are within the specifications of ISO 8217. The metals that can be tested for include calcium, zinc, phosphorus, and combinations of the same.

[0024] The marine fuel composition can have an API gravity between 11.2 and 40. The marine fuel composition can have an amount of sulfur between 0.1 wt % and 5 wt %, alternately between

0.101 wt % and 5 wt %, alternately between 0.101 wt % and 3.5 wt %, alternately between 0.1 wt % and 0.5 wt %, and alternately between 0.101 wt % and 0.5 wt %. The marine fuel composition can have a viscosity between 3 centiStokes (cSt) and 400 cSt at 122 deg F.

[0025] The fuel component can include one or more types of hydrocarbon fraction that can be used as a fuel in combustion engines. The fuel component can be any composition intended to be consumed in marine engines. Examples of hydrocarbon fractions useful as the fuel component can include high sulfur fuel oil (HSFO), low sulfur fuel oil (LSFO), slurry oil from a fluid catalytic cracker, heavy coker gas oil (HCGO), light cycle oil (LCO) from a fluid catalytic cracker, vacuum tower bottoms (VTB), atmospheric tower bottoms (ATB), low sulfur straight run (LSSR), high sulfur straight run (HSSR), distillate base stock (DBS), low sulfur vacuum gas oil (LSVGO), high sulfur vacuum gas oil (HSVGO), cracked or straight run fuel oil (m100), straight run gas oil (SRGO), ultra low sulfur heating oil (ULSHO), residues, and combinations of the same. Examples of residues include straight run residues, thermal residues, cracked residues, and combinations of the same.

[0026] The fuel component can be present in an amount between 10 percent by volume (vol %) of the marine fuel composition and 99.9 vol % of the marine fuel composition, alternately between 20 vol % and 99.9 vol % of the marine fuel composition, alternately 30 vol % and 99.9 vol % of the marine fuel composition, alternately 40 vol % and 99.9 vol % of the marine fuel composition, alternately 50 vol % and 99.9 vol % of the marine fuel composition, alternately 60 vol % and 99.9 vol % of the marine fuel composition, alternately 70 vol % and 99.9 vol % of the marine fuel composition, alternately 80 vol % and 99.9 vol % of the marine fuel composition, alternately 90 vol % and 99.9 vol % of the marine fuel composition, alternately 90 vol % and 99.8 vol % of the marine fuel composition, alternately 90 vol % and 99.5 vol % of the marine fuel composition, alternately 90 vol % and 99 vol %, alternately between 92 vol % and 99.9 vol %, and alternately between 92 vol % and 99.5 vol %.

[0027] The lubricity component can be any combustible component that can act as a lubricant to an engine as part of a fuel blend. Examples of combustible components suitable for use as the lubricity component include base oils, aromatic extracts, and combinations of the same. Examples of base oil components include group I base oils, group II base oils, group III base oils, group IV base oils, group V base oils, and combinations of the same. In at least one embodiment, the

lubricity component can include a group I base oil. In at least one embodiment, the lubricity component can include a group II base oil. In at least one embodiment, the lubricity component can include a group III base oil. In at least one embodiment, the lubricity component can include a group IV base oil. In at least one embodiment, the lubricity component can include a group V base oil. The lubricity component is not considered a fuel component in the marine fuel composition. The lubricity component can be selected based on the desired properties of the marine fuel composition and not the type of engine used.

[0028] The lubricity component can be present in an amount between 1 vol % of the marine fuel composition and 8 vol % of the marine fuel composition, alternately between 0.5 vol % of the marine fuel composition and 8 vol % of the marine fuel composition, alternately between 0.2 vol % of the marine fuel and 8 vol % of the marine fuel composition, alternately between 1 vol % of the marine fuel composition and 10 vol % of the marine fuel composition, alternately 0.5 vol % and 10 vol % of the marine fuel composition, alternately between 0.2 vol % and 10 vol % of the marine fuel composition, alternately between 0.1 vol % and 10 vol % of the marine fuel composition, alternately between 0.1 vol % and 20 vol % of the marine fuel composition, alternately between 0.1 vol % and 30 vol % of the marine fuel composition, alternately between 0.1 vol % and 40 vol % of the marine fuel composition, alternately between 0.1 vol % and 50 vol % of the marine fuel composition, alternately between 0.1 vol % and 60 vol % of the marine fuel composition, alternately between 0.1 vol % and 70 vol % of the marine fuel composition, alternately between 0.1 vol % and 80 vol % of the marine fuel composition, and alternately between 0.1 vol % and 90 vol % of the marine fuel composition.

[0029] The marine fuel composition can include fuel additives. Fuel additives can be any compound formulated to enhance the quality, efficiency, or a performance characteristic of the marine fuel composition. The fuel additives can be added to enhance or improve a target property or to impart a property on the fuel. Fuel additives suitable for use can include pour point additives, solubility additives, lubricity additives, and combinations of the same. In an alternate embodiment, fuel additives suitable for use can include solubility additives, lubricity additives, and combinations of the same. As used here, lubricity additives differ from the lubricity component in that a lubricity additive are added to improve one or more properties of the marine fuel composition and not added for the purpose of increasing the release of energy in the marine engine. Fuel additives can be present in amount of between 0 vol % and 25 vol % of the marine fuel

compositions. Lubricity additives can be included to address compatibility and stability concerns. Compatibility and stability concerns include the ability to blend the components in a homogeneous mixture, the reduction or elimination of the precipitation of asphaltenes or other solid materials. In at least one embodiment of the marine fuel composition, the lubricity component can act as a pour point additive in addition to adding lubricity to the marine fuel composition.

[0030] The overall amount of the fuel component in the marine fuel composition, the specific types of hydrocarbon fractions selected as the fuel component, and the amount of each hydrocarbon fraction selected as the fuel component can be chosen to meet the desired target properties and required the use of the marine fuel composition. It will be appreciated by one of skill in the art that not only the type of hydrocarbon fraction selected, but also the amount of that hydrocarbon fraction can impact the properties of the fuel component. By way of non-limiting example, a fuel component that contains 80 vol % ultra low sulfur heating oil and 20 vol % high sulfur fuel oil can result in a fuel component with less sulfur than a fuel component that contains 20 vol % ultra low sulfur heating oil and 80 vol % high sulfur fuel oil. By way of non-limiting example, it is anticipated that to achieve a marine fuel composition having an amount of sulfur of about 0.101 wt %, the resulting marine fuel composition can include primarily ultra low sulfur heating oil with small amounts of gas oils and low sulfur fuel oils. To achieve marine fuel compositions that have an amount of sulfur of about 0.5 wt % the amount of ultra low sulfur heating oil can be decreased while the amount of other hydrocarbon fractions can be increased. The specific compounds selected as the fuel component and lubricity component can be selected to optimize the desired properties of the marine fuel composition. It will be appreciated by one of skill in the art that each type of hydrocarbon fraction can have slightly different values for the target properties based on the source of the hydrocarbon fraction and the processing conditions.

[0031] The marine fuel composition can be prepared according to the following method. The specifications of the hydrocarbon fractions available for use as the fuel component and the specifications of the lubricity component are loaded into a computer blend model. The computer blend model is used to develop a fuel component and lubricity component that meets the desired values of the target properties for the marine fuel composition. In a second step, a physical sample of the fuel component is prepared based on the volumetric ratios identified in the computer blend model. The fuel component is then mixed with a physical sample of the lubricity component according to the volumetric ratios identified in the computer blend model. The prepared physical

sample of marine fuel composition containing the fuel component and lubricity component is then tested for one or more target properties. Testing the physical sample can provide assurance that the marine fuel composition does not have any compatibility or stability concerns. If the test results suggest desired values for the target properties are not met, or there are compatibility and stability concerns, then fuel additives can be mixed into the marine fuel composition to achieve the desired values or to address the compatibility and stability concerns. Alternately, if the test results are considered negative, the physical sample can be discarded and the process can be started again with the computer blend model. The test methodology employed to test the physical sample can depend on the target property being tested. In at least one embodiment, the test methodology of the target property is defined by an International Standards Organization (ISO) standard, such as ISO 8217:2017.

[0032] When the test results confirm the physical sample of the marine fuel composition possesses the desired values of the target properties tested, a commercial volume of the marine fuel composition can be mixed. The commercial volume of the marine fuel composition can be prepared in a mixing tank or can be prepared directly into a distribution vessel. Distribution vessels can include trucks, railcars, ships, barges, and combinations of the same.

[0033] The marine fuel compositions can have values of properties that make them advantageous for use in marine engines over the fuel compositions alone. The marine fuel compositions can have values of sediment, ash content, and micro carbon residue that can reduce the amount of deposit on engines, prolonging engine life as compared to the use of fuel compositions in the absence of lubricity components.

[0034] The marine fuel compositions can be in the absence of biofuels. The marine fuel compositions can be in the absence of fatty ester biofuels. The marine fuel compositions can be in the absence of fatty acid methyl esters. The marine fuel compositions can be in the absence of thickeners and anti-foam additives. The marine fuel compositions can be in the absence of anti-oxidants, ashless dispersants, anti-wear agents, detergents, rust inhibitors, dehazing agents, demulsifying agents, metal deactivating agents, friction modifiers, antifoaming agents, co-solvents, package compatibilisers, corrosion-inhibitors, dyes, extreme pressure agents and the like and mixtures thereof.

[0035] **Examples**

[0036] **Examples 1-9.** Each of the Examples 1-9 was developed based on computer modeling of a blend sample of a marine fuel composition. Each Example 1-9 was developed to achieve a specified amount of sulfur. Amongst all of the Examples 1-9, similar components were given the same values for the target properties of API Gravity, amount of sulfur and viscosity.

[0037] **Example 1.** Example 1 provides an example of a marine fuel composition with 0.1 wt % sulfur.

[0038] **Table 1. Properties of the marine fuel composition of Example 1.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 94.0 vol%				
Low Sulfur Fuel Oil (LSFO)	6.0 %	0.700	19.00	900.00
Straight Run Gas Oil (SRGO)	8.0 %	0.117	36.20	3.27
Ultra Low Sulfur Oil (ULSHO)	80.0 %	0.057	37.80	2.13
Amount of Lubricity Component 6.0 vol%				
Group II Base Oil	6.0 %	0.00	29.70	96.00

[0039] The API gravity of the marine fuel composition of Example 1 was 35.91. The sulfur content of the marine fuel composition of Example 1 was 0.10 %. The viscosity of the marine fuel composition of Example 1 was 3.06 centiStokes (cSt).

[0040] **Example 2.** Example 2 provides an example of a marine fuel composition with 0.3 wt % sulfur.

[0041] **Table 2. Properties of the marine fuel composition of Example 2.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 94.8 vol%				
Low Sulfur Fuel Oil (LSFO)	11.3 %	0.700	19.00	900.00
Distillate Base Stock (DBS)	75.5 %	0.280	30.80	2.53

Straight Run Gas Oil (SRGO)	7.5 %	0.117	36.20	3.27
Amount of Lubricity Component 5.0 vol%				
Group II Base Oil	5.7 %	0.00	29.70	96.00

[0042] The API gravity of the marine fuel composition of Example 2 was 29.70. The sulfur content of the marine fuel composition of Example 2 was 0.30 %. The viscosity of the marine fuel composition of Example 2 was 4.18 cSt.

[0043] **Example 3.** Example 3 provides an example of a marine fuel composition with 0.5 wt % sulfur.

[0044] **Table 3. Properties of the marine fuel composition of Example 3.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 97.7 vol%				
Low Sulfur Fuel Oil (LSFO) #1	15.6 %	0.700	19.00	900.00
Light Cycle Oil (LCO)	11.7 %	0.430	24.00	2.23
Low Sulfur Vacuum Gas Oil (LSVGO)	58.6 %	0.368	26.00	34.00
Low Sulfur Fuel Oil (LSFO) #2	11.7 %	1.040	14.70	4078.00
Amount of Lubricity Component 2.3 vol%				
Group II Base Oil	2.3 %	0	34.3	20.50

[0045] The API gravity of the marine fuel composition of Example 3 was 23.42. The sulfur content of the marine fuel composition of Example 3 was 0.50 %. The viscosity of the marine fuel composition of Example 3 was 43.8 cSt.

[0046] **Example 4.** Example 4 provides an example of a marine fuel composition with 0.5 wt % sulfur.

[0047] **Table 4. Properties of the marine fuel composition of Example 4.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 98.5 vol%				
Distillate Base Stock (DBS)	25.6 %	0.280	19.00	2.53
High Sulfur Fuel Oil (HSFO)	3.6 %	2.950	12.40	2549.00
Low Sulfur Straight Run (LSSR)	61.5 %	0.500	36	264.00
Straight Run Gas Oil (SRGO)	7.7 %	0.117	14.70	3.27
Amount of Lubricity Component 1.5 vol%				
Group II Base Oil	1.5 %	0.000	29.70	96.00

[0048] The API gravity of the marine fuel composition of Example 4 was 23.00. The sulfur content of the marine fuel composition of Example 4 was 0.49 %. The viscosity of the marine fuel composition of Example 4 was 32.02 cSt.

[0049] **Example 5.** Example 5 provides an example of a marine fuel composition with 0.5 wt % sulfur.

[0050] **Table 5. Properties of the marine fuel composition of Example 5.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 92.9 vol%				
Low Sulfur Fuel Oil (LSFO)	28.6 %	0.700	19.00	900.00
Light Cycle Oil (LCO)	10.7 %	0.430	24.00	2.23
Low Sulfur Straight Run (LSSR)	50.0 %	0.500	19.00	264.00
Ultra Low Sulfur Oil (ULSHO)	3.6 %	0.057	37.80	2.13
Amount of Lubricity Component 7.1 vol%				
Group II Base Oil	7.1 %	0.000	31.80	42.2

[0051] The API gravity of the marine fuel composition of Example 5 was 20.98. The sulfur content of the marine fuel composition of Example 5 was 0.50 %. The viscosity of the marine fuel composition of Example 5 was 97.46 cSt.

[0052] **Example 6.** Example 6 provides an example of a marine fuel composition with 1 wt % sulfur.

[0053] **Table 6. Properties of the marine fuel composition of Example 6.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 98.3 vol%				
Low Sulfur Fuel Oil (LSFO)	28.9 %	0.700	19.00	900.00
Light Cycle Oil (LCO)	17.3 %	0.430	24.00	2.23
Slurry Oil from FCC	11.6 %	1.520	7.30	56.00
Low Sulfur Vacuum Gas Oil (LSVGO)	26.0 %	0.368	26.00	34.00
High Sulfur Fuel Oil (HSFO)	14.5 %	2.950	12.40	2549.00
Amount of Lubricity Component 1.7 vol%				
Group II Base Oil	1.7 %	0.000	29.70	96.00

[0054] The API gravity of the marine fuel composition of Example 6 was 19.29. The sulfur content of the marine fuel composition of Example 6 was 0.97 %. The viscosity of the marine fuel composition of Example 6 was 55.75 cSt.

[0055] **Example 7.** Example 7 provides an example of a marine fuel composition with 1 wt % sulfur.

[0056] **Table 7. Properties of the marine fuel composition of Example 7.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 97.8 vol%				
Low Sulfur Fuel Oil (LSFO) #1	50.4 %	0.700	19.00	900.00
Light Cycle Oil (LCO)	7.2 %	0.430	24.00	2.23
Slurry Oil from FCC	12.9 %	1.520	7.30	56.00
Low Sulfur Fuel Oil (LSFO) #2	21.6 %	1.040	14.70	4078.00
High Sulfur Fuel Oil (HSFO)	5.8 %	2.950	12.40	2549.00
Amount of Lubricity Component 2.2 vol%				
Group II Base Oil	2.2 %	0.000	29.70	96.00

[0057] The API gravity of the marine fuel composition of Example 7 was 16.61. The sulfur content of the marine fuel composition of Example 7 was 0.97 %. The viscosity of the marine fuel composition of Example 7 was 340.22 cSt.

[0058] **Example 8.** Example 8 provides an example of a marine fuel composition with 2 wt % sulfur.

[0059] **Table 8. Properties of the marine fuel composition of Example 8.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 98.4 vol%				
Low Sulfur Fuel Oil (LSFO)	6.9 %	0.700	19.00	900.00
Slurry Oil from FCC	20.6 %	1.520	7.30	56.00
Vacuum Tower Bottoms (VTB)	29.6 %	3.180	16.30	3071.00
Cracked or Straight Run Fuel Oil (m100)	41.3 %	1.690	15.80	141.00
Amount of Lubricity Component 1.6 vol%				

Group II Base Oils	1.6 %	0.000	31.50	10.70
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[0060] The API gravity of the marine fuel composition of Example 8 was 14.54. The sulfur content of the marine fuel composition of Example 8 was 2.00 %. The viscosity of the marine fuel composition of Example 8 was 248.52 cSt.

[0061] **Example 9.** Example 9 provides an example of a marine fuel composition with about 2.5 wt % sulfur.

[0062] **Table 9. Properties of the marine fuel composition of Example 9.**

Component	Amount (vol %)	Sulfur Content (%)	API Gravity	Viscosity (cSt)
Amount of Fuel Component 97.8 vol%				
Light Cycle Oil (LCO)	5.8 %	0.430	24.00	2.23
Slurry Oil from FCC	23.8 %	1.520	7.30	56.00
Low Sulfur Fuel Oil (LSFO) #2	3.5 %	1.040	14.70	4078.00
High Sulfur Fuel Oil (HSFO)	21.6 %	2.950	12.40	2549.00
Vacuum Tower Bottoms (VTB)	43.2 %	3.180	16.30	3071.00
Amount of Lubricity Component 2.2 vol%				
Group II Base Oils	2.2 %	0.00	13.91	20.50

[0063] The API gravity of the marine fuel composition of Example 9 was 13.91. The sulfur content of the marine fuel composition of Example 9 was 2.43 %. The viscosity of the marine fuel composition of Example 9 was 378.94 cSt.

[0064] **Example 10.** Example 10 contains the analysis of actual blends developed in laboratory. Blend 1 contained 35 vol% low sulfur straight run (LSSR), 11 vol % low sulfur fuel oil (VLSFO), and 54 vol % straight run gas oil (SRGO). The components of Blend 1 had the properties in Table 10.

[0065] **Table 10. Properties of Blend 1**

Component	Amount (vol %)	Sulfur Content (wt%)	API Gravity	Viscosity (cSt)
Low Sulfur Straight Run (LSSR)	35	1.09	19.9	136
Low Sulfur Fuel Oil (VLSFO)	11	0.27	30.5	21.86
Straight Run Gas Oil (SRGO)	54	0.145	35.9	4.3

[0066] Blend 2 contained 95 vol % of Blend 1 as the fuel component and 5 vol % of a Group II Base Oil as the lubricity component. Blend 3 contained 90 vol % of Blend 1 and 10 vol % of a Group II Base Oil as the lubricity component. Blend 4 contained 95 vol % of Blend 1 and 5 vol % of a Group II Base Oil as the lubricity component. Blend 5 contained 90 vol % of Blend 1 and 10 vol % of a Group II Base Oil as the lubricity component. The Group II Base Oil in Blend 2 and Blend 3 was the same. The Group II Base Oil in Blend 4 and Blend 5 was the same, but different from that used in Blend 2 and Blend 3. The results for each blend are shown in Table 11.

[0067] **Table 11. Properties of Blends for Example 10.**

Blend	Sulfur Content (wt%)	API Gravity	Viscosity (cSt)	Total Sediment	Ash Content	Micro Carbon Residue	Lubricity
1	0.48	29.0	7.79	0.03	0.009	2.16	320
2	0.46	29.1	8.42	<0.01	0.005	2.01	300
3	0.44	29.2	9.17	<0.01	0.005	1.88	330
4	0.47	29.0	8.25	<0.01	0.005	1.97	330
5	0.44	29.4	8.58	<0.01	0.005	1.86	290

[0068] Each of the blends 1 through 5 have a cleanliness rating of 1 and a compatibility rating of 1. The total sediment and the ash content are a quantitative analysis of the benefits of the lubricity component on the engines. Blends 2-5 show better properties of total sediment, ash content, and

micro carbon residue compared to Blend 1, which is an indication that such blends would create less deposit on the engines.

[0069] Although the present embodiments have been described in detail, it should be understood that various changes, substitutions, and alterations can be made hereupon without departing from the principle and scope. Accordingly, the scope should be determined by the following claims and their appropriate legal equivalents.

[0070] The singular forms “a,” “an,” and “the” include plural referents, unless the context clearly dictates otherwise.

[0071] Optional or optionally means that the subsequently described event or circumstances can or may not occur. The description includes instances where the event or circumstance occurs and instances where it does not occur.

[0072] Ranges may be expressed herein as from about one particular value, and/or to about another particular value. When such a range is expressed, it is to be understood that another embodiment is from the one particular value and/or to the other particular value, along with all combinations within said range.

[0073] As used herein and in the appended claims, the words “comprise,” “has,” and “include” and all grammatical variations thereof are each intended to have an open, non-limiting meaning that does not exclude additional elements or steps.

[0074] As used herein, terms such as “first” and “second” are arbitrarily assigned and are merely intended to differentiate between two or more components of an apparatus. It is to be understood that the words “first” and “second” serve no other purpose and are not part of the name or description of the component, nor do they necessarily define a relative location or position of the component. Furthermore, it is to be understood that the mere use of the term “first” and “second” does not require that there be any “third” component, although that possibility is contemplated under the scope of the embodiments.

CLAIMS

What is claimed is:

1. A marine fuel composition for use in marine engines, the marine fuel composition comprising:

a fuel component, the fuel component selected from the group consisting of high sulfur fuel oil (HSFO), low sulfur fuel oil (LSFO), slurry oil from a fluid catalytic cracker, heavy coker gas oil (HCGO), light cycle oil (LCO) from a fluid catalytic cracker, vacuum tower bottoms (VTB), atmospheric tower bottoms (ATB), low sulfur straight run (LSSR), high sulfur straight run (HSSR), distillate base stock (DBS), low sulfur vacuum gas oil (LSVGO), high sulfur vacuum gas oil (HSVGO), cracked or straight run fuel oil (m100), straight run gas oil (SRGO), ultra low sulfur heating oil (ULSHO), residues, and combinations of the same,

wherein the fuel component is present in an amount between 10 vol% and 99.9 vol%; and

a lubricity component operable to increase the lubricity of the fuel component, the lubricity component selected from the group consisting of a base oil, an aromatic extract, and combinations of the same,

wherein a sulfur content is between 0.101 wt % and 5 wt %.

2. The marine fuel composition of claim 1, wherein the lubricity component is present in an amount between 0.1 vol % and 90 vol %.

3. The marine fuel composition of claim 1, wherein the base oil is selected from the group consisting of group II base oils, group III base oils, group IV base oils, group V base oils, and combinations of the same.

4. The marine fuel composition of claim 1, further comprising fuel additives.

5. The marine fuel composition of claim 1, wherein the residues are selected from the group consisting of straight run residue, thermal residue, cracked residue, and combinations of the same.

6. The marine fuel composition of claim 1, wherein an API gravity is between 11.2 and 40.

7. The marine fuel composition of claim 1, wherein a viscosity is between 3 cSt and 400 cSt at 122 deg F.

8. The marine fuel composition of claim 1, wherein an amount of calcium is less than 30 mg/kg.
9. The marine fuel composition of claim 1, wherein an amount of zinc is less than 15 mg/kg.
10. The marine fuel composition of claim 1, wherein an amount of phosphorus is less than 15 mg/kg.
11. The marine fuel composition of claim 1, wherein the lubricity component further comprises a group I base oil.
12. A method of making a marine fuel composition, the method comprising the steps of:
 - developing a computer blend model for a fuel component and a lubricity component based on a desired value for a target property, wherein the computer blend model comprises a volumetric ratio of the fuel component, wherein the computer blend model comprises a volumetric ratio of the lubricity component;
 - preparing a physical sample of the fuel component based on the volumetric ratio of the computer blend model;
 - mixing the lubricity component with the fuel component to produce the marine fuel composition;
 - testing the target property of the marine fuel composition for conformance with the desired value; and
 - preparing a commercial volume of the marine fuel composition.
13. The method of claim 12, further comprising the step of mixing a fuel additive into the marine fuel composition.
14. The method of claim 12, wherein the computer blend model comprises a value for each target property of the fuel component and the lubricity component.
15. The method of claim 12, wherein the fuel component is selected from the group consisting of high sulfur fuel oil (HSFO), low sulfur fuel oil (LSFO), slurry oil from a fluid catalytic cracker, heavy coker gas oil (HCGO), light cycle oil (LCO) from a fluid catalytic cracker, vacuum tower bottoms (VTB), atmospheric tower bottoms (ATB), low sulfur straight run (LSSR), high sulfur straight run (HSSR), distillate base stock (DBS), low sulfur vacuum gas oil (LSVGO), high sulfur

vacuum gas oil (HSVGO), cracked or straight run fuel oil (m100), straight run gas oil (SRGO), ultra low sulfur heating oil (ULSHO), residues, and combinations of the same.

16. The method of claim 12, wherein the lubricity component is selected from the group consisting of a base oil, an aromatic extract, and combinations of the same.

17. The method of claim 12, wherein the target property is selected from the group consisting of amount of sulfur, the API gravity, the kinematic viscosity, the flash point, the amount of hydrogen sulfide, the amount and types of metal components, the acid number, the total sediment by hot filtration, the oxidation stability, the amount of fatty acid methyl ester, the cloud point, the cold filter plugging point, the pour point, the lubricity, the amount of calcium and zinc, the amount of calcium and phosphorus, and combinations of the same.

18. The method of claim 12, wherein the target property is API gravity, and wherein the desired value of the API gravity is between 11.2 and 40.

19. The method of claim 12, wherein the target property is viscosity, and wherein the desired value of the viscosity is between 3 cSt and 400 cSt at 122 deg F.

20. The method of claim 12, wherein the target property is an amount of sulfur, and wherein the amount of sulfur is between 0.101 wt % and 5 wt %.