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(54) **TREATMENT OF HEAVY OILS TO REDUCE
OLEFIN CONTENT**

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C10G 7/00 (2006.01)
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(2013.01); **C10G 9/007** (2013.01); **C10G**
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See application file for complete search history.

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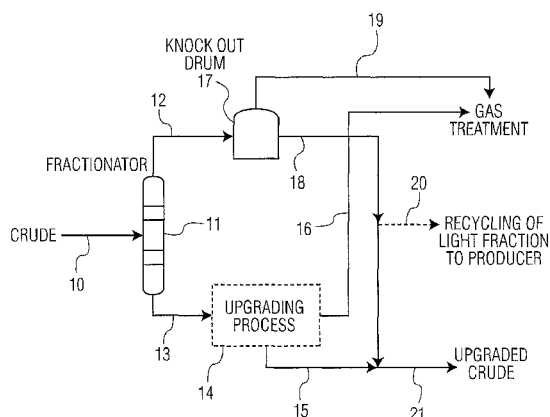
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(57) **ABSTRACT**

A process for treating heavy oil to provide a treated heavy oil having a reduced density and viscosity, as well as an olefin content that does not exceed 1.0 wt. %. The process comprises separating the initial heavy oil into a first fraction, which in general contains lower-boiling components, and a second fraction. The second fraction comprises a heavy oil having a p-value of at least 5% greater than the p-value of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction, and the second fraction has an aromaticity that is no more than 5% less than the aromaticity of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction. The second fraction then is upgraded to reduce the density and viscosity of the heavy oil. After the second fraction is upgraded, it is recombined with at least a portion of the first fraction to provide a treated heavy oil having an olefin content that does not exceed 1.0 wt. %. The separation of the initial heavy oil into first and second fractions enables one to achieve improved reduction of the density and viscosity of the treated heavy oil while maintaining the olefin content at an acceptable level.

67 Claims, 3 Drawing Sheets



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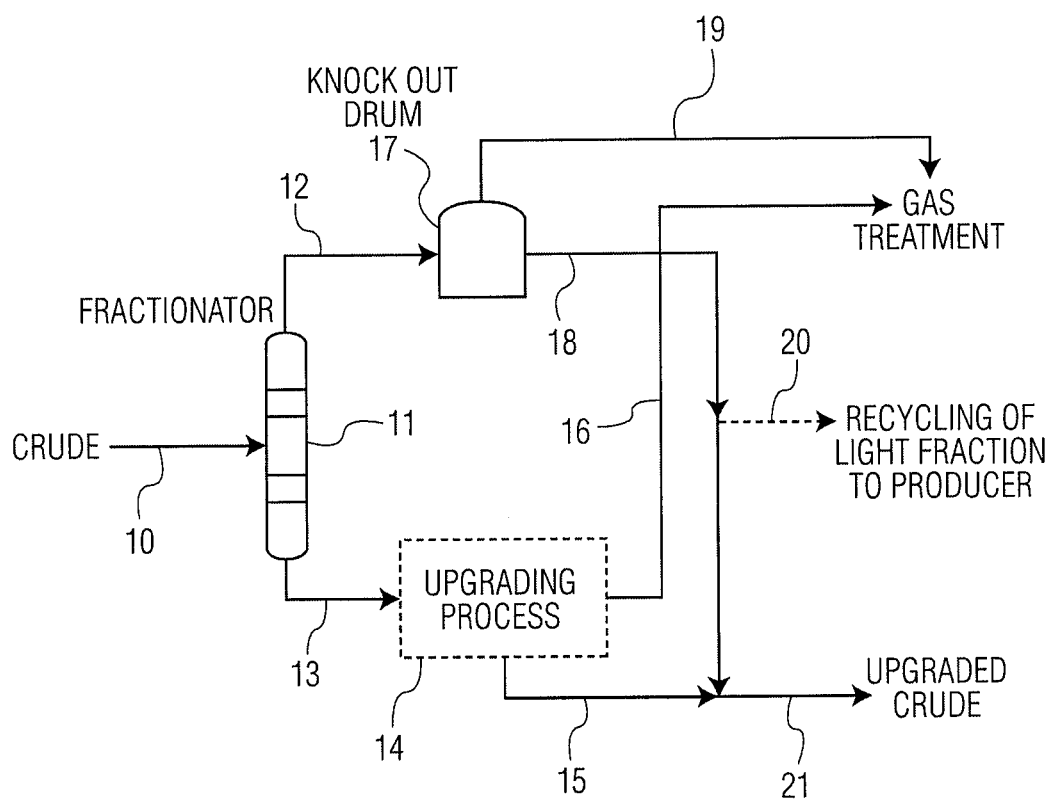


FIG. 1

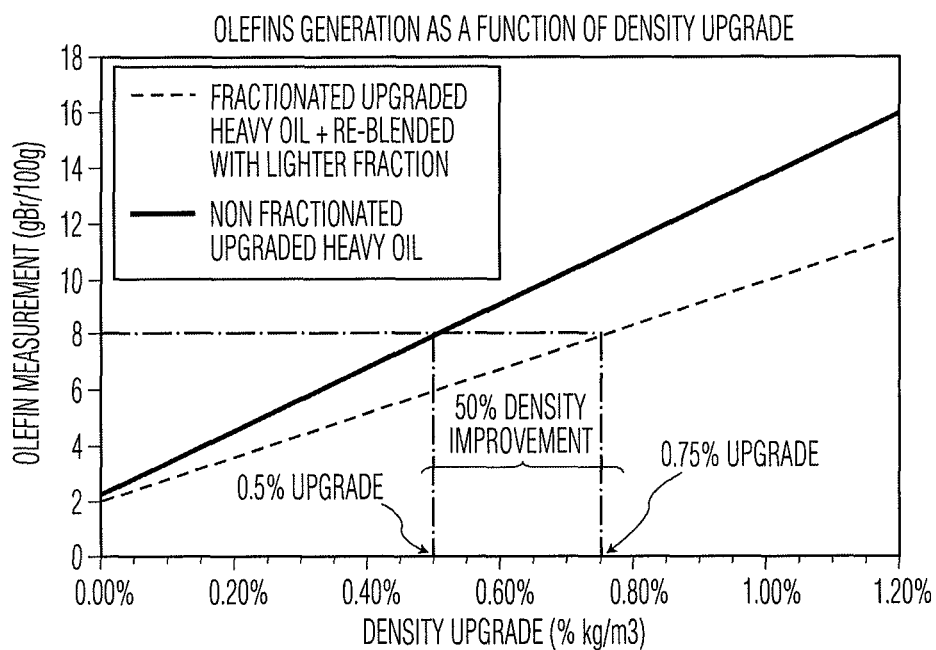


FIG. 2

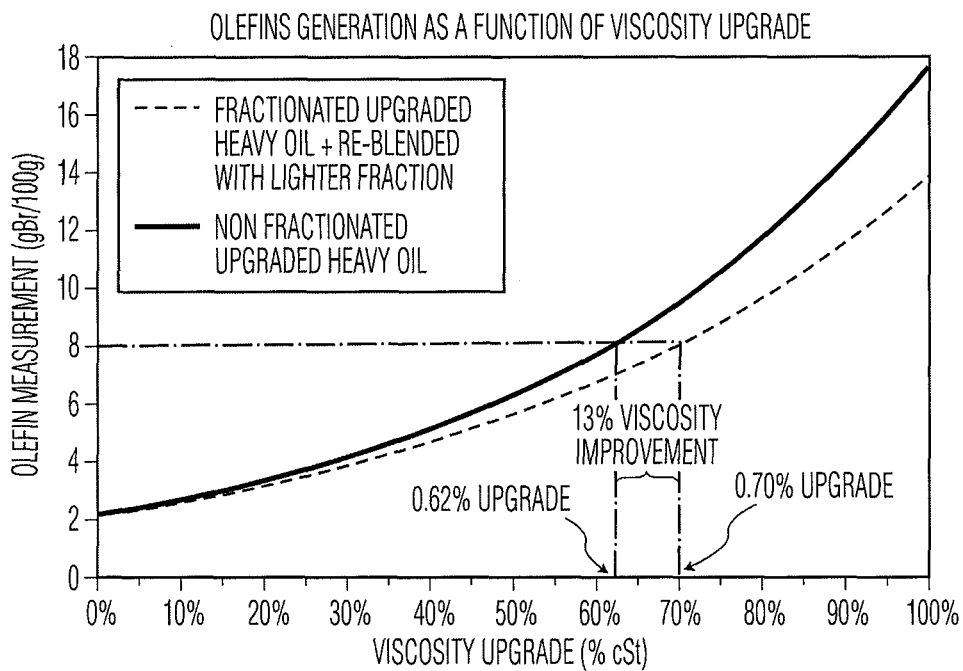


FIG. 3

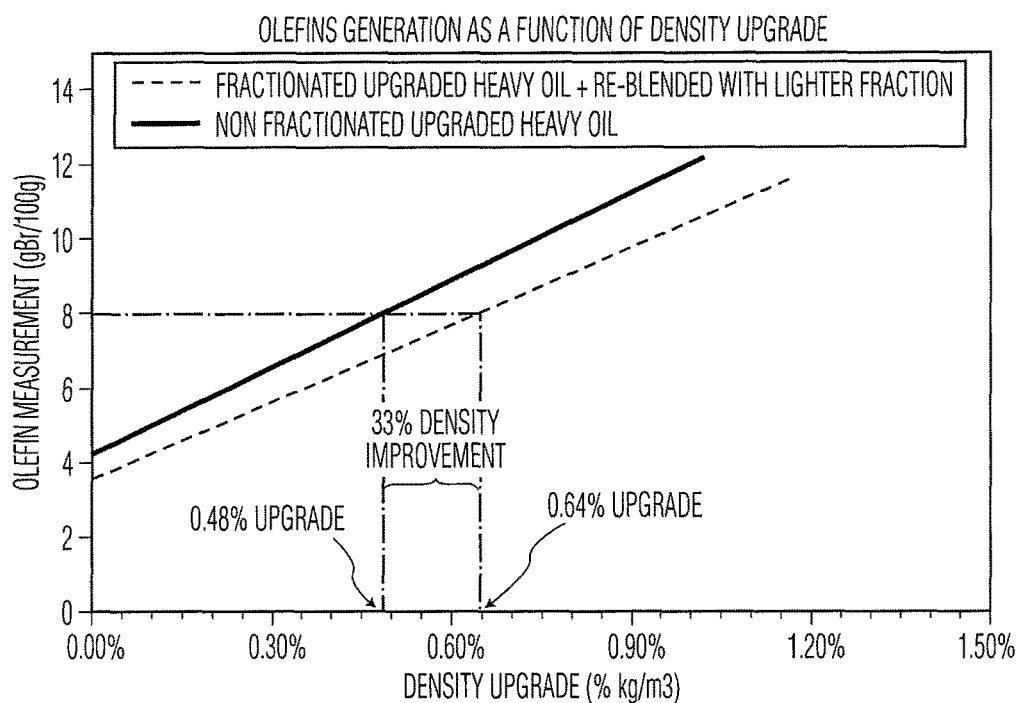


FIG. 4

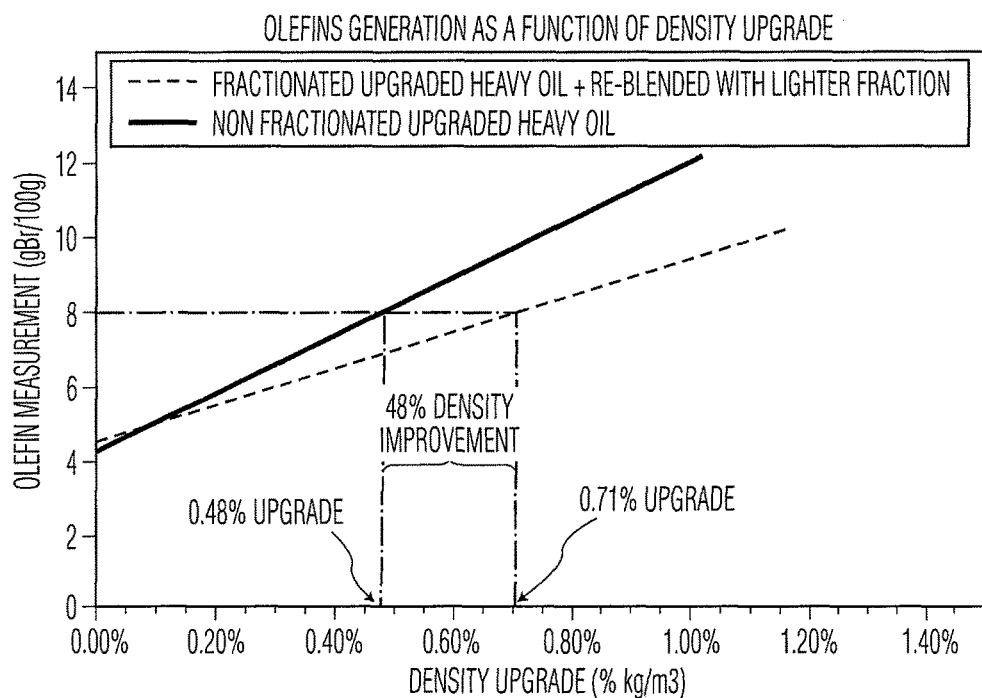


FIG. 5

1

TREATMENT OF HEAVY OILS TO REDUCE OLEFIN CONTENT

This application claims priority based on provisional Application Ser. No. 61/864,827, filed Aug. 12, 2013, the contents of which are incorporated by reference in their entirety.

This invention relates to the treatment of heavy oils to achieve improved reduction of the density and viscosity of the heavy oils, while maintaining the olefin content of the heavy oils at acceptable levels. More particularly, this invention relates to treating a heavy oil by separating the heavy oil into a first, or lower-boiling range, or light, fraction, and a second, or higher-boiling range, or heavy, fraction. The second, or heavy, fraction is upgraded, such as by thermal (e.g., visbreaking), mechanical (e.g., hydrodynamic and/or ultrasonic cavitation), oxydesulfurization and/or other upgrading processes in order to reduce its density and viscosity. After upgrading, it is recombined with at least a portion of the first fraction to provide a treated heavy oil having an olefin content that does not exceed 1.0 wt. %.

The term "heavy oil", as used herein, includes oils which are classified by the American Petroleum Institute (API), as heavy oils or extra heavy oils, as well as blended oils, such as dilbit (a diluent-bitumen blend) or synbit (a synthetic oil-bitumen blend). In general, a heavy hydrocarbon oil has an API gravity between 22.3° (density of 920 kg/m³ or 0.920 g/cm³) and 10.0° (density of 1,000 kg/m³ or 1 g/cm³). An extra heavy oil in general has an API gravity of less than 10.0° (density greater than 1,000 kg/m³ or greater than 1 g/cm³). For example, heavy oils may be extracted from oil sands, atmospheric tar bottoms products, vacuum tar bottoms products, shale oils, coal-derived liquids, crude oil residues, and topped crude oils.

Heavy oils in general have macro and micro structural properties as well as having specific chemical constitutive molecules. The chemical constitutive molecules belong to two generic categories, maltenes and asphaltenes. Maltenes are soluble in pentane or light saturated hydrocarbons, while asphaltenes are soluble in toluene but insoluble in pentane or light saturated hydrocarbons. Also present in the heavy oils are metals, particularly nickel and vanadium. The metals are associated mainly with the asphaltenes. The spatial organization of maltenes and asphaltenes results in the macro and micro structural properties, with the molecular organization causing the high viscosities, which pose a problem in transporting such oils, and in separating the asphaltenes from the maltenes.

More particularly, the asphaltenes are formed by a core of polynuclear aromatic molecules grouped in layers, to which alkyl chains are attached. The core is surrounded by and immersed in the maltene material. The maltene material includes free saturates (some of them cyclic), mono- and diaromatics, polyaromatics, and polar components or resins which are believed to be associated closely with the asphaltenes. This organization is considered to be the micro-structure and the core of the asphaltenes can be considered as possessing microcrystalline arrangements. The micro-structural organization forms aggregates in which several microcrystalline arrangements form a micellar structure known as a macrostructure. The micellar structure or macrostructure has strong associative and cohesive forces between the aggregates, which accounts for the high viscosity of the heavy oil.

Heavy oils may be upgraded in order to decrease their density and viscosity, thus making the heavy oil more pumpable and transportable. Such upgrading may include

2

thermal processes, mechanical processes, such as hydrodynamic and/or ultrasonic cavitation, or a combination of thermal and mechanical processes, and/or hydrogen addition processes, and/or oxydesulfurization.

Such upgrading of the heavy oil, however, may result in the formation of undesirable amounts of olefins or unsaturated compounds, also known as alkenes. The term "olefin", as used herein, means any unsaturated hydrocarbon containing one or more pairs of carbon atoms linked by a double bond. Olefins may decrease the stability of the heavy oil, and/or may create problems during transportation and refining. In addition, olefins and aromatics are precursors of coke formation.

Thus, it is desired to reduce the density and viscosity of a heavy oil as much as possible, while preventing the formation of an unacceptable amount or level of olefins. Such a heavy oil also will have desired stability, and a desired aromaticity, and will have improved pumpability and transportability.

Olefin content can be measured by the bromine number test or by the proton Nuclear Magnetic Resonance Spectroscopy (HNMR) test. The bromine number is the amount of bromine (in grams) absorbed by 100 grams of a sample. The bromine number is measured according to the ASTM-D1159 procedure. The number indicates the degree of unsaturation, which is related to olefin content. A bromine number under 10 is considered acceptable for normal crude oil handling. The HNMR test measures olefin content on the full crude by mass as 1-decene equivalent. A test result that is greater than 1.0% olefin by mass as 1-decene equivalent indicates the presence of an unacceptable amount of olefins. A bromine number of 10 corresponds generally and approximately to an olefin content of 1.0% by weight. With respect to the transportation of heavy oils, the olefin content of the heavy oil should not exceed 1.0% by weight, as measured by HNMR or bromine number.

The p-value of a heavy oil is a measure of the flocculation potential of asphaltenes and their tendency to form solid deposits. The p-value is a stability indicator and also is a measure of asphaltene solubility. The p-value is determined by testing the heavy oil according to the ASTM-D7157 method or a method similar to ASTM D-7157, and ranges from 1 (unstable) to 5 (very stable). The method consists of solubilizing three samples of the heavy oil using different amounts of toluene or xylenes. These three different mixtures of heavy oil samples and aromatic solvent (i.e., toluene or xylene) then are titrated with a paraffinic solvent, such as n-heptane, to precipitate the asphaltenes. The amounts of heavy oil and solvents added, including the titration solvent, up to the onset of the peptization of the asphaltenes, are used to calculate the stability parameters and their intrinsic stability. A p-value which is at least 1.5 indicates that the heavy oil is stable, while a heavy oil having a p-value of less than 1.5 generally is considered unstable.

Aromaticity is measured using a carbon-13 NMR (or ¹³C NMR or carbon NMR) test. In this test, nuclear magnetic resonance (NMR) is applied to carbon. This test is analogous to proton NMR (1H NMR) testing and allows the identification among others of aromatic carbon atoms in an organic molecule just as proton NMR testing identifies hydrogen atoms. By using ¹³C NMR, one can determine the level of aromaticity in a heavy oil.

Applicants have discovered that, by removing aliphatic or paraffinic components that are concentrated in the lighter fractions of a heavy oil prior to upgrading the heavy oil, the solubility of the asphaltenes is increased (as shown by the observed increase in the p-value), which in turn reduces the

3

formation of olefins during upgrading of the heavy oil, such as by thermal treatment, mechanical treatment (e.g., hydrodynamic and/or ultrasonic cavitation), oxydesulfurization, and/or hydrogen addition processes, to reduce the density and viscosity of the heavy oil.

Therefore, by removing such aliphatic or paraffinic components that are contained in the lighter fractions of the heavy oil prior to upgrading the heavy oil, Applicants have achieved through a subsequent upgrading process improved reduction of the density and viscosity of the heavy oil while maintaining the olefin content at acceptable levels.

Thus, in accordance with an aspect of the present invention, there is provided a process for treating a heavy oil to provide a treated heavy oil having a reduced density and viscosity and an olefin content that does not exceed 1.0 wt. %. The process comprises a pre-treatment which comprises separating the initial heavy oil into a first fraction and a second fraction. The second fraction comprises a heavy oil having a p-value of at least 5% greater than the p-value of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction. The second fraction also has an aromaticity that is no more than 5% less than the aromaticity of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction. The density and viscosity of the second fraction then are reduced. The second fraction then is combined or rebled with at least a portion of the first fraction to provide a treated heavy oil having an olefin content that does not exceed 1.0 wt. %.

Although the scope of the present invention is not to be limited to any theoretical reasoning, it is believed that when the initial heavy oil is separated into a first fraction and a second fraction as hereinabove described, the first fraction, in general, contains low-boiling components such as aliphatic or paraffinic components which, if not separated from the heavy oil, may result in the formation of olefins when the heavy oil is subjected to upgrading to reduce the density and viscosity of the heavy oil. By removing these components prior to upgrading the heavy oil, the solubility of the asphaltenes is increased, and one achieves improved reduction of the density and viscosity of the heavy oil while the possibility of the formation of unacceptable levels of olefin is reduced, and the resulting upgraded heavy oil is more pumpable and transportable, while further density and viscosity reductions are possible with respect to a given threshold level of olefin.

In general, the initial heavy oil is separated into a first fraction and a second fraction by flashing, boiling, distilling, or fractionating the heavy oil. In a non-limiting embodiment, the first fraction has a boiling range that does not exceed 450° C., i.e., none of the components in the first fraction boils at a temperature that exceeds 450° C. In another non-limiting embodiment, the first fraction has a boiling range that does not exceed 325° C. In yet another non-limiting embodiment, the first fraction has a boiling range that does not exceed 250° C. In a further non-limiting embodiment, the first fraction has a boiling range that does not exceed 180° C. In another non-limiting embodiment, the first fraction has a boiling range that does not exceed 150° C.

In a non-limiting embodiment, the second fraction has a p-value which is at least 10% greater than the p-value of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction. In another non-limiting embodiment, the second fraction has a p-value which is at least 15% greater than the p-value of the initial heavy oil prior to separating the initial heavy oil into the first

4

fraction and the second fraction. In yet another non-limiting embodiment, the second fraction has a p-value which is at least 25% greater than the p-value of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction.

In a non-limiting embodiment, the second fraction has an aromaticity that is no more than 3% less than the aromaticity of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction. In another non-limiting embodiment, the second fraction has an aromaticity that is at least 3% greater than the aromaticity of the initial heavy oil prior to the separation of the initial heavy oil into the first fraction and the second fraction. In yet another non-limiting embodiment, the second fraction has an aromaticity that is at least 5% greater than the aromaticity of the initial heavy oil prior to the separation of the initial heavy oil into the first fraction and the second fraction.

After the initial heavy oil is separated into the first fraction and the second fraction, the second fraction then is treated further to reduce the density and viscosity of the second fraction, thereby making the second fraction more pumpable and transportable. Such treatment includes, but is not limited to, subjecting the second fraction to thermal treatment by heating the second fraction and/or subjecting the second fraction to mechanical upgrading such as hydrodynamic and/or ultrasonic cavitation and/or other upgrading technologies, such as hydrogen addition processes, including using hydrogen donors, pure hydrogen, and/or synthesis gas. Because the first fraction has been separated from the second fraction prior to the upgrading of the second fraction, one achieves improved reduction of the density and viscosity of the second fraction while maintaining the olefin content of the second fraction at acceptable levels.

In a non-limiting embodiment, the second fraction is subjected to thermal treatment, such as visbreaking, by heating the second fraction to a temperature of from about 200° C. to about 600° C., thereby reducing the density and viscosity of the second fraction. In another non-limiting embodiment, the second fraction is treated thermally by heating to a temperature of from about 350° C. to about 450° C. In yet another non-limiting embodiment, the second fraction is treated thermally by heating to a temperature of from about 380° C. to about 420° C.

In a non-limiting embodiment, the second fraction is subjected to the hereinabove described thermal treatment, such as visbreaking, for a period of time of from about 1 minute to about 20 minutes. In another non-limiting embodiment, the second fraction is subjected to the above-mentioned thermal treatment for a period of time of from about 3 minutes to about 8 minutes.

In another non-limiting embodiment, the second fraction is heated to a temperature of from about 200° C. to about 600° C., and then subjected to hydrodynamic cavitation, thereby reducing the density and viscosity of the second fraction. In another non-limiting embodiment, the second fraction is heated to a temperature of from about 350° C. to about 450° C., and then is subjected to hydrodynamic cavitation to reduce the density and viscosity of the second fraction. In yet another non-limiting embodiment, the second fraction is heated to a temperature of from about 380° C. to about 420° C., and then is subjected to hydrodynamic cavitation to reduce the density and viscosity of the second fraction.

In another non-limiting embodiment, the second fraction is subjected to hydrodynamic cavitation by passing the second fraction from a conduit into a cavitation zone, which is in the form of a restriction or nozzle. In general, the ratio

5

of the width of the cavitation zone to the width of the conduit is from about $\frac{1}{230}$ to about $\frac{1}{75}$. The ratio of the length of the cavitation zone to the width of the cavitation zone, in general, is from about 10 to about 125. In another non-limiting embodiment, the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 50 to about 125.

In a non-limiting embodiment, the second fraction is passed through the cavitation zone, which may be in the form of a capillary or nozzle or other type of restriction, at a velocity of from about 100 m/sec to about 300 m/sec, and as the second fraction passes through the cavitation zone such as a capillary or nozzle, the second fraction is subjected to a pressure drop of from about 150 psig to about 5,000 psig. In the cavitation zone, the second fraction is subjected to cavitation. As known in the art, cavitation is produced by microbubbles of gas dispersed in the second fraction. Such microbubbles expand and then implode or collapse. The implosion or collapse of the microbubbles raises the temperature at the interface of the microbubbles and second fraction to very high levels, for example, from about 1,000° C. to about 2,000° C., for a period of microseconds, which facilitates free radical formation and chemical reactions.

In a non-limiting embodiment, the second fraction is passed through the cavitation zone at a velocity of from about 150 m/sec to about 300 m/sec. In another embodiment, the second fraction is passed through the cavitation zone at a velocity of from about 200 m/sec to about 300 m/sec.

In a non-limiting embodiment, the second fraction is subjected to a pressure drop in the cavitation zone of from about 400 psig to about 4,000 psig.

In another non-limiting embodiment, the second fraction is subjected to a pressure drop in the cavitation zone of from about 1,500 psig to about 3,500 psig.

Examples of hydrodynamic cavitation apparatuses having cavitation zones that may be used in the present invention are disclosed in U.S. Pat. Nos. 7,943,035 and 8,105,480, the contents of which are incorporated by reference in their entireties.

Thus, in a non-limiting embodiment, the second fraction, which has a p-value of at least 5% greater than the p-value of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction, and an aromaticity that is no more than 5% less than the aromaticity of the initial heavy oil prior to separating the initial heavy oil into the first fraction and the second fraction, is heated to a temperature of from about 385° C. to about 420° C., whereby a portion of the second fraction becomes a vapor, and then is passed from a conduit through a hydrodynamic cavitation zone at a velocity of from about 100 m/sec to about 300 m/sec, and at a pressure drop of from about 150 psig to about 5,000 psig, and wherein the ratio of the width of the cavitation zone to the width of the conduit is from about $\frac{1}{230}$ to about $\frac{1}{75}$, and the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 10 to about 125. The second fraction is subjected to hydrodynamic cavitation for a period of time which in general does not exceed 10 seconds.

Because certain components, such as aliphatic and paraffinic compounds, were separated from the second fraction prior to subjecting the second fraction to the above-mentioned thermal treatment and hydrodynamic cavitation, one obtains improved or further reduction of the density and viscosity of the second fraction, while unacceptable levels of olefins are not produced as a result of such thermal treatment and cavitation. That is, the removal of the lighter ends

6

permits reaching a given threshold level of olefins with greater density and viscosity upgrades when using thermal treatment, and/or cavitation and/or other upgrading technologies.

In a non-limiting embodiment, after the second fraction is subjected to heating and/or cavitation to reduce the density and viscosity of the second fraction, the second fraction may be subjected to further treatment to remove undesired components, such as naphtha and hydrogen sulfide, therefrom.

After the second fraction is heated and/or subjected to cavitation to reduce the density and viscosity thereof, the second fraction is recombined with at least a portion of the first fraction, which boils at a temperature that does not exceed 450° C. In a non-limiting embodiment, at least 50 wt. % of the first fraction is recombined with the stable heavy oil. The resulting combined heavy oil stream, which has an olefin content that does not exceed 1.0 wt. %, then is transported for further processing.

The invention now will be described with respect to the drawings, wherein.

FIG. 1 is a schematic of an embodiment of the method for treating a heavy oil in accordance with the present invention;

FIG. 2 is a graph showing density upgrade (% kg/m³) versus olefin measurement (gBr₂/100 g) of an upgraded heavy oil that was fractionated to remove a 250° C. fraction prior to upgrading, followed by reblending with the 250° C. fraction, compared to a non-fractionated upgraded heavy oil;

FIG. 3 is a graph showing viscosity upgrade (% cSt) versus olefin measurement (gBr₂/100 g) of an upgraded heavy oil that was fractionated to remove a 250° C. fraction prior to upgrading, followed by reblending with the 250° C. fraction, compared to a non-fractionated upgraded heavy oil;

FIG. 4 is a graph showing density upgrade (% kg/m³) versus olefin measurement (gBr₂/100 g) of an upgraded heavy oil that was fractionated to remove a 180° C. fraction prior to upgrading, followed by reblending with the 180° C. fraction, compared to a non-fractionated heavy oil; and

FIG. 5 is a graph showing density upgrade (% kg/m³) versus olefin measurement (gBr₂/100 g) of an upgraded heavy oil that was fractionated to remove a 325° C. fraction prior to upgrading, followed by reblending with the 325° C. fraction, compared to a non-fractionated heavy oil.

Referring now to FIG. 1, an initial heavy oil in line 10 is pumped and heated and sent to fractionator 11. Fractionator 11 is operated under conditions such that the heavy oil is separated into two fractions, i.e., a first fraction and a second fraction. In general, the first fraction is a lower-boiling fraction that includes light components such as diluents, water vapor, aliphatic hydrocarbons, and paraffinic hydrocarbons. The second fraction is a heavy oil that has a p-value that is at least 5% greater than the p-value of the initial heavy oil prior to the separation of the initial heavy oil into the first fraction and the second fraction, and has an aromaticity that is no more than 5% less than the aromaticity of the initial heavy oil prior to the separation of the initial heavy oil into the first fraction and the second fraction. In general, fractionator 11 is operated at a temperature of no more than 450° C. Thus, the first fraction boils at a temperature that does not exceed 450° C. Fractionator 11 may be operated, in non-limiting embodiments, at temperatures that exceed slightly, for example, boiling points of 325° C., 250° C., 180° C., or 150° C., thereby providing first fractions that boil at temperatures that do not exceed 325° C., 250° C., 180° C., and 150° C., respectively.

The first fraction, including the lower-boiling compounds, or light components, is withdrawn from fractionator 11 through line 12 and passed to knock-out drum 17. Off gases

are withdrawn from knock-out drum **17** through line **19**, while the remainder of the first, or light, fraction is withdrawn from knock-out drum **17** through line **18**. Thus, a fraction that has low-boiling point, or that has light, components is separated from the second fraction, whereby the second fraction is a heavy oil that contains a minimal amount of components that may not be converted easily to olefins during further upgrading of the second fraction.

The second fraction is withdrawn from fractionator **11** through line **13** and subjected to further upgrading to reduce the density and viscosity of the heavy oil, schematically indicated as **14**. For example, the second fraction may be subjected to thermal treatment at a temperature of about 200° C. to about 600° C. for a period of time of from about 1 minute to about 20 minutes, and then subjected to hydrodynamic cavitation by passing the second fraction through a restriction or nozzle such as those hereinabove described and at a velocity and pressure as hereinabove described. It is to be understood, however, that the scope of the present invention is not to be limited to any specific upgrading processes for reducing the density and viscosity of the second fraction.

After the second fraction is upgraded, incondensable gases or off gases are withdrawn from upgrading zone **14** through line **16**, while the remainder of the second fraction, which is a heavy oil having a reduced density and viscosity, is withdrawn from upgrading zone **14** through line **15**.

The light fraction in line **18** then is passed to line **15**, whereby the first, or light, fraction is recombined with the second fraction. Prior to being passed to line **15**, a portion of the light fraction may be withdrawn from line **18** through line **20**.

The recombination of at least a portion of the light fraction from line **18** with the second fraction in line **15** provides a combined heavy oil stream in line **21** that has an olefin content that does not exceed 1.0 wt. %, and has a reduced density and viscosity, whereby such oil is pumpable and transportable, and can be subjected to further processing, such as refining.

EXAMPLES

The invention now will be described with respect to the following examples; however, the scope of the present invention is not intended to be limited thereby.

Example 1

A heavy oil having a p-value of 3.20 and an aromaticity of 31% is distilled such that fractions having boiling points of 180° C., 250° C., or 325° C. were removed. The recovered volumes, in percent, of the fractions removed by distillation, and the p-values and aromaticity increases for the remaining heavy oils, are measured for each fraction. The results are shown in Table 1 below.

TABLE 1

Distillation Temperature (° C.)	Recovered Volume (%)	P-value	P-value increase (%)	Aromaticity	Aromaticity Increase (%)
Undistilled	0.0%	3.20	0.0%	31%	0.0%
180	13.0%	3.57	11.6%	32%	3.2%
250	18.0%	3.58	11.9%	32%	3.2%
325	22.0%	3.54	10.6%	30%	-3.2%

The above results show that, when fractions that boil at temperatures of no more than 180° C., or no more than 250° C., or no more than 325° C., are removed from the heavy oil, there is provided a heavy oil having improved solubility of asphaltenes, as shown by the increase in the p-value by over 10%, while the aromaticity of the heavy oil remains at acceptable levels.

Example 2

A heavy oil was distilled or flashed to remove a 250° C. fraction. The inlet temperature at the distillation or fractionation column was 273° C. The 250° C. heavy oil fraction then was treated thermally by heating to temperatures of 390° C., 400° C., 410° C., and 420° C. for a period of time of 6 minutes. This oil then was subjected to cavitation by passing the oil through a cavitation nozzle having a length of 1 inch and a diameter of 0.008 inch.

After the 250° C. heavy oil fraction was subjected to cavitation, it was recombined with the 250° C. fraction.

A second heavy oil sample then was subjected to a thermal treatment and hydrodynamic cavitation as hereinabove described, to reduce the density and viscosity of the heavy oil, but a lower-boiling 250° C. fraction was not removed from this heavy oil sample prior to subjecting the heavy oil to the thermal treatment and hydrodynamic cavitation.

FIGS. 2 and 3 show the olefin content (measured in terms of the bromine number as gBr₂/100 g) for both samples as a function of density and viscosity upgrades, respectively, for all thermal treatment temperatures. The results show that the removal of the 250° C. fraction from the heavy oil, permits greater density and viscosity reduction with respect to a given level of olefins. Conversely, the removal of the 250° C. fraction from the heavy oil, prior to the upgrading of the heavy oil, provides a heavy oil with an improved reduced olefin content with respect to a given density reduction and a given viscosity reduction.

Example 3

A heavy oil was distilled or flashed to remove a 180° C. fraction. The inlet temperature at the distillation or fractionation column was 205° C. The 180° C. heavy oil fraction then was treated thermally by heating to temperatures of 390° C., 400° C., 410° C., and 420° C. for a period of time of 6 minutes. This oil then was subjected to hydrodynamic cavitation by passing the oil through a cavitation nozzle having a length of 1 inch and a diameter of 0.008 inch. After the 180° C. heavy oil fraction was subjected to cavitation, thereby providing a heavy oil with reduced density and viscosity, it was recombined with the 180° C. fraction.

A second heavy oil sample then was subjected to a thermal treatment and hydrodynamic cavitation as hereinabove described to reduce the density and viscosity of the heavy oil, but a lower-boiling 180° C. fraction was not removed from the heavy oil sample prior to subjecting the heavy oil to the thermal treatment and hydrodynamic cavitation.

FIG. 4 shows the olefin content (measured in terms of the bromine number as gBr₂/100 g) for both samples as a function of density reduction for all thermal treatment temperatures. The results show that the removal of the 180° C. fraction from the heavy oil, prior to the upgrading of the heavy oil, permits a greater density reduction with respect to a given level of olefins. Conversely, the removal of the 180° C. fraction from the heavy oil, prior to the upgrading of the

heavy oil, provides a heavy oil with an improved reduced olefin content with respect to a given density reduction.

Example 4

A heavy oil was distilled or flashed to remove a 325° C.⁻ fraction. The inlet temperature at the distillation or fractionation column was 345° C. The 325° C.⁺ heavy oil fraction was treated thermally by heating to temperatures of 390° C., 400° C., 410° C., and 420° C. for a period of time of 6 minutes. This oil then was subjected to hydrodynamic cavitation by passing the oil through a cavitation nozzle having a length of 1 inch and a diameter of 0.008 inch.

After the 325° C.⁺ heavy oil fraction was subjected to cavitation, thereby providing a heavy oil having a reduced density and viscosity, it was recombined with the 325° C.⁻ fraction.

A second heavy oil sample then was subjected to a thermal treatment and hydrodynamic cavitation as hereinabove described to reduce the density and viscosity of the heavy oil, but a lower-boiling 325° C.⁻ fraction was not removed from the heavy oil prior to subjecting the heavy oil to the thermal treatment and hydrodynamic cavitation.

FIG. 5 shows the olefin content (measured in terms of the bromine number as gBr₂/100 g) for both samples as a function of density upgrades for all thermal treatment temperatures. The results shows that the removal of the 325° C.⁻ fraction from the heavy oil, prior to the upgrading of the heavy oil, permits a greater density reduction with respect to a given level of olefins. Conversely, the removal of the 325° C.⁻ fraction from the heavy oil, prior to the upgrading of the heavy oils, provides a heavy oil with an improved reduced olefin content with respect to a given density reduction.

The disclosures of all patents and publications, including published patent applications, are herein incorporated by reference to the same extent as if each patent and publication were incorporated individually by reference.

It is to be understood, however, that the scope of the present invention is not to be limited to the specific embodiments described above. The invention may be practiced other than as particularly described and still be within the scope of the accompanying claims.

What is claimed is:

1. A process for treating a heavy oil to provide a treated heavy oil having a reduced density and viscosity, and an olefin content that does not exceed 1.0 wt. %, comprising:

- (a) separating an initial heavy oil into a first fraction, said first fraction having a boiling range that does not exceed 180° C. and a second fraction, wherein said second fraction comprises a heavy oil having a p-value of at least 5% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction, and said second fraction has an aromaticity that is no more than 5% less than the aromaticity of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction;

- (b) reducing the density and viscosity of said second fraction; and

- (c) combining said second fraction with at least a portion of said first fraction to provide a treated heavy oil having an olefin content that does not exceed 1.0 wt. %.

2. The process of claim 1 wherein said first fraction has a boiling range that does not exceed 150° C.

3. The process of claim 1 wherein said second fraction has a p-value which is at least 10% greater than the p-value of

said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

4. The process of claim 3 wherein said second fraction has a p-value which is at least 15% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

5. The process of claim 4 wherein said second fraction has a p-value which is at least 25% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

6. The process of claim 1 wherein said second fraction has an aromaticity that is no more than 3% less of the aromaticity of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

7. The process of claim 6 wherein said second fraction has an aromaticity that is at least 3% greater than the aromaticity of said initial heavy oil prior to separation of initial said heavy oil into said first fraction and said second fraction.

8. The process of claim 7 wherein said second fraction has an aromaticity that is at least 5% greater than the aromaticity of said initial heavy oil prior to separation of said initial heavy oil into said first fraction and said second fraction.

9. The method of claim 1 wherein the density and viscosity of said second fraction are reduced by heating said second fraction to a temperature of from about 200° C. to about 600° C.

10. The method of claim 9 wherein the density and viscosity of said second fraction are reduced by heating said second fraction to a temperature of from about 350° C. to about 450° C.

11. The method of claim 10 wherein the density and viscosity of said second fraction are reduced by heating said second fraction to a temperature of from about 380° C. to about 420° C.

12. The method of claim 9 where said second fraction is heated for a period of time of from about 1 minute to about 20 minutes.

13. The method of claim 12 wherein said second fraction is heated for a period of time of from about 3 minutes to about 8 minutes.

14. The method of claim 1 wherein the density and viscosity of said second fraction are reduced by subjecting said second fraction to cavitation.

15. The method of claim 14 wherein said second fraction is subjected to hydrodynamic cavitation.

16. The method of claim 15 wherein said second fraction is subjected to hydrodynamic cavitation by passing said second fraction from a conduit through a cavitation zone, wherein the ratio of the width of said cavitation zone to the width of said conduit is from about 1/230 to 1/75.

17. The method of claim 16 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 10 to about 125.

18. The method of claim 17 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 50 to about 125.

19. The method of claim 1 wherein the density and viscosity of said second fraction are reduced by heating said second fraction to a temperature of from about 200° C. to about 600° C., and then subjecting said second fraction to cavitation.

20. The method of claim 19 wherein said second fraction is heated to a temperature of from about 350° C. to about 450° C.

21. The method of claim 20 wherein said second fraction is heated to a temperature of from about 380° C. to about 420° C.

11

22. The method of claim 19 wherein said second fraction is subjected to hydrodynamic cavitation.

23. The method of claim 22 wherein said second fraction is subjected to hydrodynamic cavitation by passing said second fraction from a conduit through a cavitation zone, wherein the ratio of the width of said cavitation zone to the width of said conduit is from about $\frac{1}{230}$ to $\frac{1}{75}$.

24. The method of claim 23 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 10 to about 125.

25. The method of claim 24 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 50 to about 125.

26. The method of claim 1 wherein the density and viscosity of said second fraction are reduced by subjecting said second fraction to a hydrogen addition process.

27. A process for treating a heavy oil to provide a treated heavy oil having a reduced density and viscosity, and an olefin content that does not exceed 1.0 wt. %, comprising:

(a) separating an initial heavy oil into a first fraction and a second fraction, wherein said second fraction comprises a heavy oil having a p-value of at least 5% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction, and said second fraction has an aromaticity that is no more than 5% less than the aromaticity of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction;

(b) subjecting, without the addition of external gas, said second fraction to cavitation, thereby reducing the density and viscosity of said second fraction; and

(c) combining said second fraction with at least a portion of said first fraction to provide a treated heavy oil having an olefin content that does not exceed 1.0 wt. %.

28. The process of claim 27 wherein said first fraction has a boiling range that does not exceed 450° C.

29. The process of claim 28 wherein said first fraction has a boiling range that does not exceed 325° C.

30. The process of claim 29 wherein said first fraction has a boiling range that does not exceed 250° C.

31. The process of claim 29 wherein said first fraction has a boiling range that does not exceed 180° C.

32. The process of claim 31 wherein said first fraction has a boiling range that does not exceed 150° C.

33. The process of claim 27 wherein said second fraction has a p-value which is at least 10% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

34. The process of claim 33 wherein said second fraction has a p-value which is at least 15% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

35. The process of claim 34 wherein said second fraction has a p-value which is at least 25% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

36. The process of claim 27 wherein said second fraction has an aromaticity that is no more than 3% less of the aromaticity of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

37. The process of claim 36 wherein said second fraction has an aromaticity that is at least 3% greater than the aromaticity of said initial heavy oil prior to separation of initial said heavy oil into said first fraction and said second fraction.

12

38. The process of claim 37 wherein said second fraction has an aromaticity that is at least 5% greater than the aromaticity of said initial heavy oil prior to separation of said initial heavy oil into said first fraction and said second fraction.

39. The process of claim 27 wherein, subsequent to step (a), and prior to subjecting said second fraction to cavitation, said second fraction is heated to a temperature of from about 200° C. to about 600° C.

40. The method of claim 39 wherein said second fraction is heated to a temperature of from about 350° C. to about 450° C.

41. The method of claim 40 wherein said second fraction is heated to a temperature of from about 380° C. to about 420° C.

42. The method of claim 39 where said second fraction is heated for a period of time of from about 1 minute to about 20 minutes.

43. The method of claim 42 wherein said second fraction is heated for a period of time of from about 3 minutes to about 8 minutes.

44. The method of claim 27 wherein said cavitation is hydrodynamic cavitation.

45. The method of claim 44 wherein said second fraction is subjected to hydrodynamic cavitation by passing said second fraction from a conduit through a cavitation zone, wherein the ratio of the width of said cavitation zone to the width of said conduit is from about $\frac{1}{230}$ to $\frac{1}{75}$.

46. The method of claim 45 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 10 to about 125.

47. The method of claim 46 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 50 to about 125.

48. A process for treating a heavy oil to provide a treated heavy oil having a reduced density and viscosity, and an olefin content that does not exceed 1.0 wt. %, comprising:

(a) separating an initial heavy oil into a first fraction and a second fraction wherein said second fraction comprises a heavy oil having a p-value of at least 5% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction, and said second fraction has an aromaticity that is no more than 5% less than the aromaticity of said initial heavy oil prior to separating said initial heavy oil to said first fraction and said second fraction;

(b) heating said second fraction to a temperature of from about 200° C. to about 600° C., and then subjecting, without the addition of external gas, said second fraction to cavitation, thereby reducing the density and viscosity of said second fraction; and

(c) combining said second fraction with at least a portion of said first fraction to provide a treated heavy oil having an olefin content that does not exceed 1.0 wt. %.

49. The process of claim 48 wherein said first fraction has a boiling range that does not exceed 450° C.

50. The process of claim 49 wherein said first fraction has a boiling range that does not exceed 325° C.

51. The process of claim 50 wherein said first fraction has a boiling range that does not exceed 250° C.

52. The process of claim 51 wherein said first fraction has a boiling range that does not exceed 180° C.

53. The process of claim 52 wherein said first fraction has a boiling range that does not exceed 150° C.

54. The process of claim 48 wherein said second fraction has a p-value which is at least 10% greater than the p-value

13

of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

55. The process of claim 54 wherein said second fraction has a p-value which is at least 15% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

56. The process of claim 55 wherein said second fraction has a p-value which is at least 25% greater than the p-value of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

57. The process of claim 48 wherein said second fraction has an aromaticity that is no more than 3% less of the aromaticity of said initial heavy oil prior to separating said initial heavy oil into said first fraction and said second fraction.

58. The process of claim 57 wherein said second fraction has an aromaticity that is at least 3% greater than the aromaticity of said initial heavy oil prior to separation of initial said heavy oil into said first fraction and said second fraction.

59. The process of claim 58 wherein said second fraction has an aromaticity that is at least 5% greater than the aromaticity of said initial heavy oil prior to separation of said initial heavy oil into said first fraction and said second fraction.

14

60. The method of claim 48 wherein said second fraction is heated to a temperature of from about 350° C. to about 450° C.

61. The method of claim 60 wherein said second fraction is heated to a temperature of from about 380° C. to about 420° C.

62. The method of claim 48 where said second fraction is heated for a period of time of from about 1 minute to about 20 minutes.

63. The method of claim 62 wherein said second fraction is heated for a period of time of from about 3 minutes to about 8 minutes.

64. The method of claim 48 wherein said cavitation is hydrodynamic cavitation.

65. The method of claim 64 wherein said second fraction is subjected to hydrodynamic cavitation by passing said second fraction from a conduit through a cavitation zone, wherein the ratio of the width of said cavitation zone to the width of said conduit is from about $\frac{1}{230}$ to $\frac{1}{75}$.

66. The method of claim 65 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 10 to about 125.

67. The method of claim 66 wherein the ratio of the length of the cavitation zone to the width of the cavitation zone is from about 50 to about 125.

* * * * *

Doctor José Luis Salazar

Director de Nuevas Creaciones (C)

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

E.

S.

D.

Referencia: Expediente No. **16.029.362**

Solicitud de Patente de Invención titulada: *"Proceso para tratar aceites pesados con un valor p mejorado y bajo contenido de olefinas"*

Solicitante: Fractal Systems, Inc.

Asunto: **RESPUESTA OFICIO NO. 9225. EXAMEN DE FONDO**

ÁLVARO CORREA ORDÓÑEZ, mayor de edad y vecino de Bogotá D.C., identificado tal como aparece al pie de mi firma, en mi carácter de apoderado de la sociedad en referencia, doy respuesta al auto emanado por ese Despacho dentro del término de prórroga solicitado el 20 de septiembre de 2017.

1. Respuesta a las objeciones del Examinador

1.1 Título

Menciona la Examinadora que el título de la invención es general, y no está de acuerdo al objeto de la solicitud, ya que no incluye el proceso para obtener aceites pesados con un valor p incrementado que se encuentra dentro del alcance de las reivindicaciones y descripción presentadas. Para dar respuesta a esta objeción, el título se ha modificado siguiendo la sugerencia del examinador:

"Proceso para tratar aceites pesados con un valor p mejorado y bajo contenido de olefinas"

De esta forma se da por superada la anterior observación.

1.2 Reivindicaciones

1.2.1. La examinadora menciona que las siguientes reivindicaciones no son claras, por las razones que se exponen a continuación:

a) Reivindicación 1, 2 y 23

Las reivindicaciones 1, 2 y 23 tienen por objeto un proceso, sin embargo, muestran las etapas técnicas de manera general (separar, reducir la densidad y viscosidad, someter a cavitación) sin reivindicar sus condiciones técnicas, las cuales definirían completamente la invención.

b) Reivindicaciones 1, 2 y 23

En las reivindicaciones de proceso 1, 2 y 23 se está definiendo el aceite pesado únicamente por parámetros “*valor p*” y “*aromaticidad*” lo cual no es permitido, pues es posible definir tanto el proceso por sus condiciones técnicas y al aceite pesado por sus características químicas estructurales.

c) Las reivindicaciones presentan características esenciales como términos generales, que aunque corresponden a términos conocidos, abarcan una extensa gama de posibilidades sugiriendo de forma imprecisa que la protección se extiende a otras posibles variaciones.

d) Los términos “*primera fracción*”, “*segunda fracción*”, “*al menos*”, “*mayor que*”, “*menor que*”, “*una porción*” de algunas reivindicaciones son imprecisos o relativos, por lo cual no permite distinguir la invención del estado de la técnica.

e) Las reivindicaciones contienen expresiones que corresponden a resultados a alcanzar, ventajas o efectos esperados y no definen el método, puesto que la reivindicación incluiría no sólo la solución propuesta por el solicitante, sino todas las alternativas presentes o futuras que lleguen a ese resultado.

- Con relación a los términos considerados como generales, imprecisos o relativos o que son resultados a alcanzar, aclaramos a su Despacho que dichos términos son bien conocidos por aquellos versados en la materia técnica correspondiente y pueden lograrse mediante métodos bien conocidos por aquellos también versados en la materia técnica correspondiente.

Por ejemplo, la solicitante aclara que la etapa de "*separar*" puede lograrse por medio de la destilación, o vaporización parcial del aceite pesado, y la reducción de viscosidad se logra al someter el aceite pesado a cavitación y/o viscoreducción.

- Con respecto a la observación en cuanto a que no es permitido definir el aceite pesado únicamente por parámetros "valor p" y "aromaticidad", la solicitante aclara que el procedimiento para determinar el valor p se describe en las páginas 3 y 4 de la memoria descriptiva originalmente presentada, y el procedimiento para determinar la aromaticidad se describe en el segundo párrafo de la página 4, de la memoria descriptiva originalmente presentada.

- Con respecto a la observación en cuanto a que las reivindicaciones 57 a 59 y 64 a 66 no es conciso ya que están reclamando la misma materia,

Aclaramos al examinador que algunas de esas reivindicaciones se dirigen a rangos de ebullición de la primera fracción, o al valor p de la segunda fracción y otras se dirigen a la aromaticidad de la segunda fracción, o al calentamiento de la segunda fracción. Por lo tanto, estas reivindicaciones no reclaman la misma materia.

- Con relación a la sugerencia del examinador en cuanto a que se sugiere revisar el orden de numeración de la reivindicación 43 a 67 ya que su relación de dependencia principalmente es con la reivindicación 1.

Aclaramos a su Despacho que el nuevo pliego reivindicatorio que se presenta con este escrito corresponde a las reivindicaciones ya otorgadas en la solicitud estadounidense 14/454,001 con número de patente US 9,745,525. Por lo tanto, las reivindicaciones 43-52 dependen de la reivindicación independiente 32, que con la nueva numeración corresponde a la reivindicación 27, y las reivindicaciones 53 a 67 definen otro aspecto de la invención.

Ninguna de estas reivindicaciones dependen de la reivindicación independiente 1.

- Con relación a la sugerencia de su Despacho de incluir entre paréntesis () los números de referencia de cada uno de los elementos de los procesos (equipos o corrientes de proceso) incluidos en las reivindicaciones.

Al respecto se aclara a su Despacho que las reivindicaciones independientes 1, 2 y 48, en la etapa a) puede efectuarse en un fraccionador 11, mientras que la etapa b) puede efectuarse en un proceso de refinado 14.

De conformidad con el nuevo pliego reivindicatorio presentado y los argumentos arriba dados se concluye que las reivindicaciones cumplen a cabalidad con el requisito de claridad de la Decisión 486.

1.3 Novedad

El Examinador reconoce la novedad de la presente invención, por lo tanto, el requisito a sustentar es el nivel inventivo.

1.4 Nivel Inventivo

Sobre el requisito del nivel inventivo, el Examinador establece que los documentos **D3** (US2008/0217211 "*Process for treating heavy oils*") y **D4** (WO96/06899) "*A process for removing essentially naphthenic acid from a hydrocarbon oil*" afectan el nivel inventivo de la presente invención.

En particular, el examinador afirma:

"El documento D4 se considera el estado de la técnica más cercano a la invención definida en la reivindicación 1 porque divulga un proceso para remover ácidos nafténicos de un aceite crudo el cual no ha sido previamente fraccionado por destilación , o solo la fracción nafta se ha destilado (Resumen).

El examinador afirma que el documento D4 no menciona la etapa de reducir la densidad y la viscosidad de la segunda fracción.

El examinador establece que el documento D3 divulga la cavitación para reducir la viscosidad del aceite pesado.

El examinador concluye que la persona normalmente versada en la materia, estaría motivada a incluir una etapa de cavitación para reducir la densidad y viscosidad de un aceite crudo del documento D3 en el proceso para remover ácidos nafténicos de un aceite crudo del documento D4 para así llegar al objeto de la reivindicación 1. Por lo cual se considera obvia.

1.5 Argumentos en favor del nivel inventivo de la solicitud en estudio con respecto a D3 y D4:

El nivel inventivo de una solicitud se encuentra definido en el Artículo 18 de la Decisión 486 y se establece cuando *“si para una persona del oficio normalmente versada en la materia técnica correspondiente, esa invención no hubiese resultado obvia ni se hubiese derivado de manera evidente del estado de la técnica”*.

Contrario a lo que plantea el Examinador, los documentos D3 y D4 no afectan el nivel inventivo de la presente solicitud por cuanto no es posible derivar la presente invención a partir de las enseñanzas presentadas en dichos documentos.

En primer lugar, con el presente escrito se presenta un pliego reivindicatorio modificado. El capítulo reivindicatorio modificado no solamente es novedoso sino que también tiene nivel inventivo.

La solicitante reitera que el documento **D3** divulga el someter un aceite pesado a cavitación con el fin de reducir la densidad y la viscosidad del aceite pesado. El documento D3, sin embargo, no divulga ni sugiere a una persona medianamente versada en la materia cómo reducir el contenido de olefina de los aceites pesados tal como se reivindica en la presente solicitud.

Con relación al documento **D4**, este documento se dirige a la remoción de ácidos nafténicos de un aceite pesado (hydrocarbon oil) mediante hidrogenación del aceite en presencia de un catalizador. El documento **D4** no revela ni sugiere de ninguna manera a una persona

medianamente versada en la materia la reducción del contenido de olefina de los aceites pesados.

Por lo anteriormente expuesto se concluye que ninguno de los documentos D3 y D4 solos o combinados enseñan cómo reducir el contenido de olefina de los aceites pesados tal como se reivindica en la presente solicitud.

En este orden de ideas, tenemos que la invención propuesta por el solicitante si cumple con los requisitos de patentabilidad y de esta manera es susceptible de ostentar el título de patente de invención.

2. Solicitudes concedidas en otros países para esta misma invención.

A manera informativa, pongo en conocimiento del Examinador que la patente US 9,745,525 equivalente a la presente solicitud colombiana ha sido otorgada. Aún cuando entiendo que estas decisiones de ninguna manera obligan al Despacho para decidir de igual forma, considero que por tratarse de una pregunta fáctica la determinación de la existencia de novedad, nivel inventivo y aplicación industrial, las decisiones de otras oficinas de patentes constituyen un antecedente persuasivo en la materia.

En virtud de lo anterior, solicito que se acepten las razones expuestas en el presente documento y en consecuencia, se otorgue el privilegio de patente de invención para el invento que se tramita en este expediente.

Atentamente,



ÁLVARO CORREA ORDÓÑEZ

C.C.No.79.143.366 de Usaquén

T.P. 20.281

Anexos: - Capítulo reivindicatorio modificado conformado por 67 reivindicaciones
 - Copia de la Patente US 9,745,525
 - Pago de examen de patentabilidad.

REIVINDICACIONES

1. Un proceso para tratar un aceite pesado para suministrar un aceite pesado tratado que tenga la densidad y la viscosidad reducidas, y un contenido de olefinas que no exceda 1,0% en peso, comprende:
 - (a) Separar un aceite pesado inicial en una primera fracción, dicha primera fracción tiene un rango de ebullición que no excede 180° C y una segunda fracción, en donde dicha segunda fracción comprende un aceite pesado que tiene un valor p al menos 5% mayor que el valor p de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción, y dicha segunda fracción tiene una aromaticidad que no es más del 5% menor que la aromaticidad de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción;
 - (b) Reducir la densidad y la viscosidad de dicha segunda fracción; y
 - (c) Combinar dicha segunda fracción con al menos una porción de dicha primera fracción para suministrar un aceite pesado tratado que tenga un contenido de olefinas que no excede 1,0% en peso.
2. Un proceso para tratar un aceite pesado para suministrar un aceite pesado tratado que tenga la densidad y la viscosidad reducidas, y un contenido de olefinas que no exceda 1,0% en peso, comprende:
 - (a) Separar un aceite pesado inicial en una primera fracción y una segunda fracción, en donde dicha segunda fracción comprende un aceite pesado que tiene un valor p de al menos 5% mayor que el valor p de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción, y dicha segunda fracción tiene una aromaticidad que no es más del 5% menor que la aromaticidad de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción;

- (b) someter, sin la adición de gas externo, dicha segunda fracción a cavitación, reduciendo de esta manera la densidad y la viscosidad de dicha segunda fracción; y
- (c) Combinar dicha segunda fracción con al menos una porción de dicha primera fracción para suministrar un aceite pesado tratado que tenga un contenido de olefinas que no excede 1,0% en peso.
3. El proceso de la reivindicación 2 en donde dicha primera fracción tiene un rango de ebullición que no excede 450°C.
 4. El proceso de la reivindicación 3 en donde dicha primera fracción tiene un rango de ebullición que no excede 325°C.
 5. El proceso de la reivindicación 4 en donde dicha primera fracción tiene un rango de ebullición que no excede 250°C.
 6. El proceso de la reivindicación 4 en donde dicha primera fracción tiene un rango de ebullición que no excede 180°C.
 7. El proceso de la reivindicación 6 en donde dicha primera fracción tiene un rango de ebullición que no excede 150°C.
 8. El proceso de la reivindicación 2 en donde dicha segunda fracción tiene un valor p que es al menos 10% mayor que el valor p de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
 9. El proceso de la reivindicación 8 en donde dicha segunda fracción tiene un valor p que es al menos 15% mayor que el valor p del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
 10. El proceso de la reivindicación 9 en donde dicha segunda fracción tiene un valor p que es al menos 25% mayor que el valor p del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
 11. El proceso de la reivindicación 2 en donde dicha segunda fracción tiene una aromaticidad que no es más de 3% menor que la aromaticidad de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
 12. El proceso de la reivindicación 11 en donde dicha segunda fracción tiene una aromaticidad que es al menos 3% mayor que la aromaticidad del aceite pesado inicial

antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.

- 13.El proceso de la reivindicación 12 en donde dicha segunda fracción tiene una aromaticidad que es al menos 5% mayor que la aromaticidad del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
- 14.El proceso de la reivindicación 2 en donde, luego de la etapa (a), y antes de someter dicha segunda fracción a cavitación, dicha segunda fracción se calienta a una temperatura de desde 200°C a 600°C.
- 15.El proceso de la reivindicación 14 en donde la densidad y la viscosidad de dicha segunda fracción se han reducido mediante calentar dicha segunda fracción a una temperatura desde 350°C a 450°C.
- 16.El proceso de la reivindicación 15 en donde dicha segunda fracción se calienta a una temperatura de desde 380°C a 420°C.
- 17.El proceso de la reivindicación 14 en donde dicha segunda fracción es calentada durante un periodo de tiempo desde 1 minuto a 20 minutos.
18. El proceso de la reivindicación 17 en donde dicha segunda fracción es calentada durante un periodo de tiempo desde 3 minutos a 8 minutos.
- 19.El proceso de la reivindicación 2 en donde dicha cavitación es cavitación hidrodinámica.
20. El método de la reivindicación 19 en donde dicha segunda fracción se somete a cavitación hidrodinámica al pasar dicha segunda fracción de un conducto a través de una zona de cavitación, en donde la proporción del ancho de dicha zona de cavitación con respecto al ancho de dicho conducto es de 1/230 a 1/75.
21. El método de la reivindicación 20 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 10 a 125.
- 22.El método de la reivindicación 21 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 50 a 125.
23. Un proceso para tratar un aceite pesado para suministrar un aceite pesado tratado que tenga la densidad y la viscosidad reducidas, y un contenido de olefinas que no exceda 1,0% en peso, comprende:

(a) Separar un aceite pesado inicial en una primera fracción y una segunda fracción, en donde dicha segunda fracción comprende un aceite pesado que tiene un valor p de al menos 5% mayor que el valor p de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción, y dicha segunda fracción tiene una aromaticidad que no es más del 5% menor que la aromaticidad de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción;

(b) calentar dicha segunda fracción a una temperatura de desde 200° C a 600° C, y luego someter, sin la adición de gas externo, dicha segunda fracción a cavitación, reduciendo de esta manera la densidad y viscosidad de dicha segunda fracción; y

(c) Combinar dicha segunda fracción con al menos una porción de dicha primera fracción para suministrar un aceite pesado tratado que tenga un contenido de olefinas que no excede 1,0% en peso.

24. El proceso de la reivindicación 23 en donde dicha primera fracción tiene un rango de ebullición que no excede 450°C.

25. El proceso de la reivindicación 24 en donde dicha primera fracción tiene un rango de ebullición que no excede 325°C.

26. El proceso de la reivindicación 25 en donde dicha primera fracción tiene un rango de ebullición que no excede 250°C.

27. El proceso de la reivindicación 26 en donde dicha primera fracción tiene un rango de ebullición que no excede 180°C.

28. El proceso de la reivindicación 27 en donde dicha primera fracción tiene un rango de ebullición que no excede 150°C.

29. El proceso de la reivindicación 23 en donde dicha segunda fracción tiene un valor p que es al menos 10% mayor que el valor p del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.

30. El proceso de la reivindicación 29 en donde dicha segunda fracción tiene un valor p que es al menos 15% mayor que el valor p de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.

31. El proceso de la reivindicación 30 en donde dicha segunda fracción tiene un valor p que es al menos 25% mayor que el valor p del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
32. El proceso de la reivindicación 23 en donde dicha segunda fracción tiene una aromaticidad que no es más de 3% menor que la aromaticidad de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
33. El proceso de la reivindicación 32 en donde dicha segunda fracción tiene una aromaticidad que es al menos 3% mayor que la aromaticidad del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
34. El proceso de la reivindicación 33 en donde dicha segunda fracción tiene una aromaticidad que es al menos 5% mayor que la aromaticidad del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
35. El método de la reivindicación 23 en donde dicha segunda fracción es calentada a una temperatura desde 350°C a 450°C.
36. El método de la reivindicación 35 en donde dicha segunda fracción es calentada a una temperatura de desde 380°C a 420°C.
37. El proceso de la reivindicación 23 en donde dicha segunda fracción es calentada durante un periodo de tiempo desde 1 minuto a 20 minutos.
38. El proceso de la reivindicación 37 en donde dicha segunda fracción es calentada durante un periodo de tiempo desde 3 minutos a 8 minutos.
39. El método de la reivindicación 23 en donde dicha cavitación es cavitación hidrodinámica.
40. El método de la reivindicación 39 en donde dicha segunda fracción se somete a cavitación hidrodinámica al pasar dicha segunda fracción de un conducto a través de la zona de cavitación, en donde la proporción del ancho de dicha zona de cavitación con respecto al ancho de dicho conducto es de 1/230 a 1/75.
41. El método de la reivindicación 40 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 10 a 125.

42. El método de la reivindicación 41 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 50 a 125.
43. El proceso de la reivindicación 1 en donde dicha primera fracción tiene un rango de ebullición que no excede 150°C.
44. El proceso de la reivindicación 1 en donde dicha segunda fracción tiene un valor p que es al menos 10% mayor que el valor p de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
45. El proceso de la reivindicación 44 en donde dicha segunda fracción tiene un valor p que es al menos 15% mayor que el valor p del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
46. El proceso de la reivindicación 45 en donde dicha segunda fracción tiene un valor p que es al menos 25% mayor que el valor p del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
47. El proceso de la reivindicación 1 en donde dicha segunda fracción tiene una aromaticidad que no es más de 3% menor que la aromaticidad de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
48. El proceso de la reivindicación 47 en donde dicha segunda fracción tiene una aromaticidad que es al menos 3% mayor que la aromaticidad de dicho aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
49. El proceso de la reivindicación 48 en donde dicha segunda fracción tiene una aromaticidad que es al menos 5% mayor que la aromaticidad del aceite pesado inicial antes de separar dicho aceite pesado inicial en dicha primera fracción y dicha segunda fracción.
50. El método de la reivindicación 1 en donde la densidad y la viscosidad de la segunda fracción se reducen al calentar dicha segunda fracción a una temperatura de desde 200°C a 600°C.
51. El método de la reivindicación 50 en donde la densidad y la viscosidad de dicha segunda fracción se han reducido mediante calentar dicha segunda fracción a una temperatura desde 350°C a 450°C.

- 52.El método de la reivindicación 51 en donde la densidad y la viscosidad de dicha segunda fracción se han reducido mediante calentar dicha segunda fracción a una temperatura desde 380°C a 420°C.
- 53.El método de la reivindicación 50 en donde dicha segunda fracción es calentada durante un periodo de tiempo desde 1 minuto a 20 minutos.
54. El método de la reivindicación 53 en donde dicha segunda fracción es calentada durante un periodo de tiempo desde 3 minutos a 8 minutos.
55. El método de la reivindicación 1 en donde la densidad y la viscosidad de dicha segunda fracción se reducen al someter dicha segunda fracción a cavitación.
- 56.El método de la reivindicación 55 en donde dicha segunda fracción es sometida a cavitación hidrodinámica.
- 57.El método de la reivindicación 56 en donde dicha segunda fracción es sometida a cavitación hidrodinámica mediante pasar dicha segunda fracción desde un conducto por una zona de cavitación, en donde la proporción del ancho de la zona de cavitación respecto del ancho de dicho conducto es de 1/230 a 1/75.
- 58.El método de la reivindicación 57 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 10 a 125.
- 59.El método de la reivindicación 58 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 50 a 125.
- 60.El método de la reivindicación 1 en donde la densidad y la viscosidad de dicha segunda fracción se reducen al calentar dicha segunda fracción a una temperatura de desde 200°C a 600°C, y someter dicha segunda fracción a cavitación.
- 61.El método de la reivindicación 60 en donde dicha segunda fracción se calienta a una temperatura desde 350°C a 450°C.
- 62.El método de la reivindicación 61 en donde dicha segunda fracción se calienta a una temperatura desde 380°C a 420°C.
- 63.El método de la reivindicación 60 en donde dicha segunda fracción es sometida a cavitación hidrodinámica.
- 64.El método de la reivindicación 63 en donde dicha segunda fracción es sometida a cavitación hidrodinámica mediante pasar dicha segunda fracción desde un conducto

por una zona de cavitación, en donde la proporción del ancho de la zona de cavitación respecto del ancho de dicho conducto es de $1/230$ a $1/75$.

65. El método de la reivindicación 64 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 10 a 125.

66. El método de la reivindicación 65 en donde la proporción de la longitud de la zona de cavitación respecto del ancho de la zona de cavitación es de 50 a 125.

67. El método de la reivindicación 1 en donde la densidad y la viscosidad de dicha segunda fracción se reducen al someter dicha segunda fracción a un proceso de adición de hidrógeno.