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(54) **METHOD AND SYSTEM FOR STABILITY DETERMINATION OF ASPHALTENES UTILIZING DIELECTRIC CONSTANT MEASUREMENTS**

(71) Applicant: **The Texas A&M University System**,
College Station, TX (US)

(72) Inventors: **Berna Hascakir**, College Station, TX
(US); **Abhishek Punase**, College
Station, TX (US)

(73) Assignee: **The Texas A&M University System**,
College Station, TX (US)

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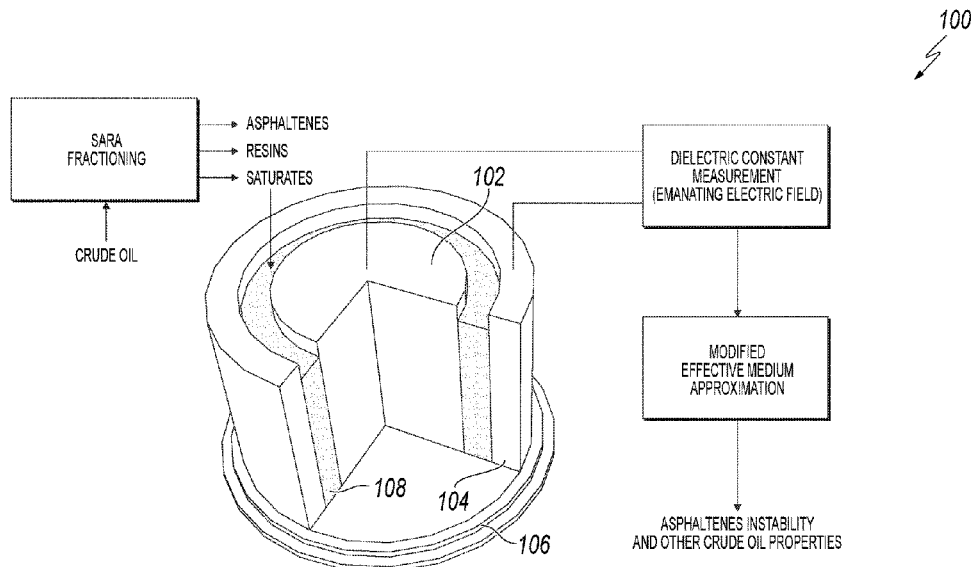
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Primary Examiner — Reena Aurora
(74) *Attorney, Agent, or Firm* — Winstead PC

(57) **ABSTRACT**

A method of determining asphaltene stability within a crude
oil sample that includes obtaining a crude oil sample and
performing a fractional analysis of the crude oil sample. The
method further includes measuring, via a cylindrical capaci-
tor, a dielectric constant of the crude oil sample and its
fractions. Responsive to the measured dielectric constant,
the stability of the asphaltenes within crude oil sample is
determined.

16 Claims, 7 Drawing Sheets



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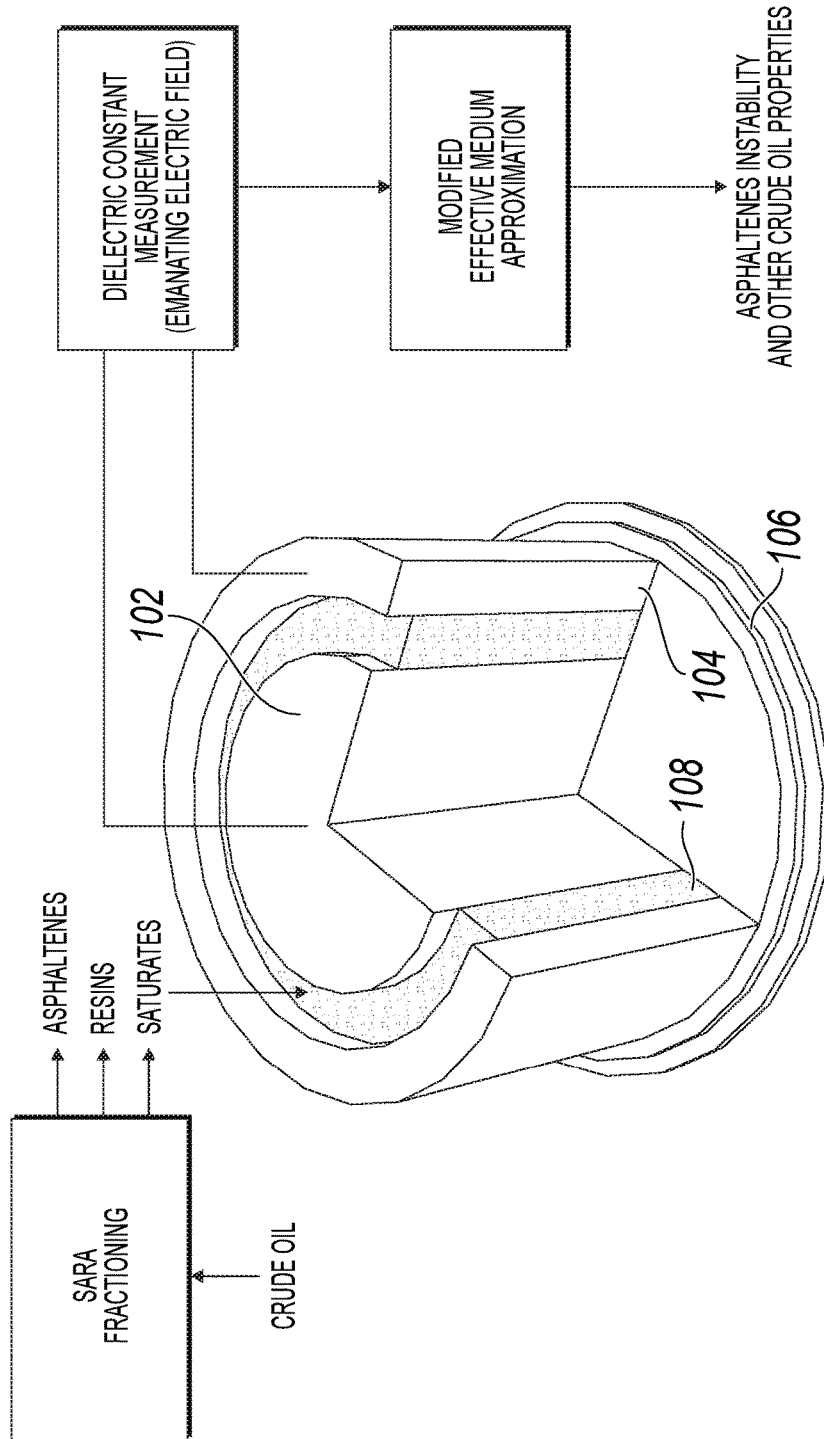


FIG. 1

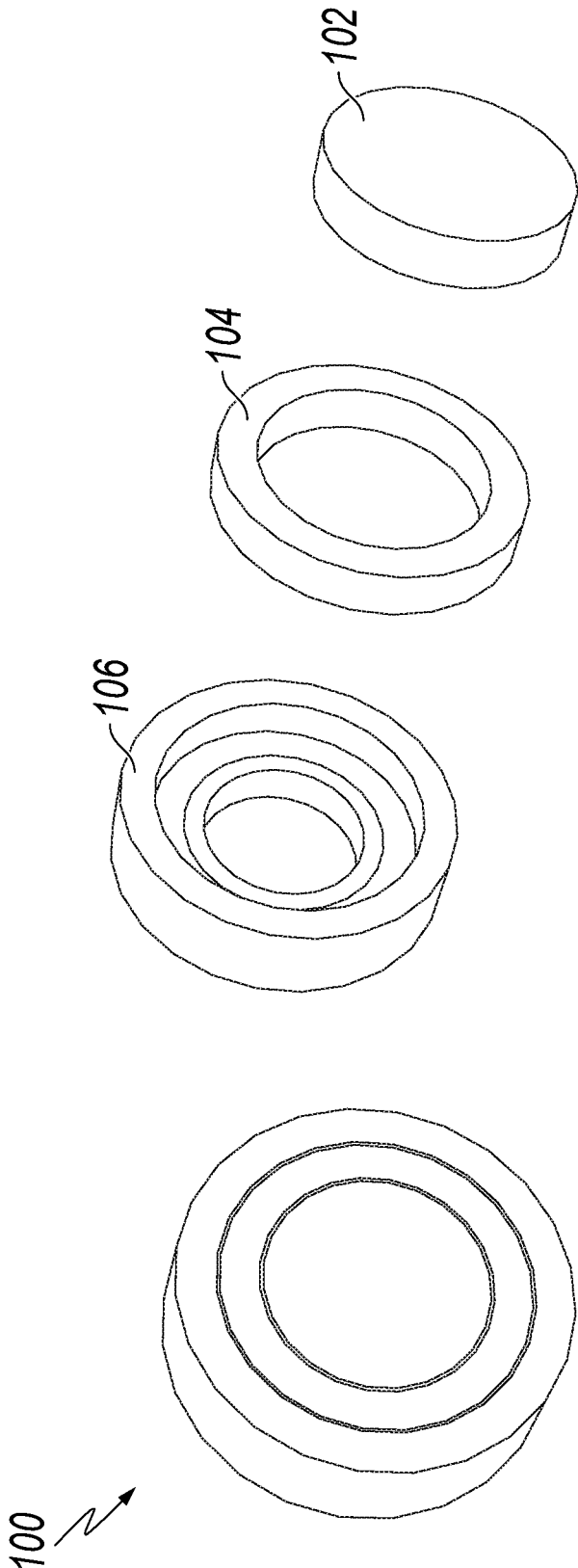
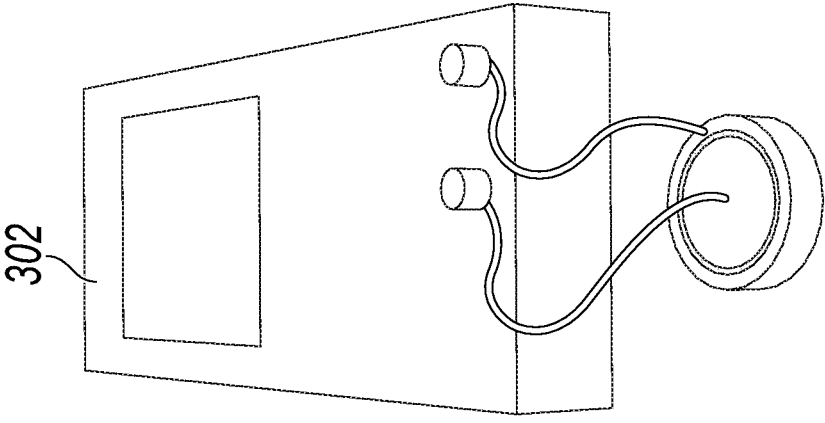
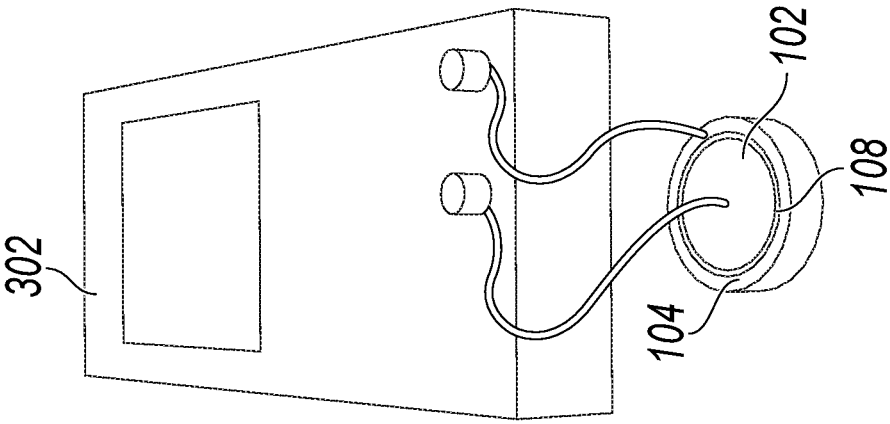


FIG. 2



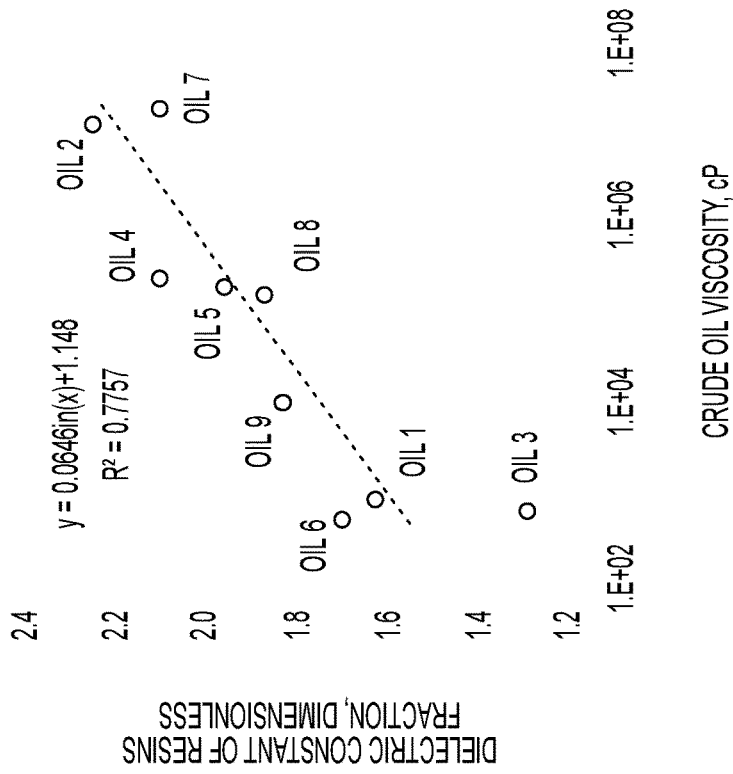
CAPACITANCE -
SATURATES

FIG. 3B



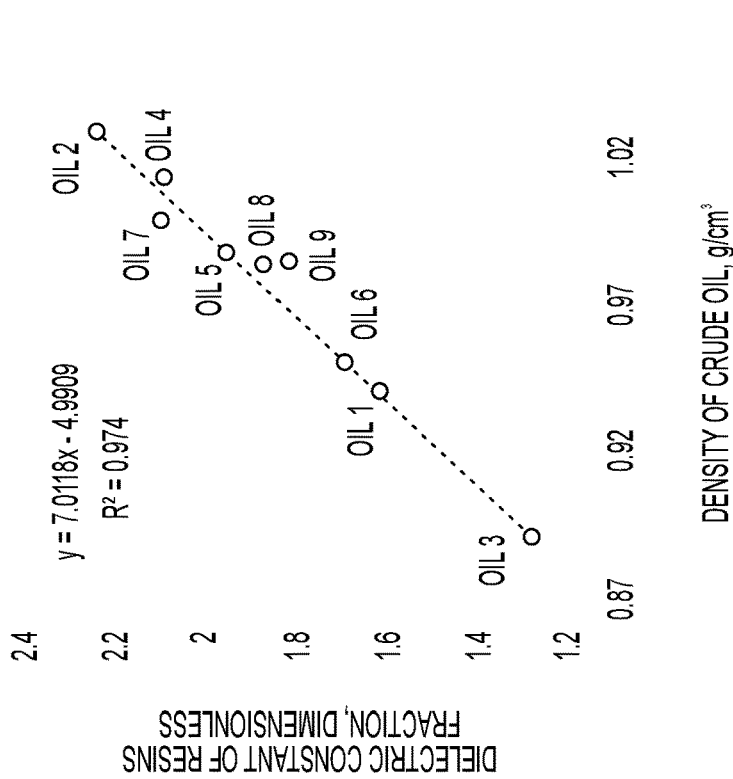
CAPACITANCE -
AIR

FIG. 3A



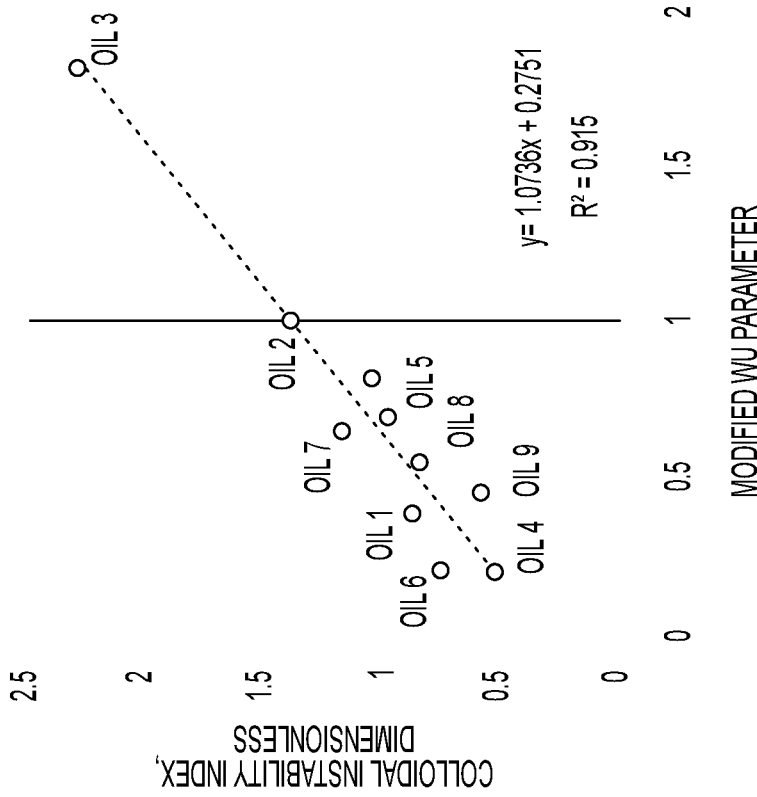
B - RELATION BETWEEN DIELECTRIC CONSTANT OF RESINS AND VISCOSITY OF CRUDE OIL

FIG. 4B

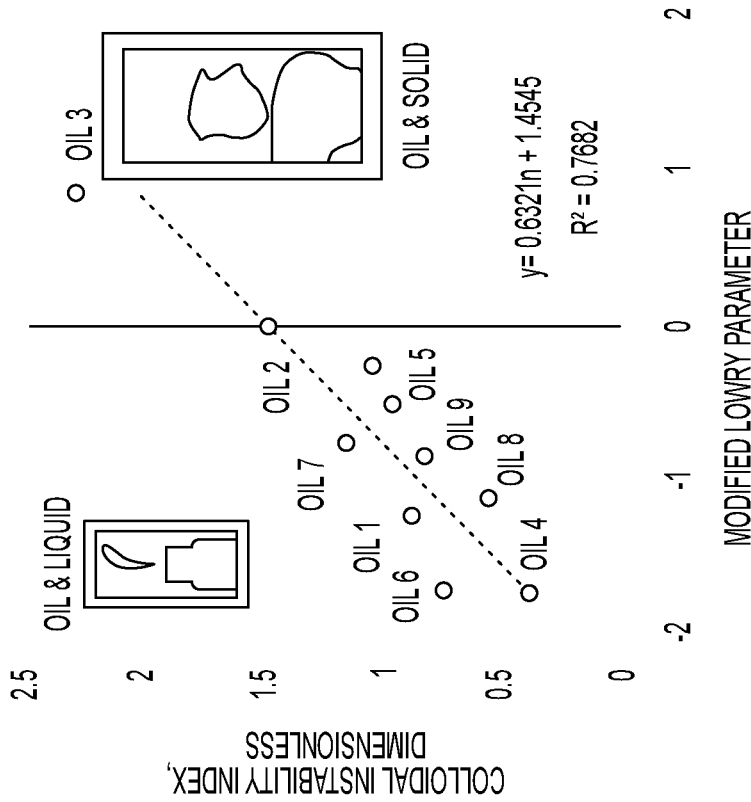


A - RELATION BETWEEN DIELECTRIC CONSTANT OF RESINS AND DENSITY OF CRUDE OIL

FIG. 4A



A - RELATION BETWEEN COLLOIDAL INSTABILITY INDEX AND MODIFIED LOWRY PARAMETER



B - RELATION BETWEEN COLLOIDAL INSTABILITY INDEX AND MODIFIED WU PARAMETER

FIG. 5A

FIG. 5B

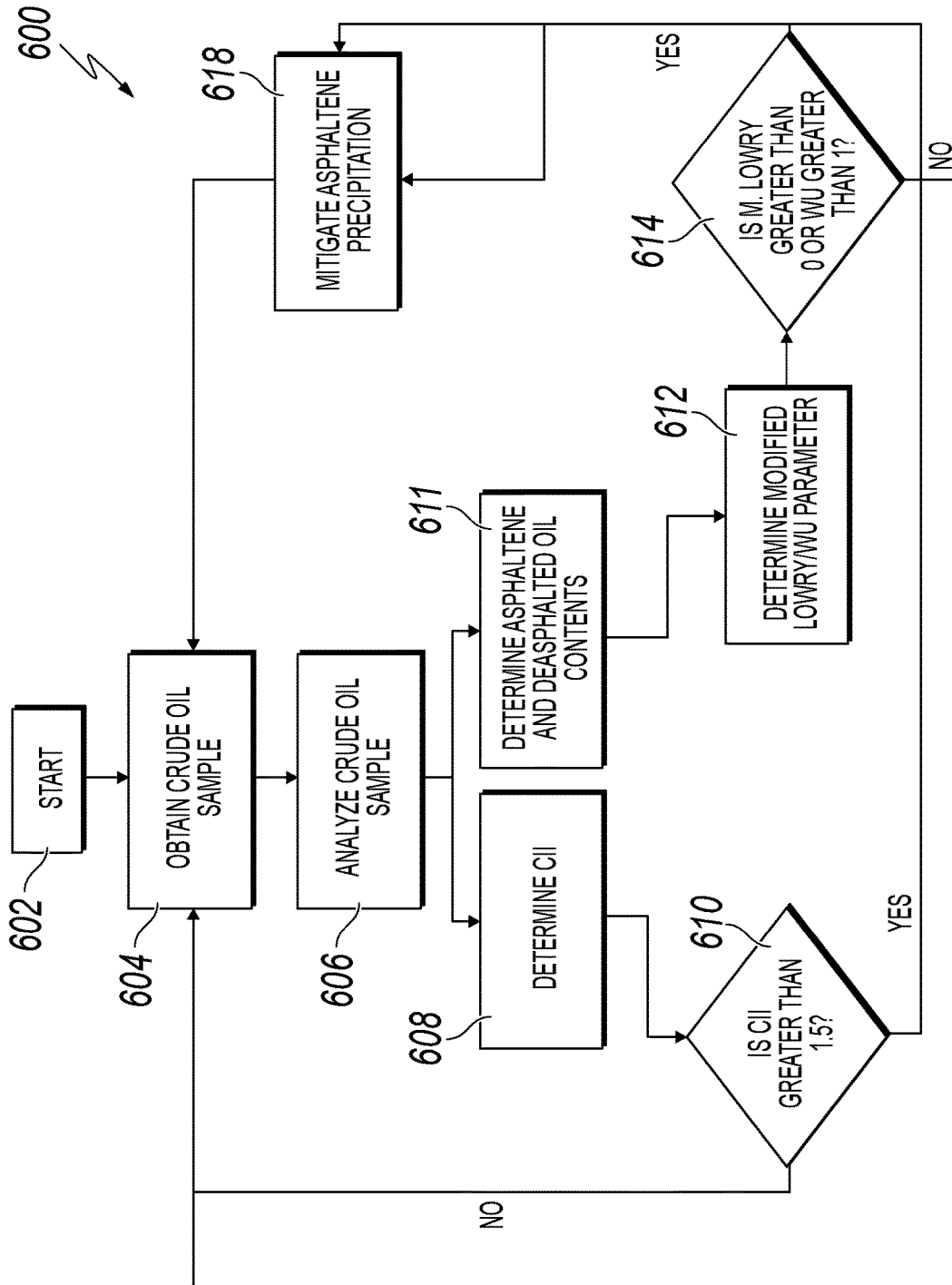


FIG. 6A

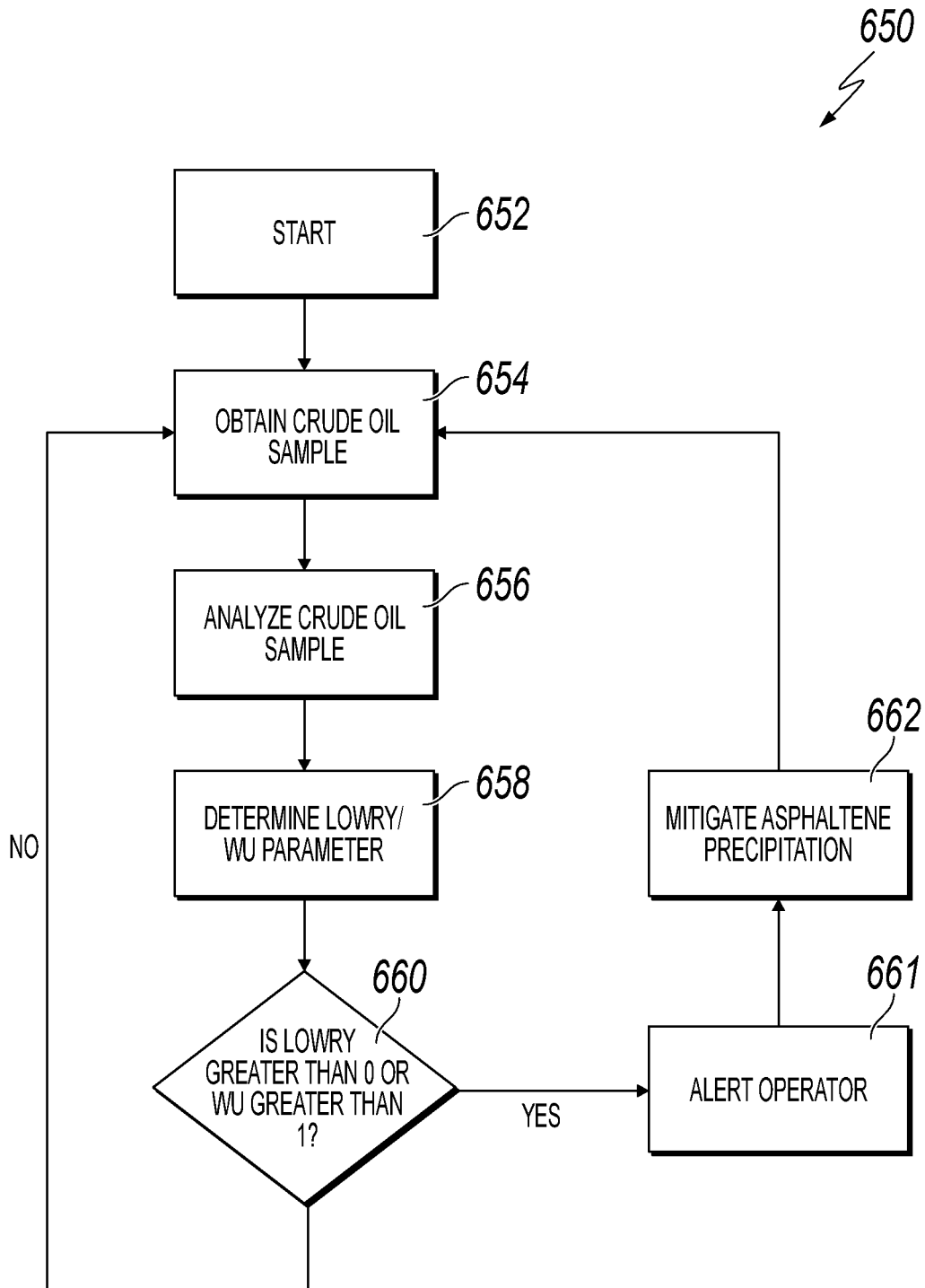


FIG. 6B

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**METHOD AND SYSTEM FOR STABILITY
DETERMINATION OF ASPHALTENES
UTILIZING DIELECTRIC CONSTANT
MEASUREMENTS**

CROSS REFERENCE TO RELATED
APPLICATIONS

The present application claims priority to, and incorporates by reference the entire disclosure of, U.S. Provisional Patent Application No. 62/365,831, filed on Jul. 22, 2016.

BACKGROUND

Field of the Invention

The present application relates generally to stability determinations of asphaltenes and more particularly, but not by way of limitation, to methods and systems for making stability determinations of asphaltenes present in crude oil through dielectric constant measurements of polar oil fractions.

History of the Related Art

With continuous rise in energy demand, exploration and production from unconventional reservoirs is gaining high applicability. Heavy oil, extra heavy oil, and bitumen reservoirs contribute to approximately 70% of the world's remaining oil reserves. One challenge associated with crude-oil production from unconventional reservoirs is high asphaltene content in the crude oil. Asphaltenes represent the heaviest and the most polar fraction of crude oil. Interaction of asphaltenes with other fractions of crude oil, such as saturates, aromatics, and resins, can affect the overall polarity and stability of the asphaltenes. Unstable asphaltenes are likely to form solid precipitants in crude oil. Precipitation of unstable asphaltenes can clog reservoir pores and foul downstream production equipment and transportation flow lines causing flow assurance problems and equipment damage.

SUMMARY

The present application relates generally to stability determination of asphaltenes and more particularly, but not by way of limitation, to methods and systems for making a stability determination of asphaltenes present in crude oil through dielectric constant measurements of polar oil fractions. In one aspect, the present invention relates to a method of determining asphaltene stability of a crude oil sample. The method includes obtaining a crude oil sample and performing a fractional analysis of the crude oil sample. The method further includes measuring, via a cylindrical capacitor, a dielectric constant of the crude oil sample. Responsive to the measured dielectric constant, a stability of the crude oil sample is determined.

In another aspect, the present invention relates to a method of determining asphaltene stability of a crude oil sample. The method includes obtaining a crude oil sample and performing a fractional analysis of the crude oil sample. A colloidal instability index of the crude oil sample is determined. Responsive to the determined colloidal-instability index, stability of the crude oil sample is determined.

In another aspect, the present invention relates to a system for determining a dielectric constant of a crude oil sample. The system includes a cylindrical capacitor having an inner

2

cylinder, an outer cylinder, and a base coupled to the inner cylinder and the outer cylinder. The inner cylinder and the outer cylinder define an annulus there between. The system includes a measuring device electrically coupled to the inner cylinder and to the outer cylinder. The measuring device measures a capacitance across the annulus.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further objects and advantages thereof, reference may now be had to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a sectional view of a cylindrical capacitor for measuring a dielectric constant of crude oil according to an exemplary embodiment;

FIG. 2 is an exploded view of the cylindrical capacitor of FIG. 1 according to an exemplary embodiment;

FIGS. 3A and 3B are illustrations of the steps involved in calculating a dielectric constant of a crude oil sample according to an exemplary embodiment;

FIG. 4A is a plot of dielectric constant versus crude-oil density;

FIG. 4B is a plot of dielectric constant versus crude-oil viscosity;

FIG. 5A is a plot of colloidal instability index (CII) versus modified Lowry Parameter;

FIG. 5B is a plot of CII versus modified Wu Parameter;

FIG. 6A is a flow diagram of a process for determining asphaltene stability of a crude oil sample according to an exemplary embodiment; and

FIG. 6B is a flow diagram of a process for determining asphaltene stability of a crude oil sample according to an exemplary embodiment.

DETAILED DESCRIPTION

Various embodiments of the present invention will now be described more fully with reference to the accompanying drawings. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

Asphaltene precipitation represents a significant cost to businesses engaged in crude-oil production and exploration. Due to the complex nature of the molecules constituting asphaltenes, determining asphaltene polarity and thereby predicting asphaltene stability is, however, difficult. A practical way to estimate asphaltene instability would have important implications in predicting reservoir performance. Currently, asphaltene stability is approximated by calculating a "colloidal stability index" which involves calculation of weight percentages of various crude-oil components. This is a very involved analysis that, often times, takes as long as a month to complete.

FIG. 1 is a sectional view of a cylindrical capacitor 100 for measuring a dielectric constant of crude oil. FIG. 2 is an exploded view of the cylindrical capacitor 100. Referring to FIGS. 1 and 2 collectively, the cylindrical capacitor 100 includes an inner cylinder 102 and an outer cylinder 104. The inner cylinder 102 and the outer cylinder 104 are arranged generally coaxially thereby defining an annulus 108 there between. In a typical embodiment, the inner cylinder 102 and the outer cylinder 104 are made of a conductive material such as, for example, aluminum; however, in alternative embodiments, the inner cylinder 102 and the outer cylinder 104 may be constructed from any conductive material in accordance with design requirements.

The inner cylinder **102** and the outer cylinder **104** are attached to a base **106**. In a typical embodiment, the base **106** is constructed from a non-conductive material such as, for example, polytetrafluoroethylene, which is sold, for example, under the name Teflon® by The Chemours Company of Wilmington, Del. In a typical embodiment, the inner cylinder **102** and the outer cylinder **104** are coupled to the base **106** using, for example, RTV-102 white adhesive; however, in alternative embodiments, the inner cylinder **102** and the outer cylinder **104** are coupled to the base **106** using utilizing any non-conductive adhesive or other appropriate bonding agent or process. In certain embodiments, a length of the inner cylinder **102** and the outer cylinder **104** is approximately 0.78 cm whereas a radii of the inner cylinder **102** and outer cylinder **104** are approximately 2 cm and approximately 2.1 cm, respectively. In a typical embodiment, the dimensional correlation between the radii and lengths of the inner cylinder **102** and the outer cylinder **104** is determined by Gauss's flux theorem for a cylindrical charged surface. There is no limitation related to the width of the annulus as long as the dimensions of the capacitor follow Equation 1, the annulus width may be modified as per the requirement. The overall capacitance for this specific geometry is given by Equation 1.

$$C = \frac{2\pi\epsilon_0\epsilon L}{\ln\left(\frac{b}{a}\right)} \quad \text{Equation 1}$$

Where C is the capacitance (F), ϵ_0 is the permittivity of a vacuum (8.85×10^{-12} F/m), ϵ is the dielectric constant of a sample present in the annulus **108**, L is the length of the cylinders (in meters), a is the radius of the inner cylinder **102** (in meters), and b is inner the radius of the outer cylinder **104** (in meters). A cylindrical capacitor presents the advantage of easily containing and measuring the dielectric constant of both liquid as well as solid test samples within the annulus (**108**) created by the inner cylinder **102** and the outer cylinder **104**.

FIGS. 3A and 3B illustrate steps of determining the dielectric constant of a test sample. During operation, the inner cylinder **102** and the outer cylinder **104** are connected to respective leads of a measuring device **302**. In a typical embodiment, the measuring device **302** is, for example, a multimeter; however, in alternative embodiments, any capacitance meter can be used to measure the overall capacitance of the test sample. In a first step, the annulus **108** of the cylindrical capacitor **100** is empty and the measuring device applies an electrical voltage across the annulus **108** to measure a capacitance of air (C_{Air}). In a second step, the annulus **108** is completely filled with a test sample such as, for example, crude oil sampled from a production well head or a production flow line. The measuring device **302** is applies an electrical voltage across the annulus and measures the capacitance of the sample (C_{Sample}). During operation, all the dimensional parameters of the cylindrical capacitor **100** and the permittivity of vacuum remain unchanged, thus the ratio of the measured capacitances (C_{Sample}/C_{Air}) calculates a dielectric constant of the test sample. In various embodiments, the measuring device **302** provides a measurement of a dielectric constant of the crude oil sample,

provide a measurement of asphaltene stability, or provide an alert to an operator of a high probability of asphaltene instability.

Still referring to FIGS. 3A-3B, in certain embodiments, the dielectric constant of solid materials may include errors generated by air that is present in the pore space of the solid materials. In various embodiments, the measuring device **302** corrects the dielectric constant for this type of error by using a density correlation. The density value is used in conjunction with the measured density value as in Equation 2 (Table 1 provides a comparison of measured dielectric constants with literature values).

TABLE 1

Comparison of the Measured Dielectric Constants with Data Compiled from Literature^{39,40}

Material	Dielectric Constants	
	Measured Value	Value from literature
n-pentane	1.76	1.84
n-hexane	1.80	1.88
n-heptane	1.82	1.90
n-decane	1.86	2.00
toluene	1.93	2.40
Sodium Chloride*	5.20	5.50
Potassium Chloride*	4.65	4.50

*The dielectric constants of solid samples were corrected by excluding the contribution of air in the pores of the solid materials

$$\epsilon_{corrected} = (\epsilon_{measured} - 1) \left(\frac{\rho_{solid}}{\rho_{measured}} \right) + 1 \quad \text{Equation 2}$$

Where ϵ and ρ denotes the dielectric constant and density, respectively. The subscript "measured" signifies the measured parameter value in the laboratory which includes the contribution of air in the pore space of the samples, and the subscript "solid" represents the compiled parameter value of the solid material from literature. The measured and literature-provided values of the chemicals listed in Table 1 show good matches which highlight the accuracy of the cylindrical capacitor **100** in measuring dielectric constants for both solid and liquid samples. In a typical embodiment, the cylindrical capacitor **100** and the measuring device **302** can be utilized to estimate the dielectric constant of a bulk crude oil samples as well as individual fractions of the bulk crude oil sample including, for example, saturates, aromatics, resins, and asphaltenes. The dielectric constant of bulk crude oil can also be measured by introducing it directly in the capacitor annulus.

FIG. 4A is a plot of dielectric constant versus crude-oil density. FIG. 4B is a plot of dielectric constant versus crude-oil viscosity. In various embodiments, a higher degree of coherence between physical properties of the crude oil and the dielectric constant of the resins fraction as compared to an asphaltene fraction may arise due to impurities present within or along-with the asphaltene molecules. In certain embodiments, the density of asphaltenes is measured by calculating the density of asphaltene-toluene mixtures for known volume and mass fraction of toluene. Table 2 provides sample density data that is used by FIGS. 4A and 4B.

TABLE 2

Characterization of Crude Oil Samples and Asphaltene Density							
Sample #	Gravity, *API	Viscosity, cP*	Crude Oil Components based on ASTM D2007-11, wt. %				Asphaltenes Density, gm/cm ³
			Saturates	Aromatics	Resins	Asphaltenes	
OIL 1	18.84	884	22.63	37.57	16.03	23.76	1.16
OIL 2	6.11	12,100,000	10.68	29.10	20.14	40.08	1.12
OIL 3	27.05	676	24.28	25.00	5.430	45.30	0.95
OIL 4	7.97	251,000	12.70	42.11	22.93	22.26	1.18
OIL 5	11.56	209,000	10.14	38.01	13.09	36.76	1.16
OIL 6	17.12	496	30.03	41.84	15.56	12.57	1.21
OIL 7	10.01	19,200,000	11.05	30.47	16.06	42.41	1.15
OIL 8	12.19	168,000	11.01	44.89	20.75	23.95	1.16
OIL 9	12.09	10,100	16.51	37.81	17.10	28.58	1.28

*Viscosity values are given at ambient conditions and were obtained through viscosity-temperature correlations due to limitations of the equipment. Similarly all API gravity values were also estimated using density-temperature correlations to obtain value at standard conditions. Relative error range for the measurements are $\pm 0.15\%$, $\pm 1\%$, $\pm 15\%$ for API gravity, viscosity, and SARA fractionation, respectively.

TABLE 3

Measured Dielectric Constants of Bulk Crude Oil Samples and Deasphalted Oil, Saturates, Resins, and Asphaltene Fractions of Crude Oils					
Sample Name	Dielectric Constants*				
	Crude Oil	Deasphalted Oil (DAO)	Saturates	Resins	Asphaltenes
OIL 1	2.31	2.52	1.84	1.62	4.22
OIL 2	2.12	2.28	1.84	2.25	3.23
OIL 3	1.72	1.88	1.55	1.26	4.57
OIL 4	2.09	2.34	1.73	2.10	3.77
OIL 5	2.07	2.49	1.78	1.96	3.56
OIL 6	2.34	2.44	1.85	1.69	5.01
OIL 7	1.81	3.45	1.53	2.10	3.94
OIL 8	1.93	2.31	1.82	1.87	3.75
OIL 9	2.00	2.45	1.78	1.83	4.90

*The dielectric constants of the aromatics fraction could not be obtained due to low amount of aromatics collection at the end of each fractionation method.

Still referring to FIGS. 4A and 4B, in certain embodiments, the dielectric constant may be used as an indirect measure of the polarity of each component in the crude oil. Table 3 contains sample data used to plot FIGS. 4A and 4B. In a typical embodiment, the physical properties of the crude oil sample reflect how polar the crude oil sample is due to the fact that polarity is indicative of intermolecular forces of attraction. A comparative analysis of the dielectric constants of saturates, resins, and asphaltene fractions (Table 3) with density and viscosity of crude oil (Table 2) to evaluate the effect of crude oil physical characteristic on the dielectric constant of individual fractions is depicted in FIGS. 4A and 4B. As illustrated in FIGS. 4A and 4B, the dielectric constant of resins exhibits strong correlation with the density as well as the viscosity of the crude oil sample.

In certain embodiments, a higher degree of coherence between the physical properties of the crude oil sample and the dielectric constant of resins fraction as compared to asphaltene fraction may arise due to impurities present within or along with the asphaltene molecules. Within the reservoir environment, the most polar asphaltene fraction of the crude oil can physically and chemically interact with different minerals present in, for example, reservoir rocks, clays, and brines. Interactions of asphaltene fractions can increase the presence of polar molecules and ultimately increase the dielectric constant value for asphaltene fractions. In certain embodiments, resins fractions including mainly organic constituents provide a better representation

of the organic origin of the crude oil due to physical properties of crude oils being dominated by the organic constituents. Thus, in a typical embodiment, crude oil samples having an asphaltene fraction with a higher dielectric constant are generally less stable than crude oil samples having an asphaltene fraction having a lower dielectric constant. Higher dielectric constants indicate higher polarity which indicates a higher possibility of asphaltene to come together and precipitate.

In a typical embodiment, two alternative parameters are utilized to gain a relative measurement of the dielectric constant of an asphaltene fraction of a crude oil sample. These parameters are the Lowry Parameter and the Wu Parameter. Traditionally, the Lowry parameter has been determined according to Equations 3. Similarly, the Wu Parameter has been determined according to Equation 4.

$$\text{LowryParameter} = v_{\text{asphaltene}} \epsilon_{\text{asphaltene}} + v_{\text{DAO}} \epsilon_{\text{DAO}} \quad \text{Equation 3:}$$

$$\text{WuParameter} = 10^{(\log(v_{\text{asphaltene}} \epsilon_{\text{asphaltene}}) + \log(v_{\text{DAO}} \epsilon_{\text{DAO}}))} \quad \text{Equation 4:}$$

Where v and ϵ denote the volume fraction and dielectric constant, respectively, of asphaltene and deasphalted oil (DAO) in the crude oil mixture. It has been found, however, that calculating the Lowry Parameter and the Wu Parameter utilizing Equations 3 and 4 is insufficient as Equations 3 and 4 overestimate the overall dielectric constant values of a bulk oil mixture. Thus, in the exemplary method, a modified Lowry Parameter or a modified Wu Parameter are calculated by the measuring device 302 according to equations 5 and 6.

$$\text{Modified Lowry Parameter} = v_{\text{Asphaltenes}} \epsilon_{\text{Asphaltenes}} - v_{\text{DAO}} \epsilon_{\text{DAO}} \quad \text{Equation 5}$$

$$\text{Modified Wu Parameter} = 10^{(\log 10(v_{\text{Asphaltenes}} \epsilon_{\text{Asphaltenes}}) - \log 10(v_{\text{DAO}} \epsilon_{\text{DAO}}))} \quad \text{Equation 6}$$

In a typical embodiment, a crude oil sample having a modified Lowry Parameter greater than 0 has a high probability of containing unstable asphaltene. Likewise, a crude oil sample having a modified Wu parameter greater than 1 has a high probability of containing unstable asphaltene. In various embodiments, the measuring device 302 calculates the modified Lowry parameter and the modified Wu parameter and returns a measurement to an operator.

It has been found that asphaltene and saturates contribute to asphaltene instability while aromatics and resins contribute to asphaltene stability. To that end, an embodiment utilizes a measurement of Colloidal Instability Index (CII). FIG. 5A is a plot of CII versus modified Lowry Parameter.

FIG. 5B is a plot of CII versus modified Wu Parameter. The calculated amounts are derived from modified Lowry or Wu Parameters (Equations 5 and 6). As previously noted, this distinction is made because each of the respective original parameter overestimates the overall dielectric constant values of a bulk oil mixture. The modified Lowry or Wu parameter is used to directly describe the overall stability of asphaltenes within the bulk crude oil. Quantitative assessment of the overall asphaltenes stability is carried out based on the dielectric constant values of the asphaltenes and deasphalted oil fractions. Thus the dielectric constant of pure state asphaltenes and DAO fractions is utilized to assess stability.

The Colloidal Instability Index is calculated based on data given in Table 2 to yield FIGS. 5A and 5B. CII considers the crude oil mixture as a colloidal solution made of asphaltenes, asphaltene flocculants (saturates), and asphaltenes peptizers (aromatics and resins). Equation 7 provides the mathematical definition of CII, where the terms represent weight percentages of each fraction within the crude oil. In a typical embodiment, the weight percentages of each fraction within the crude oil sample is determined via a SARA analysis according to, for example, ASTM D-2007-11.

$$CII = \frac{(\text{Asphaltenes} + \text{Saturates})}{(\text{Aromatics} + \text{Resins})} \quad \text{Equation 7}$$

Still referring to FIGS. 5A and 5B, an increase in CII indicates lower stability and higher propensity of asphaltenes to precipitate within the crude oil mixture. The data used to calculate FIGS. 5A and 5B was all taken from the data presented in Tables 2 and 3. Direct linear correlation can be observed between the CII and the modified Lowry and Wu parameters, highlighting that the asphaltenes become more unstable at higher modified parameter values. In certain embodiments, the modified Wu parameter, shown in FIG. 5B, exhibits a higher degree of coherence with CII as compared to the modified Lowry parameter, shown in FIG. 5A. It has been found that a colloidal instability index higher than approximately 1.5 is a threshold for asphaltene stability. Thus, a modified Lowry parameter greater than zero and the colloidal instability index greater than 1.5 determines unstable asphaltenes that are likely to precipitate. Similarly, a modified Wu parameter greater than 1 and having a CII higher than 1.5 determines the unstable asphaltenes that are likely to precipitate.

FIG. 6A is a flow diagram illustrating a process 600 for determining asphaltene stability of a crude oil sample. The process 600 begins at step 602. At step 604, a crude oil sample is obtained from, for example, a production well. At step 606, a SARA analysis is performed on the crude oil sample to determine a fractional composition of the crude oil sample. In a typical embodiment, the SARA analysis of step 606 is performed according to, for example, ASTM D-2007-11 discussed above. At step 608, a CII is determined by the measuring device 302 according to Equation 7. At step 610, it is determined by the measuring device 302 if the CII is greater than 1.5. If, in step 610, the CII is determined by the measuring device 302 to be less than 1.5, the process returns to step 604. If, in step 610, the CII is determined by the measuring device 302 to be greater than 1.5, then the process 600 proceeds to step 618. At step 618, responsive to an indication of asphaltene instability, actions are taken to

mitigate asphaltene precipitation such as, for example, modulation of temperature, pressure, or chemical content.

Alternatively, from step 606, the process 600 proceeds to step 611. At step 611, a content of asphaltenes and deasphalted oil present in the crude oil sample is determined by the measuring device 302. At step 612, the modified Lowry or modified Wu parameter is determined using the cylindrical capacitor 100 and the measuring device 302 described above with respect to FIGS. 1 and 2. At step 614, the measuring device 302 determines if the modified Lowry Parameter is greater than 0 or, alternatively, if the modified Wu Parameter is greater than 1. At step 614, if the measuring device 302 determines that the modified Lowry Parameter is greater than 0, or the modified Wu Parameter is greater than 1, the process 600 proceeds to step 618. Responsive to an indication of asphaltene instability, the measuring device 302 may, in various embodiments, alert an operator to a high probability of asphaltene instability. A modified Lowry Parameter greater than 0 or a modified Wu Parameter greater than 1 is indicative of unstable asphaltenes that are likely to precipitate. At step 618, responsive to an indication of asphaltene instability, actions are taken to mitigate asphaltene precipitation such as, for example, modulation of temperature, pressure, or chemical content. If, at step 614, the measuring device 302 determines that the modified Lowry Parameter is less than 0 or the modified Wu Parameter is less than 1, the process 600 returns to step 604. A modified Lowry Parameter less than 0 or a modified Wu Parameter less than 1 is indicative of stable asphaltenes that are unlikely to precipitate.

FIG. 6B is a flow diagram illustrating a process 650 for determining asphaltene stability of a crude oil sample. The process 650 begins a step 652. At step 654, a crude oil sample is obtained from, for example, a production well. At step 656, the crude oil is analyzed to determine a weight percent asphaltenes content of the crude oil sample. In a typical embodiment, procedure described in ASTM D2007-11 is followed to determine the asphaltene content by weight percent of crude oil. In a typical embodiment, the dielectric constant is determined using the cylindrical capacitor 100 described above with respect to FIGS. 1 and 2. At step 658, the measuring device 302 determines at least one of a modified Lowry Parameter and a modified Wu Parameter. In a typical embodiment, determination of at least one of the modified Lowry Parameter and the modified Wu Parameter facilitates approximation of the dielectric constant of the crude-oil sample. At step 660, the measuring device 302 determines if the modified Lowry Parameter is greater than 0 or, alternatively, if the modified Wu Parameter is greater than 1. At step 660, if the modified Lowry Parameter is greater than 0, or the modified Wu Parameter is greater than 1, the process 650 proceeds to step 661. At step 661, responsive to a determination by the measuring device 302 that a modified Lowry Parameter is greater than 0 or a modified Wu Parameter is greater than 1, the measuring device 302 alerts an operator to a high probability of asphaltene instability. A modified Lowry Parameter greater than 0 or a modified Wu Parameter greater than 1 is indicative of unstable asphaltenes that are likely to precipitate. At step 662, actions are taken to mitigate asphaltene precipitation such as, for example, modulation of temperature, pressure, or chemical content. If, at step 660, the measuring device 302 determines that the modified Lowry Parameter is less than 0 or the modified Wu Parameter is less than 1, the process 650 returns to step 654. A modified Lowry Parameter less than 0 or a modified Wu Parameter less than 1 is indicative of stable asphaltenes that are

unlikely to precipitate. Using the modified Lowry Parameter or the modified Wu parameter as a proxy for the dielectric constant of the crude-oil sample allows determination of asphaltene stability in approximately 1 minute or less.

Referring to FIGS. 6A and 6B collectively, it is contemplated that at least one of the modified Lowry Parameter, the modified Wu Parameter, or the CII will be measured periodically during, for example, production of an active well, delivery of crude oil to a refinery, or operation of a refinery. By observing trends over time of the modified Lowry Parameter, the modified Wu Parameter, or the CII, changes in the composition of the crude oil and, particularly, changes in asphaltene stability over time can be observed. For example, if the modified Lowry Parameter or the modified Wu Parameter begins to rise, well or refinery operators will be signaled by, for example, the measuring device 302, to take action to mitigate the possibility of asphaltene precipitation such as, for example, modulating a temperature or pressure of the crude oil reservoir or adjusting the chemical composition of the crude oil flow.

Although various embodiments of the method and system of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Specification, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit and scope of the invention as set forth herein. It is intended that the Specification and examples be considered as illustrative only.

What is claimed is:

1. A method of determining asphaltene stability within a crude oil sample, the method comprising:
 - obtaining a crude oil sample;
 - introducing the crude oil sample to an annulus formed in a cylindrical capacitor;
 - applying, via a measuring device, an electrical voltage across the annulus and through the crude oil sample;
 - measuring, via the measuring device, a dielectric constant of asphaltenes and desasphalted oil fractions of the crude oil sample; and
 - responsive to the measured dielectric constant, determining a stability of asphaltene fraction within crude oil sample.
2. The method of claim 1, comprising providing a signal responsive to a stability of the asphaltene fraction being below a minimum threshold.
3. The method of claim 1, wherein the method is performed in approximately one minute or less.
4. The method of claim 1, wherein the determining the stability of the asphaltene fraction comprises calculating a modified Lowry parameter.
5. The method of claim 1, wherein the determining the stability of the asphaltene fraction comprises calculating a modified Wu parameter.

6. The method of claim 1, comprising performing a fractional analysis of the crude oil sample in order to obtain a volume fraction of asphaltenes and desasphalted oil present in the crude oil sample.

7. The method of claim 6, wherein the determining the stability of the asphaltene fraction comprises calculating a colloidal stability index.

8. The method of claim 1, comprising determining, based on the stability of the asphaltene fraction, a probability of asphaltene precipitation.

9. A method of determining asphaltene stability of a crude oil flow, the method comprising:

- placing a crude oil sample in an annulus formed in a cylindrical capacitor;
- performing a fractional analysis of the crude oil sample in order to obtain a volume fraction of asphaltenes and desasphalted oil present in the crude oil sample;
- determining a colloidal instability index of the crude oil sample;
- applying, via a measuring device, an electrical voltage across the annulus and through the crude oil sample;
- measuring, via the measuring device, a dielectric constant of the asphaltenes and the desasphalted oil fractions of the crude oil sample;
- responsive to the measured dielectric constant, determining a stability of asphaltene fraction within crude oil sample; and
- responsive to the determined asphaltene stability being below a minimum threshold, mitigating asphaltene instability in the crude oil flow.

10. The method of claim 9, wherein the mitigating comprises at least one of modulating a temperature of the crude oil flow.

11. The method of claim 9, wherein the mitigating comprises modulating a pressure of the crude oil flow.

12. The method of claim 9, wherein the mitigating comprises modulating a chemical composition of the crude oil flow.

13. The method of claim 9, comprising providing a signal responsive to a stability of the asphaltene fraction being below a minimum threshold.

14. The method of claim 9, wherein the determining the stability of the asphaltene fraction comprises calculating a modified Lowry parameter.

15. The method of claim 9, wherein the determining the stability of the asphaltene fraction comprises calculating a modified Wu parameter.

16. The method of claim 9, comprising determining, based on the stability of the asphaltene fraction, a probability of asphaltene precipitation.

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