MULTI-PURPOSE PARAFFIN ADDITIVES FOR DEPOSIT CONTROL, ANTI-SETTLING AND WAX SOFTENING IN OIL-BASED FLUIDS

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ABSTRACT

An additive may be added to an oil-based fluid having at least one wax foulant therein. The additive may be or include an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate terpolymer, imidazoline, and combinations thereof. The additive may alter at least one property of the wax foulant as compared to an otherwise identical oil-based fluid absent the additive. The altered property may be or include the amount of wax foulant deposited, the amount of paraffinic wax dispersed, settling rate of the paraffinic wax foulant, viscosity of the paraffinic wax foulant, shape of the paraffinic wax foulant, such as but not limited to softening the wax foulant, and combinations thereof.
MULTI-PURPOSE PARAFFIN ADDITIVES FOR DEPOSIT CONTROL, ANTI-SETTLING AND WAX SOFTENING IN OIL-BASED FLUIDS

RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 13/786,674, for “COLD FLOW IMPROVEMENT OF DISTILLATE FUELS USING ALPHA-OLEFIN COMPOSITIONS”, filed on Mar. 6, 2013, and claims the benefit of priority from the aforementioned application, which is herein incorporated in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to compositions and methods for altering at least one property of at least one wax foulant within an oil-based fluid, and more specifically relates to adding an effective amount of an additive to the oil-based fluid where the additive may be or include an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate copolymer, ethylene vinyl acetate terpolymer, imidazole, and combinations thereof.

BACKGROUND

[0003] Shale oil and other types of unconventional crude oils, such as but not limited to black wax crude, yellow wax crude, and the like, are being extracted because of the increasing difficulties to extract and obtain conventional types of crude oils. Shale oil may be produced from oil shale by pyrolysis, hydrogenation, thermal dissolution, and the like to convert the organic matter within the rock into synthetic oil and/or gas. The resulting shale oil may be used immediately as a fuel or refined for the same purposes and products as those derived from conventional crude oil.

[0004] Black wax crude and yellow wax crude are thick crude oils with a higher paraffinic or wax content than conventional crude oils found in North America. These waxy crudes are viscous and have a high pour point, which means they become semi-solid at lower temperatures. These waxy crudes may solidify quickly, so effective transport and handling of these waxy crude oils has been problematic. As a result, producers have started to look at blending in shale oils to lower the pour point and reduce the heating needed in the distribution system in order to deliver and handle these type crudes.

[0005] These unconventional crude oils are increasingly available in the U.S. and are relatively inexpensive to extract. Although shale oils are typically light in nature with a relatively low pour point (defined as the last temperature at which the oil had fluidity) compared to many conventional crude oils, they tend to have a higher concentration of paraffin and wax foulants. A significant amount of long chain (e.g. greater than 30 carbons), high molecular weight paraffin and wax compounds begin to crystallize and precipitate out of the oil even at temperatures, such as 100 °F or above. While this crystallization can occur in conventional oils, the delta between the onset of wax crystallization, commonly referred to as wax appearance temperature, and the pour point of these oils is generally greater than conventional crude oils resulting in greater wax settling.

[0006] Due to this phenomena, refineries and terminals face challenges as a result of wax settling out of the unconventional crude oil when being transported by vessels (e.g. trucks, barges, rail, etc.) used to deliver the oil. Such problems include, but are not limited to, wax deposition and the potential plugging of transfer lines leading from the point of oil delivery to tankage; wax build up in the bottom of the storage tanks; wax build up in the bottom of transport vessels; sludge formation comprised of inorganics and asphaltene destabilized by the paraffins; loss of hydrocarbon recovery due to solidification in the bottom phase of the oils as a result of paraffin buildup and sludge; fouling in preheat exchangers prior to the oil being distilled, and the like. The unrecovered hydrocarbon and sludge in transport vessels commonly referred to as “Remains On Board” or “ROB” results in economic loss due to remediation/cleanup costs, increased hazardous waste generation and the cost associated with disposal of this waste, demurrage incurred on the vessels during clean up and lost oil volumes.

[0007] Thus, there is an immediate and growing need for a chemical solution. It would be desirable if additives were created for improving the properties of paraffin or wax foulants within these unconventional types of crude oils, conventional crude oil blends, and the wax foulant that has yet to be separated and deposited from the oil-based fluid or ROB in the transport vessels, pipelines, and storage tanks, etc.

SUMMARY

[0008] There is provided, in one form, a treated fluid that may include an oil-based fluid having at least one wax foulant therein. The treated fluid also includes an effective amount of an additive for improving at least one property of the wax foulant(s), such as but not limited to wax foulant deposited, the amount of wax dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof. The additive may be or include an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate terpolymer, imidazole, and combinations thereof.

[0009] In another non-limiting embodiment, the wax foulant may be a paraffinic wax, and the temperature of the treated fluid may range from about -40 °C to about 40 °C. The oil-based fluid may be or include a production fluid, a crude oil, a shale oil, a black wax crude, a yellow wax crude, a synthetic crude, an oil sand, and combinations thereof.

[0010] In a non-limiting embodiment, a method for altering at least one property of at least one wax foulant within an oil-based fluid is described. An effective amount of an additive may be added to an oil-based fluid to improve properties of the wax foulant(s) therein, such as but not limited to wax foulant deposited, the amount of wax dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof. The additive may be or include an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate co-polymer terpolymer, imidazole, and combinations thereof.

[0011] In a non-limiting embodiment, the method may be or include refining an oil-based fluid having at least one paraffinic wax therein. An effective amount of an additive may be added to an oil-based fluid to improve properties of the paraffinic wax foulant(s) therein, such as but not limited to paraffinic wax foulant deposited, the amount of paraffinic wax dispersed, settling rate of the paraffinic wax foulant, viscosity of the paraffinic wax foulant, shape of the paraffinic
wax foulant, and combinations thereof. The additive may be or include an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate co-polymer terpolymer, imidazole, and combinations thereof. The amount of the additive within the oil-based fluid may range from about 10 ppm to about 10,000 ppm. The temperature of the oil-based fluid may range from about –40°C to about 100°C.

In another embodiment, a solid wax composition derived from an oil-based fluid is described. The solid wax composition may include an effective amount of an additive to improve at least one property of the at least one wax foulant, where the additive is selected from the group consisting of an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate terpolymer, imidazole, and combinations thereof. The improved properties may or include improving the amount of wax foulant deposited, the amount of wax foulant dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof.

The additive added to the oil-based fluid or wax solid appears to reduce the amount of the wax foulant that may be deposited within the oil-based fluid and/or increase the amount of wax foulant that may be dispersed within the oil-based fluid or wax solid.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 illustrates the viscosity curve of four different samples of shale oil where each sample has a different additive within it; and

FIG. 2 illustrates the viscosity curve of three different samples of shale oil where each sample has a different additive within it with a narrower temperature range than that of FIG. 1.

**DETAILED DESCRIPTION**

It has been discovered that an effective amount of an additive may be added to an oil-based fluid or wax solid to improve at least one property of at least one wax foulant therein. When the additive is incorporated into the oil-based fluid or wax solid, the amount of wax foulant deposited, the amount of wax dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof. The additive may be or include, but is not limited to an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate (EVA) co-polymer, EVA terpolymer, imidazole, and combinations thereof.

Complete reduction in wax deposition or completely increasing the dispersion of the wax foulants within the oil-based fluid or wax solid is desirable, but it should be appreciated that neither is necessary for the compositions and methods discussed herein to be considered effective. Success is obtained if more wax foulants are dispersed or less wax foulants are deposited using the additive than in the absence of the additive. ‘Effective amount’ is defined herein to mean any amount of the additive that may improve at least one property of the wax foulants within the oil-based fluid or wax solid.

The specific type of components within the additive may vary depending on the desired outcome, such as but not limited to deposition control of the wax foulant or dispersion of the wax foulant. For example, a C20-C24 alpha olefin maleic anhydride copolymer may be reacted with an amine (hereinafter referred to as a ‘long chain succinimide’). The long chain succinimide may also be blended with an acrylate/vinyl pyrrolidone copolymer in another non-limiting embodiment.

While this long chain succinimide may improve properties of both deposition control and dispersion of the wax foulant, it may be better suited for improving dispersion. Dispersants function by keeping the wax foulants from agglomerating together and slows the settling of the wax foulants according to Stokes’s Law. Dispersants may also be beneficial in cleaning existing wax buildup, such as solid wax buildup in the bottom of a barge or railroad car after transportation of the oil-based fluid and in the bottom of tanks used for storing the oil-based fluid prior to transporting or processing.

Another non-limiting example involves a C20-24 and C30+ alpha olefin maleic anhydride copolymer that has been fully esterified with a C18-C22 fatty alcohol (hereinafter referred to as the ‘esterified long chain AO/MA copolymer’). Similarly, this esterified long chain AO/MA copolymer may improve deposition control and dispersion of the wax foulants, but it may be better suited for reducing the amount of wax deposition. Additionally, the esterified long chain AO/MA copolymer AO/MA may function as a wax crystal modifier to impact the shape and characteristics of the wax, such as but not limited to softening the wax.

A blend of the long chain succinimide and the esterified long chain AO/MA copolymer may improve deposition control and dispersion of the wax foulants, but the blend may be better suited for reducing the amount of wax deposition. Worth noting is that the blend has better results on wax deposition than either of its components used alone.

The EVA copolymer and/or EVA terpolymer are more polar and may function as wax crystal modifiers to impact the shape and characteristics of the wax, such as but not limited to making the wax softer or more malleable. The EVA copolymer and/or terpolymer may attach to the wax crystal to modify its structure, or they may provide a nucleation site for the wax crystal to keep the wax crystal size smaller and less likely to precipitate from the oil-based fluid. If the wax crystal does precipitate out, it is less likely to settle when an EVA copolymer and/or terpolymer has been added to the oil-based fluid. The EVA copolymers and/or terpolymers may improve dispersion of the wax foulants more than improving deposition control; however, both properties may be improved by an additive having an EVA copolymer and/or terpolymer component.

The exact amount of the additive may vary depending on the temperature of the oil-based fluid, the amount of wax foulant(s) therein, and the like. The temperature of the treated fluid may range from about –40°C independently to about 100°C, alternatively from about –10°C independently to about 65°C, alternatively from about –10°C independently to about 40°C, or from about –10°C independently to about 25°C. As used herein with respect to a range, “independently” means that any lower threshold may be used together with any upper threshold to give a suitable alternative range.

Depending on the conditions of the oil-based fluid, the amount of the additive within the treated fluid or added to the wax solid may range from about 10 ppm independently to about 10,000 ppm, alternatively from about 200 ppm inde-
pendently to about 5000 ppm, from about 200 ppm independently to about 1000 ppm in another non-limiting embodiment, or from about 200 ppm independently to about 600 ppm. Between about 10 ppm independently to 200 ppm, there may be improved paraffin dispersion and wax deposition control, but performance may not be ideal.

The alpha olefin copolymer may be or include, but is not limited to, alpha olefin maleic anhydride copolymers, esters of alpha-olefin maleic anhydride copolymers, imides of alpha-olefin maleic anhydride copolymers, and combinations thereof. Alternatively, the alpha olefin copolymer may be or include, but is not limited to, alpha olefin maleic anhydride copolymers, esters of alpha-olefin maleic anhydride copolymers, imides of alpha-olefin maleic anhydride copolymers, and combinations thereof. The maleic anhydride moiety may be intact, converted to a functional group, such as but not limited to a half ester, a full ester, a di-acid, an acid/ester, an imide, and combinations thereof.

The alpha olefin copolymer may have a ratio based on weight of alpha-olefin to maleic anhydride ranging from about 0.9 alpha olefin to about 1 maleic anhydride) to (about 1 alpha olefin to about 2 maleic anhydride), such as a 1 to 2 ratio of alpha-olefin to maleic anhydride, a 1.2 to 1 ratio of alpha-olefin to maleic anhydride, a 0.9 to 1 ratio of alpha-olefin to maleic anhydride, a 1.1 to 1 ratio of alpha-olefin to maleic anhydride, and the like. The average molecular weight of the alpha olefin copolymer may range from about 2,000 independently to about 50,000, or from about 20,000 independently to about 30,000 in a non-limiting embodiment.

The alpha olefin may have a carbon chain length ranging from about 18 carbons independently to about 50 carbons, alternatively from about 20 carbons independently to about 24 carbons, from about 26 carbons independently to about 28 carbons, or from about 30 carbons independently to about 50 carbons. The phenol-formaldehyde resin may have a carbon chain length, such as but not limited to a carbon chain greater than 20 carbons, a carbon chain ranging from 6 carbons to 12 carbons, and combinations thereof.

Non-limiting examples of an alkyl acrylate may be or include, but are not limited to C16-C22 methacrylates, C16-C22 acrylates, and combinations thereof. Non-limiting examples of a polyalkyl methacrylate may be or include, but are not limited to C16-C22 methacrylates co-polymerized with C16-C22 acrylates, for example stearyl methacrylate/beheryl acrylate co-polymer at a ratio of 1:1 or 1:2, and combinations thereof. Non-limiting examples of an ethylene vinyl acetate copolymer may be or include, but are not limited to ethylene copolymerized with between 18-45% vinyl acetate, and combinations thereof. Non-limiting examples of an ethylene vinyl acetate terpolymer may be or include, but are not limited to ethylene vinyl acetate copolymer reacted with a co-nomer such as maleic anhydride, isobutylene or alpha-olefins between C6-C28, and combinations thereof. Non-limiting examples of an imidazoline may be or include, but are not limited to monomer or dimer fatty acids between C10-C36 reacted with amines, polyamines or alkanolamines, allylic carboxylic acids reacted with amines, polyamines or alkanolamines, and combinations thereof.

The oil-based fluid may be or include, but is not limited to, a production fluid, a crude oil, a shale oil, a black wax crude, a yellow wax crude, a synthetic crude, an oil sand, and combinations thereof. The amount of the wax foulant within the oil-based fluid may range from about 0.1 wt% to about 50 wt%, alternatively from about 0.1 wt% independently to about 30 wt%, alternatively from about 10 wt% independently to about 25 wt% in another non-limiting embodiment. The wax foulant(s) may have a carbon chain, such as but not limited to, a carbon chain ranging from about 10 carbons independently to about 20 carbons, greater than 20 carbons, and combinations thereof. In a non-limiting embodiment, the wax foulant may be a paraffin wax. “Paraffin wax” is defined herein to be a wax having a carbon chain length ranging from 18 carbons to 40 carbons.

Any suitable mixing apparatus may be used to incorporate the additive into the oil-based fluid. In the case of batch mixing, the additive and the oil-based fluid are blended for a period of time sufficient for incorporating the additive into the oil-based fluid. In an alternative embodiment, the additive may be added to the oil-based fluid as an injection, e.g. for a production fluid. In another non-limiting embodiment, the additive may be applied to the surface or within the matrix of deposited wax foulant, e.g. to the surface of deposits wax in railroad car. This may reduce the amount of wax foulant already deposited and/or increase the amount of dispersed wax foulant. The method may include, but is not limited to, direct or indirect contact of the additive on the surface of the wax foulant, injection within the solid wax foulant or another means for direct contact to the wax foulant by the additive.

Worth noting here, the additive may be added to the oil-based fluid having wax foulant(s) therein when the oil-based fluid and/or the wax foulants are in a fluid state, or the additive may be added directly to a solidified wax mass. The solidified wax mass may or may not have an oil-based fluid therein; typically, the wax and oil-based fluid remnants solidify, and a solid wax composition remains deposited. In another non-limiting embodiment, the additive may be added directly to the deposited wax foulant where the wax foulants have no oil-based fluid within the solidified wax mass, such as but not limited to deposited wax foulants in either the bulk oil holding system or within the processing unit for the oil-based fluid, a railroad car bottom, etc.

The amount of the additive may be added to the oil-based fluid in phases. For example, a single phase of an additive may be added to the oil-based fluid in an amount of 400 ppm. Alternatively, the additive may be added to the oil-based fluid in multiple phases, e.g. where 400 ppm is added to the oil-based fluid in three phases to total 1200 ppm over a designated time interval. As used in this example, 400 ppm is not limiting to the amount of additive that may be added to the oil-based fluid if a multi-phase addition of the additive is desirable; the amount of additive that may be added when using a multi-phase falls within the range of additive amounts previously described. Said differently, it may be desirable to one skilled in the art to add the additive in two phases where the first phase addition is 10000 ppm, and the second phase addition is 5000 ppm.

The invention will be further described with respect to the following Examples, which are not meant to limit the invention, but rather to further illustrate the various embodiments.

**EXAMPLE 1**

**FIG. 1** illustrates the viscosity curve of four different samples of shale oil where each sample has a different additive within it. The blank has no additive. Additive A is a straight alpha olefin maleic anhydride copolymer (C20-C24 and C30+) esterified with a long chain (C18-C22) fatty alcohol. Additive A is present within the oil-based fluid in an...
amount of 200 ppm based on volume. Additive B is a C20-C24 alpha olefin maleic anhydride copolymer reacted with an amine (a long chain succinimide). Additive B is present within the oil-based fluid in an amount of 200 ppm based on volume. Additive C is a C20-C24 and C30+ alpha olefin maleic anhydride copolymer that has been fully esterified with a C18-C22 fatty alcohol blended 1:1 with a C20-C24 alpha olefin maleic anhydride copolymer reacted with an amine (a long chain succinimide). Additive C is present within the oil-based fluid in an amount of 200 ppm based on volume. As noted by the graph, additives A-C have an improved viscosity from ~10 C to 65 C compared to the blank.

EXAMPLE 2

[0035] FIG. 2 illustrates the viscosity curve of three different samples of shale oil where each sample has a different additive within it. The blank has no additive. Additive A and Additive C are the same as those noted in FIG. 1. Additive A is present within the oil-based fluid in an amount of 200 ppm based on volume. Additive C is present within the oil-based fluid in an amount of 200 ppm based on volume. As noted by the graph, additives A and C have an improved viscosity from ~10 C to 25 C compared to the blank.

EXAMPLE 3

[0036] TABLE 1 compares the amount of deposited wax, the deposited density, the weight percent inhibition, and the bare probe testing for the various types of additives within a Utica shale oil-based fluid. Additives A-C are the same as additives described in FIGS. 1 and 2. Additive D is a C24-C28 alpha olefin maleic anhydride copolymer with no esterification or imidization. Additive E is a 2:1 blend of additive A and D. All of the additives were effective for improving the deposited weight, the deposited density, the weight percent inhibition, and the bare probe testing. However, the Additive C was the most effective additive for improving the deposited weight, the deposited density, the weight percent inhibition, and the bare probe testing. Moreover, increasing the dosage of the Additive C from 200 ppm to 400 ppm increased the improvement for the deposited weight, the deposited density, and the weight percent inhibition.

[0037] The cold finger test results of TABLE 1 were done at a condition temperature of 150°F, a treatment temperature of 150°F, a bulk oil temperature of 95°F, a probe temperature of 70°F, a stir speed of 450 rpm, and a duration of 24 hours.

TABLE 1

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Dosage (ppm)</th>
<th>Deposit wt. (gm)</th>
<th>Deposit density (gm/m²)</th>
<th>Wt. % inhibition</th>
<th>Bare probe (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>n/a</td>
<td>0.5166</td>
<td>90.07</td>
<td>n/a</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>200</td>
<td>0.133</td>
<td>22.84</td>
<td>74.65</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>200</td>
<td>0.2417</td>
<td>40.5</td>
<td>55.04</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td>0.4297</td>
<td>78.64</td>
<td>12.69</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>200</td>
<td>0.2206</td>
<td>40.64</td>
<td>54.88</td>
<td>50</td>
</tr>
<tr>
<td>C</td>
<td>200</td>
<td>0.0782</td>
<td>13.19</td>
<td>85.36</td>
<td>90</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
<td>0.0485</td>
<td>8.52</td>
<td>90.54</td>
<td>95</td>
</tr>
</tbody>
</table>

EXAMPLE 4

[0038] TABLE 2 compares additive A with additive C on deposited wax, the deposited density, and the weight percent inhibition within a Utica shale oil-based fluid. As noted by TABLE 2, additive C was more effective at improving the deposited weight, the deposited density, and the weight percent inhibition. Moreover, increasing the dosage of additive C from 300 ppm to 600 ppm increased the improvement for the deposited weight, the deposited density, and the weight percent inhibition.

[0039] The cold finger test results of TABLE 2 were done at a condition temperature of 150°F, a treatment temperature of 150°F, a bulk oil temperature of 103°F, a probe temperature of 73°F, and a stir speed of 750 rpm.

TABLE 2

<table>
<thead>
<tr>
<th>Additive Effect on Paraffin Deposition COLD FINGER TEST RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Blank</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>C</td>
</tr>
</tbody>
</table>

[0040] In the foregoing specification, the invention has been described with reference to specific embodiments thereof, and has been described as effective in providing fluids and methods for altering at least one property of at least one wax fountan within an oil-based fluid. However, it will be evident that various modifications and changes can be made thereto without departing from the broader spirit or scope of the invention as set forth in the appended claims. Accordingly, the specification is to be regarded in an illustrative rather than a restrictive sense. For example, specific oil-based fluids, additives, alpha olein copolymers, wax fountans, and modifications falling within the claimed parameters, but not specifically identified or tried in a particular fluid, or method, are expected to be within the scope of this invention.

[0041] The present invention may suitably comprise, consist or consist essentially of the elements disclosed and may be practiced in the absence of an element not disclosed. For instance, the treated fluid may consist of or consist essentially of an oil-based fluid comprising at least one wax fountan, and an effective amount of an additive to improve at least one property of the wax fountan, where the additive is selected from the group consisting of an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylen vinyl acetate terpolymer, imidazoline, and combinations thereof; where the property is selected from the group consisting of the amount of wax fountan deposited, the amount of wax fountan dispersed, settling rate of the wax fountan, viscosity of the wax fountan, shape of the wax fountan, and combinations thereof.

[0042] There is further provided a method for improving at least one property of at least one wax fountan within an oil-based fluid where the method consists of or consists essentially of adding an effective amount of an additive to improve at least one property of the wax fountan where the additive is selected from the group consisting of an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a
polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate terpolymer, imidazoline, and combinations thereof; and where at least one property is selected from the group consisting of the amount of wax foulant deposited, the amount of wax foulant dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof.

[0043] The words "comprising" and "comprises" as used throughout the claims, are to be interpreted to mean "including but not limited to" and "includes but not limited to", respectively.

1.11. (canceled)

12. A method for improving at least one property of at least one wax foulant within an oil-based fluid, the method comprising:

adding an effective amount of an additive to improve at least one property of the at least one wax foulant, where the additive is selected from the group consisting of an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate terpolymer, imidazoline, and combinations thereof; and wherein the at least one property is selected from the group consisting of the amount of wax foulant deposited, the amount of wax foulant dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof.

13. The method of claim 12, wherein the effective amount of the additive range from about 10 ppm to about 10,000 ppm.

14. The method of claim 12, wherein the alpha olefin copolymer is selected from the group consisting of alpha olefin maleic anhydride copolymers, esters of alpha-olefin maleic anhydride copolymers, imides of alpha-olefin maleic anhydride copolymers, and combinations thereof.

15. The method of claim 14, wherein the alpha olefin copolymer has a ratio based on weight of alpha-olefin to maleic anhydride ranging from [about 0.9 alpha olefin to about 1 maleic anhydride] to [about 1.1 alpha olefin to about 2 maleic anhydride].

16. The method of claim 12, wherein the average molecular weight of the alpha olefin copolymer ranges from about 2,000 to about 50,000.

17. The method of claim 12, wherein the phenol-formaldehyde resin has a carbon chain selected from the group consisting of a carbon chain of greater than 20 carbons, a carbon chain ranging from 6 carbons to 12 carbons, and combinations thereof.

18. The method of claim 12, wherein the oil-based fluid is selected from the group consisting of a production fluid, a crude oil, a shale oil, a black wax crude, a yellow wax crude, a synthetic crude, an oil sand, and combinations thereof.

19. The method of claim 12, wherein the alpha olefin has a carbon chain ranging from 18 carbons to 50 carbons.

20. The method of claim 12, wherein the at least one wax foulant is present within the oil-based fluid in a total amount ranging from about 0.1 wt % to about 50 wt %.

21. The method of claim 12, wherein the at least one wax foulant has a carbon chain selected from the group consisting of a carbon chain ranging from about 10 carbons to about 20 carbons, 20 carbons to 30 carbons, greater than 30 carbons, and combinations thereof.

22. A method of refining an oil-based fluid having at least one paraffinic wax therein, the method comprising:

adding an effective amount of an additive to improve at least one property of the at least one paraffinic wax foulant, where the additive is selected from the group consisting of an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate co-polymer terpolymer, imidazoline, and combinations thereof; wherein the amount of the additive within the oil-based fluid ranges from about 10 ppm to about 10,000 ppm; and wherein the at least one property is selected from the group consisting of the amount of paraffinic wax foulant deposited, the amount of paraffinic wax foulant dispersed, settling rate of the paraffinic wax foulant, viscosity of the paraffinic wax foulant, shape of the paraffinic wax foulant, and combinations thereof; and wherein the temperature of the oil-based fluid ranges from about −40 °C to about 100 °C.

23. A treated wax composition, where the composition comprises:

at least one wax foulant; and

an effective amount of an additive to improve at least one property of the at least one wax foulant, where the additive is selected from the group consisting of an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate co-polymer terpolymer, imidazoline, and combinations thereof; wherein the at least one property is selected from the group consisting of the amount of wax foulant deposited, the amount of wax foulant dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof.

24. The treated wax composition of claim 23, further comprising an oil-based fluid.

25. The treated wax composition of claim 24, wherein the oil-based fluid is selected from the group consisting of a production fluid, a crude oil, a shale oil, a black wax crude, a yellow wax crude, a synthetic crude, an oil sand, and combinations thereof.

26. The treated wax composition of claim 24, wherein the at least one wax foulant is present within the oil-based fluid in a total amount ranging from about 0.1 wt % to about 50 wt %.

27. The treated wax composition of claim 23, wherein the effective amount of the additive ranges from about 10 ppm to about 10,000 ppm.

28. The treated wax composition of claim 23, wherein the alpha olefin copolymer is selected from the group consisting of alpha olefin maleic anhydride copolymers, esters of alpha-olefin maleic anhydride copolymers, imides of alpha-olefin maleic anhydride copolymers, and combinations thereof.

29. The treated wax composition of claim 26, wherein the alpha olefin copolymer has a ratio based on weight of alpha-olefin to maleic anhydride ranging from [about 0.9 alpha olefin to about 1 maleic anhydride] to [about 1.1 alpha olefin to about 2 maleic anhydride].

30. The treated wax composition of claim 23, wherein the average molecular weight of the alpha olefin copolymer ranges from about 2,000 to about 50,000.

31. The treated wax composition of claim 23, wherein the phenol-formaldehyde resin has a carbon chain selected from the group consisting of a carbon chain of greater than 20 carbons, a carbon chain ranging from 6 carbons to 12 carbons, and combinations thereof.
32. The treated wax composition of claim 23, wherein the alpha olefin has a carbon chain ranging from 18 carbons to 50 carbons.

33. The treated wax composition of claim 23, wherein the at least one wax foulant has a carbon chain selected from the group consisting of a carbon chain ranging from about 10 carbons to about 20 carbons, 20 carbons to 30 carbons, greater than 30 carbons, and combinations thereof.

34. A treated wax composition comprising:
   at least one wax foulant;
   an oil-based fluid; and
   an effective amount of an additive to improve at least one property of the at least one wax foulant, where the additive is selected from the group consisting of an alpha olefin copolymer, an alkyl phenol-formaldehyde resin, an alkyl acrylate, a polyalkyl methacrylate, ethylene vinyl acetate co-polymer, ethylene vinyl acetate terpolymer, imidazoline, and combinations thereof;
   wherein the at least one property is selected from the group consisting of the amount of wax foulant deposited, the amount of wax foulant dispersed, settling rate of the wax foulant, viscosity of the wax foulant, shape of the wax foulant, and combinations thereof.

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