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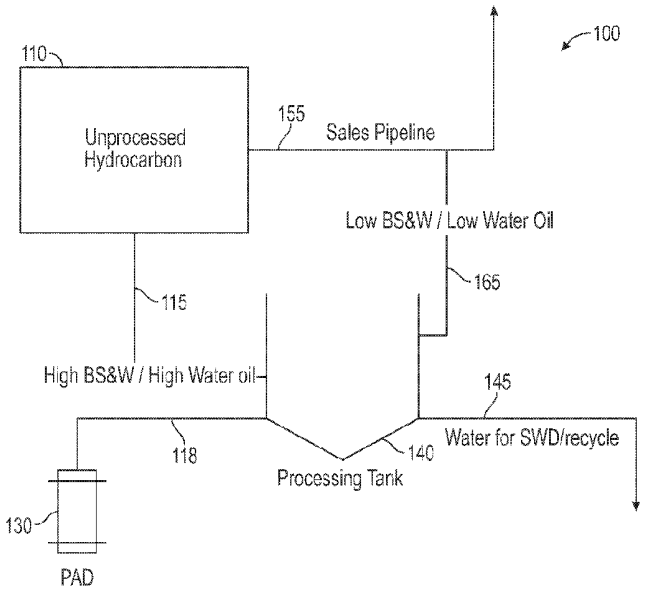

FIG. 1

(57) **Abstract:** A method of reducing impurities in a mixture of a nonaqueous fluid with an aqueous component comprising contacting the mixture with a purification additive comprising: (i) one or more sugar oxidation products, (ii) a chelating agent, (iii) a biobased additive (BBA), and (iv) an enhancing agent to form a treated mixture; allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase; separating the at least one aqueous phase from the at least one nonaqueous phase; and recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both. A method of servicing an oil and gas field comprising a well penetrating a subterranean formation, the method comprising: recovering a hydrocarbon resource from the well, wherein the hydrocarbon resource has an aqueous component; contacting the hydrocarbon resource with a purification additive comprising (i) one or more sugar oxidation products, (ii) a chelating agent, and (iii) a biobased additive (BBA) to form a treated mixture; allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase; separating the at least one aqueous phase from the at least one nonaqueous phase; and recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both.

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HYDROCARBON UPGRADING METHOD AND APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. provisional patent application Serial No. 63/652,315 filed May 28, 2024 and entitled "HYDROCARBON UPGRADING METHODS AND APPARATUS," which is hereby incorporated herein by reference in its entirety for all purposes.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

TECHNICAL FIELD

[0003] The present disclosure relates generally to methods and compositions for the upgrading of nonaqueous fluids. More particularly, the present disclosure relates to methods and compositions for reducing impurities present in mixtures of nonaqueous fluids. Still more particularly, the present disclosure relates to methods and compositions for reducing impurities in hydrocarbons obtained during oilfield production processes.

BACKGROUND

[0004] Significant quantities of water are present in hydrocarbon reservoirs. When brought to the land surface during oil, gas, and coalbed methane production, the water, either naturally-occurring or injected as a method to enhance production, is termed produced water. Produced water is currently managed through processes such as recycling, treatment and discharge, spreading on roads, evaporation or infiltration, and deep well injection. In conventional oil and gas wells, produced water generally consists of naturally-occurring brine present in the reservoir and water injected nearby to push the hydrocarbon deposit into production wells. In continuous or unconventional resources, such as shale gas or tight oil, fracturing fluid and a solid material (e.g., proppant) are injected into the reservoir under very high pressure in order to create fractures to increase rock porosity and permeability. In this scenario, the produced water is usually a mixture of the injected fluids with formation brines in the reservoir.

[0005] The quality of produced water is variable, ranging in salinity from similar to that of drinking water to several times more saline than sea water. Various constituents can be contained in produced water from petroleum or coal reservoirs, including dissolved salt, petroleum and other organic compounds, suspended solids, trace elements,

bacteria, naturally-occurring radioactive materials (NORM), and anything injected into the well. Because of the considerable variability in water chemistry and the potentially large volumes involved, the management of produced water is an important and complex issues that usually increases the unit cost of oil production.

[0006] For example, costs increases are in part because produced water must be separated from the oil, treated, and disposed of properly. Furthermore, sellable crude oil must comply with certain product specifications, including the amount of basic sediment and water (BS&W) and salt.

[0007] Produced water may be produced as "free" water (i.e., water that will settle out fairly rapidly) and/or it may be produced in the form of an emulsion. A regular oilfield emulsion is a dispersion of water droplets in oil. Emulsions can be difficult to treat and may cause several operational problems in wet-crude handling facilities and gas/oil separating plants. Emulsions can create high-pressure drops in flow lines, lead to an increase in demulsifier use, and sometimes cause trips or upsets in wet-crude handling facilities. The problem is usually at its worst during the winter because of lower surface temperatures.

[0008] Nonaqueous fluids such as hydrocarbons often are treated to remove any associated impurities in order to meet crude specifications for transportation, storage, and export and to reduce detrimental effects such as corrosion and catalyst poisoning in downstream processing facilities. An ongoing need exists for methods and compositions that facilitate the removal of these impurities from oleaginous fluids.

[0009] Further, with sustainability being a desired goal, tremendous progress in bio-based production routes from renewable raw materials to commercial goods continues to occur. Of particular interest is the formation of higher value chemicals from what are termed "platform molecules." Herein platform molecules refer to bio-based or bio-derived chemicals whose constituting elements totally originated from biomass and could be used as building blocks for the generation of commodity and refined chemicals. An ongoing need also exists for novel methods utilizing platform molecules in the production of commodity and refined chemicals.

BRIEF SUMMARY OF THE DISCLOSURE

[0010] Disclosed herein is a method of reducing impurities in a mixture of a nonaqueous fluid with an aqueous component comprising contacting the mixture with a purification additive comprising: (i) one or more sugar oxidation products, (ii) a chelating agent, (iii)

a biobased additive (BBA), and (iv) an enhancing agent to form a treated mixture; allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase; separating the at least one aqueous phase from the at least one nonaqueous phase; and recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both.

[0011] Also disclosed herein is a method of servicing an oil and gas field comprising a well penetrating a subterranean formation, the method comprising: recovering a hydrocarbon resource from the well, wherein the hydrocarbon resource has an aqueous component; contacting the hydrocarbon resource with a purification additive comprising (i) one or more sugar oxidation products, (ii) a chelating agent, and (iii) a biobased additive (BBA) to form a treated mixture; allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase; separating the at least one aqueous phase from the at least one nonaqueous phase; and recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both. Aspects described herein comprise a combination of features and characteristics **intended** to address various shortcomings associated with certain prior devices, systems, and methods. The foregoing has outlined rather broadly the features and technical characteristics of the disclosed aspects in order that the detailed description that follows may be better understood. The various characteristics and features described above, as well as others, will be readily apparent to those skilled in the art upon reading the following detailed description, and by referring to the accompanying drawings. It should be appreciated that the conception and the specific aspects disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes as the disclosed aspects. It should also be realized that such equivalent constructions do not depart from the spirit and scope of the principles disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a detailed description of various exemplary aspects, reference will now be made to the accompanying drawings in which:

[0013] Figure 1 depicts a general process flow diagram for impurity reduction in a hydrocarbon with an aqueous component using a process tank.

[0014] Figure 2 depicts a general process flow diagram for impurity reduction in a hydrocarbon with an aqueous component including an electrocoagulation unit.

[0015] Figure 3 depicts a general process flow diagram for impurity reduction in a hydrocarbon with an aqueous component including an electrocoagulation unit and a sludge recovery step.

[0016] Figure 4 depicts a general process flow diagram for impurity reduction in a hydrocarbon with an aqueous component sourced from a salt water disposal unit.

[0017] Figure 5 depicts a general process flow diagram for impurity reduction in a hydrocarbon with an aqueous component with a centrifugation unit.

[0018] Figure 6 depicts a general process flow diagram for impurity reduction in a hydrocarbon with an aqueous component sourced from a transporting vehicle (truck).

DETAILED DESCRIPTION

[0019] The following discussion is directed to various exemplary aspects. However, one of ordinary skill in the art will understand that the examples disclosed herein have broad application, and that the discussion of any aspect is meant only to be exemplary of that aspect, and not intended to suggest that the scope of the disclosure, including the claims, is limited to that aspect.

[0020] The figures are not necessarily to scale. Certain features and components herein may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in interest of clarity and conciseness.

[0021] In the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to... ." As used herein, the terms "approximately," "about," "substantially," and the like mean within 10% (i.e., plus or minus 10%) of the recited value. Thus, for example, a recited angle of "about 80 degrees" refers to an angle ranging from 72 degrees to 88 degrees.

[0022] Disclosed herein are compositions, methods, and apparati that may be used to reduce the amount of impurities present in a nonaqueous system comprising a nonaqueous fluid and an aqueous component, designated NAA. Herein such compositions are termed purification additives and designated PADs. In one or more aspects, the PAD comprises (i) one or more sugar oxidation products (SOPs), (ii) a chelating agent, (iii) a biobased additive (BBA), and (iv) an enhancing agent. Herein a PAD is used to treat a NAA and reduce the level of undesirable materials, collectively termed impurities, in the NAA. Nonlimiting examples of impurities that may be reduced by treatment of a NAA with a PAD include inorganic salts, metals and water.

[0023] In an aspect, the PAD comprises one or more SOPs. The one or more SOPs may comprise aldonic acid, uronic acid, aldaric acid, or a combination thereof and a counter cation. For example, the one or more SOPs may be a mixture of aldaric acids, uronic acids, and their respective counter-cations.

[0024] Additionally or alternatively, in an aspect, the one or more SOPs comprise a glucose oxidation product, a gluconic acid oxidation product, a gluconate, or a combination thereof. The glucose oxidation product, gluconic acid oxidation product, or combination thereof may be buffered to a suitable pH. In such aspects, the one or more SOPs may comprise a buffered glucose oxidation product, a buffered gluconic acid oxidation product, or combinations thereof which are buffered to a suitable pH. For example, the glucose oxidation product, gluconic acid oxidation product or combination thereof may be buffered to a pH in the range of from about 1 to about 5. Buffering of the one or more SOPs may be carried out using any suitable acid, base, or combination thereof.

[0025] Additionally or alternatively, in one or more aspects, the one or more SOPs comprise glucaric acid, gluconic acid, glucuronic acid, glucose oxidation products, gluconic acid oxidation products or a combination thereof. Additionally or alternatively, in one or more aspects, the one or more SOPs comprise disaccharides, oxidized disaccharides, uronic acid, aldaric acid or a combination thereof.

[0026] Additionally or alternatively, the one or more SOPs comprise gluconic acid, glucaric acid, glucuronic acid, n-keto-acids, C_2 to C_6 diacids or a combination thereof.

[0027] Additionally or alternatively, in one or more aspects, the one or more SOPs comprise galactonic acid, galactaric acid, an oxidation product comprising predominantly (e.g., greater than about 50 weight percent) galactonic acid and/or galactaric acid with minor component species of n-keto-acids, C_2 to C_6 diacids or a combination thereof. Additionally or alternatively, the one or more SOPs comprise glutamic acid. Additionally or alternatively, the one or more SOPs comprise glucodialdose, 2-ketoglucose, or a combination thereof.

[0028] In aspects, the one or more SOPs comprise aldonic acid, uronic acid, aldaric acid, a gluconic acid oxidation product, a gluconate, glucaric acid, gluconic acid, glucuronic acid, glucose oxidation products, galactonic acid, galactaric acid, glutamic acid, a lactone of gluconic acid, a lactone of glucaric acid, a lactone of galactaric acid,

a lactone of galactonic acid, glucodialdose, 2-ketoglucose, disaccharides, oxidized disaccharides, n-keto-acids, C_2 to C_6 diacids, salts thereof, or combinations thereof.

[0029] In an aspect, the one or more SOPs comprise a glucose oxidation product, a gluconic acid oxidation product, a gluconate, glucaric acid, an oxidized glucuronolactone, a uronic acid oxidation product or combinations thereof. In an example of such aspects, the one or more SOPs comprise a mixture of gluconic acid and glucaric acid and further comprise a minor component species comprising n-keto-acids, C_2-C_6 diacids or combinations thereof.

[0030] In an aspect, the one or more SOPs comprise glucodiamine, glucodialdose, 2-ketoglucose, glucaric acid, lactones of glucaric acid, gluconic acid, lactones of gluconic acid, galactonic acid, lactones of galactonic acid, galactaric acid, lactones of galactaric acid, glucoheptonic acid, lactones of glucoheptonic acid, or combinations thereof.

[0031] In an aspect, the one or more one or more SOPs suitable for use in the present disclosure comprise less than about 5 wt.% maltose, maltotriose, fructose, higher molecular weight polysaccharides, oxidation products thereof or a combination thereof based on the total weight of the sugar oxidation product. In one or more aspects, the one or more SOPs comprises aldonic acid, uronic acid, aldaric acid or combinations thereof.

[0032] In an aspect, the one or more SOPs comprise a mixture of gluconic acid and glucaric acid. In such aspects, the ratio of gluconic acid to glucaric acid may range from about 0.1:10 to about 10:0.1, alternatively about 0.15:10, or about 0.5:10, about 1:10, about 1:5, about 1:4, about 1:3, about 1:2, about 1:1, about 10:0.1, about 10:0.5, about 10:1, about 5:1, about 4:1, about 3:1, or about 2:1.

[0033] In one or more aspects, the PAD has the one or more SOPs present in an amount of about 0.1 weight percent (wt.%), or about 0.25 wt.%, or about 0.5 wt.%, or about 0.75 wt.%, or about 1 wt.%, or about 1.25 wt.%, or about 1.5 wt.%, or about 1.75 wt.%, or about 2 wt.%, or about 2.25 wt.%, or about 2.5 wt.%, or about 2.75 wt.%, or about 3 wt.%, or about 3.25 wt.%, or about 3.5 wt.%, or about 3.75 wt.%, or about 4 wt.%, or about 4.25 wt.%, or about 4.5 wt.%, or about 4.75 wt.%, or about 5 wt.%, or about 10 wt.%, or about 12.5 wt.%, or about 15 wt.%, or about 17.5 wt.%, or about 20 wt.%, or about 22.5 wt.%, or about 25 wt.%, or about 27.5 wt.%, or about 30 wt.%, or about 32.5 wt.%, or about 35 wt.%, or about 37.5 wt.%, or about 40 wt.%, or about 42.5 wt.%, or about 45 wt.%, or about 47.5 wt.%, or about 50 wt.%, or about 52.5 wt.%, or about 55

wt.%, or about 57.5 wt.%, or about 60 wt.%, or about 62.5 wt.%, or about 65 wt.%, or about 67.5 wt.%, or about 70 wt.%, or about 72.5 wt.%, or about 75 wt.%, or about 77.5 wt.%, or about 80 wt.%, or about 82.5 wt.%, or about 85 wt.%, or about 87.5 wt.%, or about 90 wt.%, or about 92.5 wt.%, or about 95 wt.%, or about 97.5 wt.%, or about 100 wt.%, or about 0.1 wt.% to about 100 wt.%, or about 1 wt.% to about 95 wt.%, or about 5 wt.% to about 90 wt.%, or about 10 wt.% to about 90 wt.%, or about 15 wt.% to about 85 wt.%, or about 20 wt.% to about 80 wt.%, or about 25 wt.% to about 75 wt.%, or about 40 wt.% to about 60 wt.%, or about 50 wt.%, or about 0.1 wt.% to about 10 wt.%, or about 1 wt.% to about 20 wt.%, or about 5 wt.% to about 50 wt.% based on the total weight of the PAD. In some aspects, the PAD has one or more SOPs present in an amount between any of the end points listed herein.

[0034] In aspects, any of the one or more SOPs or combination of one or more SOPs disclosed herein may further comprise a counter-cation such as a Group 1 alkali metal, a Group 2 alkaline earth metal, a Group 8 metal, Group 11 metal, Group 12 metal or a combination thereof. For example, the counter-cation may comprise silicates, borates, aluminum, calcium, magnesium, ammonium, sodium, potassium, cesium, strontium, zinc, copper, ferric iron or ferrous iron, or combinations thereof.

[0035] In an aspect, the PAD comprises a chelating agent. Herein a chelating agent refers to a compound able to form two or more separate coordinate bonds with a single central metal atom. Any suitable chelating agent may be present in the PAD in amounts effective to improve one or more performance characteristics of the PAD. Nonlimiting examples of chelating agents suitable for use in the present disclosure include gluconic acid, glucaric acid, galactonic acid, galactaric acid, glucoheptonic acid, trisodium phosphate, phosphonates, ethylenediaminetetraacetic acid (EDTA), nitrilotriacetic acid (NTA), methylglycinediacetic acid (MGDA), glutamic acid, N,N-diacetic acid (GLDA), ethylenediamine-N,N'-disuccinic acid (EDDS), diethylenetriaminepentaacetic acid (DTPA), hydroxyethylethylenediaminetriacetic acid (HEDTA), ethanoldiglycine (EDG), salts thereof or combinations thereof. In some aspects, the chelating agent comprises an SOP of the type disclosed herein. In some aspects, the chelating agent present in the PAD is different than the SOP present in the PAD.

[0036] In one or more aspects, the chelating agent is present in the PAD in amounts ranging from about 0.1 wt.% to about 20 wt.%, alternatively from about 1.0 wt.% to about 15 wt.%, alternatively from about 5 wt.% to about 10 wt.% or alternatively about 0.1

wt.%, about 0.5 wt.%, about 1 wt.%, about 1.5 wt.%, about 2 wt.%, about 2.5 wt.%, about 3 wt.%, about 3.5 wt.%, about 4 wt.%, about 4.5 wt.%, about 5 wt.%, about 5.5 wt.%, about 6 wt.%, about 6.5 wt.%, about 7 wt.%, about 7.5 wt.%, about 8 wt.%, about 8.5 wt.%, about 9 wt.%, about 9.5 wt.%, about 10 wt.%, about 10.5 wt.%, about 11 wt.%, about 11.5 wt.%, about 12 wt.%, about 12.5 wt.%, about 13 wt.%, about 13.5 wt.%, about 14 wt.%, about 14.5 wt.%, about 15 wt.%, about 15.5 wt.%, about 16 wt.%, about 16.5 wt.%, about 17 wt.%, about 17.5 wt.%, about 18 wt.%, about 18.5 wt.%, about 19 wt.%, about 19.5 wt.% or about 20 wt.% based on the total weight of the PAD. In some aspects, the PAD has a chelating agent present in an amount between any of the end points listed herein.

[0037] In one or more aspects, the PAD comprises a biobased additive which is characterized by equal to or greater than about 70% of the carbon atoms in the molecule originating from a renewable resource; additionally or alternatively equal to or greater than about 75%; additionally or alternatively equal to or greater than about 80%; additionally or alternatively equal to or greater than about 85%; additionally or alternatively equal to or greater than about 90%. Herein a renewable resource refers to a natural resource which will replenish to replace the portion depleted by usage and consumption, either through natural reproduction or other recurring processes in a finite amount of time on a human time scale. In one or more aspects, the renewable resource is a sugar. In one or more aspects, the renewable resource is glucose.

[0038] Nonlimiting examples of BBAs suitable for use in the PAD include glyoxal, glycine, glucodialdose, nitriles derived from glucose, oxime derived from glucose, salts thereof or combinations thereof.

[0039] In one or more aspects, the BBA is present in the PAD in amounts ranging from about 0.1 wt.% to about 20 wt.%, alternatively from about 1.0 wt.% to about 15 wt.%, alternatively from about 5 wt.% to about 10 wt.% or alternatively about 0.1 wt.%, about 0.5 wt.%, about 1 wt.%, about 1.5 wt.%, about 2 wt.%, about 2.5 wt.%, about 3 wt.%, about 3.5 wt.%, about 4 wt.%, about 4.5 wt.%, about 5 wt.%, about 5.5 wt.%, about 6 wt.%, about 6.5 wt.%, about 7 wt.%, about 7.5 wt.%, about 8 wt.%, about 8.5 wt.%, about 9 wt.%, about 9.5 wt.%, about 10 wt.%, about 10.5 wt.%, about 11 wt.%, about 11.5 wt.%, about 12 wt.%, about 12.5 wt.%, about 13 wt.%, about 13.5 wt.%, about 14 wt.%, about 14.5 wt.%, about 15 wt.%, about 15.5 wt.%, about 16 wt.%, about 16.5 wt.%, about 17 wt.%, about 17.5 wt.%, about 18 wt.%, about 18.5 wt.%, about 19 wt.%,

about 19.5 wt.% or about 20 wt.% based on the total weight of the PAD. In some aspects, the PAD has a chelating agent present in an amount between any of the end points listed herein.

[0040] In one or more aspects, the PAD further comprises an enhancing agent selected from the group consisting of carboxylates, sugar alcohols, and acids. Nonlimiting examples of carboxylates, sugar alcohols, and acids include ethanoic acid, sulfamic acid, sulfonic acid, propanoic acid, benzoic acid, acrylic acid, lactic acid, pyruvic acid, butyric acid, succinic acid, fumaric acid, malic acid, citric acid, acetic acid, mucic acid, sorbitol, mannitol, and combinations thereof. Herein an enhancing agent may function to facilitate the separation of one or more impurities found in the produced water-hydrocarbon mixture.

[0041] In one or more aspects, the enhancing agent is present in the PAD in amounts ranging from about 0.1 wt.% to about 20 wt.%, alternatively from about 1.0 wt.% to about 15 wt.%, alternatively from about 5 wt.% to about 10 wt.% or alternatively about 0.1 wt.%, about 0.5 wt.%, about 1 wt.%, about 1.5 wt.%, about 2 wt.%, about 2.5 wt.%, about 3 wt.%, about 3.5 wt.%, about 4 wt.%, about 4.5 wt.%, about 5 wt.%, about 5.5 wt.%, about 6 wt.%, about 6.5 wt.%, about 7 wt.%, about 7.5 wt.%, about 8 wt.%, about 8.5 wt.%, about 9 wt.%, about 9.5 wt.%, about 10 wt.%, about 10.5 wt.%, about 11 wt.%, about 11.5 wt.%, about 12 wt.%, about 12.5 wt.%, about 13 wt.%, about 13.5 wt.%, about 14 wt.%, about 14.5 wt.%, about 15 wt.%, about 15.5 wt.%, about 16 wt.%, about 16.5 wt.%, about 17 wt.%, about 17.5 wt.%, about 18 wt.%, about 18.5 wt.%, about 19 wt.%, about 19.5 wt.% or about 20 wt.% based on the total weight of the PAD. In some aspects, the PAD has an enhancing agent present in an amount between any of the end points listed herein.

[0042] In one or more aspects, the PAD further comprises one or more optional additives as needed to achieve some user and/or process goal. Nonlimiting examples of additives suitable for use in the PAD include a defoamer, an acid, a base, a salt, a corrosion inhibitor, a mutual solvent, a conventional breaking agent, a relative permeability modifier, lime, a flocculant, a water softener, a thinner, a scavenger, a gas scavenger, a surfactant, a biostatic agent, a storage stabilizer, a foaming agent, a foam stabilizer, emulsion breakers and the like, or combinations thereof. In one or more aspects, the PAD further comprises carbamates, carbamides, emulsion breakers, water clarifiers, coagulants, flocculants, quaternary ammonium compounds such as ADBAC,

DDAC, ammonium decyl ether sulfate, lauramine oxide, sodium alpha olefin sulfonates, laurl hydroxysultaines, betaines, dimethylamine oxides, diphenyl oxide sulfonates, alkanolamides, laureth sulfates, benzene sulfonic acids, alkyl benzene sulfonates, alpha olefin sulfonates, tall oil fatty acid quats, coco-quats and combinations thereof. In aspects, the additives are present singularly or in combination in amounts effective to achieve some user and/or process objective.

[0043] In one or more aspects, a PAD of the type disclosed herein is contacted with a NAA. Nonlimiting examples of aqueous fluids that may be a component of the NAA can include fresh water, surface water, ground water, produced water, sea water, salt water, brine, or combinations thereof. In some aspects, the nonaqueous fluid is a component of the mixture or is a nonaqueous phase of a solution having multiple phases. In some aspects, the nonaqueous fluid includes, but is not limited to: crude oil, refined oil products, fuels such as gasoline, diesel, kerosene, heating oil, fuel oils, olefins, alkanes, paraffins, alkenes, aromatics such as BTX, alcohols such as ethanol, bio-based oils such as vegetable oil, which include soybean, rapeseed, canola, safflower, sunflower, nut oils, palm oil, citrus oils, oil-based muds, and synthetic muds. In some aspects, the NAA comprises hydrocarbons or oleaginous fluids. Additionally or alternatively, the NAA comprises mixtures of hydrocarbons or oleaginous and aqueous solvents such as produced water, fresh water and wastewater (industrial, municipal, storm water sources). Contacting of the PAD with the NAA may be carried out using any suitable methodology.

[0044] In one or more aspects, a quantity of aqueous fluid (e.g., distilled water) may be contacted with the NAA prior to or subsequent to addition of a PAD. The NAA with the added quantity of aqueous fluid may be agitated (e.g., stirred, mixed) to improve transfer of ionic impurities to the aqueous fluid and facilitate removal of the impurities. The quantity of water contacted with the NAA will depend on a variety of factors such as the impurity level of the NAA and the amount of NAA and may be determined by one or ordinary skill in the art.

[0045] In one or more aspects, contacting of the PAD with the NAA may comprise mixing the PAD and NAA, with or without added aqueous fluid, using mixing equipment (e.g., a jet mixer, re-circulating mixer, a batch mixer, a blender, a mixing head of a solid feeding system) and then allowing the mixture to separate. Any container(s) that is

compatible with the components and has sufficient space can be used for mixing may be used.

[0046] In one or more aspects, mixing of the PAD and NAA can be on-the-fly (e.g., in real time or on-location). In some aspects, the mixing equipment may be disposed on one or more trucks as will be apparent to those of ordinary skill in the art.

[0047] Without wishing to be limited by theory, the PAD may facilitate the removal of cations from the NAA and consequently the amount of undesirable materials present in the nonaqueous fluid component of the NAA. The undesirable materials can be removed into the aqueous phase for separation from the nonaqueous fluid component of the NAA. In one or more aspects, the PAD facilitates the removal of metals from the NAA.

[0048] In one or more aspects, a PAD of the present disclosure is utilized in the purification of one or more hydrocarbons having an aqueous component. For example, the PAD may be contacted with a hydrocarbon obtained from a wellbore that contains some amount of nonaqueous fluid having an aqueous component (i.e., NAA) and some amount of impurities. For example and with reference to Figure 1, a method for reducing impurities in an unprocessed hydrocarbon 100 is schematically depicted. In some aspects, an unprocessed hydrocarbon 110 may be suitable for use in some applications and communicated via conduit 155 to a sales pipeline. In another aspect, the unprocessed hydrocarbon 110 is conveyed via conduit 115 to a processing tank 140 which is fluidly communicated via conduit 118 with a container 130 having a PAD disposed therein. The processing tank 140 may have the means to mix the unprocessed hydrocarbon 110 and PAD (e.g., a static or active mixer, etc.) and allow the water to separate from the unprocessed hydrocarbon. While shown as being combined in the processing tank 140, the PAD can also be combined with the unprocessed hydrocarbon 110 upstream of the processing tank 140 to mix prior to entering the processing tank 140. In some aspects, separated water can be conveyed via conduit 145 to any suitable process such as a storage tank, salt water disposal (SWD) system or recycling while the low water oil and low BS&W is conveyed via conduit 165 to a sales pipeline. It is to be understood that any hydrocarbon conveyed to the sales pipeline may be used without further processing or may be subjected to any number of additional processes to meet one or more user and/or process goals.

[0049] In one or more other aspects and with reference to Figure 2, a method for reducing impurities in an unprocessed hydrocarbon 200 is schematically depicted. In some aspects, an unprocessed hydrocarbon 210 may be suitable for use in some applications and fluidly communicated via conduit 265 to a sales pipeline. In another aspect, the unprocessed hydrocarbon 210 is conveyed via conduit 215 to a processing tank 220, which is in fluid communication via conduit 219 with a container 240 having a PAD disposed therein. The processing tank 220 may have the means to mix the unprocessed hydrocarbon 210 and PAD 240 and allow the water to separate from the unprocessed hydrocarbon 210. While shown as being combined in the processing tank 220, the PAD can also be combined with the unprocessed hydrocarbon 210 upstream of the processing tank 220 to mix prior to entering the processing tank 220. In some aspects, the water-hydrocarbon mixture is conveyed via conduit 218 to an electro-demulsification process such as an electrocoagulation unit 230 via conduit 218, which aids in coalescing any water to help remove water dispersed within the oil.

[0050] Electrocoagulation (EC) is an oil removal technology where metal ions (e.g., Fe, Al) are dissociated by applying an electric current, which hydrolyzes, hydroxy-metal species, and causes flocs to develop that remove pollutants from the wastewater. In an aqueous medium, when an electric current is applied, metallic ions are produced at the anode and hydrogen gas at the cathode. The produced hydrogen gas creates slight turbulence in the reactor and interacts with the pollutants. Hydrogen gas bubbles bond with pollutants and reduce their relative specific gravity. EC may result in the removal of natural organic matter, arsenic, hardness , phosphate and fluoride. Water may exit the EC 230 via conduit 225 to any suitable process such as a storage tank, salt water disposal (SWD) system or recycling while the low water oil and low BS&W is conveyed via conduit 265 to a sales pipeline.

[0051] In one or more other aspects and with reference to Figure 3, a method for reducing impurities in an unprocessed hydrocarbon 300 is schematically depicted. In some aspects, an unprocessed hydrocarbon 310 may be suitable for use in some applications and fluidly communicated via conduit 375 to a sales pipeline. In another aspect, the unprocessed hydrocarbon 310, or a portion thereof, can be conveyed via conduit 315 to a processing tank 320, which is in fluid communication via conduit 318 with a container 340 having a PAD disposed therein. The processing tank 320 may have the means to mix the unprocessed hydrocarbon 310 and PAD and allow the water to

separate from the unprocessed hydrocarbon 310. While shown as being combined in the processing tank 320, the PAD can also be combined with the unprocessed hydrocarbon 310 upstream of the processing tank 320 to mix prior to entering the processing tank 320. In some aspects, the water-hydrocarbon mixture is conveyed via conduit 316 to an EC unit 330 which removes water dispersed within the oil. The oil may be conveyed via conduit 332 from the EC 330 to the sales pipeline. Water and sludge may exit the EC 330 via conduit 335 and be conveyed to a sludge recovery unit 350 which separates the mixture into water which is conveyed via conduit 355, sludge via conduit 365 and low water oil via conduit 345 to any suitable process such as a storage tank, salt water disposal (SWD) system, or recycling.

[0052] In one or more other aspects and with reference to Figure 4, a method for reducing impurities in an unprocessed hydrocarbon 400 is schematically depicted. In some aspects, the oil in water mixture 410 is obtained from a salt water disposal facility may be suitable for use in some applications and fluidly communicated via a conduit to a sales pipeline. In another aspect, the unprocessed hydrocarbon 410 is conveyed via conduit 415 to a processing tank 420 which is in fluid communication via conduit 445 with a container 430 having a PAD disposed therein. The processing tank 420 may have the means to mix the unprocessed hydrocarbon 410 and PAD and allow the water to separate from the unprocessed hydrocarbon 410. While shown as being combined in the processing tank 420, the PAD can also be combined with the unprocessed hydrocarbon 410 upstream of the processing tank 420 to mix prior to entering the processing tank 420. In some aspects, the water-hydrocarbon mixture can optionally be processed in an EC unit as described herein to remove water dispersed within the oil. The oil may be conveyed via conduit 425 to a sales pipeline. Water may exit via conduit 435 and be conveyed to any suitable process such as salt water disposal (SWD) or recycling.

[0053] In one or more other aspects, and with reference to Figure 5, a method for reducing impurities in a water source having oil dispersed therein 500 is schematically depicted. In some aspects, the oil in water mixture 510 is conveyed via conduit 515 to a centrifuge 520 which is in fluid communication via conduit 525 with a container 530 having a PAD disposed therein. The centrifuge 520 may have the means to mix the oil in water mixture 510 and PAD and allow the water to separate from the oil in water mixture 510. While shown as being combined in the centrifuge 520, the PAD can also

be combined with the oil in water mixture 510 upstream of the centrifuge 520 to mix prior to entering the centrifuge 520. This may allow for some separation to occur prior to entering the centrifuge 520. The centrifuge 520 can be an active centrifuge or a static centrifuge that uses centrifugal force to separate the oil and water having different densities. In some aspects, water may exit the centrifuge 520 via conduit 535 and low water oil via conduit 545 to any suitable process such as recovery or recycling

[0054] In one or more other aspects, and with reference to Figure 6, a method for reducing impurities in a water source having oil dispersed therein, for example a trucked oil in water mixture, 600 is schematically depicted. In some aspects, the oil in water mixture 610 is in fluid communication via conduit 615 with a container 620 having a PAD disposed therein. In some aspects, the PAD is contacted with the oil in water mixture 610 and subsequently conveyed to a SWD facility 630 via conduit 625. Within the SWD facility 630 the mixture of PAD and oil in water mixture may be separated and water may exit the SWD via conduit 645 and low water oil via conduit 635 to any suitable process such as recovery or recycling.

[0055] Disclosed herein is a method of reducing impurities in a mixture comprising nonaqueous fluid having an aqueous component comprising contacting the mixture with a purification additive comprising ii) a chelating agent, (iii) a biobased additive, and (iv) an enhancing agent to form a treated mixture. The method may further comprise allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase. The method may further comprise separating the at least one aqueous phase from the at least one nonaqueous phase; and recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both.

[0056] Nonlimiting examples of metals that may be removed by the treating the NAA with a PAD as disclosed herein include aluminum, vanadium, cobalt, copper, calcium, magnesium, and/or iron.

[0057] In one or more aspects, a nonaqueous fluid comprising an aqueous component when treated as disclosed herein, has a reduction in cationic metal content of from about 10% to about 50% when compared to the reduction in cationic metal achieved in the absence of a PAD, additionally or alternatively from about 20% to about 50%, additionally or alternatively from about 30% to about 50%, additionally or alternatively about 10%, about 11%, about 12%, about 13%, about 14%, about 15%, about 16%, about 17%, about 18%, about 19%, about 20%, about 21%, about 22%, about 23%,

about 24%, about 25%, about 26%, about 27%, about 28%, about 29%, about 30%, about 31%, about 32%, about 33%, about 34%, about 35%, about 36%, about 37%, about 38%, about 39%, about 40%, about 41%, about 42%, about 43%, about 44%, about 45%, about 46%, about 47%, about 48%, about 49%, or about 50%.

[0058] Nonaqueous fluid (e.g., oil) having water content dispersed therein subsequent to contacting with a PAD results in removal of water in the amounts disclosed herein, This treated fluid is referred to as low water oil.

[0059] In one or more aspects, a nonaqueous fluid comprising an aqueous component when treated as disclosed herein, has a reduction in the amount of aqueous component of from about 10% to about 50% when compared to the reduction in the amount of aqueous component achieved in the absence of a PAD, additionally or alternatively from about 20% to about 50%, additionally or alternatively from about 30% to about 50%, additionally or alternatively about 10%, about 11%, about 12%, about 13%, about 14%, about 15%, about 16%, about 17%, about 18%, about 19%, about 20%, about 21%, about 22%, about 23%, about 24%, about 25%, about 26%, about 27%, about 28%, about 29%, about 30%, about 31%, about 32%, about 33%, about 34%, about 35%, about 36%, about 37%, about 38%, about 39%, about 40%, about 41%, about 42%, about 43%, about 44%, about 45%, about 46%, about 47%, about 48%, about 49%, or about 50%.

[0060] In one or more aspects, a mixture comprises a nonaqueous fluid and an aqueous component when treated as disclosed herein, with a PAD of the type disclosed herein, advantageously allows for the recovery of an increased amount of purified hydrocarbons from the mixture; for example an increased recovery of from about 10% to about 50%, additionally or alternatively from about 20% to about 50%, additionally or alternatively from about 30% to about 50%, additionally or alternatively about 10%, about 11%, about 12%, about 13%, about 14%, about 15%, about 16%, about 17%, about 18%, about 19%, about 20%, about 21%, about 22%, about 23%, about 24%, about 25%, about 26%, about 27%, about 28%, about 29%, about 30%, about 31%, about 32%, about 33%, about 34%, about 35%, about 36%, about 37%, about 38%, about 39%, about 40%, about 41%, about 42%, about 43%, about 44%, about 45%, about 46%, about 47%, about 48%, about 49%, or about 50% when compared to conventional methods of hydrocarbon fluid purification. In one or more aspects, a PAD of the present disclosure is contacted with a nonaqueous fluid as part of an oil reclamation process.

ADDITIONAL DISCLOSURE

[0061] A first aspect which is a method of reducing impurities in a mixture of a nonaqueous fluid with an aqueous component comprising contacting the mixture with a purification additive comprising: (i) one or more sugar oxidation products, (ii) a chelating agent, (iii) a biobased additive (BBA), and (iv) an enhancing agent to form a treated mixture; allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase; separating the at least one aqueous phase from the at least one nonaqueous phase; and recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both.

[0062] A second aspect which is the method of the first aspect wherein the nonaqueous fluid comprises crude oil, refined oil, refined oil products, fuels, olefins, alkanes, paraffins, alkenes, aromatics, alcohols, bio-based oils citrus oils, oil-based mud, synthetic muds or combinations thereof.

[0063] A third aspect which is the method of any of the first through second aspects wherein the nonaqueous fluid comprises crude oil, refined oil, oil-based muds, synthetic muds or combinations thereof.

[0064] A fourth aspect which is the method of any of the first through third aspects wherein the aqueous fluid comprises fresh water, surface water, ground water, produced water, sea water, salt water, brine or combinations thereof.

[0065] A fifth aspect which is the method of any of the first through fourth aspects wherein the one or more sugar oxidation products comprise aldonic acid, uronic acid, aldaric acid, a gluconic acid oxidation product, a gluconate, glucaric acid, gluconic acid, glucuronic acid, glucose oxidation products, galactonic acid, galactaric acid, glutamic acid, a lactone of gluconic acid, a lactone of glucaric acid, a lactone of galactaric acid, a lactone of galactonic acid, glucodialdose, 2-ketoglucose, disaccharides, oxidized disaccharides, n-keto-acids, C2 to C6 diacids, salts thereof or combinations thereof.

[0066] A sixth aspect which is the method of any of the first through fifth aspects wherein the one or more sugar oxidation products comprise glucodiamine, glucodialdose, 2-ketoglucose, glucaric acid, lactones of glucaric acid, gluconic acid, lactones of gluconic acid, galactonic acid, lactones of galactonic acid, galactaric acid, lactones of galactaric acid, glucoheptonic acid, lactones of glucoheptonic acid, or combinations thereof.

[0067] A seventh aspect which is the method of any of the first through sixth aspects wherein the one or more sugar oxidation products comprise a mixture of gluconic acid and glucaric acid.

[0068] An eighth aspect which is the method of the seventh aspect wherein the ratio of gluconic acid:glucaric acid ranges from about 0.1:10 to about 10:0.1.

[0069] A ninth aspect which is the method of any of the first through eighth aspects wherein the one or more sugar oxidation products is present in an amount of from about 0.1 wt.% to about 100 wt.% based on the total weight of the purification additive.

[0070] A tenth aspect which is the method of any of the first through ninth aspects wherein the chelating agent comprises trisodium phosphate, phosphonates, ethylenediaminetetraacetic acid (EDTA), nitrilotriacetic acid (NTA), methylglycinediacetic acid (MGDA), glutamic acid, N,N-diacetic acid (GLDA), ethylenediamine-N,N'-disuccinic acid (EDDS), diethylenetriaminepentaacetic acid (DTPA), hydroxyethylethylenediaminetriacetic acid (HEDTA), ethanoldiglycine (EDG), salts thereof or combinations thereof.

[0071] An eleventh aspect which is the method of any of the first through tenth aspects wherein the chelating agent is present in an amount of from about 0.1 wt.% to about 20 wt.% based on the total weight of the purification additive.

[0072] A twelfth aspect which is the method of any of the first through eleventh aspects wherein the biobased additive has equal to or greater than about 70% of the carbon atoms in the molecule originating from a renewable resource.

[0073] A thirteenth aspect which is the method of any of the first through twelfth aspects wherein the biobased additive comprises glyoxal, glycine, glucodialdose, nitriles derived from glucose, oxime derived from glucose, salts thereof or combinations thereof.

[0074] A fourteenth aspect which is the method of any of the first through thirteenth aspects wherein the biobased additive is present in an amount of from about 0.1 wt.% to about 20 wt.% based on the total weight of the purification additive.

[0075] A fifteenth aspect which is the method of any of the first through fourteenth aspects wherein the enhancing agent comprises carboxylates, sugar alcohols, and acids include ethanoic acid, sulfamic acid, sulfonic acid, propanoic acid, benzoic acid, acrylic acid, lactic acid, pyruvic acid, butyric acid, succinic acid, fumaric acid, malic acid, citric acid, acetic acid, mucic acid, sorbitol, mannitol, or combinations thereof

[0076] A sixteenth aspect which is the method of any of the first through fifteenth aspects wherein the enhancing agent is present in an amount of from about 0.1 wt.% to about 20 wt.% based on the total weight of the purification additive.

[0077] A seventeenth aspect which is the method of the first through sixteenth aspects wherein there is a reduction in an amount of aqueous component of from about 10% to about 50% when compared to the reduction in the amount of aqueous component achieved in the absence of the process additive.

[0078] An eighteenth aspect which is a method of servicing an oil and gas field comprising a well penetrating a subterranean formation, the method comprising recovering a hydrocarbon resource from the well, wherein the hydrocarbon resource has an aqueous component contacting the hydrocarbon resource with a purification additive comprising (i) one or more sugar oxidation products, (ii) a chelating agent, and (iii) a biobased additive (BBA) to form a treated mixture; allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase; separating the at least one aqueous phase from the at least one nonaqueous phase; and

recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both.

[0079] A nineteenth aspect which is the method of the eighteenth aspect wherein the one or more sugar oxidation product comprise aldonic acid, uronic acid, aldaric acid, a gluconic acid oxidation product, a gluconate, glucaric acid, gluconic acid, glucuronic acid, glucose oxidation products, galactonic acid, galactaric acid, glutamic acid, a lactone of gluconic acid, a lactone of glucaric acid, a lactone of galactaric acid, a lactone of galactonic acid, glucodialdose, 2-ketoglucose, disaccharides, oxidized disaccharides, n-keto-acids, C_2 to C_6 diacids, salts thereof or combinations thereof.

[0080] A twentieth aspect which is the method of any of the eighteenth through nineteenth aspects wherein allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase comprises centrifugation, electrocoagulation or both.

[0081] A twenty-first aspect which is the method of any of the eighteenth through twentieth aspects wherein there is a reduction in an amount of the aqueous component of from about 10% to about 50% when compared to the reduction in the amount of aqueous component achieved in the absence of the purification additive.

[0082] The subject matter having been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of the subject matter. The aspects described herein are exemplary only and are not intended to be limiting. Many variations and modifications of the subject matter disclosed herein are possible and are within the scope of the disclosed subject matter. Where numerical ranges or limitations are expressly stated, such express ranges or limitations should be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations (e.g., from about 1 to about 10 includes, 2, 3, 4, etc.; greater than 0.10 includes 0.11, 0.12, 0.13, etc.). Use of the term "optionally" with respect to any element of a claim is intended to mean that the subject element is required, or alternatively, is not required. Both alternatives are intended to be within the scope of the claim. Use of broader terms such as comprises, includes, having, etc. should be understood to provide support for narrower terms such as consisting of, consisting essentially of, comprised substantially of, etc.

[0083] Accordingly, the scope of protection is not limited by the description set out above but is only limited by the claims which follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated into the specification as an aspect of the present disclosure. Thus, the claims are a further description and are an addition to the aspects of the present invention. The discussion of a reference herein is not an admission that it is prior art to the presently disclosed subject matter, especially any reference that may have a publication date after the priority date of this application. The disclosures of all patents, patent applications, and publications cited herein are hereby incorporated by reference, to the extent that they provide exemplary, procedural or other details supplementary to those set forth herein.

CLAIMS

What is claimed is:

1. A method of reducing impurities in a mixture of a nonaqueous fluid with an aqueous component comprising:

contacting the mixture with a purification additive comprising: (i) one or more sugar oxidation products, (ii) a chelating agent, (iii) a biobased additive (BBA), and (iv) an enhancing agent to form a treated mixture;

allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase;

separating the at least one aqueous phase from the at least one nonaqueous phase; and

recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both.

2. The method of claim 1, wherein the nonaqueous fluid comprises crude oil, refined oil, refined oil products, fuels, olefins, alkanes, paraffins, alkenes, aromatics, alcohols, bio-based oils citrus oils, oil-based mud, synthetic muds or combinations thereof.

3. The method of claim 1, wherein the nonaqueous fluid comprises crude oil, refined oil, oil-based muds, synthetic muds or combinations thereof.

4. The method of claim 1, wherein the aqueous fluid comprises fresh water, surface water, ground water, produced water, sea water, salt water, brine or combinations thereof.

5. The method of claim 1, wherein the one or more sugar oxidation products comprise aldonic acid, uronic acid, aldaric acid, a gluconic acid oxidation product, a gluconate, glucaric acid, gluconic acid, glucuronic acid, glucose oxidation products, galactonic acid, galactaric acid, glutamic acid, a lactone of gluconic acid, a lactone of glucaric acid, a lactone of galactaric acid, a lactone of galactonic acid, glucodialdose, 2-ketoglucose, disaccharides, oxidized disaccharides, n-keto-acids, C_2 to C_6 diacids, salts thereof or combinations thereof.

6. The method of claim 1, wherein the one or more sugar oxidation products comprise glucodiamine, glucodialdose, 2-ketoglucose, glucaric acid, lactones of glucaric acid, gluconic acid, lactones of gluconic acid, galactonic acid, lactones of galactonic acid, galactaric acid, lactones of galactaric acid, glucoheptonic acid, lactones of glucoheptonic acid, or combinations thereof.

7. The method of claim 1, wherein the one or more sugar oxidation products comprise a mixture of gluconic acid and glucaric acid.

8. The method of claim 7, wherein the ratio of gluconic acid:glucaric acid ranges from about 0.1:10 to about 10:0.1.

9. The method of claim 1, wherein the one or more sugar oxidation products is present in an amount of from about 0.1 wt.% to about 100 wt.% based on the total weight of the purification additive.

10. The method of claim 1, wherein the chelating agent comprises trisodium phosphate, phosphonates, ethylenediaminetetraacetic acid (EDTA), nitrilotriacetic acid (NTA), methylglycinediacetic acid (MGDA), glutamic acid, N,N-diacetic acid (GLDA), ethylenediamine-N,N'-disuccinic acid (EDDS), diethylenetriaminepentaacetic acid (DTPA), hydroxyethylethylenediaminetriacetic acid (HEDTA), ethanoldiglycine (EDG), salts thereof or combinations thereof.

11. The method of claim 1, wherein the chelating agent is present in an amount of from about 0.1 wt.% to about 20 wt.% based on the total weight of the purification additive.

12. The method of claim 1, wherein the biobased additive has equal to or greater than about 70% of the carbon atoms in the molecule originating from a renewable resource.

13. The method of claim 1, wherein the biobased additive comprises glyoxal, glycine, glucodialdose, nitriles derived from glucose, oxime derived from glucose, salts thereof or combinations thereof.

14. The method of claim 1, wherein the biobased additive is present in an amount of from about 0.1 wt.% to about 20 wt.% based on the total weight of the purification additive.

15. The method of claim 1, wherein the enhancing agent comprises carboxylates, sugar alcohols, and acids include ethanoic acid, sulfamic acid, sulfonic acid, propanoic acid, benzoic acid, acrylic acid, lactic acid, pyruvic acid, butyric acid, succinic acid, fumaric acid, malic acid, citric acid, acetic acid, mucic acid, sorbitol, mannitol, or combinations thereof

16. The method of claim 1, wherein the enhancing agent is present in an amount of from about 0.1 wt.% to about 20 wt.% based on the total weight of the purification additive.

17. The method of claim 1, wherein there is a reduction in an amount of aqueous component of from about 10% to about 50% when compared to the reduction in the amount of aqueous component achieved in the absence of the process additive.

18. A method of servicing an oil and gas field comprising a well penetrating a subterranean formation, the method comprising:

recovering a hydrocarbon resource from the well, wherein the hydrocarbon resource has an aqueous component;

contacting the hydrocarbon resource with a purification additive comprising (i) one or more sugar oxidation products, (ii) a chelating agent, and (iii) a biobased additive (BBA) to form a treated mixture;

allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase;

separating the at least one aqueous phase from the at least one nonaqueous phase; and

recovering at least a portion of the aqueous phase, at least a portion of the nonaqueous phase, or both.

19. The method of claim 18, wherein the one or more sugar oxidation product comprise aldonic acid, uronic acid, aldaric acid, a gluconic acid oxidation product, a gluconate, glucaric acid, gluconic acid, glucuronic acid, glucose oxidation products, galactonic acid, galactaric acid, glutamic acid, a lactone of gluconic acid, a lactone of glucaric acid, a lactone of galactaric acid, a lactone of galactonic acid, glucodialdose, 2-ketoglucose, disaccharides, oxidized disaccharides, n-keto-acids, C_2 to C_6 diacids, salts thereof or combinations thereof.

20. The method of claim 18, wherein allowing the treated mixture to form at least one aqueous phase and at least one nonaqueous phase comprises centrifugation, electrocoagulation or both.

21. The method of claim 18, wherein there is a reduction in an amount of the aqueous component of from about 10% to about 50% when compared to the reduction in the amount of aqueous component achieved in the absence of the purification additive.

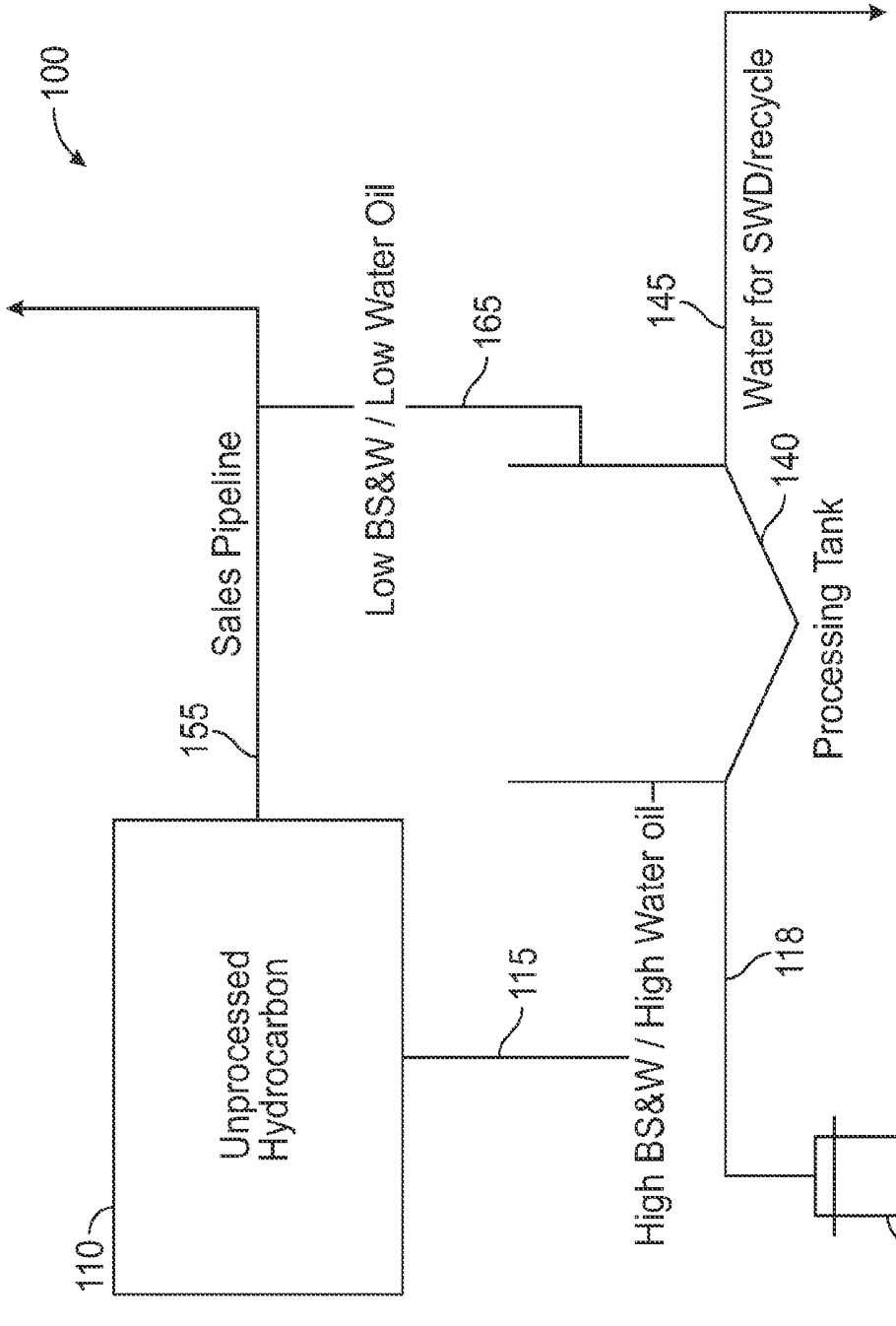
100
Sales Pipeline
155
Unprocessed Hydrocarbon
110
Low BS&W / Low Water Oil
165
High BS&W / High Water oil
115
Water for SWD/recycle
145
Processing Tank
140
118
PAD
130

FIG. 1

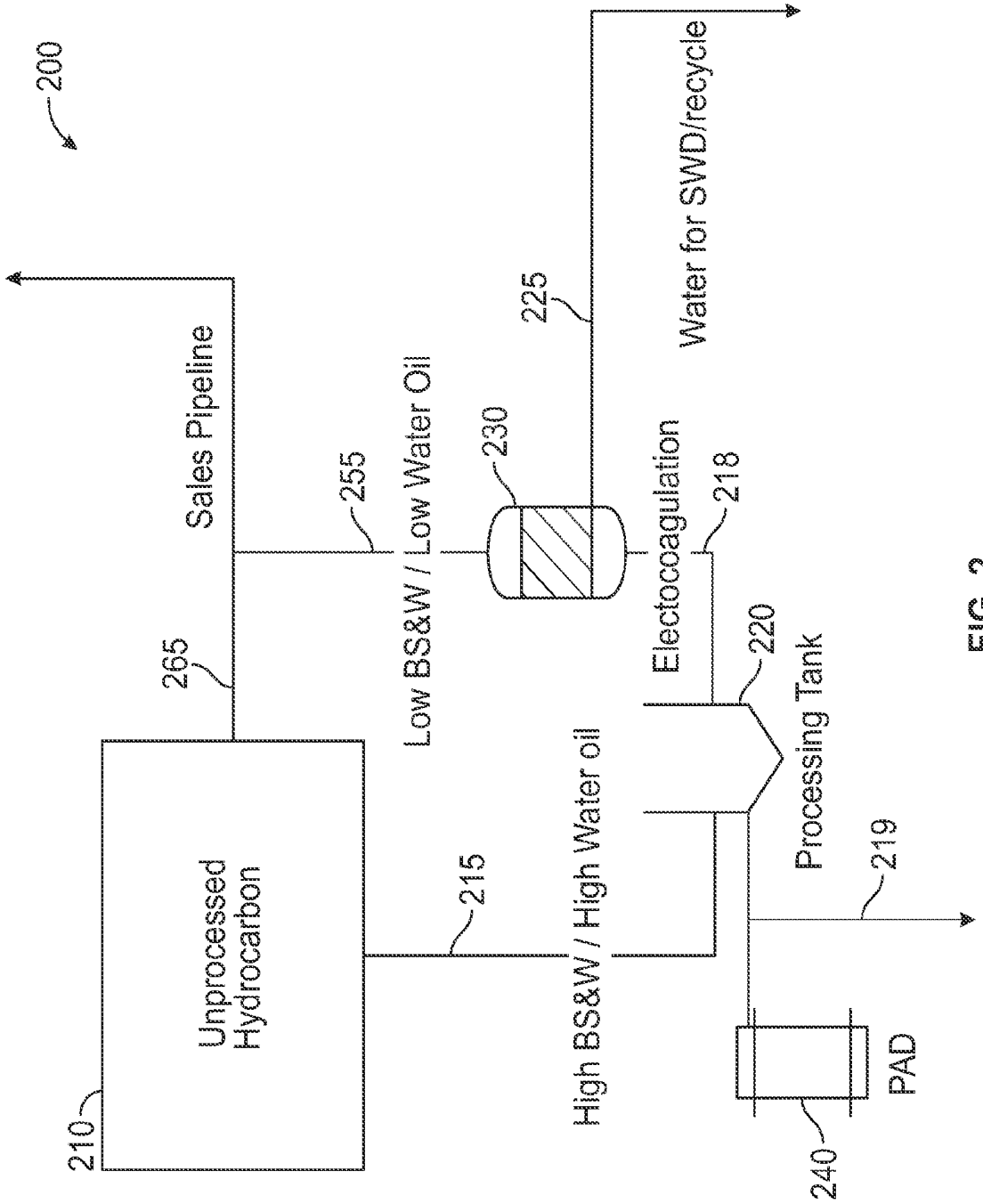
200
Sales Pipeline
Water for SWD/recycle
225
255
230
Low BS&W / Low Water Oil
Electocoagulation
218
265
220
Processing Tank
Unprocessed Hydrocarbon
215
High BS&W / High Water oil
219
PAD
210
240

FIG. 2

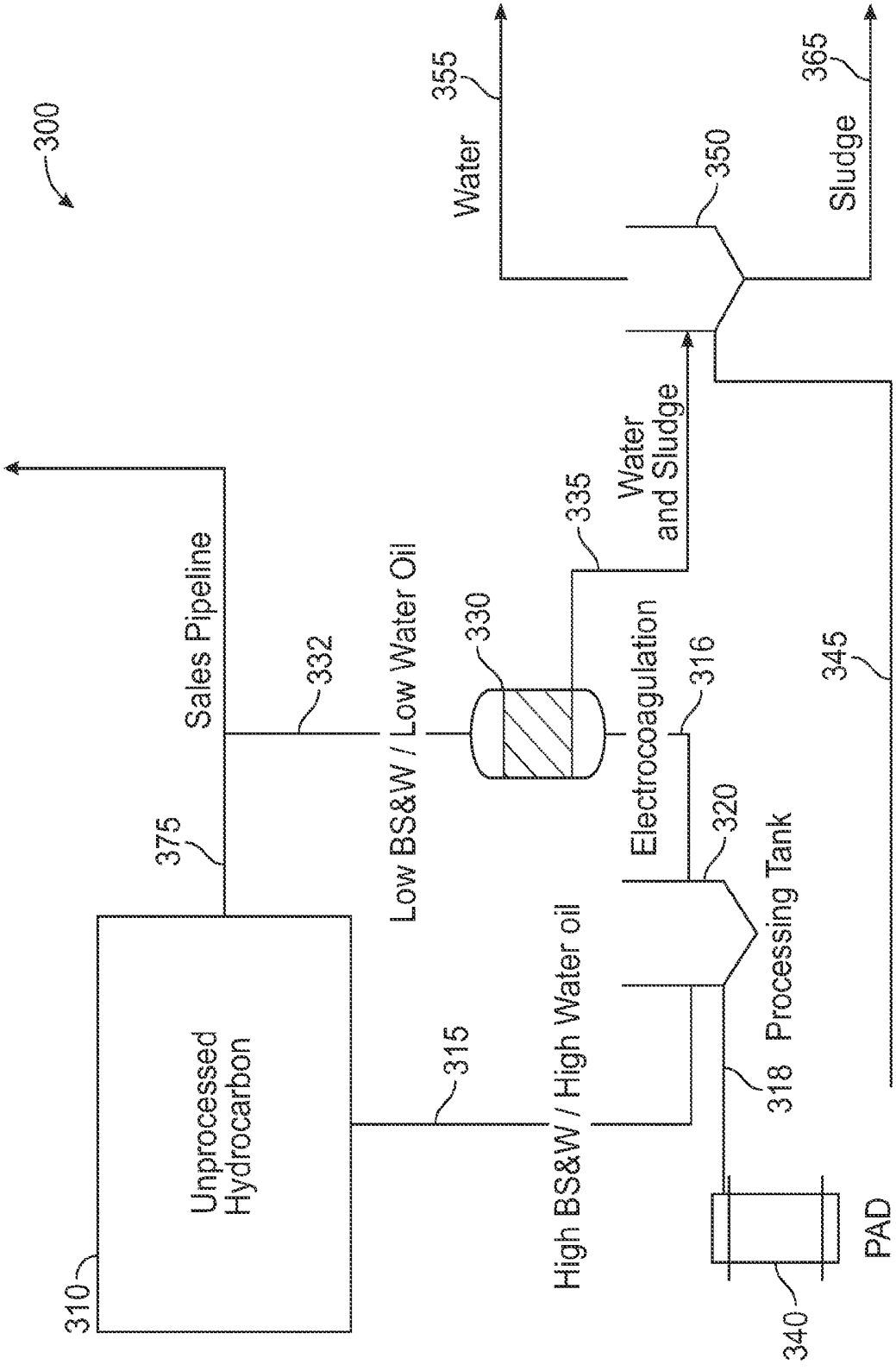
300
355
Water
365
Sludge
350
Water and Sludge
335
330
Low BS&W / Low Water Oil
332
Sales Pipeline
375
345
316
Electrocoagulation
320
Processing Tank
318
315
High BS&W / High Water oil
Unprocessed Hydrocarbon
310
PAD
340

FIG. 3

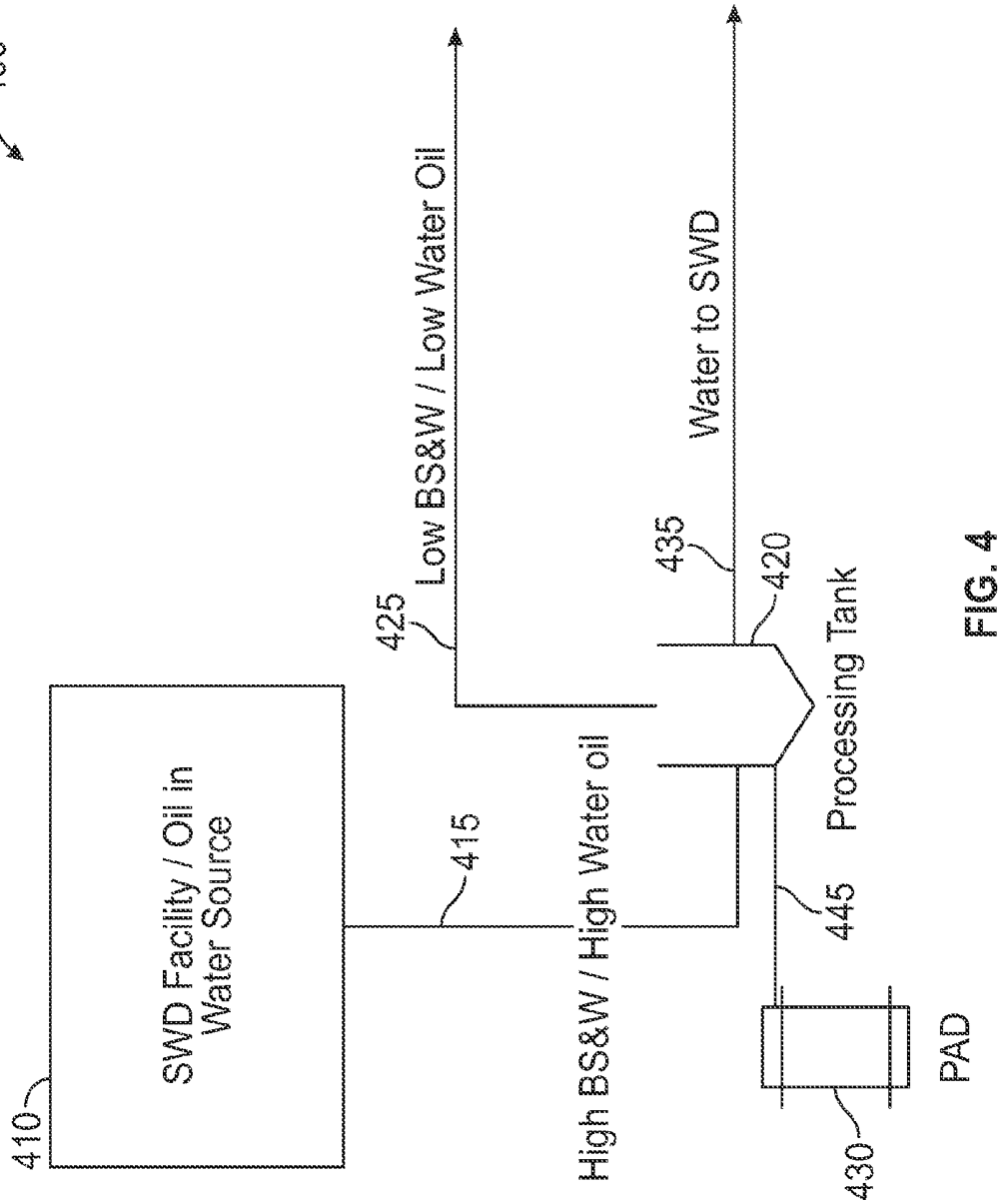
400
SWD Facility / Oil in Water Source
410
415
High BS&W / High Water oil
425
Low BS&W / Low Water Oil
435
Water to SWD
420
Processing Tank
445
PAD
430

FIG. 4

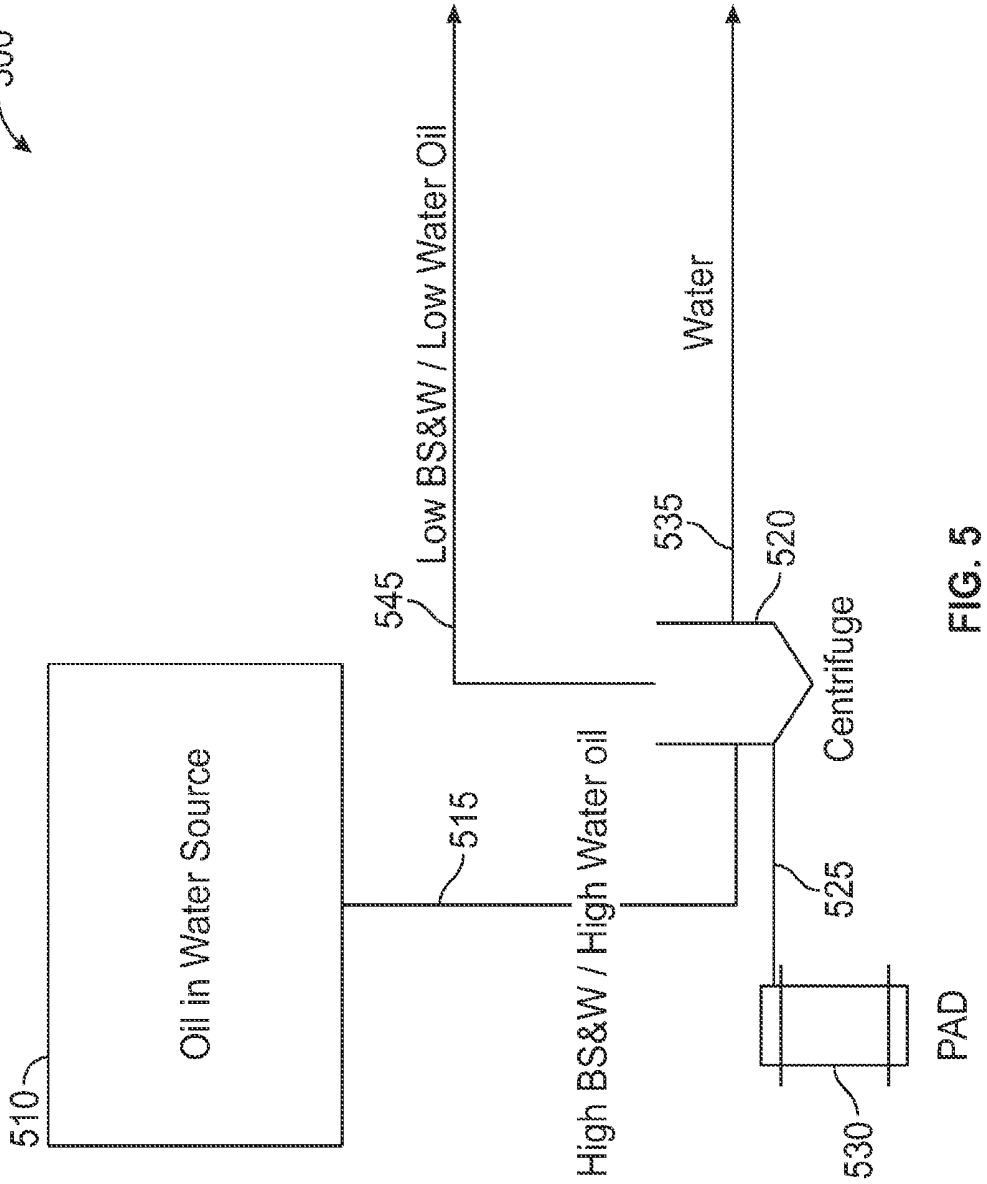
500
Oil in Water Source
510
515
High BS&W / High Water oil
Low BS&W / Low Water Oil
545
Water
535
520
Centrifuge
525
PAD
530

FIG. 5

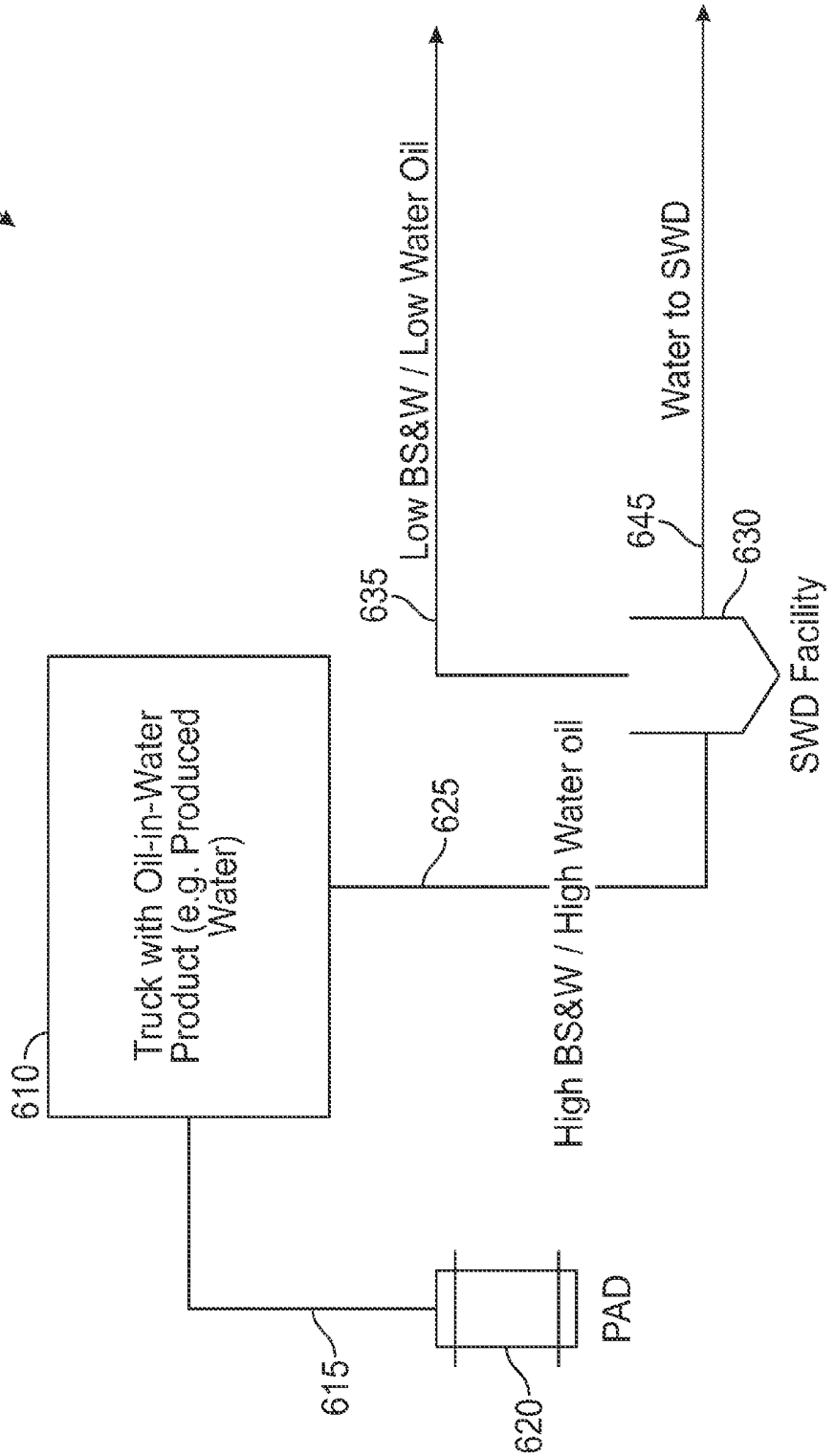
600
610
Truck with Oil-in-Water Product (e.g. Produced Water)
615
PAD
620
625
High BS&W / High Water oil
635
Low BS&W / Low Water Oil
645
Water to SWD
630
SWD Facility

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2025/031209

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***B01J 8/00*** (2025.01); *C10G 1/04* (2025.01)

CPC: ***B01J 8/005;*** *C10G 1/04*

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2022/261349 A1 (Solugen Inc.) 15 December 2022 (15.12.2022) Para [0002]; [0004]; [0020]; [0064]; [0065]; [0066]; [0067]; [0071]	1-21
Y	US 2023/0203930 A1 (Solugen Inc.) 29 June 2023 (29.06.2023) Para [0003]; [0009]; [0021]; [0026]; [0029]; [0033]; [0036]; [0037]	1-21
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☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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17 July 2025 (17.07.2025)	**05 August 2025 (05.08.2025)**

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