

CLAIMS

1. A method of determining fouling potential of a hydrocarbon composition comprising:
 - obtaining a sample of the hydrocarbon composition;
 - measuring at least a first portion or a second portion of the hydrocarbon sample, the first portion and the second portion having different chemical compositions, the first portion comprising a liquid and the second portion comprising organic or inorganic solids or gels.
2. The method according to claim 1, wherein the fouling potential is determined by measuring the concentration of the second portion in the hydrocarbon sample.
3. The method according to claim 2, wherein the measuring comprises microscopy, UV-vis spectroscopy, light scattering, or acoustic resonance.
4. The method according to claim 1, wherein determining the fouling potential comprises separating the hydrocarbon sample into the first portion and the second portion.
5. The method according to claim 4, wherein the separating of the hydrocarbon composition comprises filtration, electrophoresis, centrifugation, field-flow fractionation, cyclonic separation, gravimetric separation or a combination thereof.
6. The method according to claim 4 or claim 5, wherein the separation comprises heating.
7. The method according to any of claims 4-6, further comprising separating the second portion into at least a third portion and a fourth portion wherein the third portion comprises a composition soluble or dispersible in a solvent, and the fourth composition comprises a composition insoluble or undispersable in the solvent, and comparing the amount of the third portion and/or the fourth portion relative to the amount of the sample of hydrocarbon composition.
8. The method according to claim 7, wherein the second portion is separated into at least the third and the fourth portions with a solvent-based separation.

9. The method according to claim 8, wherein the second portion is separated at least into the third and the fourth portions by extraction with one or more polar or nonpolar solvents, dispersants, acids, bases, or combinations thereof.
10. The method according to claim 9, wherein the solvent comprises an aromatic hydrocarbon solvent.
11. The method according to claim 10, wherein the solvent comprises an aromatic hydrocarbon solvent selected from benzene, aromatic naphta, alkylbenzene, or a mixture thereof.
12. The method of claim 10, wherein the alkylbenzene comprises toluene, ethylbenzene, xylenes, or a mixture thereof.
13. The method according to any of claims 1-12, further comprising analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample.
14. The method according to claim 13, wherein analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample comprises fingerprinting, thermogravimetric analysis, and/or inductively coupled plasma mass spectrum analysis.
15. The method according to claim 13 or claim 14, wherein the hydrocarbon sample or at least one of the portions of the hydrocarbon sample is heated or thermally evaporated or subjected to vacuum evaporation during or prior to the analyzing.
16. The method according to claim 14 or 15, wherein the fingerprinting comprises using spectroscopy.
17. The method according to claim 16, wherein the spectroscopy comprises one or more of infrared spectroscopy, near-infrared spectroscopy, and nuclear magnetic resonance spectroscopy.
18. A method of reducing fouling potential in a hydrocarbon composition comprising:
- obtaining a sample of the hydrocarbon composition;
 - determining a fouling potential by measuring at least a first portion and a second portion of the hydrocarbon sample, the first portion and the second portion having different

chemical compositions, the first portion comprising a liquid and the second portion comprising organic or inorganic solids or gels; and

modifying the production, transportation, storage, processing, and/or distribution of the hydrocarbon composition to reduce fouling potential.

19. The method according to claim 18, wherein the fouling potential is determined by measuring the concentration of the second portion in the hydrocarbon sample.

20. The method according to claim 19, wherein the measuring comprises microscopy, UV-vis spectroscopy, light scattering, or acoustic resonance.

21. The method according to claim 18, wherein determining the fouling potential comprises separating the first portion and a second portion.

22. The method according to claim 21, wherein the separating of the hydrocarbon composition comprises filtration, electrophoresis, centrifugation, field-flow fractionation, cyclonic separation, gravimetric separation or a combination thereof.

23. The method according to claim 21 or claim 22, wherein the separation comprises heating.

24. The method according to any of claims 21-23, further comprising separating the second portion into at least a third portion and a fourth portion wherein the third portion comprises a composition soluble or dispersible in a solvent, and the fourth composition comprises a composition insoluble or undispersable in the solvent, and comparing the amount of the third portion and/or the fourth portion relative to the amount of the sample of hydrocarbon composition.

25. The method according to claim 24, wherein the second portion is separated into at least the third and the fourth portions with a solvent-based separation.

26. The method according to claim 25, wherein the second portion is separated at least into the third and the fourth portions by extraction with one or more polar or nonpolar solvents, dispersants, acids, bases, or combinations thereof.

27. The method according to claim 26, wherein the solvent comprises an aromatic hydrocarbon solvent.

28. The method according to claim 27, wherein the solvent comprises an aromatic hydrocarbon solvent selected from benzene, aromatic naphta, alkylbenzene, or a mixture thereof.

29. The method according to claim 28, wherein the alkylbenzene comprises toluene, ethylbenzene, xylenes, or a mixture thereof.

30. The method according to any of claims 18-29, further comprising analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample.

31. The method according to claim 30, wherein analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample comprises fingerprinting, thermogravimetric analysis, and/or inductively coupled plasma mass spectrum analysis.

32. The method according to claim 30 or claim 31, wherein the hydrocarbon sample or at least one of the portions of the hydrocarbon sample is heated or thermally evaporated or subjected to vacuum evaporation during or prior to the analyzing.

33. The method according to claim 31 or claim 32, wherein the fingerprinting comprises using spectroscopy.

34. The method according to claim 33, wherein the spectroscopy comprises one or more of infrared spectroscopy, near-infrared spectroscopy, and nuclear magnetic resonance spectroscopy.

35. The method according to any one of claims 18-34, wherein the production, transportation, storage, processing, and/or distribution of the hydrocarbon composition comprises combining the hydrocarbon composition with a chemical treatment comprising one or more wetting agents, emulsion breakers, detergents, dispersants, stabilizers, corrosion inhibitors, sulphide or metal-sulphide dissolvers, polymerization inhibitors, antioxidants and metal deactivators or combinations thereof.

36. The method according to any of claims 18-35, wherein the production, transportation, storage, processing, and/or distribution of the hydrocarbon composition comprises adding a chemical treatment to the crude in an incoming transport system or crude storage tanks, to a hydrocarbon storage tank farm that holds the crude oil entering the refining

process, to the water wash, to the de-salter, to a hot preheat train after desalting of the refining process, or combinations thereof.

37. A system for using predictive analytics in control of a hydrocarbon refining process comprising:

a memory, wherein the memory stores computer-readable instructions; and

a processor communicatively coupled with the memory, wherein the processor executes the computer-readable instructions stored on the memory, the computer-readable instructions causing the processor to:

receive an analysis of a hydrocarbon sample,

develop one or more predictive models of the hydrocarbon refining process for the hydrocarbon entering the refining process based on the analysis of the crude oil; and

control aspects of the hydrocarbon refining process as the hydrocarbon entering the refining process moves through the refining process based on the one or more predictive models,

wherein the analysis is obtained by the following steps:

obtaining a sample of the hydrocarbon composition;

determining a fouling potential by measuring at least a first portion or a second portion of the hydrocarbon sample, the first portion and the second portion having different chemical compositions, the first portion comprising a liquid and the second portion comprising organic or inorganic solids or gels.

38. The system according to claim 37, wherein the fouling potential is determined by measuring the concentration of the second portion in the hydrocarbon sample.

39. The system according to claim 38, wherein the measuring comprises microscopy, UV-vis spectroscopy, light scattering, or acoustic resonance.

40. The system according to claim 37, wherein determining the fouling potential comprises separating the first portion and a second portion.

41. The system according to claim 40, wherein the separating of the hydrocarbon composition comprises filtration, electrophoresis, centrifugation, field-flow fractionation, cyclonic separation, gravimetric separation or a combination thereof.
42. The system according to claim 40 or claim 41, wherein the separation comprises heating.
43. The system according to any of claims 40-42, further comprising separating the second portion into at least a third portion and a fourth portion wherein the third portion comprises a composition soluble or dispersible in a solvent, and the fourth composition comprises a composition insoluble or undispersable in the solvent, and comparing the amount of the third portion and/or the fourth portion relative to the amount of the sample of hydrocarbon composition.
44. The system according to claim 43, wherein the second portion is separated into at least the third and the fourth portions with a solvent-based separation.
45. The system according to claim 44, wherein the second portion is separated at least into the third and the fourth portions by extraction with one or more polar or nonpolar solvents, dispersants, acids, bases, or combinations thereof.
46. The system according to claim 45, wherein the solvent comprises an aromatic hydrocarbon solvent.
47. The system according to claim 46, wherein the solvent comprises an aromatic hydrocarbon solvent selected from benzene, aromatic naphta, alkylbenzene, or a mixture thereof.
48. The system according to claim 47, wherein the alkylbenzene comprises toluene, ethylbenzene, xylenes, or a mixture thereof.
49. The system according to any of claims 37-48, further comprising analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample.
50. The system according to claim 49, wherein analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample comprises fingerprinting, thermogravimetric analysis, and/or inductively coupled plasma mass spectrum analysis.

51. The system according to claim 49 or claim 50, wherein the hydrocarbon sample or at least one of the portions of the hydrocarbon sample is heated or thermally evaporated or subjected to vacuum evaporation during or prior to the analyzing.

52. The system according to claim 50 or 51, wherein the fingerprinting comprises using spectroscopy.

53. The system according to claim 52, wherein the spectroscopy comprises one or more of infrared spectroscopy, near-infrared spectroscopy, and nuclear magnetic resonance spectroscopy.

54. The system according to any of claims 37-53, wherein developing one or more predictive models of the hydrocarbon refining process for the hydrocarbon entering the refining process based on the analysis of the hydrocarbon sample comprises developing one or more predictive models based on the analysis that estimate or predict one or more of density, viscosity, total acid number (TAN), percent saturates, percent asphaltenes, percent resins, percent aromatics, asphaltene stability, crude stabilizer (CS) dosage demand, emulsion stability and demulsifier (EB) dosage demand, fouling potential and antifoulant (AF) dosage demand, and corrosion related performance and corrosion inhibitor dosage demand during the hydrocarbon refining process.

55. A non-transitory, computer-readable medium storing instructions that, when executed by a computer processor, cause the computer processor to perform a method useful in a crude oil refinement process, the method comprising:

receive an analysis of a hydrocarbon sample, wherein the hydrocarbon sample is representative of an amount of hydrocarbon entering a refining process, wherein the analysis is obtained by the following steps:

obtaining a sample of the hydrocarbon composition;

determining a fouling potential by measuring at least a first portion or a second portion of the hydrocarbon sample, the first portion and the second portion having different chemical compositions, the first portion comprising a liquid and the second portion comprising organic or inorganic solids or gels;

develop one or more predictive models of the hydrocarbon refining process for the hydrocarbon entering the refining process based on the analysis of the hydrocarbon sample; and

dynamically control aspects of the hydrocarbon refining process as the hydrocarbon entering the refining process moves through the refining process based on the one or more predictive models.

56. A method of obtaining hydrocarbon composition with reduced fouling potential comprising:

obtaining a sample of two or more different hydrocarbon compositions, and for each sample,

determining a fouling potential by measuring at least a first portion or a second portion of the hydrocarbon sample, the first portion and the second portion having different chemical compositions, the first portion comprising a liquid and the second portion comprising organic or inorganic solids or gels; and

blending the two or more hydrocarbons in a ratio based on their individual fouling potentials or the fouling potential of the resulted blend to give a blended hydrocarbon composition with reduced fouling potential.

57. The method according to claim 56, wherein the fouling potential is determined by measuring the concentration of the second portion in the hydrocarbon sample.

58. The method according to claim 56, wherein the measuring comprises microscopy, UV-vis spectroscopy, light scattering, or acoustic resonance.

59. The method according to claim 56, wherein determining the fouling potential comprises separating the first portion and a second portion.

60. The method according to claim 59, wherein the separating of the hydrocarbon composition comprises filtration, electrophoresis, centrifugation, field-flow fractionation, cyclonic separation, gravimetric separation or a combination thereof.

61. The method according to claim 59 or claim 60, wherein the separation comprises heating.

62. The method according to any of claims 59-61, further comprising separating the second portion into at least a third portion and a fourth portion wherein the third portion comprises a composition soluble or dispersible in a solvent, and the fourth composition comprises a composition insoluble or undispersable in the solvent, and comparing the amount of the third portion and/or the fourth portion relative to the amount of the sample of hydrocarbon composition.

63. The method according to claim 62, wherein the second portion is separated into at least the third and the fourth portions with a solvent-based separation.

64. The method according to claim 63, wherein the second portion is separated at least into the third and the fourth portions by extraction with one or more polar or nonpolar solvents, dispersants, acids, bases, or combinations thereof.

65. The method according to claim 64, wherein the solvent comprises an aromatic hydrocarbon solvent.

66. The method according to claim 65, wherein the solvent comprises an aromatic hydrocarbon solvent selected from benzene, aromatic naphtha, alkylbenzene, or a mixture thereof.

67. The method according to claim 66, wherein the alkylbenzene comprises toluene, ethylbenzene, xylenes, or a mixture thereof.

68. The method according to any of claims 56-67, further comprising analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample.

69. The method according to claim 68, wherein analyzing the hydrocarbon sample or at least one of the portions of the hydrocarbon sample comprises fingerprinting, thermogravimetric analysis, and/or inductively coupled plasma mass spectrum analysis.

70. The method according to claim 68 or claim 69, wherein the hydrocarbon sample or at least one of the portions of the hydrocarbon sample is heated or thermally evaporated or subjected to vacuum evaporation during or prior to the analyzing.

71. The method according to claim 69 or 70, wherein the fingerprinting comprises using spectroscopy.

72. The method according to claim 71, wherein the spectroscopy comprises one or more of infrared spectroscopy, near-infrared spectroscopy, and nuclear magnetic resonance spectroscopy.

73. The method according to any claims 56-68, further comprising modifying the production, transportation, storage, processing, and/or distribution of a least one hydrocarbon composition to reduce fouling potential.

74. The method according to claim 73, wherein the production, transportation, storage, processing, and/or distribution of the hydrocarbon composition comprises combining the hydrocarbon composition with a chemical treatment comprising one or more wetting agents, emulsion breakers, detergents, dispersants, stabilizers, corrosion inhibitors, sulphide or metal-sulphide dissolvers, polymerization inhibitors, antioxidants and metal deactivators or combinations thereof.

75. The method according to claim 74, wherein the production, transportation, storage, processing, and/or distribution of the hydrocarbon composition comprises adding a chemical treatment to the crude in an incoming transport system or crude storage tanks, to a hydrocarbon storage tank farm that holds the crude oil entering the refining process, to the water wash, to the de-salter, to a hot preheat train after desalting of the refining process, or combinations thereof.