[006] There is still a need for improved methods for trace elements, e.g., mercury, extraction from hydrocarbons such as crude oil, wherein the heavy metals form water soluble metal complexes for subsequent removal from the crude oil by phase separation.

SUMMARY OF THE DISCLOSURE~~INVENTION~~

[007] In one aspect, a method to reduce mercury in a crude oil is provided. The method comprises converting at least a portion of mercury in the crude oil to mercuric iodide in an oil-water emulsion upon contact with a molecular iodine source; and separating the water containing the soluble mercuric iodide from the crude oil for a treated crude oil having a reduced concentration of mercury.

[008] In another aspect, the disclosure~~invention~~ relates to a method to reduce or remove trace elements of heavy metals such as mercury from a crude oil. The method comprises converting at least a portion of mercury in the crude oil to mercuric iodide in an oil-water emulsion upon contact with an iodine source, wherein molecular iodine is generated in-situ in an oxidation-reduction reaction between an iodine species having a negative charge and an oxidizing reagent; and separating the water containing the soluble mercuric iodide from the crude oil for a treated crude oil having a reduced concentration of mercury.

[009] In yet another aspect, the molecular iodine is generated in-situ in an oxidation-reduction reaction between an iodine species having a positive charge and a reducing reagent. In this method, a complexing agent is further added to the crude oil to form a water-soluble heavy metal compound, for the water containing the soluble heavy metal compound to be subsequently separated from the crude oil, resulting in a treated crude oil having a reduced concentration of heavy metal.

[009a] In another aspect, there is provided a method for treating a crude oil to reduce its mercury level, comprising:

a) converting at least a portion of mercury in the crude oil to water soluble mercuric iodide in an oil-water emulsion upon contact with a molecular iodine source; and

b) separating the water containing the soluble mercuric iodide from the crude oil for a treated crude oil having a reduced concentration of mercury;

wherein crude oil is a natural liquid hydrocarbon product or a synthetic liquid hydrocarbon product selected from petroleum products, intermediate petroleum stream products and refined petroleum products.

[009b] In another aspect, there is provided a method for treating a crude oil to reduce its mercury level, comprising:

a) providing a reagent and an iodine species having a charge;

b) mixing the reagent and the iodine species with the crude oil containing mercury, wherein molecular iodine is generated in-situ in the crude oil in an oxidation-reduction reaction between the iodine species having a charge and the reagent to convert at least a portion of the mercury to water soluble mercuric iodide in an oil-water emulsion; and

c) separating the water containing the water soluble mercuric iodide from the crude oil for a treated crude oil having a reduced concentration of mercury.

[009c] In another aspect, there is provided a method for treating a crude oil to reduce its mercury level, comprising:

a) adding an effective amount of a reagent that functions as an oxidizing agent to the crude oil;

b) adding a negatively charged iodine species in an excess amount at a molar ratio of iodine to mercury of at least 2:1 to generate molecular iodine in-situ in the crude oil in an oxidation-reduction reaction between the negatively charged iodine species and the reagent, wherein the in-situ iodine converts mercury to cationic mercury in a water-oil emulsion and forms water soluble mercury complexes; and

c) separating the water containing the soluble mercury complexes from the crude oil for a treated crude oil having a reduced concentration of mercury;

wherein the iodine species is selected from the group of RX and RX_2, wherein X is iodide and R is selected from potassium, lithium, sodium, calcium, magnesium, and ammonium.

[009d] In another aspect, there is provided a method for treating a crude oil to reduce its mercury level, comprising:

a) passing a stream of crude oil through a bed comprising molecular iodine to convert at least a portion of mercury in the crude oil to water soluble mercuric iodide in an oil-water emulsion phase; and

b) separating the water containing the mercuric iodide from the crude oil in a phase separation device for a treated crude oil having a reduced concentration of mercury.

[009e] In another aspect, there is provided a method for treating a crude oil to reduce its mercury level, comprising:

a) converting at least a portion of mercury in the crude oil to soluble mercuric iodide in a water phase upon contact with iodine in a solvent; and

b) separating the water containing the soluble mercuric iodide from the crude oil in a phase separation device for a treated crude oil having less than 50 ppb mercury.

[009f] In another aspect, there is provided a method for treating a crude oil to reduce its heavy metal level, comprising:

a) providing a reducing reagent and an iodine source containing an iodine species having a positive charge;

b) mixing the reducing reagent and the iodine source with the crude oil containing mercury, wherein molecular iodine is generated in-situ in the crude oil in an oxidation-reduction reaction between the iodine species having a positive charge and a reducing reagent, wherein the in-situ molecular iodine converts heavy metal to heavy metal cations;

c) contacting the heavy metal cations with a complexing agent to form a water soluble heavy metal compound in an oil-water emulsion; and

d) separating the water containing the soluble heavy metal compound from the crude oil for a treated crude oil having a reduced concentration of heavy metal;

wherein the heavy metal is mercury.

[009g] In another aspect, there is provided a method for reducing a trace element of mercury in a crude oil, comprising:

a) adding an effective amount of an iodine containing species and a reducing agent to the crude oil to generate iodine in-situ, converting mercury to cationic mercury in a water-oil emulsion;

b) adding an effective amount of a complexing agent to the water-oil emulsion mixture to form soluble mercury complexes in a water phase; and

c) separating the water containing the soluble mercury complexes from the crude oil for a treated crude oil having a reduced concentration of mercury.

DETAILED DESCRIPTION

[010] The following terms will be used throughout the specification and will have the following meanings unless otherwise indicated.

[011] "Crude oil" refers to natural and synthetic liquid hydrocarbon products including but not limited to petroleum products; intermediate petroleum streams such as residue, naphtha, cracked stock; refined petroleum products including gasoline, other fuels, and solvents. The liquid hydrocarbon products can be directly from oil wells or after the products have been further processed or derived. The term "petroleum products" refer to crude oil, solid, and semi-solid hydrocarbon products including but not limited to tar sand,