CLAIMS

1. A method for reducing a trace amount of heavy metals in a crude oil, comprising:

mixing into the crude oil an effective amount of at least an oxidizing agent selected from the group of hydroperoxides, organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, molecular halogens, ozone and combinations thereof to extract at least a portion of the heavy metals in a water oil emulsion;

separating the extracted heavy metals from the crude oil to obtain a treated crude oil having a reduced concentration of heavy metals;

wherein the heavy metals comprise any of mercury, arsenic and combinations thereof.

2. The method of claim 1, prior to separating the extracted heavy metals from the crude oil, further comprising;

adding an effective amount of a complexing agent to convert at least a portion of the extracted heavy metals in the water oil emulsion to soluble heavy metal compounds in a water phase; and

separating the water phase containing the soluble heavy metal compounds from the crude oil to obtain a treated crude oil having a reduced concentration of heavy metals.

3. The method of claim 1, wherein the oxidizing agent is selected from the group of sodium perborate, potassium perborate, sodium carbonate perhydrate, potassium peroxymonosulfate, sodium peroxocarbonate, sodium peroxodicarbonate, and mixtures thereof.

4. The method of any of claims 1 - 3, wherein the effective amount of oxidizing agent for mixing into the crude oil is in a molar ratio of oxidizing agent to heavy metals of 5:1 to 20,000:1.

5. The method of claim 2, wherein the water phase containing the soluble heavy metal compounds is formed within 20 minutes of adding the complexing agent.

6. The method of claim 2, wherein the complexing agent is a metal halide.

7. The method of any of claims 2, 5, and 6, wherein the addition of the complexing agent results in at least 50 mole % of the heavy metals being extracted from the water-oil emulsion into the water phase as soluble heavy metal compounds.

8. The method of any of claims 2, 5, and 6, wherein the complexing agent is selected from the group of ethylenediamine, propylenediamine, triaminotriethylamine, diethylenetriamine, triethylenetetramine (TRIEN), tetra-2-aminoethylethlenediamine, tetraethylenepentamine (TETREN), sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, and alkaline earth metal dithionites, and mixtures thereof.

9. The method of any of claims 1-3, wherein the effective amount of oxidizing agent is mixed to the crude oil in an amount of water, with a volume ratio of water to crude oil ranging from 0.1:1 to 1:1.

10. The method of claim 2, further comprising injecting the water phase containing the soluble heavy metal compounds into a reservoir.

11. A method for reducing a trace amount of mercury in a crude oil, comprising:

mixing into the crude oil an amount of at least an oxidizing agent selected from the group of oxyhalites, hydroperoxides, organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, ozone and combinations thereof to extract at least a portion of the mercury into a water-oil emulsion;

adding an amount of a complexing agent to convert the extracted mercury to soluble mercury compounds in a water phase; and

separating the water phase containing the soluble mercury compounds from the crude oil, leaving a treated crude oil having a reduced concentration of mercury.

12. The method of claim 11, wherein the complexing agent is a metal halide.

13. The method of any of claims 11-12, wherein the oxidizing agent is an oxygen containing compound selected from the group of oxyhalites, hydroperoxides, and organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, ozone, and combinations thereof.

14. The method of any of claims 11-12, wherein the addition of the complexing agent converts at least 50 mole % of the extracted mercury to soluble mercury compounds, and the complexing agent is selected from the group of sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, alkaline earth metal dithionites, alkali metal peroxomonosulfate compounds, ethylenediamine, propylenediamine, triaminotriethylamine, diethylenetriamine, triethylenetetramine (TRIEN), tetra-2-aminoethylethlenediamine, tetraethylenepentamine (TETREN), sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, and alkaline earth metal dithionites, and mixtures thereof.

15. The method of any of claims 11-12, wherein the oxidizing agent is selected from oxyhalites, ferrous halide, potassium peroxymonosulfate, and combinations thereof, and the complexing agent is a metal halide selected frown the group of K, Li, Na, Ca, Fe, Ni, and Zn, and wherein the formation of soluble metal compounds in the water phase occurs 15 minutes after the addition of the complexing agent.

16. In a method for treating a crude oil to reduce its mercury level, comprising adding to the crude oil a water stream consisting essentially of an oxidizing agent selected from the group of elemental halogens, halogen containing compounds, ozone, oxyhalites, hydroperoxides, and organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, to convert at least a portion of the mercury to mercury cations, and extracting at least a portion of the mercury cations into the water stream forming a mercury-rich wastewater, and separating the wastewater from the crude oil, leaving a treated crude oil having a reduced concentration of mercury, the improvement comprising:

adding a complexing agent to convert at least a portion of the mercury cations to soluble mercury compounds in a water phase prior to separating the water phase containing soluble

mercury compounds from the crude oil, leaving a treated crude oil having a reduced mercury level.

17. The method of claim 16, wherein the oxidizing agent is selected from NaOCl, $Ca(OCl)_2$, ferrous halide and mixtures thereof.

18. The method of any of claims 16 - 17, wherein the addition of the complexing agent results in at least 50 mole % of the mercury cations being converted to soluble mercury compounds.

19. The method of any of claims 16 - 17, wherein the complexing agent is a metal halide selected from the group of K, Na, Li, Ca, Fe, Ni, and Zn.

20. The method of any of claims 16 - 17, wherein the complexing agent is selected from the group of sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, alkaline earth metal dithionites, alkali metal peroxomonosulfate compounds, ethylenediamine, propylenediamine, triaminotriethylamine, diethylenetriamine, triethylenetetramine (TRIEN), tetra-2-aminoethylethlenediamine, tetraethylenepentamine (TETREN), an inorganic sulfur compound selected from the group of sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, and alkaline earth metal dithionites, and mixtures thereof.

CLAIMS

1. A method for reducing a trace amount of heavy metals in a crude oil, comprising:

mixing into the crude oil an effective amount of at least an oxidizing agent selected from the group of hydroperoxides, organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, molecular halogens, ozone and combinations thereof to extract at least a portion of the heavy metals in a water oil emulsion;

adding an effective amount of a complexing agent to convert at least a portion of the extracted heavy metals in the water oil emulsion to soluble heavy metal compounds in a water phase;

separating the water phase containing the soluble heavy metal compounds from the crude oil to obtain a treated crude oil having a reduced concentration of heavy metals;

wherein the heavy metals comprise any of mercury, arsenic and combinations thereof.

2. The method of claim 1, wherein the oxidizing agent is selected from the group of sodium perborate, potassium perborate, sodium carbonate perhydrate, potassium peroxymonosulfate, sodium peroxocarbonate, sodium peroxodicarbonate, and mixtures thereof.

3. The method of any of claims 1 - 2, wherein the effective amount of oxidizing agent for mixing into the crude oil is in a molar ratio of oxidizing agent to heavy metals of 5:1 to 20,000:1.

4. The method of claim 1, wherein the water phase containing the soluble heavy metal compounds is formed within 20 minutes of adding the complexing agent.

5. The method of claim 1, wherein the complexing agent is a metal halide.

6. The method of any of claims 1, 4, and 5, wherein the addition of the complexing agent results in at least 50 mole % of the heavy metals being extracted from the water-oil emulsion into the water phase as soluble heavy metal compounds.

7. The method of any of claims 1, 4, and 5, wherein the complexing agent is selected from the group of ethylenediamine, propylenediamine, triaminotriethylamine, diethylenetriamine, triethylenetetramine (TRIEN), tetra-2-aminoethylethlenediamine, tetraethylenepentamine (TETREN), sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, and alkaline earth metal dithionites, and mixtures thereof.

8. The method of any of claims 1-2, wherein the effective amount of oxidizing agent is mixed to the crude oil in an amount of water, with a volume ratio of water to crude oil ranging from 0.1:1 to 1:1.

9. The method of claim 1, further comprising injecting the water phase containing the soluble heavy metal compounds into a reservoir.

10. A method for reducing a trace amount of mercury in a crude oil, comprising:

mixing into the crude oil an amount of at least an oxidizing agent selected from the group of oxyhalites, hydroperoxides, organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, ozone and combinations thereof to extract at least a portion of the mercury into a water-oil emulsion;

adding an amount of a complexing agent to convert the extracted mercury to soluble mercury compounds in a water phase; and

separating the water phase containing the soluble mercury compounds from the crude oil, leaving a treated crude oil having a reduced concentration of mercury.

11. The method of claim 10, wherein the complexing agent is a metal halide.

12. The method of any of claims 10-11, wherein the oxidizing agent is an oxygen containing compound selected from the group of oxyhalites, hydroperoxides, and organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, ozone, and combinations thereof.

13. The method of any of claims 10-11, wherein the addition of the complexing agent converts at least 50 mole % of the extracted mercury to soluble mercury compounds, and the complexing agent is selected from the group of sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, alkaline earth metal dithionites, alkali metal peroxomonosulfate compounds, ethylenediamine, propylenediamine, triaminotriethylamine, diethylenetriamine, triethylenetetramine (TRIEN), tetra-2-aminoethylethlenediamine, tetraethylenepentamine (TETREN), sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, and alkaline earth metal dithionites, and mixtures thereof.

14. The method of any of claims 10-11, wherein the oxidizing agent is selected from oxyhalites, ferrous halide, potassium peroxymonosulfate, and combinations thereof, and the complexing agent is a metal halide selected frown the group of K, Li, Na, Ca, Fe, Ni, and Zn, and wherein the formation of soluble metal compounds in the water phase occurs 15 minutes after the addition of the complexing agent.

15. In a method for treating a crude oil to reduce its mercury level, comprising adding to the crude oil a water stream consisting essentially of an oxidizing agent selected from the group of elemental halogens, halogen containing compounds, ozone, oxyhalites, hydroperoxides, and organic peroxides, inorganic peracids and salts thereof, organic peracids and salts thereof, to convert at least a portion of the mercury to mercury cations, and extracting at least a portion of the mercury cations into the water stream forming a mercury-rich wastewater, and separating the wastewater from the crude oil, leaving a treated crude oil having a reduced concentration of mercury, the improvement comprising:

adding a complexing agent to convert at least a portion of the mercury cations to soluble mercury compounds in a water phase prior to separating the water phase containing soluble mercury compounds from the crude oil, leaving a treated crude oil having a reduced mercury level.

16. The method of claim 15, wherein the oxidizing agent is selected from NaOCl, $Ca(OCl)_2$, ferrous halide and mixtures thereof.

17. The method of any of claims 15 - 16, wherein the addition of the complexing agent results in at least 50 mole % of the mercury cations being converted to soluble mercury compounds.

18. The method of any of claims 15 - 16, wherein the complexing agent is a metal halide selected from the group of K, Na, Li, Ca, Fe, Ni, and Zn.

19. The method of any of claims 15 - 16, wherein the complexing agent is selected from the group of sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, alkaline earth metal dithionites, alkali metal peroxomonosulfate compounds, ethylenediamine, propylenediamine, triaminotriethylamine, diethylenetriamine, triethylenetetramine (TRIEN), tetra-2-aminoethylethlenediamine, tetraethylenepentamine (TETREN), an inorganic sulfur compound selected from the group of sulfides, ammonium thiosulfate, alkali metal thiosulfates, alkaline earth metal thiosulfates, iron thiosulfates, alkali metal dithionites, and alkaline earth metal dithionites, and mixtures thereof.