CLAIMS

1. A method for recovering organic heteroatom compounds from a hydrocarbon feedstock, the method comprising:

feeding a hydrocarbon feedstock into a contactor, wherein the hydrocarbon feedstock comprises crude oil or a crude oil fraction and at least one organic heteroatom compound chosen from pyrrole, pyridine, quinoline, carbazole, indole, nickel-tetraphenyl-porphyrin, vanadyl-tetraphenyl-porphyrin, thiophene, benzothiophene, dibenzothiophene, and 7,8,9,10-tetrahydro-benzo[b]naphtho[2,3-d]thiophene, and combinations thereof;

feeding an aqueous solvent into the contactor to form an extraction mixture of the aqueous solvent with the hydrocarbon feedstock, the aqueous solvent comprising an ionic liquid formed from pressurized carbon dioxide and water;

establishing a contactor pressure and a contactor temperature of the extraction mixture in the contactor that together tune the aqueous solvent to selectively form a solvent complex with the at least one organic heteroatom compound;

extracting the solvent complex to a recovery vessel from the extraction mixture in the contactor;

adjusting a recovery temperature of the recovery vessel, a recovery pressure of the recovery vessel, or both, to decompose the solvent complex in the recovery vessel into carbon dioxide and the at least one organic heteroatom compound; and

recovering the at least one organic heteroatom compound from the recovery vessel.

2. The method of claim 1, wherein the pressurized carbon dioxide in the aqueous solvent comprises supercritical CO_2, subcritical CO_2, or both.

3. The method of claim 1, wherein the contactor pressure is from about 2 bar to about 300 bar.

4. The method of claim 3, wherein the contactor pressure is greater than or equal to the critical pressure of CO_2.

5. The method of claim 3, wherein adjusting a recovery temperature of the recovery vessel, a recovery pressure of the recovery vessel, or both comprises reducing the recovery pressure to less than the contactor pressure.

6. The method of claim 1, wherein the contactor temperature is from greater than the critical temperature of carbon dioxide to about 100°C.

7. The method of claim 6, wherein adjusting a recovery temperature of the recovery vessel, a recovery pressure of the recovery vessel, or both comprises lowering the recovery temperature to less than the contactor temperature.

8. The method of claim 1, wherein recovering the at least one organic heteroatom compound comprises mixing an aromatic solvent with the solvent complex.

9. The method of claim 1, wherein:

feeding the hydrocarbon feedstock comprises spraying the hydrocarbon feedstock into a bottom of the contactor; and

feeding the aqueous solvent comprises spraying the aqueous solvent into a top of the contactor.

10. The method of claim 9, wherein the density of the aqueous solvent is greater than the density of the hydrocarbon feedstock, whereby the extraction mixture phase separates into at least an organic phase and an aqueous phase and at least a portion of the solvent complex migrates into the aqueous phase.

11. The method of claim 10, wherein extracting the solvent complex comprises removing the at least a portion of the solvent complex from the aqueous phase or from a CO_2 phase that forms above the aqueous phase in the contactor.

12. The method of claim 1, further comprising mixing the hydrocarbon feedstock with supercritical CO_2 before feeding the hydrocarbon feedstock into the contactor.

13. The method of claim 1, wherein the contactor comprises electrical plates, the method further comprising activating the electrical plates to align ions of the ionic liquid and ions of the at least one organic heteroatom compound.

14. A method for recovering organic heteroatom compounds from a hydrocarbon feedstock, the method comprising:

feeding a hydrocarbon feedstock into a contactor, the hydrocarbon feedstock comprising crude oil or a crude oil fraction and at least one organic heteroatom compound chosen from pyrrole, pyridine, quinoline, carbazole, indole, nickel-tetraphenyl-porphyrin, vanadyl-tetraphenyl-porphyrin, thiophene, benzothiophene, dibenzothiophene, and 7,8,9,10-tetrahydro-benzo[b]naphtho[2,3-d]thiophene, and combinations thereof;

feeding an aqueous solvent into the contactor to form an extraction mixture of the aqueous solvent with the hydrocarbon feedstock, the aqueous solvent comprising an ionic liquid formed from pressurized carbon dioxide and water;

establishing a contactor pressure and a contactor temperature of the extraction mixture in the contactor that together tune the aqueous solvent to selectively form a solvent complex with the at least one organic heteroatom compound;

extracting the solvent complex to a recovery vessel from the extraction mixture in the contactor;

depressurizing the solvent complex in the recovery vessel to decompose the solvent complex into carbon dioxide and the at least one organic heteroatom compound; and

recovering the at least one organic heteroatom compound from the recovery vessel.

15. The method of claim 14, further comprising recycling at least a portion of the carbon dioxide released during the depressurizing of the solvent complex in the recovery vessel back to the contactor.