CLAIMS

1. A method for sulfur removal and upgrading, the method comprising the steps of:

mixing a heated oil feed and a supercritical water feed in a feed mixer to produce a mixed stream, wherein a ratio of the volumetric flow rate of the heated oil feed to the supercritical water feed is such that there is a greater amount of water than oil by volume as measured at standard temperature and pressure (SATP);

introducing the mixed stream to a supercritical water reactor;

allowing conversion reactions to occur in the supercritical water reactor to produce a reactor effluent;

introducing the reactor effluent to a cooling device;

reducing the temperature of the reactor effluent in the cooling device to produce a cooled fluid;

introducing the cooled fluid to a depressurizing device;

reducing the pressure of the cooled fluid in the depressurizing device to produce a discharged fluid;

introducing the discharged fluid to a gas-liquid separator;

separating the discharged fluid in the gas-liquid separator to produce a gas phase product and a liquid phase product;

feeding the liquid phase product to a pump;

increasing the pressure of liquid phase product to produce pressurized liquid product, wherein the pressure of pressurized liquid product is greater than the critical pressure of water;

introducing the pressurized liquid product to a hydration reactor, wherein the pressurized liquid product comprises water;

processing the hydration reactor to produce a hydrated oil stream, wherein the hydrated oil stream comprises water and oxygenates, wherein the hydration reactor is at a temperature between 300 deg C. and 370 deg C. and a pressure of greater than the critical pressure of water such that water is near-critical in the liquid phase;

introducing the hydrated oil stream to an extraction unit;

separating the hydrated oil stream to produce an extracted upgraded oil and an oxygenate concentrated stream, wherein the oxygenate concentrated stream comprises the oxygenates and water;

feeding the extracted upgraded oil to a hydrotreater; and

processing the extracted upgraded oil in the hydrotreater to produce a desulfurized upgraded oil.

2. The method of claim 1, wherein the hydration reactor comprises a hydration catalyst.

3. The method of claim 2, wherein the hydration catalyst is selected from the group consisting of a solid acid catalyst, a heteropolyacid, a zeolite, a titanium dioxide, an alumina, and combinations of the same.

4. The method of –claim 1, wherein the hydration reactor is selected from a CSTR, a tubular reactor, a vessel-type reactor, and combinations of the same.

5. The method of –claim 1, wherein the hydrated oil stream comprises a decreased amount of olefins relative to the pressurized liquid product.

6. The method of –claim 1, wherein the desulfurized upgraded oil comprises a decreased amount of sulfur relative to the heated oil feed.

7. The method of –claim 1, wherein the feed oil is selected from the group comprising petroleum, coal liquid, and biomaterials.

8. A method for sulfur removal, the method comprising the steps of:

introducing a mixed stream to a supercritical water reactor, wherein the mixed stream comprises supercritical water and hydrocarbons, wherein the mixed stream comprises a greater amount of water than hydrocarbons by volume as measured at standard temperature and pressure (SATP);

allowing conversion reactions to occur in the supercritical water reactor to produce a reactor effluent;

introducing the reactor effluent to a cooler;

reducing the temperature of the reactor effluent in the cooling device to produce a cooled effluent;

introducing the cooled effluent to a hydration reactor;

processing the cooled effluent in the hydration reactor to produce a hydrated effluent, wherein the hydration reactor is at a temperature between 300 deg C. and 370 deg C. and a pressure of greater than the critical pressure of water such that water is near-critical in the liquid phase;

introducing the hydrated effluent to a cooling device;

reducing the temperature of the hydrated effluent in the cooling device to produce a cooled treated effluent;

introducing the cooled treated effluent to a depressurizing device;

reducing the pressure of the cooled treated effluent in the depressurizing device to produce a depressurized effluent;

introducing the depressurized effluent to a gas-liquid separator;

separating the depressurized effluent in the gas-liquid separator to produce a vapor product and a liquid product;

feeding the liquid product to an oil-water separator;

separating the liquid product in the oil-water separator to produce an upgraded oil and an oxygenated water, wherein the oxygenated water comprises oxygenates;

introducing the upgraded oil to a hydrotreater unit; and

processing the upgraded oil in the hydrotreater unit to produce a desulfurized upgraded oil.

9. The method of claim 8, further comprising the steps of:

introducing the oxygenated water to an oxygenates separator; and

separating the oxygenated water in the oxygenates separator to produce a separated water and an oxygenates stream, wherein the oxygenates stream comprises a concentration of oxygenates.

10. The method of claim 9, further comprising the steps of:

mixing the oxygenates stream and a water feed in a feed mixer to produce an oxygenated water feed, wherein the oxygenated water feed comprises oxygenates;

introducing oxygenated water feed to a water pump;

increasing the pressure of the oxygenated water feed to produce a pressurized water stream;

introducing the pressurized water stream to a decomposition reactor, wherein the temperature in the decomposition reactor is between 550 deg C. and 600 deg C.;

facilitating the decomposition of oxygenates in the pressurized water stream to produce a heated water feed, wherein the decomposition of oxygenates hydrates the oxygenates to olefins and converts the olefins oxygenates to non-olefinic compounds, wherein the non-olefinic compounds are selected from the group consisting of aromatics, paraffins, and combinations of the same; and

mixing the heated water feed with a feed oil to produce the mixed stream.

11. The method of –claim 10, wherein the residence time in the decomposition reactor is at least 10 seconds.

12. The method of –claim 9, wherein the concentration of oxygenates in oxygenates stream is at least 10 wt %.

13. The method of –claim 8, wherein the feed oil is selected from the group comprising petroleum, coal liquid, and biomaterials.