CLAIMS

What is claimed is:

1. A method for hydrothermally processing biomass, comprising:

introducing a biomass feed having a water to biomass ratio of at least 1:1 into a reaction zone, the biomass feed having a phosphorus content;

hydrothermally treating the biomass feed under effective hydrothermal treatment conditions to produce a multi-phase product, the multi-phase product including a solids portion containing at least about 80% of the phosphorus content of the biomass feed; and

separating the multi-phase product to produce at least a gas phase portion, a liquid hydrocarbon product, and the solids portion.

2. The method of claim 1, wherein the biomass feed comprises algae, microalgae, or cyanobacteria.

3. The method of claim 2, wherein the weight ratio of water to algae is from about 2:1 to about 10:1.

4. The method of claim 1, wherein the effective hydrothermal treatment conditions include a temperature from about 150°C to about 500°C and a pressure from about 25 barg (about 2.5 MPag) to about 300 barg (about 30 MPag).

5. The method of claim 1, wherein the effective hydrothermal treatment conditions include a temperature from about 250°C to about 375°C.

6. The method of claim 1, wherein the effective hydrothermal treatment conditions include hydrothermal treatment in the presence of a catalyst, and wherein one of the following is satisfied:

the processing time is from about 45 minutes to about 90 minutes when the temperature is from about 250°C to about 300°C;

the processing time is from about 30 minutes to about 60 minutes when the

temperature is from about 275°C to about 325°C; or

the processing time is from about 15 minutes to about 30 minutes when the temperature is from about 300°C to about 350°C.

7. The method of claim 1, wherein contacting the algae based feed with water under effective hydrothermal processing conditions does not result in a phase change for the water.

8. The method of claim 1, further comprising separating the hydrocarbon liquid product to produce a fraction having at least 90 wt% of its boiling range between about 193°C and about 360°C.

9. The method of claim 1, wherein the phosphorus to carbon molar ratio of the solids portion is at least about 0.2.

10. The method of claim 1, wherein the solids portion includes at least about 90% of the phosphorus content of the biomass feed and its phosphorus to carbon molar ratio is at least about 0.25.

11. The method of claim 9, wherein the biomass feed further comprises a multivalent metal.

12. The method of claim 11, wherein the multivalent metal comprises Ca, Mg, Fe, Al, or a combination thereof.

13. The method of claim 1, wherein the biomass feed further comprises a multivalent metal.

14. The method of claim 13, wherein the multivalent metal comprises Ca, Mg, Fe, Al, or a combination thereof.

~~11.~~15. A method for hydrothermally processing biomass, comprising:

adding a multivalent metal to a biomass feed having a phosphorus content, the multivalent metal being added in a form suitable for increasing the amount of available multivalent metal cations in the biomass feed;

contacting the biomass feed with water in the presence of the multivalent metal under effective hydrothermal treatment conditions to produce a multi-phase product, the multi-phase product including a solids portion containing at least about 80% of the phosphorus content of the biomass feed; and

separating the multi-phase product to produce at least a gas phase portion, a liquid hydrocarbon product, and the solids portion.

~~12.~~16. The method of claim ~~11~~ 15, wherein the multivalent metal comprises Ca, Mg, Fe, Al, or a combination thereof.

~~13.~~17. The method of claim ~~11~~15, wherein contacting the biomass feed with water comprises contacting the biomass feed with water in the presence of about 0.1 wt% to about 1.0 wt% of the multivalent metal and in the presence of a catalyst, and wherein separating the multi-phase product to produce a solids portion comprises separating the multi-phase product to produce a catalyst portion and an algae-based solids portion.

~~14.~~18. The method of claim ~~13~~ 17, wherein the algae-based solids portion includes at least about 80% of the phosphorus content of the biomass feed and includes a majority of the multivalent metal.

~~15.~~19. The method of claim ~~11~~ 15, wherein the multivalent metal is added to the biomass feed in a reaction zone for the contacting of the biomass feed with water under effective hydrothermal conditions.

20. The method of claim 15, wherein the biomass feed comprises algae, microalgae, or cyanobacteria.

21. The method of claim 15, wherein the phosphorous to carbon molar ratio of the

solids portion is at least about 0.2.

22. The method of claim 15, wherein the solids portion includes at least about 90% of the phosphorous content of the biomass feed and its phosphorous to carbon molar ratio is at least about 0.25.

~~16.~~23. A method for hydrothermally processing biomass, comprising:

contacting an algae-containing feed having a phosphorus content with water under effective hydrothermal treatment conditions to produce a multi-phase product, the multi-phase product including a solids portion containing at least about 80% of the phosphorus content of the algae-containing feed;

separating the multi-phase product to produce at least a gas phase portion, a liquid hydrocarbon product, and the solids portion; and

recycling phosphorus from the solids portion to an algae process.

~~17.~~24. The method of claim ~~16~~ 23, wherein recycling phosphorus from the solids portion comprises:

extracting phosphorus from the solids portion to form a phosphorus based nutrient or nutrient precursor; and

introducing the phosphorus based nutrient or nutrient precursor into the algae growth process.

~~18.~~25. The method of claim ~~16~~ 23, wherein the phosphorus based nutrient or nutrient precursor is phosphoric acid.

~~19.~~26. The method of claim ~~16~~ 23, wherein the weight ratio of water to algae is from about 3:1 to about 5:1.

~~20.~~27. The method of claim ~~16~~ 23, wherein the solids portion includes at least about 90% of the phosphorus content of the biomass feed and its phosphorus to carbon molar ratio of at least about 0.25.

28. The method of claim 23, wherein the algae-containing feed further comprises a multivalent metal.

29. The method of claim 28, wherein the multivalent metal comprises Ca, Mg, Fe, Al, or a combination thereof.