Claims:

1. A method of liquefaction, the method comprising:

providing a hydrogen donor; and

contacting a solid carbonaceous material and the hydrogen donor to convert at least a portion of the solid carbonaceous material to a product;

wherein the providing of the hydrogen donor comprises -

(a) irradiating a susceptor material with electromagnetic energy to provide a heated susceptor material, and

(b) contacting the hydrogen donor and the heated susceptor material to heat the hydrogen donor to a temperature of at least 300 °C;

wherein the susceptor material and the heated susceptor material do not contact the solid carbonaceous material, and wherein the susceptor material and the heated susceptor material do not contact the product.

~~2. The method of claim 1, wherein the providing of the hydrogen donor comprises:~~

~~(a) irradiating a susceptor material with electromagnetic energy to provide a heated susceptor material; and~~

~~(b) contacting the hydrogen donor and the heated susceptor material to heat the hydrogen donor to a temperature of at least 300 °C.~~

~~3~~2. The method of claim ~~2~~1, wherein the electromagnetic energy comprises microwave energy.

~~4~~3. The method of claim 1, further comprising:

providing a reactor configured to host the contacting of the solid carbonaceous material and the hydrogen donor; and

optionally pre-heating the reactor to a pre-heat reactor temperature of at least 300 °C prior to the contacting of the solid carbonaceous material and the hydrogen donor in the reactor.

~~5~~4. The method of claim ~~4~~3, wherein the pre-heat reactor temperature is about 450 °C to about 550 °C.

~~6~~5. The method of claim ~~4~~3, wherein the contacting of the solid carbonaceous material and the hydrogen donor comprises mixing the solid carbonaceous material and the hydrogen donor.

~~7~~6. The method of claim ~~6~~5, wherein the mixing of the solid carbonaceous material and the hydrogen donor comprises:

(i) stirring the solid carbonaceous material and the hydrogen donor in the reactor;

(ii) removing from the reactor and then returning to the reactor (a) at least a portion of the solid carbonaceous material, (b) at least a portion of the hydrogen donor, or (c) a combination thereof; or

(iii) a combination thereof.

~~8~~7. The method of claim 1, wherein the contacting of the solid carbonaceous material and the hydrogen donor occurs at a pressure greater than atmospheric pressure.

~~9~~8. The method of claim ~~8~~7, wherein the pressure greater than atmospheric pressure is equal to or greater than the critical pressure of the hydrogen donor.

~~10~~9. The method of claim 1, wherein the contacting of the solid carbonaceous material and the hydrogen donor occurs in an inert atmosphere.

~~11~~10. The method of claim 1, further comprising heating the solid carbonaceous material to a temperature of about 100 °C to about 300 °C prior to the contacting of the solid carbonaceous material and the hydrogen donor.

~~12~~11. The method of claim 1, wherein the solid carbonaceous material is in a particulate form, and has an average particle size of about 0.1 μm to about 5 mm.

~~13~~12. The method of claim 1, further comprising grinding the solid carbonaceous material prior to the contacting of the solid carbonaceous material and the hydrogen donor.

~~14~~13. The method of claim ~~13~~12, wherein the grinding of the solid carbonaceous material comprises:

disposing in a grinding chamber of a jet mill a first stream comprising (i) a circulating fluid and (ii) particles of a carbonaceous material to produce a second stream comprising (a) the circulating fluid and (b) a ground carbonaceous material, wherein the jet mill is pressurized by the circulating fluid;

forwarding the second stream to a cyclone separator, wherein the cyclone separator is configured to separate a first portion of the ground carbonaceous material from a second portion of the ground carbonaceous material, wherein the first portion of the ground carbonaceous material includes particles having a particle size equal to or greater than a threshold particle size, and the second portion of the ground carbonaceous material includes particles having a particle size less than the threshold particle size;

collecting the first portion of the ground carbonaceous material in a first collector;

forwarding to a second collector a third stream comprising (1) the circulating fluid and (2) the second portion of the ground carbonaceous material, wherein the second collector is configured to separate the second portion of the ground carbonaceous material from the third stream to produce a fourth stream comprising the circulating fluid; and

contacting the fourth stream with additional particles of the carbonaceous material to produce a fifth stream;

wherein the first portion of the ground carbonaceous material comprises the solid carbonaceous material.

~~15~~14. The method of claim ~~14~~13, wherein the circulating fluid comprises nitrogen gas, carbon dioxide, or a combination thereof.

~~16~~15. The method of claim 1, wherein the product is a fluid product, the fluid product comprising a product gas, a product condensate, a product liquid, or a combination thereof.

~~17~~16. The method of claim 1, wherein the solid carbonaceous material comprises coal.

~~18~~17. The method of claim 1, wherein the hydrogen donor comprises tetralin.

~~19~~18. The method of claim 1, wherein the hydrogen donor has a temperature of at least 300 °C.

~~20~~19. The method of claim 1, wherein the solid carbonaceous material is a component of a slurry or a paste.

~~21~~20. A system comprising:

a reactor;

a hydrogen donor feeder; and

a product liquid collection reservoir;

wherein the hydrogen donor feeder and the product liquid collection reservoir are in fluid communication with the reactor,

wherein the reactor is configured to receive a carbonaceous material from a carbonaceous material feeder; and

wherein the hydrogen donor feeder is configured to provide to the reactor a hydrogen donor.

~~22~~21. The system of claim ~~21~~20, further comprising a circulation conduit configured to remove from the reactor and then return to the reactor at least a portion of the reactor's contents.

~~23~~22. The system of claim ~~22~~21, wherein the circulation conduit comprises:

a pump in fluid communication with (i) the reactor, (ii) the reactor and the hydrogen donor feeder, (iii) the reactor and the product liquid collection reservoir, or (iv) the reactor, the hydrogen donor feeder, and the product liquid collection reservoir.

~~24~~23. The system of claim ~~23~~22, wherein the pump is a positive displacement pump having a cavity volume sufficient to displace, per each cycle, about 2 % to about 15 %, by weight, of the reactor's contents.

~~25~~24. The system of claim ~~21~~20, further comprising a reactor heater.

~~26~~25. The system of claim ~~21~~20, further comprising:

a condenser; and

a product condensate collection reservoir;

wherein the condenser is in fluid communication with the reactor, and the product condensate collection reservoir is in fluid communication with the condenser.

~~27~~26. The system of claim ~~21~~20, further comprising a first process gas feeder, wherein the first process gas feeder is in fluid communication with the reactor, the carbonaceous material feeder, the product liquid collection reservoir, or a combination thereof.

~~28~~27. The system of claim ~~27~~26, wherein the first process gas feeder is in fluid communication with the reactor and the carbonaceous material feeder.

~~29~~28. The system of claim ~~27~~26, further comprising a second process gas feeder, wherein the second process gas feeder is in fluid communication with the product liquid collection reservoir.

~~30~~29. The system of claim ~~21~~20, wherein the carbonaceous material feeder comprises a hopper.

~~31~~30. The system of claim ~~30~~29, wherein the carbonaceous material feeder further comprises a lock hopper, wherein the lock hopper is (i) arranged between the hopper and the reactor, and (ii) in fluid communication with a first process gas feeder, the hopper, the reactor, or a combination thereof.

~~32~~31. The system of claim ~~21~~20, further comprising a mixing apparatus disposed in the reactor.

~~33~~32. The system of claim ~~21~~20, wherein the hydrogen donor feeder comprises an apparatus, the apparatus comprising:

a tube formed at least in part of an electromagnetic wave-transparent material; and

an applicator, wherein (i) a first end of the tube is fixably mounted or spring mounted to the applicator, and (ii) at least a portion of the tube is arranged in the applicator.

~~34~~33. The system of claim ~~33~~32, further comprising a susceptor material disposed in the tube, wherein at least a portion of the susceptor material in the tube is arranged in the applicator.

~~35~~34. The system of claim ~~34~~33, wherein the susceptor material is in a particulate form.

~~36~~35. The system of claim ~~33~~32, wherein a second end of the tube is fixably mounted or spring mounted to the applicator.

~~37~~36. The system of claim ~~36~~35, wherein the first end of the tube is spring mounted to the applicator, the second end of the tube is spring mounted to the applicator, or both the first end of the tube and the second end of the tube are spring mounted to the applicator.

~~38~~37. The system of claim ~~33~~32, further comprising a heat exchanger in fluid communication with the apparatus.

~~39~~38. The system of any one of claims ~~21~~ 20 to ~~38~~37, further comprising at least one valve selected from the group consisting of -

(i) a first valve arranged between the first process gas feeder and the reactor;

(ii) a second valve arranged between the hydrogen donor feeder and the reactor;

(iii) a third valve arranged between the condenser and the reactor;

(iv) a fourth valve arranged between the product liquid collection reservoir and the reactor;

(v) a fifth valve arranged between the first process gas feeder and the carbonaceous material feeder;

(vi) a sixth valve arranged between the second process gas feeder and the product liquid collection reservoir;

(vii) a seventh valve arranged between and in fluid communication with a first opening of the reactor and the pump of the circulation conduit; and

(viii) an eighth valve arranged between the product liquid collection reservoir and the circulation conduit.

~~40~~39. The system of claim ~~39~~38, wherein the seventh valve is a circulation valve, and the fourth valve is a drain valve.

~~41~~40. The system of claim ~~39~~38, wherein the second valve is arranged between the hydrogen donor feeder and the circulation conduit.

~~42~~41. The system of claim ~~39~~38, wherein the fourth valve is arranged between a second opening of the reactor and the pump of the circulation conduit, and the eighth valve is arranged between the pump of the circulation conduit and the product liquid collection reservoir.

~~43~~42. A method of liquefaction, the method comprising:

providing the system of claim ~~39~~38;

optionally heating the reactor with the reactor heater to a pre-heat reactor temperature of at least 300 °C;

optionally disposing a process gas in the reactor from the first process gas feeder to pressurize the reactor to a pressure greater than atmospheric pressure;

disposing the hydrogen donor in the reactor;

optionally maintaining in the reactor the pressure greater than atmospheric pressure;

disposing the carbonaceous material from the carbonaceous material feeder into the reactor to contact the carbonaceous material and the hydrogen donor in the

reactor to convert at least a portion of the carbonaceous material to a product;

collecting a product condensate in the product condensate collection reservoir; and

collecting a product liquid in the product liquid collection reservoir.

4443. The method of claim 4342, further comprising, prior to the collecting of the product condensate and/or the product liquid, depressurizing the reactor via the third valve arranged between the condenser and the reactor.

4544. The method of claim 4342, further comprising, during and/or after the disposing of the carbonaceous material from the carbonaceous material feeder into the reactor, removing and then returning to the reactor at least a portion of the carbonaceous material and the hydrogen donor via the circulation conduit.

4645. The method of claim 4342, wherein the maintaining in the reactor the pressure greater than atmospheric pressure comprises (i) disposing an additional amount of the process gas in the reactor from the first process gas feeder, (ii) permitting a portion of the process gas to evacuate the reactor via the condenser, or (iii) a combination thereof.

4746. The method of claim 4342, wherein the disposing of the carbonaceous material from the carbonaceous material feeder into the reactor comprises:

(i) disposing the carbonaceous material into the lock hopper from the hopper,

(ii) contacting the carbonaceous material in the lock hopper with the process gas from the first process gas feeder, and

(iii) disposing the carbonaceous material into the reactor from the lock hopper.

4847. The method of claim 4342, further comprising heating the carbonaceous to a temperature of about 100 °C to about 300 °C prior to the disposing of the carbonaceous material into the reactor from the carbonaceous material feeder.

~~49~~48. The method of claim ~~43~~42, further comprising closing the first valve, the second valve, the third valve, and the fourth valve prior to and/or after the disposing of the carbonaceous material from the carbonaceous material feeder into the reactor, wherein the first valve, the second valve, the third valve, and the fourth are closed for a time effective to produce the product.

~~50~~49. The method of claim ~~43~~42, further comprising disposing the process gas from the second process gas feeder into the product liquid collection reservoir prior to the collecting of the product liquid in the product liquid collection reservoir.

~~51~~50. The method of claim ~~43~~42, wherein the collecting of the product liquid in the product liquid collection reservoir comprises opening (i) the fourth valve, or (ii) the fourth valve and the eighth valve.

~~52~~51. The method of claim ~~43~~42, wherein the pressure greater than atmospheric pressure is equal to or greater than the critical pressure of the hydrogen donor provided by the hydrogen donor feeder.