CLAIMS:

1. A method of making alkenes and alkynes, the method comprising:

(a) combusting a fuel and an oxidizer in a combustion zone of a pyrolytic reactor to create a combustion gas stream;

(b) transitioning a velocity of the combustion gas stream from subsonic to supersonic in an expansion zone of the pyrolytic reactor;

(c) injecting a light hydrocarbon into the supersonic combustion gas stream to create a mixed stream including the light hydrocarbon;

(d) transitioning the velocity of the mixed stream from supersonic to subsonic in a reaction zone of the pyrolytic reactor to produce an alkyne; and

(e) catalytically hydrogenating the alkyne in a hydrogenation zone to produce an alkene.

2. The method of claim 1 wherein:

the fuel is hydrogen,

the oxidizer is oxygen,

the light hydrocarbon is methane,

the alkyne is acetylene,

the alkene is ethylene, and

wherein transitioning the velocity of the mixed stream from supersonic to subsonic in step (d) forms a shockwave resulting in an increase in pressure and temperature of the mixed stream.

3. The method of claim 2 wherein:

a first temperature of the mixed stream immediately upstream of the shock wave is 1500 K to 2300 K, and

a second temperature of the mixed stream is 1600 K to 2800 K immediately downstream of the shockwave.

4. The method of claim 1 wherein step (e) comprises:

introducing a product stream including the alkyne from the pyrolytic reactor into a hydrogenation reactor for catalytically hydrogenating the alkyne to produce the alkene;

introducing a treated product stream including the alkene into a product separator;

separating the alkene from the treated product stream in the product separator to create a recyclable stream including at least one of hydrogen and methane; and

directing the recyclable stream into the pyrolytic reactor.

5. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon monoxide;

(g) treating the recyclable stream to: (i) convert at least a portion of the carbon monoxide to hydrogen, (ii) remove carbon dioxide, or (iii) both convert at least a portion of the carbon monoxide to hydrogen and remove carbon dioxide; and

(h) directing the treated recyclable stream into the pyrolytic reactor.

6. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including hydrogen and methane;

(g) treating the recyclable stream to separate the hydrogen and the methane and to create a hydrogen stream and a methane stream;

(h) directing the hydrogen stream as the fuel into the combustion zone of the pyrolytic reactor; and

(i) directing the methane stream as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.

7. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon monoxide;

(g) treating the recyclable stream to convert at least a portion of the carbon monoxide to hydrogen;

(h) treating the recyclable stream to separate the hydrogen and create a hydrogen stream; and

(i) directing the hydrogen stream as the fuel into the combustion zone of the pyrolytic reactor.

8. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon dioxide;

(g) converting at least a portion of the carbon dioxide in the recyclable stream to methane in a carbon dioxide conversion and methanation zone; and

(h) directing the methane as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.

9. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon dioxide;

(g) converting at least a portion of the carbon dioxide in the recyclable stream to methane in a carbon dioxide conversion and methanation zone;

(h) treating the recyclable stream to remove carbon dioxide;

(i) treating the recyclable stream to separate the hydrogen and the methane and to create a hydrogen stream and a methane stream;

(j) directing the hydrogen stream as the fuel into the combustion zone of the pyrolytic reactor; and

(k) directing the methane stream as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.

10. The method of claim 1 wherein:

step (e) comprises

(i) introducing a product stream including the alkyne from the pyrolytic reactor into a hydrogenation reactor for catalytically hydrogenating the alkyne to produce the alkene;

(ii) introducing a treated product stream including the alkene into a product separator;

(iii) separating the alkene from the treated product stream in the product separator to create a recyclable stream including carbon dioxide; and

the method further comprises:

(f) converting at least a portion of the carbon dioxide in the recyclable stream to methane in a carbon dioxide conversion and methanation zone; and

(g) directing the methane as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.

CLAIMS

1. A method of making C_1 to C_4 alkenes and C_1 to C_4 alkynes, the method comprising:

(a) combusting a fuel and oxidizer in a combustion zone of a pyrolytic reactor to create a combustion gas stream;

(b) transitioning a velocity of the combustion gas stream from subsonic to supersonic in an expansion zone of the pyrolytic reactor;

(c) injecting a light hydrocarbon (C_1 to C_4) at a temperature of 300K to 2000K into the supersonic combustion gas stream to create a mixed stream including the light hydrocarbon;

(d) transitioning the velocity of the mixed stream from supersonic to subsonic in a reaction zone of the pyrolytic reactor forms a shockwave resulting in an increase in pressure and temperature of the mixed stream to produce an alkyne, wherein a first temperature of the mixed stream immediately upstream of the shockwave is 1500K to 2300K and a second temperature of the mixed stream is 1600K to 2800K immediately downstream of the shockwave; and

(e) catalytically hydrogenating the alkyne in a hydrogenation zone to produce an alkene.

2. The method of claim 1 wherein

the fuel is hydrogen,

the oxizdizer is oxygen,

the light hydrocarbon is methane,

the alkyne is acetylene, and

the alkene is ethylene.

3. The method of claim 1 wherein step (e) comprises:

introducing a product stream including the alkyne from the pyrolytic reactor into a hydrogenation reactor for catalytically hydrogenating the alkyne to produce the alkene;

introducing a treated product stream including the alkene into a product separator;

separating the alkene from the treated product stream in the product separator to create a recyclable stream including at least one of hydrogen and methane; and

directing the recyclable stream into the pyrolytic reactor.

4. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon monoxide;

(g) treating the recyclable stream to: (i) convert at least a portion of the carbon monoxide to hydrogen, (ii) remove carbon dioxide, or (iii) both convert at least a portion of the carbon monoxide to hydrogen and remove carbon dioxide; and

(h) directing the treated recyclable stream into the pyrolytic reactor.

5. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including hydrogen and methane;

(g) treating the recyclable stream to separate the hydrogen and the methane and to create a hydrogen stream and a methane stream;

(h) directing the hydrogen stream as the fuel into the combustion zone of the pyrolytic reactor;

(i) directing the methane stream as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.

6. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon monoxide;

(g) treating the recyclable stream to convert at least a portion of the carbon monoxide to hydrogen;

(h) treating the recyclable stream to separate the hydrogen and create a hydrogen stream; and

(i) directing the hydrogen stream as the fuel into the combustion zone of the pyrolytic reactor.

7. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon dioxide;

(g) converting at least a portion of the carbon dioxide in the recyclable stream to methane in a carbon dioxide conversion and methanation zone; and

(h) directing the methane as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.

8. The method of claim 1 further comprising:

(f) separating a recyclable stream from the hydrogenation zone, the recyclable stream including carbon dioxide;

(g) converting at least a portion of the carbon dioxide in the recyclable stream to methane in a carbon dioxide conversion and methanation zone;

(h) treating the recyclable stream to remove carbon dioxide;

(i) treating the recyclable stream to separate the hydrogen and the methane and to create a hydrogen stream and a methane stream;

(j) directing the hydrogen stream as the fuel into the combustion zone of the pyrolytic reactor; and

(k) directing the methane stream as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.

9. The method of claim 1 wherein:

step (e) comprises

(i) introducing a product stream including the alkyne from the pyrolytic reactor into a hydrogenation reactor for catalytically hydrogenating the alkyne to produce the alkene;

(ii) introducing a treated product stream including the alkene into a product separator;

(iii) separating the alkene from the treated product stream in the product separator to create a recyclable stream including carbon dioxide; and

the method further comprises:

(f) converting at least one portion of the carbon dioxide in the recyclable stream to methane in a carbon dioxide conversion and methanation zone; and

(g) directing the methane as the light hydrocarbon into the combustion gas stream in the pyrolytic reactor.