air separation process that involves cryogenically cooling air into liquid form and distilling pure oxygen from nitrogen in the liquid air.

[0007] Given the reliance on fossil fuels, widespread adoption of CCS is imperative for reduction of greenhouse gases and control of global warming. Although some companies are focused on finding alternative CCS processes, a significant amount of research is focused on increasing the efficiency of current carbon dioxide-capture processes.

SUMMARY

[0008] It is an object of the present disclosure to provide a method for the absorption and separation of carbon dioxide that overcomes many of the disadvantages of the prior art. The inventor has identified methods for the production of mineral ion salts that can be used to sequester carbon dioxide in the form of mineral ion carbonate salts. The mineral ion salts can be obtained from different sources, including industrial waste materials and various geological silicate minerals.

[0009] The disclosure is directed to a method of employing a waste material to sequester carbon dioxide. The method comprises the steps of reacting a magnesium chloride hydrate-containing material with steam to generate hydrochloric acid and magnesium hydroxide, contacting the magnesium hydroxide with a gas stream comprising carbon dioxide to provide a partially or fully carbonated stream, contacting waste material with the hydrochloric acid and optionally water to leach mineral ion salts from the waste material into a brine or slurry, recovering the mineral ion salts from the brine or slurry, and reacting the mineral ions salts with the partially or fully carbonated stream to sequester carbon dioxide in the form of mineral ion carbonate salts. In some examples, the partially or fully carbonated stream comprises $Mg(OH)_x(HCO_3)_y$, where $x+y = 2$. In some examples, the mineral ion carbonate salts comprise precipitated calcium carbonate (PCC). In some examples, the mineral ion carbonate salts further comprise lesser value, mixed carbonates.

[0009a] In one aspect, the disclosure is directed to a method of employing a waste material to sequester carbon dioxide, the method comprising: reacting a magnesium chloride hydrate-containing material with steam to generate HCl and $Mg(OH)_2$; contacting the $Mg(OH)_2$ with a gas stream comprising carbon dioxide to provide a partially or fully carbonated stream comprising $Mg(OH)_x(HCO_3)_y$ where $x+y = 2$; contacting waste material with the HCl and optionally water to leach mineral ion salts from the waste material into a brine or slurry; recovering the mineral ion salts from the brine or slurry;

and reacting the mineral ions salts with the partially or fully carbonated stream to sequester carbon dioxide in the form of mineral ion carbonate salts comprising calcium carbonate,

wherein the waste material is selected from the group consisting of masonry, concrete, steel furnace slag, bio-mass fuel production slag, and waste coal fly ash.

[0010] The disclosure is directed to a method of employing a geological silicate mineral to sequester carbon dioxide. The method comprises the steps of reacting a magnesium chloride hydrate-containing material with steam to generate hydrochloric acid and magnesium hydroxide, contacting the magnesium hydroxide with a gas stream comprising carbon dioxide to provide a partially or fully carbonated stream, contacting the geological silicate mineral with the hydrochloric acid and optionally water to

leach mineral ion salts from the geological silicate mineral into a brine or slurry, recovering the mineral ion salts from the brine or slurry, reacting the mineral ions salts with the partially or fully carbonated stream to sequester carbon dioxide in the form of mineral ion carbonate salts. In some examples, the partially or fully carbonated stream comprises $Mg(OH)_x(HCO_3)_y$, where $x+y = 2$. In some examples, the mineral ion carbonate salts comprise precipitated calcium carbonate. In some examples, the mineral ion carbonate salts further comprise lesser value, mixed carbonates.

[0011] In some examples, the mineral ion salts comprise at least one Group II metal cation. In some examples, the Group II metal cation is a calcium cation. In some examples, the Group II metal cation is a magnesium cation. In some examples, the waste material is an industrial waste material. In some examples, the industrial waste material is selected from the group consisting of masonry, concrete, steel furnace slag, bio-mass fuel production slag, and waste coal fly ash.

[0012] In some examples, the carbon dioxide is a component of a flue gas stream. In some examples, the carbon dioxide is atmospheric carbon dioxide. In some examples, the step of contacting the waste material with the hydrochloric acid is performed at ambient temperature. In some examples, the step of contacting the waste material with the hydrochloric acid is performed at greater-than-ambient temperature. In some examples, the step of contacting the waste material with the hydrochloric acid is performed at ambient pressure.

[0013] In some examples, the step of contacting the waste material with the hydrochloric acid does not involve mechanical agitation or abrasion of solids. In some examples, the step of contacting the waste material with the hydrochloric acid involves mechanical agitation or abrasion of solids. In some examples, the step

of contacting the waste material with the hydrochloric acid further comprises recirculating liquids to increase contact between the waste material and the hydrochloric acid.

[0014] In some examples, the step of contacting the geological silicate mineral with the hydrochloric acid is performed at ambient temperature. In some examples, the step of contacting the geological silicate mineral with the HCl is performed at greater-than-ambient temperature. In some examples, the step of contacting the geological silicate mineral with the hydrochloric acid is performed at ambient pressure. In some examples, the step of

CLAIMS

1. A method of employing a waste material to sequester carbon dioxide, the method comprising:

reacting a magnesium chloride hydrate-containing material with steam to generate HCl and $Mg(OH)_2$;

contacting the $Mg(OH)_2$ with a gas stream comprising carbon dioxide to provide a partially or fully carbonated stream comprising $Mg(OH)_x(HCO_3)_y$ where $x+y = 2$;

contacting waste material with the HCl and optionally water to leach mineral ion salts from the waste material into a brine or slurry;

recovering the mineral ion salts from the brine or slurry; and

reacting the mineral ions salts with the partially or fully carbonated stream to sequester carbon dioxide in the form of mineral ion carbonate salts comprising calcium carbonate,

wherein the waste material is selected from the group consisting of masonry, concrete, steel furnace slag, bio-mass fuel production slag, and waste coal fly ash.

2. The method of claim 1, wherein the mineral ion salts comprise a magnesium cation.

3. The method of claim 1, wherein the carbon dioxide is atmospheric carbon dioxide or is a component of a flue gas stream.

4. The method of claim 1, wherein the carbon dioxide is atmospheric carbon dioxide.

5. The method of claim 1, wherein the step of contacting the waste material with the HCl is performed at ambient temperature.

6. The method of claim 1, wherein the step of contacting the waste material with the HCl is performed at ambient pressure.

7. The method of claim 1, wherein the step of contacting the waste material with the HCl does not involve mechanical agitation or abrasion of solids.

8. The method of claim 1, wherein the step of contacting the waste material with the HCl further comprises recirculating liquids to increase contact between the waste material and the HCl.

9. The method of claim 1, further comprising transferring the brine or slurry to a settling tank and allowing solids in the brine or slurry to settle at the bottom of the settling tank.

10. The method of claim 1, further comprising transferring the brine or slurry to an evaporation pond and allowing liquid in the brine or slurry to evaporate.

11. The method of claim 10, wherein solar energy and/or naturally occurring wind are harnessed to increase the rate of evaporation.

12. The method of claim 10, wherein non-renewable energy is not used to increase the rate of evaporation.

13. The method of claim 10, wherein no energy is provided to the evaporation pond to increase the rate of evaporation.