CLAIMS

1. A solid adsorbent for capturing carbon dioxide (CO_2) from a gas stream comprising CO_2, the solid adsorbent comprising an amine covalently bonded to a polymer resin,

wherein the solid adsorbent has a CO_2 uptake capacity of greater than about 7 wt. % at a temperature of about 40 °C, and wherein the solid adsorbent has a CO_2 uptake capacity of less than about 1.5 wt. % at a temperature of about 100 °C, as measured when the gas stream further comprises a concentration of the CO_2 of about 4 vol. %, by volume of the gas stream.

2. The solid adsorbent according to claim 1, wherein at least one of:

the polymer resin comprises a pore volume from about .001 cm^3/g to about .5 cm^3/g;

the polymer resin comprises a surface area from about 1 m^2/g to about 60 m^2/g;

the polymer resin comprises polystyrene;

the polymer resin comprises a porosity from about 15 % to about 60 %.

3. The solid adsorbent according to claim 1 or 2, where at least one of:

the solid adsorbent comprises a dry nitrogen content from about 5 mol/kg to about 10 mol/kg.

4. The solid adsorbent according to claim 1, wherein the amine comprises at least one of a primary amine, a secondary amine, a benzylamine, an ethylenediamine, a diethylenetriamine, a tetraethylenepentamine, a pentaethylenehexamine, a triethylenetetramine, a 1,3-diaminopropane, a 1,4-diaminobutane, a 1,5-diaminopentane, a 1,6-diaminohexane, a 1,7-diaminoheptane, a 1,8-diaminooctane, a 1,9-diaminononane, a 1,10-diaminodecane, a 1,3-diaminopentane, a 1,2-diaminopropane, and combinations thereof.

5. The solid adsorbent according to any one of the preceding claims wherein the amine is an alkyl diamine and wherein the amine has a chain length and wherein the chain length of the alkyl amine covalently bonded to the resin is for at least for 95% the same.

6. A process for capturing carbon dioxide (CO_2) from a gas stream comprising CO_2, the process comprising:

(a) contacting the gas stream with a solid adsorbent in an adsorption zone to form a CO_2-enriched solid adsorbent, wherein the solid adsorbent comprises an amine covalently bonded to a polymer resin; and

(b) heating a portion of the CO_2-enriched solid adsorbent in a desorption zone to a temperature of greater than about 90 °C to desorb at least a portion of the CO_2 from the CO_2-enriched solid adsorbent to form a desorbed CO_2 and a CO_2-depleted solid adsorbent,

wherein the solid adsorbent has a CO_2 uptake capacity of greater than about 7 wt. % at a temperature of about 40 °C, and wherein the solid adsorbent has a CO_2 uptake capacity of less than about 1.5 wt. % at a temperature of about 100 °C, as measured when the gas stream further comprises a concentration of the CO_2 of about 4 vol. %, by volume of the gas stream.

7. The process according to claim 6, further comprising transferring the CO_2-enriched solid adsorbent from the adsorption zone to a pre-regenerator comprising heating coils; and

heating the CO_2-enriched solid adsorbent in the pre-regenerator to a temperature of greater than about 90 °C to desorb an initial portion of the CO_2 from the CO_2-enriched solid adsorbent to form a partially CO_2-depleted solid adsorbent.

8. The process according to claim 7, further comprising transferring the partially CO_2-depleted solid adsorbent to the desorption zone; and

heating a portion of the partially CO_2-depleted solid adsorbent in the desorption zone to a temperature of greater than about 90 °C to desorb an additional portion of the CO_2 from the pre-regenerator treated solid adsorbent to form a second portion of the desorbed CO_2 and a further CO_2-depleted solid adsorbent.

9. The process according to any one of claims 6 to 8, further comprising recycling the CO_2-depleted solid adsorbent by transferring the CO_2-depleted solid adsorbent from the desorption zone to the adsorption zone.

10. The process according to claim 8, further comprising recycling the further CO_2-depleted solid adsorbent by transferring the CO_2-depleted solid adsorbent from the desorption zone to the adsorption zone.

11. A system for capturing carbon dioxide (CO_2) from a gas stream comprising CO_2, the system comprising:

(a) an adsorption zone connected to a desorption zone through a transfer line and a recycle line, the adsorption zone comprising:

a gas stream inlet for receiving the gas stream;

a flue gas outlet for releasing a gas; and

at least one adsorbent bed comprising a solid adsorbent, wherein the solid adsorbent comprises an amine covalently bonded to a polystyrene resin,

wherein the adsorption zone is configured to receive the gas stream such that the gas stream contacts the solid adsorbent to form a CO_2-enriched solid adsorbent,

wherein the desorption zone is configured to receive at least a portion of the CO_2-enriched solid adsorbent from the adsorption zone through the transfer line and to heat a portion of the CO_2-enriched solid adsorbent at a temperature of greater than about 90 °C to desorb at least a portion of the CO_2 from the CO_2-enriched solid adsorbent to form a desorbed CO_2 and a CO_2-depleted solid adsorbent,

wherein the recycle line is configured to transfer the CO_2-depleted solid adsorbent from the desorption zone to the adsorption zone, and

wherein the solid adsorbent has a CO_2 uptake capacity of greater than about 7 wt. % at a temperature of about 40 °C, and wherein the solid adsorbent has a CO_2 uptake capacity of less than about 1.5 wt. % at a temperature of about 100 °C, as measured when the gas stream further comprises a concentration of the CO_2 of about 4 vol. %, by volume of the gas stream.

12. The system of claim 11, wherein the adsorption zone comprises two or more solid adsorbent beds.

13. The system of claim 11 or 12, further comprising a pre-regenerator comprising heating coils, wherein the pre-regenerator is connected to the adsorption zone through a second transfer line and configured to receive at least a portion of the CO_2-enriched solid adsorbent from the adsorption zone through the second transfer line, and wherein the pre-regenerator is configured to heat the portion of the CO_2-enriched solid adsorbent to a temperature of greater than about 90 °C to form a partially CO_2-depleted solid adsorbent.

14. The system of claim 11, wherein the pre-regenerator is connected to the desorption zone through a third transfer line and is configured to transfer the partially CO_2-depleted solid adsorbent to the desorption zone, wherein the desorption zone is configured to

heat the partially CO_2-depleted solid adsorbent to form a second portion of the desorbed CO_2 and a further CO_2-depleted solid adsorbent.

15. A method for preparing a solid adsorbent for capturing carbon dioxide (CO_2) from a gas stream comprising CO_2, the method comprising:

combining an amine with a chloromethylated polymer resin to form the solid adsorbent,

wherein the solid adsorbent comprises a dry nitrogen content from about 5 mol/kg to about 10 mol/kg, wherein the solid adsorbent has a CO_2 uptake capacity of greater than about 7 wt. % at a temperature of about 40 °C, and wherein the solid adsorbent has a CO_2 uptake capacity of less than about 1.5 wt. % at a temperature of about 100 °C, as measured when the gas stream further comprises a concentration of the CO_2 of about 4 vol. %, by volume of the gas stream.

16. Use of a polymer resin having an amine covalently bonded thereto, as a solid adsorbent for capturing carbon dioxide (CO2) from a gas stream comprising CO2, wherein the solid adsorbent has a CO2 uptake capacity of greater than about 7 wt. % at a temperature of about 40 °C, and wherein the solid adsorbent has a CO2 uptake capacity of less than about 1.5 wt. % at a temperature of about 100 °C, as measured when the gas stream further comprises a concentration of the CO2 of about 4 vol. %, by volume of the gas stream.