

CLAIMSWhat is claimed is:

1. A solid adsorbent for capturing carbon dioxide (CO₂) from a gas stream
5 comprising CO₂, the solid adsorbent comprising an amine covalently bonded to a polymer resin,

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
10 further comprises a concentration of the CO₂ 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 cm³/g to about .5 cm³/g;
the polymer resin comprises a surface area from about 1 m²/g to about 60 m²/g;
15 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
20 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 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 (CO₂) from a gas stream comprising
10 CO₂, the process comprising:

(a) contacting the gas stream with a solid adsorbent in an adsorption zone to form a CO₂-enriched solid adsorbent, wherein the solid adsorbent comprises an amine covalently bonded to a polymer resin; and

(b) heating a portion of the CO₂-enriched solid adsorbent in a desorption zone to a
15 temperature of greater than about 90 °C to desorb at least a portion of the CO₂ from the CO₂-enriched solid adsorbent to form a desorbed CO₂ and a CO₂-depleted solid adsorbent,

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
20 further comprises a concentration of the CO₂ of about 4 vol. %, by volume of the gas stream.

7. The process according to claim 6, further comprising transferring the CO₂-enriched solid adsorbent from the adsorption zone to a pre-regenerator comprising heating coils; and

heating the CO₂-enriched solid adsorbent in the pre-regenerator to a temperature of greater than about 90 °C to desorb an initial portion of the CO₂ from the CO₂-enriched solid adsorbent to form a partially CO₂-depleted solid adsorbent.

5 8. The process according to claim 7, further comprising transferring the partially CO₂-depleted solid adsorbent to the desorption zone; and

 heating a portion of the partially CO₂-depleted solid adsorbent in the desorption zone to a temperature of greater than about 90 °C to desorb an additional portion of the CO₂ from the pre-regenerator treated solid adsorbent to form a second portion of the desorbed CO₂ and
10 a further CO₂-depleted solid adsorbent.

 9. The process according to any one of claims 6 to 8, further comprising recycling the CO₂-depleted solid adsorbent by transferring the CO₂-depleted solid adsorbent from the desorption zone to the adsorption zone.

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 10. The process according to claim 8, further comprising recycling the further CO₂-depleted solid adsorbent by transferring the CO₂-depleted solid adsorbent from the desorption zone to the adsorption zone.

20 11. A system for capturing carbon dioxide (CO₂) from a gas stream comprising CO₂, 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

5 stream contacts the solid adsorbent to form a CO₂-enriched solid adsorbent,

wherein the desorption zone is configured to receive at least a portion of the CO₂-enriched solid adsorbent from the adsorption zone through the transfer line and to heat a portion of the CO₂-enriched solid adsorbent at a temperature of greater than about 90 °C to desorb at least a portion of the CO₂ from the CO₂-enriched solid adsorbent to form a desorbed

10 CO₂ and a CO₂-depleted solid adsorbent,

wherein the recycle line is configured to transfer the CO₂-depleted solid adsorbent from the desorption zone to the adsorption zone, and

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
15 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.

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

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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 CO₂-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 CO₂-enriched solid adsorbent to a

14. The system of claim 11, wherein the pre-regenerator is connected to the
5 desorption zone through a third transfer line and is configured to transfer the partially CO₂-depleted solid adsorbent to the desorption zone, wherein the desorption zone is configured to heat the partially CO₂-depleted solid adsorbent to form a second portion of the desorbed CO₂ and a further CO₂-depleted solid adsorbent.

10 15. A method for preparing a solid adsorbent for capturing carbon dioxide (CO₂) from a gas stream comprising CO₂, 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
15 about 10 mol/kg, 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.

20 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.