What is Claimed is:

1. A method of applying a sorbent coating on a substrate, a support, and/or a substrate coated with a support, the method comprising:

(i) optionally, preparing the substrate coated with the support by pre-treating the substrate with a slurry, wherein the slurry comprises:

a. solvent,

b. a binder,

c. the support, and

d. optional dispersant; and

(ii) treating the substrate, the support, and/or the substrate coated with the support, with a sorbent;

wherein the substrate is (a) a monolithic or honeycomb structure made of ceramic, metal, or plastic; (b) a polyurethane foam, a polypropylene foam, a polyester foam, a metal foam, or a ceramic foam; or (c) woven or non-woven plastic or cellulosic fibers,

wherein the support is alumina, silica, silica-alumina, titania, zirconia, carbon, zeolite, metal-organic framework (MOF), or combinations thereof, and

wherein the sorbent adsorbs carbon dioxide and the sorbent is selected from the group consisting of amines; monoethanolamine; diethanolamine; polyethylenimine (PEI); aminopropyltrimethoxysilane; polyethyleneimine-trimethoxysilane; amide or amine containing polymers including nylon, polyurethane, polyvinylamine, or melamine; and combinations thereof.

2. The method of claim 1, wherein the ceramic substrate is selected from the group consisting of cordierite, alumina, cordierite-α alumina, silicon nitride, zircon mullite,

spodumene, alumina-silica magnesia, zircon silicate, sillimanite, magnesium silicates, zircon, petalite, aluminosilicates, and combinations thereof.

3. The method of claim 2, wherein the ceramic substrate is cordierite, alumina, or a combination thereof.

4. The method of claim 1, wherein the metal substrate is aluminum, titanium, stainless steel, a Fe--Cr alloy, or a Cr--Al--Fe alloy in the form of a sheet, mesh, foil, flakes, powder, wire, rod, or combinations thereof.

5. The method of claim 4, wherein the metal substrate is aluminum, stainless steel, Cr--Al--Fe alloy, or combinations thereof in the form of a sheet, mesh, or foil.

6. The method of claim 1, wherein the plastic substrate is a polymer and/or copolymer of polyolefin(s), polyester(s), polyurethane(s), polycarbonate(s), polyetheretherketone(s), polyphenylene oxide(s), polyether sulfone(s), melamine(s), polyamide(s), polyacrylates, polystyrenes, polyacrylonitriles, polyimides, polyfurfural alcohol, phenol furfuryl alcohol, melamine formaldehydes, resorcinol formaldehydes, cresol formaldehyde, phenol formaldehyde, polyvinyl alcohol dialdehyde, polycyanurates, polyacrylamides, various epoxies, agar, and agarose, or combinations thereof.

7. The method of claim 6, wherein the plastic substrate is a polymer and/or copolymer of polyolefin, polyester, polyurethane, melamine, polypropylene, or polyamide.

8. The method of claim 1, wherein the monolithic structure has channels having about 50 to about 900 cells per square inch.

9. The method of claim 9, wherein the channels are square, triangular, or sinusoidal in cross-section.

10. The method of claim 9, wherein the channels are straight, zig-zag, skewed, or herringbone in shape.

11. The method of claim 9, wherein the channels have walls that are perforated or louvered.

12. The method of claim 1, wherein the ceramic or plastic monolithic structure is made by extrusion.

13. The method of claim 1, wherein the metal or plastic monolithic structure is made by layering corrugated metal foil or corrugated plastic sheets.

14. The method of claim 1, wherein step (i) further comprises:

a. coating the substrate with the slurry;

b. removing excess solvent from the coated substrate; and

c. calcining the binder and the support onto the substrate.

15. The method of claim 14, wherein the calcining occurs at a temperature range of 200° C to 550° C.

16. The method of claim 15, wherein the calcining occurs at a temperature of 425° to 475° C.

17. The method of claim 16, wherein the calcining occurs at a temperature of 450° C.

18. The method of claim 1, wherein the binder in step (i) is alumina sol, aluminum oxide hydroxide, silica sol, titania sol, zirconium acetate, silicone, or combinations thereof.

19. The method of claim 18, wherein the alumina sol is milled to have a D50 particle size ranging from 1 μm to 10 μm.

20. The method of claim 19, wherein the alumina sol is milled to have a D50 particle size ranging from 3 μm to 6 μm.

21. The method of claim 1 further comprising:

(iii) after step (ii), drying the treated substrate to remove excess amounts of the sorbent and to remove excess solvent to obtain to obtain a sorbent coated substrate, a sorbent coated support, and/or a sorbent coated substrate coated with a support.

22. The method of claim 21, wherein the drying occurs at a temperature range of 30° C to 70° C.

23. The method of claim 22, wherein the drying occurs at a temperature range of 40° C to 60° C.

24. The method of claim 23, wherein the drying occurs at a temperature 50° C.

25. The method of claim 1, wherein the solvent is selected from the group consisting of water, methanol, ethanol, toluene, isopropanol, 2-methoxyethyl ether, and mixtures thereof.

26. A method of applying a sorbent coating on a substrate, a support, and/or a substrate coated with a support, the method comprising:

(i) treating the substrate, the support, and/or the substrate coated with the support, with a slurry comprising:

a. a solvent,

b. a binder, and

c. the sorbent;

wherein the substrate is (a) a monolithic or honeycomb structure made of ceramic, metal, or plastic; (b) a polyurethane foam, a polypropylene foam, a polyester foam, a metal foam, or a ceramic foam; or (c) woven or non-woven plastic or cellulosic fibers,

wherein the support is alumina, silica, silica-alumina, titania, zirconia, carbon, zeolite, metal-organic framework (MOF), or combinations thereof, and

wherein the sorbent adsorbs carbon dioxide and the sorbent is selected from the group consisting of amines; monoethanolamine; diethanolamine; polyethylenimine (PEI); aminopropyltrimethoxysilane; polyethyleneimine-trimethoxysilane; amide or amine containing polymers including nylon, polyurethane, polyvinylamine, or melamine; and combinations thereof.

27. The method of claim 26 further comprising:

(ii) after step (i), drying the slurry treated substrate, support, and/or substrate coated with the support; and then

(iii) removing excess sorbent and solvent at a temperature so as to prevent degradation of the binder or the sorbent to obtain a sorbent coated substrate, a sorbent coated support, and/or a sorbent coated substrate coated with a support.

28. The method of claim 26, wherein the ceramic substrate is selected from the group consisting of cordierite, alumina, cordierite-α alumina, silicon nitride, zircon mullite, spodumene, alumina-silica magnesia, zircon silicate, sillimanite, magnesium silicates, zircon, petalite, aluminosilicates, and combinations thereof.

29. The method of claim 28, wherein the ceramic substrate is cordierite, alumina, or a combination thereof.

30. The method of claim 26, wherein the metal substrate is aluminum, titanium, stainless steel, a Fe--Cr alloy, or a Cr--Al--Fe alloy in the form of a sheet, mesh, foil, flakes, powder, wire, rod, or combinations thereof.

31. The method of claim 30, wherein the metal substrate is aluminum, stainless steel, Cr--Al--Fe alloy, or combinations thereof in the form of a sheet, mesh, or foil.

32. The method of claim 26, wherein the plastic substrate is a polymer and/or copolymer of polyolefin(s), polyester(s), polyurethane(s), polycarbonate(s), polyetheretherketone(s), polyphenylene oxide(s), polyether sulfone(s), melamine(s), polyamide(s), polyacrylates, polystyrenes, polyacrylonitriles, polyimides, polyfurfural alcohol, phenol furfuryl alcohol,

melamine formaldehydes, resorcinol formaldehydes, cresol formaldehyde, phenol formaldehyde, polyvinyl alcohol dialdehyde, polycyanurates, polyacrylamides, various epoxies, agar, and agarose, or combinations thereof.

33. The method of claim 32, wherein the plastic substrate is a polymer and/or copolymer of polyolefin, polyester, polyurethane, melamine, polypropylene, or polyamide.

34. The method of claim 33, wherein the polyolefin is ethylene vinyl acetate, ethylene methyl acrylate, polyethylene, polypropylene, ethylene-propylene rubber, ethylene-propylene-diene rubbers, poly(1-butene), polystyrene, poly(2-butene), poly(1-pentene), poly(2-pentene), poly(3-methyl-1-pentene), poly(4-methyl-1-pentene), 1,2 poly-1,3-butadiene, 1,4-poly-1,3-butadiene, polyisoprene, polychloroprene, poly(vinyl acetate), poly(vinylidene chloride), poly(vinylidene fluoride), poly(tetrafluoroethylene) or a mixture thereof.

35. The method of claim 33, wherein the polyester is polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polyethylene naphthalate (PEN), copolymers of PET, copolymers of PBT and copolymers of PEN.

36. The method of claim 26, wherein the monolithic structure has channels having about 50 to about 900 cells per square inch.

37. The method of claim 36, wherein the channels are square, triangular, or sinusoidal in cross-section.

38. The method of claim 36, wherein the channels are straight, zig-zag, skewed, or herringbone in shape.

39. The method of claim 36, wherein the channels have walls that are perforated or louvered.

40. The method of claim 26, wherein the ceramic or plastic monolithic structure is made by extrusion.

41. The method of claim 26, wherein the metal or plastic monolithic structure is made by layering corrugated metal foil or corrugated plastic sheets.

42. The method of claim 26, wherein the binder in step (i) is selected from the group consisting of polyethylene, polypropylene, polyolefin copolymers, polyisoprene, polybutadiene, polybutadiene copolymers, chlorinated rubber, nitrile rubber, polychloroprene, ethylene-propylene-diene elastomers, polystyrene, polyacrylate, polymethacrylate, polyacrylonitrile, poly(vinyl esters), poly(vinyl halides), polyamides, cellulosic polymers, polyimides, acrylics, vinyl acrylics and styrene acrylics, polyvinyl alcohol, thermoplastic polyesters, thermosetting polyesters, poly(phenylene oxide), poly(phenylene sulfide), fluorinated polymers such as poly(tetrafluoroethylene) polyvinylidene fluoride, poly(vinylfluoride) and chloro/fluoro copolymers such as ethylene chlorotrifluoro-ethylene copolymer, polyamide, phenolic resins and epoxy resins, polyurethane, silicone polymers, and combinations thereof.

43. The method of claim 27, wherein the drying occurs at a temperature range of from 50° C to 150° C.

44. The method of claim 43, wherein the drying occurs at a temperature range of from 70° C to 110° C.

45. The method of claim 44, wherein the drying occurs at a temperature of about 110° C.

46. The method of claim 26, wherein the solvent is selected from the group consisting of water, methanol, ethanol, toluene, isopropanol, 2-methoxyethyl ether, and mixtures thereof.

47. The sorbent coated substrate, the sorbent coated support, and the sorbent coated substrate coated with the support of claim 21.

48. The sorbent coated substrate, the sorbent coated support, and the sorbent coated substrate coated with the support of claim 27.

49. The sorbent coating of claim 1.

50. The sorbent coating of claim 26.

51. An alumina support comprising a sorbent coating,

wherein the sorbent adsorbs carbon dioxide and the sorbent is selected from the group consisting of amines; monoethanolamine; diethanolamine; polyethylenimine (PEI); aminopropyltrimethoxysilane; polyethyleneimine-trimethoxysilane; amide or amine

containing polymers including nylon, polyurethane, polyvinylamine, or melamine; and combinations thereof, and

wherein the alumina support has a surface area of about 150 m^2/g to 250 m^2/g and a pore volume of about 0.7 cc/g to 1.5 cc/g.

52. The alumina support of claim 51,

wherein the sorbent is polyethylenimine (PEI), and

wherein the alumina support has a surface area of about 170 m^2/g to 180 m^2/g and a pore volume of about 0.9 cc/g to 1.2 cc/g.

53. The alumina support of claim 5, wherein the alumina support has a surface area of about 175 m^2/g and a pore volume of about 1.1 cc/g.

54. The method of claim 1, wherein the sorbent adsorbs carbon dioxide from air, from off-gases, intentionally produced carbon dioxide, or from their mixtures.

55. The method of claim 54, wherein the adsorbed carbon dioxide is stored and/or used in enhanced oil recovery, in carbonation of beverages, for food processing/cooling/freezing, as a reactant in the production of chemicals, as a feedstock for algae, or as a fire extinguishing medium.

56. The method of claim 1, wherein the sorbent purifies gases or separates gases.

57. The method of claim 1, wherein the sorbent adsorbs carbon dioxide to purify natural gas, ambient air, flue gas, or other impure gas mixtures containing carbon dioxide.

CLAIMS

1. A method of applying a sorbent coating on a substrate, the method comprising:

(i) preparing the substrate by pre-treating the substrate with a slurry, wherein the slurry comprises:

a. solvent,

b. a binder, and

c. a support; and

(ii) subsequently treating the substrate with a sorbent;

wherein the substrate is (a) a monolithic or honeycomb structure made of ceramic, metal, or plastic; (b) a polyurethane foam, a polypropylene foam, a polyester foam, a metal foam, or a ceramic foam; or (c) woven or non-woven plastic or cellulosic fibers,

wherein the support comprises alumina, silica, silica-alumina, titania, zirconia, carbon, zeolite, metal-organic framework (MOF), or combinations thereof, the support having a surface area of 150 m^2/g to 250 m^2/g and a pore volume of 0.7 cc/g to 1.5 cc/g,

wherein the sorbent adsorbs carbon dioxide and the sorbent is polyethylenimine (PEI);

wherein the PEI is present at a concentration of 25 wt% to 45 wt% calculated as weight of PEI divided by weight of PEI and support; and

wherein the surface area and pore volume of the support together provide the sorbent with a carbon dioxide adsorption capacity that is greater than 1.5 mmol CO_2/g coating.

2. The method of claim 1, wherein the ceramic substrate is selected from the group consisting of cordierite, alumina, cordierite-a alumina, silicon nitride, zircon mullite, spodumene, alumina-silica magnesia, zircon silicate, sillimanite, magnesium silicates, zircon, petalite, aluminosilicates, and combinations thereof.

3. The method of claim 2, wherein the ceramic substrate is cordierite, alumina, or a combination thereof.

4. The method of claim 1, wherein the metal substrate is aluminum, titanium, stainless steel, a Fe--Cr alloy, or a Cr--A1--Fe alloy in the form of a sheet, mesh, foil, flakes, powder, wire, rod, or combinations thereof.

5. The method of claim 4, wherein the metal substrate is aluminum, stainless steel, Cr--A1--Fe alloy, or combinations thereof in the form of a sheet, mesh, or foil.

6. The method of claim 1, wherein the plastic substrate is a polymer and/or copolymer of polyolefin(s), polyester(s), polyurethane(s), polycarbonate(s), polyetheretherketone(s), polyphenylene oxide(s), polyether sulfone(s), melamine(s), polyamide(s), polyacrylates, polystyrenes, polyacrylonitriles, polyimides, polyfurfural alcohol, phenol furfuryl alcohol, melamine formaldehydes, resorcinol formaldehydes, cresol formaldehyde, phenol formaldehyde, polyvinyl alcohol dialdehyde, polycyanurates, polyacrylamides, various epoxies, agar, and agarose, or combinations thereof.

7. The method of claim 6, wherein the plastic substrate is a polymer and/or copolymer of polyolefin, polyester, polyurethane, melamine, polypropylene, or polyamide.

8. The method of claim 1, wherein the monolithic structure has channels having about 50 to about 900 cells per square inch.

9. The method of claim 8, wherein the channels are square, triangular, or sinusoidal in cross-section.

10. The method of claim 8, wherein the channels are straight, zig-zag, skewed, or herringbone in shape.

11. The method of claim 8, wherein the channels have walls that are perforated or louvered.

12. The method of claim 1, wherein the ceramic or plastic monolithic structure is made by extrusion.

13. The method of claim 1, wherein the metal or plastic monolithic structure is made by layering corrugated metal foil or corrugated plastic sheets.

14. The method of claim 1, wherein step (i) further comprises:

a. coating the substrate with the slurry;

b. removing excess solvent from the coated substrate; and

c. calcining the binder and the support onto the substrate.

15. The method of claim 14, wherein the calcining occurs at a temperature range of 200° C to 550° C.

16. The method of claim 15, wherein the calcining occurs at a temperature of 425° to 475° C.

17. The method of claim 16, wherein the calcining occurs at a temperature of 450° C.

18. The method of claim 1, wherein the binder in step (i) is alumina sol, aluminum oxide hydroxide, silica sol, titania sol, zirconium acetate, silicone, or combinations thereof.

19. The method of claim 18, wherein the alumina sol is milled to have a D50 particle size ranging from 1 μm to 10 μm.

20. The method of claim 19, wherein the alumina sol is milled to have a D50 particle size ranging from 3 μm to 6 μm.

21. The method of claim 1 further comprising:

(iii) after step (ii), drying the treated substrate to remove excess amounts of the sorbent and to remove excess solvent to obtain a sorbent coated substrate.

22. The method of claim 21, wherein the drying occurs at a temperature range of 30° C to 70° C.

23. The method of claim 22, wherein the drying occurs at a temperature range of 40° C to 60° C.

24. The method of claim 23, wherein the drying occurs at a temperature 50° C.

25. The method of claim 1, wherein the solvent is selected from the group consisting of water, methanol, ethanol, toluene, isopropanol, 2-methoxyethyl ether, and mixtures thereof.

26. The method of claim 1, wherein the sorbent adsorbs carbon dioxide from air, from off-gases, intentionally produced carbon dioxide, or from their mixtures.

27. The method of claim 26, wherein the adsorbed carbon dioxide is stored and/or used in enhanced oil recovery, in carbonation of beverages, for food processing/cooling/freezing, as a reactant in the production of chemicals, as a feedstock for algae, or as a fire extinguishing medium.

28. The method of claim 1, wherein the sorbent purifies gases or separates gases.

29. The method of claim 1, wherein the sorbent adsorbs carbon dioxide to purify natural gas, ambient air, flue gas, or other impure gas mixtures containing carbon dioxide.

30. The method of claim 1, wherein the slurry further comprises a dispersant.

31. The method of claim 1, wherein the binder is added in an amount of up to about 10 wt % based on a total weight of the support.

32. The method of claim 1, wherein the binder is added in an amount of about 6 to about 25 wt % based on a total weight of the support.

33. The method of claim 1, wherein the sorbent is added in an amount of about 25 to about 40 wt% based on the total weight of the support.

34. The method of claim 1, wherein the support has a surface area of about 170 m^2/g to 180 m^2/g and a pore volume of about 0.9 cc/g to 1.2 cc/g.