Claims

1. A carbon capture mixed matrix membrane comprising:
   - a polymeric support layer comprising spatially ordered uniform sized pores; and
   - a carbon dioxide capture layer in contact with the polymeric support layer, the carbon dioxide capture layer comprising solid porous material with at least one carbon dioxide adsorption site, the solid porous material comprising an amine-functionalised material,

wherein amine groups comprised in the amine-functionalised material are adapted to react with carbon dioxide to absorb carbon dioxide, and wherein the solid porous material provides a higher surface area to increase carbon dioxide absorption.

2. The membrane according to claim 1, wherein the carbon dioxide capture layer is in contact with the polymeric support layer by being disposed on the polymeric support layer or embedded within the polymeric support layer.

3. The membrane according to claim 1 or 2, wherein the polymeric support layer comprises a patterned surface.

4. The membrane according to any preceding claim, wherein the polymeric support layer comprises spatially ordered through-holes.

5. The membrane according to any preceding claim, wherein the pores comprised in the polymeric support layer have a diameter of 100 nm – 100 µm.

6. The membrane according to any preceding claim, wherein the polymeric support layer has a thickness of 50-500 µm.

7. The membrane according to any preceding claim, wherein the polymeric support layer comprises polyvinylidene difluoride (PVDF), polyethersulfone (PES), polysulfone (PSF), polyether block amide (PEBA) or copolymers thereof.

8. The membrane according to any preceding claim, wherein the carbon dioxide capture layer comprises polyethyleneimine(PEI)@silica, PEI@graphene oxide, polyaniline(PANI)@graphene oxide, PEI@nanoporous carbons (NPCs), PEI@metal-organic framewoks (MOF),PEI@oxidised nanofibrillated cellulose (NFC), PEI@porous organic polymer, PEI@mesoporous molecular sieve, tetraethylenepentamine(TEPA)@grahene oxide, TEPA@silica, zeolite imidazolate framework 8 (ZIF-8), amine modified or unmodified copper benzene-1,3,5-tricarboxylate (Cu-BTC), or a combination thereof.

9. The membrane according to any preceding claim, wherein the solid porous material comprises pores having an average diameter of 1-100 nm.

10. The membrane according to any preceding claim, wherein the membrane has a thickness of 50-2500 μm.

11. The membrane according to any preceding claim, wherein the solid porous material comprises a porous particle template with particles having an average particle size of 5-100 nm.

12. A membrane module comprising at least one carbon capture mixed matrix membrane according to any preceding claim.

13. The membrane module according to claim 12, wherein the membrane module comprises two or more carbon capture mixed matrix membranes.

14. The membrane module according to claim 13, wherein each of the two or more carbon capture mixed matrix membranes comprises a polymeric support layer of uniform sized pores, the pores of each polymeric support layer having a different pore size, thereby forming a hierarchical membrane module.

15. A method of forming a carbon capture mixed matrix membrane according to any of claims 1 to 11, the method comprising:

- providing a polymeric support layer; and
- forming a carbon dioxide capture layer in contact with the polymeric support layer, wherein the carbon dioxide capture layer comprises solid porous material with at least one carbon dioxide adsorption site, the solid porous material comprising an amine-functionalised material,

wherein amine groups comprised in the amine-functionalised material are adapted to react with carbon dioxide to absorb carbon dioxide, and wherein the solid porous material provides a higher surface area to increase carbon dioxide absorption.

16. The method according to claim 15, wherein the forming comprises depositing the carbon capture layer on the polymeric support layer or embedding the carbon capture layer in the polymeric support layer.

17. The method according to claim 16, wherein the depositing comprises dip-coating, spin coating, casting, or a combination thereof.

18. The method according to claim 16, wherein the embedding comprises solution processing.