

Claims:

1. A composition for removal of a target substance from a fluid stream, the composition comprising:

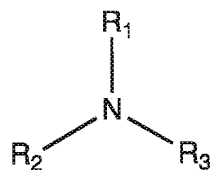
a support material comprising cellulose; and

a sorbent molecule that comprises a linear or branched polyamine having a molecular weight of less than 500;

wherein the polyamine is covalently linked to the support material; and

wherein the sorbent molecule further comprises a covalently linked hydrophobic group.

2. The composition of claim 1, wherein the support material is comprised of a material selected from one or more of the group consisting of: regenerated cellulose; lignocellulose; bacterial cellulose; cellulose pulp; microcrystalline or nanocrystalline cellulose; cellulose fibres; fibrillated cellulose and other cellulose derivatives.
3. The composition of claim 2, wherein the support material comprises a cellulose or lignocellulose powder or pulp.
4. The composition of claim 3, wherein the cellulose or lignocellulose powder or pulp is incorporated into a membrane or membrane-like filter.
5. The composition of any one of claims 1 to 4, wherein the support material comprises acetylated cellulose.
6. The composition of claim 1 or 2, wherein the support material is porous, solid, and particulate, suitably wherein the average diameter size of the particles is greater than about 0.01 mm, and less than about 1mm.
7. The composition of any one of claims 1 to 6, wherein the polyamine is selected from a linear or branched alkyl polyamine having a molecular weight of less than 300, optionally less than 200.
8. The composition of claim 7, wherein the polyamine is selected from a compound of Formula I,



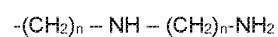
I

where R_1 and R_2 are selected from H, $-CH_3$ or a linear or branched $C_2 - C_6$ alkyl mono- or di- amine, and wherein R_1 and R_2 are not both H or $-CH_3$;

where R_3 is selected from:

a linear or branched $C_2 - C_6$ alkyl mono- or di- amine;

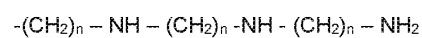
a linear dialkylamine of formula II:



II

where n may be any integer of between 2 and 6;

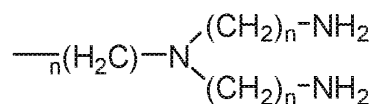
a linear alkylamine of formula III



III

where n may be any integer of between 2 and 6; and

a branched dialkylamine of formula IV:

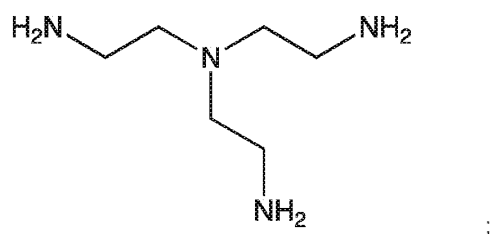


IV

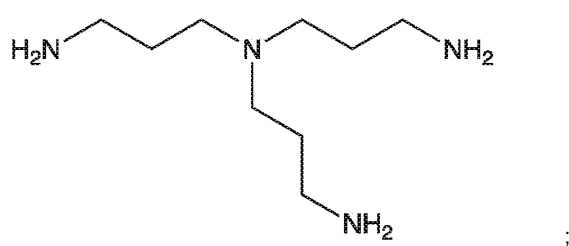
where n may be any integer of between 2 and 6.

9. The composition of claim 8, wherein the polyamine is selected from one or more of the following compounds:

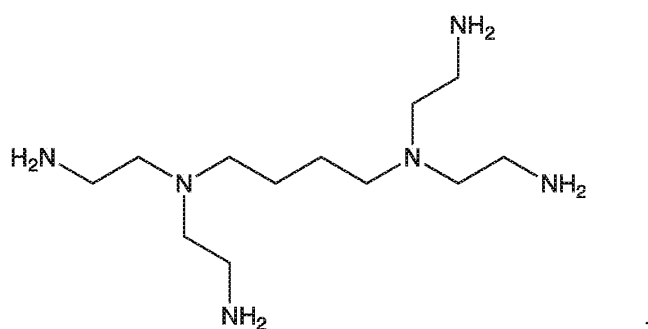
(i) Tris(2-aminoethyl)amine TREN



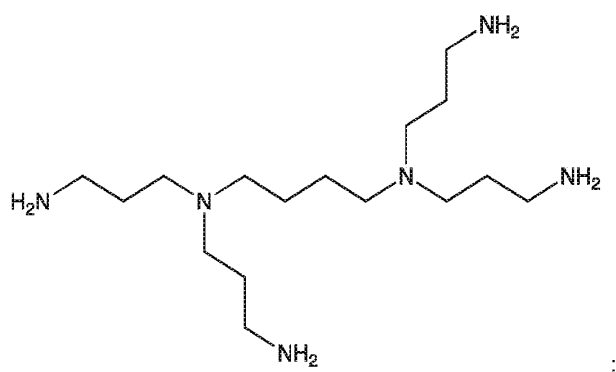
(ii) Tris (3-aminopropyl)amine



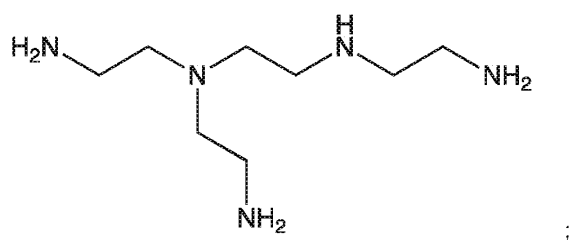
(iii) N,N,N',N'-tetrakis(2-aminoethyl)butane-1,4-diamine



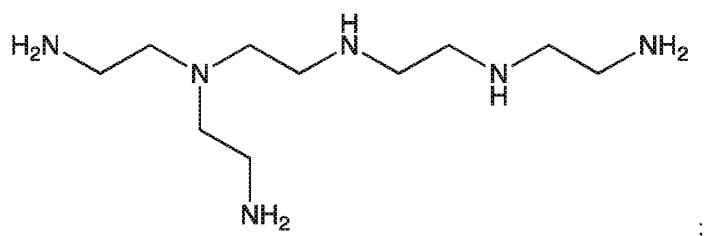
(iv) N,N,N',N'-Tetrakis(3-aminopropyl)-1,4-butanediamine



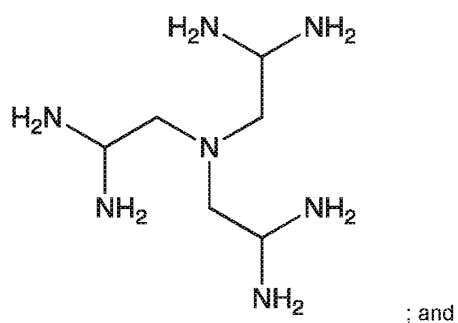
(v) Tris(2-aminoethyl)-N,N,N'-ethyldiamine



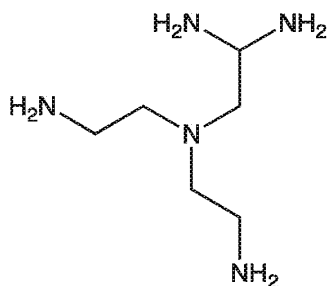
(vi) 1,11-diamino-3(2-aminoethyl)6,9-triazaundecane



(vii) 2-N,2-N-bis(2,2-diaminoethyl)ethane-1,1,2-triamine

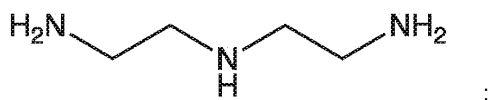


(viii) 2-N,2-N-bis(2-aminoethyl)ethane-1,1,2-triamine

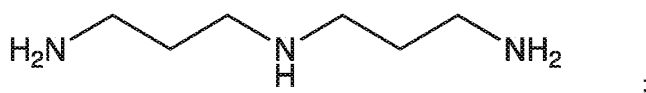


10. The composition of claim 8, wherein the polyamine is selected from one or more of the following compounds:

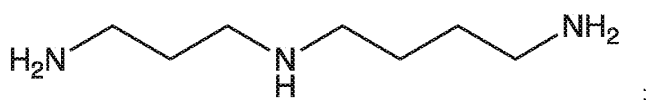
(a) diethylenetriamine



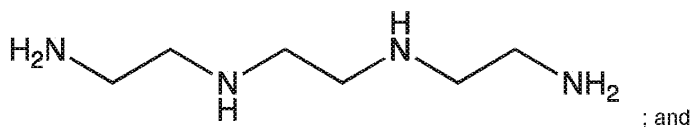
(b) bis(3-aminopropyl)amine



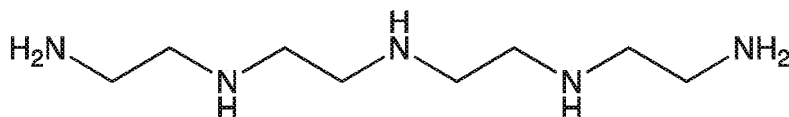
(c) spermidine



(d) triethylenetetramine



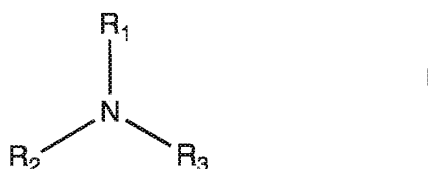
(e) tetraethylenepentamine



11. The composition of any one of claims 1 to 10, wherein the hydrophobic group comprises a group selected from: a C₂-C₂₂ branched, linear, saturated or unsaturated, or cyclic alkyl; a polyether; and an aryl.
12. The composition of claim 11, wherein the C₂-C₂₂ alkyl group is selected from the group consisting of a: butyl; hexyl; octyl; isobutyl; isohexyl; isooctyl; cyclohexyl; cycloheptyl; and cyclooctyl.
13. The composition of claim 12, wherein the aryl group is selected from phenol; or phenyl group.
14. The composition of any one of claims 1 to 13, wherein the hydrophobic group comprises a poly- or perfluoroalkyl group, suitably a C₈ perfluorooctane or C₈ polyfluorinated, 6:2 fluorotelomer.
15. The composition of any one of claims 1 to 14, wherein the sorbent molecule comprises a plurality of hydrophobic groups.
16. The composition of any one of claims 1 to 15, wherein the polyamine is linked to the hydrophobic group via a bond selected from the group consisting of: an amide bond; a urea linkage; a thiourea linkage; an isothiuronium linkage; a guanidinium linkage and a quaternisation (Menshutkin) reaction.
17. A process for removal of a target substance from a fluid stream comprising contacting the fluid stream with a composition as defined in any one of claims 1 to 16, and wherein the target substance comprises one or more poly- and perfluorinated alkyl substance (PFAS).
18. The process of claim 17, wherein the fluid comprises water, optionally contaminated water.
19. The process of any one of claims 17 or 18, wherein the PFAS is selected from a perfluorinated anionic surfactant compound, including one or more selected from the group consisting of: perfluorobutane sulfonate (PFBS); perfluorobutanoic acid (PFBA); perfluoropentanoic acid (PFPeA); perfluorohexanesulfonate (PFHS); perfluorohexanoic acid (PFHA); perfluorooctanoic acid (PFOA); perfluorooctane sulfonate (PFOS); perfluorononanoic acid (PFNA); and

perfluorodecanoic acid (PFDA); 6:2 fluorotelomer sulfonic acid (6:2 FTSA); and hexafluoropropylene oxide dimer acid (HFPO-DA).

20. The process of any one of claims 17 to 19, wherein the process further comprises regenerating the composition after removal of the contaminant substance from the fluid stream.
21. The process of claim 20, wherein regenerating the composition comprises applying one or more liquid washes to the composition, wherein the liquid wash comprises one or more of the group consisting of: an aqueous salt solution; a basic wash, optionally wherein the base is selected from ammonium hydroxide, sodium hydroxide, sodium bicarbonate and potassium hydroxide; and a polar organic solvent, optionally selected from an alcohol or a ketone.
22. A method for manufacturing a composition for removal of a contaminant substance from a fluid stream, the method comprising:
- providing a support material comprising cellulose; and
 - linking the support material to a contaminant-sorbent molecule comprising a linear or branched polyamine having a molecular weight of less than 500, wherein the sorbent molecule further comprises a covalently linked hydrophobic group.
23. The method of claim 22, wherein the sorbent molecule comprises a covalently linked hydrophobic group.
24. The method of any one of claims 22 or 23, wherein the support material is comprised of a material selected from one or more of the group consisting of: lignocellulose; bacterial cellulose; microcrystalline cellulose; microfibrillated cellulose and a cellulose derivative.
25. The method of any one of claims 22 to 24, wherein before linking to the contaminant-sorbent molecule, the support material is activated by reaction with halogenated alkyl or acyl halides, suitably alkyl bromide, bromoacetyl bromide, or bromosuccinimide.
26. The method of any one of claims 22 to 25, wherein before linking to the contaminant-sorbent molecule, the support material is reacted with acetic anhydride.
27. The method of any one of claims 22 to 26, wherein the polyamine is selected from a compound of formula I,



where R_1 and R_2 are selected from H, $-\text{CH}_3$ or a linear or branched $\text{C}_2 - \text{C}_6$ alkyl mono- or di- amine,;

where R_3 is selected from:

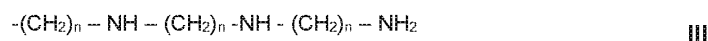
a linear or branched $\text{C}_2 - \text{C}_6$ alkyl mono- or di- amine;

a linear dialkylamine of formula II:



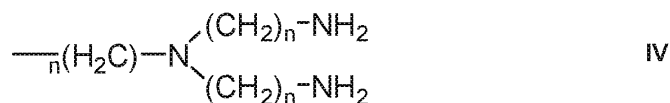
where n may be any integer of between 2 and 6;

a linear alkylamine of formula III



where n may be any integer of between 2 and 6; or

a branched dialkylamine of formula IV:



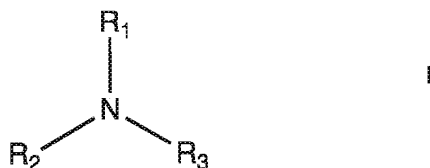
where n may be any integer of between 2 and 6.

28. The use of a molecule that comprises a linear or branched polyamine having a molecular weight of less than 500 and at least one covalently linked hydrophobic group as a sorbent group in a method for functionalising a cellulose support material.

29. The use of claim 28, wherein the functionalised cellulose support material is capable of removal of a target substance from a fluid stream, and also being regenerated following removal of the target substance.

30. The use of claim 29, wherein the target substance comprises a PFAS.

31. The use of any one of claims 28 to 30, wherein the polyamine is selected from a compound of formula I,



where R_1 and R_2 are selected from H, $-CH_3$ or a linear or branched $C_2 - C_6$ alkyl mono- or di- amine,;

where R_3 is selected from:

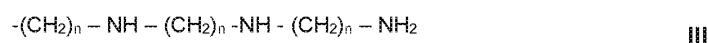
a linear or branched $C_2 - C_6$ alkyl mono- or di- amine;

a linear dialkylamine of formula II:



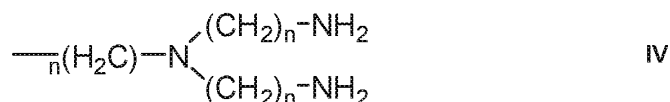
where n may be any integer of between 2 and 6;

a linear alkylamine of formula III



where n may be any integer of between 2 and 6; or

a branched dialkylamine of formula IV:



where n may be any integer of between 2 and 6.

32. The use of any one of claims 29 to 31, wherein the hydrophobic group comprises a group selected from: a C_2 - C_{22} branched, linear, saturated or unsaturated, or cyclic alkyl; a polyether; and an aryl.

33. The use of claim 32, wherein the C_2 - C_{22} alkyl group is selected from the group consisting of a: butyl; hexyl; octyl; isobutyl; isohexyl; isooctyl; cyclohexyl; cycloheptyl; and cyclooctyl.

34. The use of claim 32, wherein the aryl group is selected from phenol; or phenyl group.

35. The use of any one of claims 29 to 31, wherein the hydrophobic group comprises a poly- or perfluoroalkyl group, suitably a C₈ perfluorooctane or C₈ polyfluorinated, 6:2 fluorotelomer.
36. The use of any one of claims 29 to 35, wherein the sorbent molecule comprises a plurality of hydrophobic groups.
37. The use of any one of claims 29 to 36, wherein the polyamine is linked to the hydrophobic group via a bond selected from the group consisting of: an amide bond; a urea linkage; a thiourea linkage; an isothiuronium linkage; a guanidinium linkage and a quaternisation (Menshutkin) reaction.
38. The use of any one of claims 29 to 37, wherein the cellulose support material is comprised of a material selected from one or more of the group consisting of: regenerated cellulose; lignocellulose; bacterial cellulose; cellulose pulp; microcrystalline or nanocrystalline cellulose; cellulose fibres; fibrillated cellulose and other cellulose derivatives.
39. The use of claim 38, wherein the cellulose support material comprises a cellulose or lignocellulose powder or pulp.
40. The use of claim 39, wherein the cellulose or lignocellulose powder or pulp is incorporated into a membrane or membrane-like filter.
41. The use of any one of claims 29 to 40, wherein the cellulose support material comprises acetylated cellulose.
42. The use of any one of claims 29 to 41, wherein the cellulose support material is porous, solid, and particulate, suitably wherein the average diameter size of the particles is greater than about 0.01 mm, and less than about 1mm.
43. A filter for the adsorption of a target substance from a contaminated water source, wherein the filter comprises a composition as described in any one of claims 1 to 16.
44. The filter of claim 43, wherein the target substance comprises one or more PFAS.
45. The filter of any one of claims 43 and 44, wherein the filter may be regenerated by applying one or more liquid washes to the filter, wherein the liquid wash comprises: an aqueous salt solution; a basic wash, optionally wherein the base is selected from ammonium hydroxide, sodium hydroxide, sodium bicarbonate and potassium hydroxide; a polar organic solvent, optionally selected from an alcohol or a ketone.

46. The filter of any one of claims 42 to 45, wherein the filter is in the form of a filter cartridge.

47. The filter of any one of claims 42 to 46, wherein the filter comprises at least one filter membrane.