Claims

1. Chromatography media comprising:

porous inorganic particles having a median pore diameter of from about 600 Å to about 1600 Å; a pore size distribution relative span of at least about 0.75; and a functionalized surface comprising an average of from greater than 1 to about 3 linker molecules per square nanometer of surface area of said porous inorganic particles.

2. Chromatography media comprising:

porous inorganic particles having a median pore diameter of from about 600 Å to about 1600 Å; a pore size distribution relative span of at least about 0.75; and a functionalized surface comprising a protein covalently bonded to surface portions of said porous inorganic particles, said protein having a molecular weight ranging from about 10,000 to about 100,000 D.

3. The chromatography media of claim 2, wherein said protein is covalently bonded to surface portions of said porous inorganic particles via an average of greater than about 1 to about 3 linker molecules per square nanometer of surface area of said porous inorganic particles.

4. Chromatography media comprising:

porous inorganic particles having an average BET surface area of from about 20 m^2/g to about 100 m^2/g; an average pore volume of at least about 1 ml/g; a pore size distribution relative span of at least about 0.75; a functionalized surface comprising an average of from greater than about 1 to about 3 linker molecules per square nanometer of surface area of said porous inorganic particles; and a protein covalently bonded to at least some of said linker molecules, said protein having a molecular weight ranging from about 10,000 to about 100,000 D.

5. The chromatography media of any one of claims 1 to 4, wherein said porous inorganic particles have a pore size distribution relative span of at least about 0.9, preferably at least about 0.99, more preferred from about 1.0 to about 1.3.

6. The chromatography media of any one of claims 1 to 5, wherein at least 40% of the total pore volume is in pores having a diameter between about 600 Å to about 1600 Å, preferably from about 40% to about 90 % of the total pore volume, and/or wherein at least 20% of the total pore volume have pores in a diameter ranging from about 1000 Å to about 1600 Å, preferably from about 20% to about 60% of the total pore volume, and/or wherein at least 15% of the total pore volume have pores in a diameter ranging from about 1200 Å to about 1500 Å, preferably from about 15% to about 30% of the total pore volume.

7. The chromatography media of any one of claims 1 to 3 and 5 to 6, wherein said porous inorganic particles have an average BET surface area of greater than about 10 m^2/g, preferably from about 20 m^2/g to about 200 m^2/g, more preferred from about 25 m^2/g to about 100 m^2/g.

8. The chromatography media of any one of claims 1 to 3 and 5 to 7, wherein said porous inorganic particles have an average pore volume of at least about 1 ml/g.

9. The chromatography media of claim 8, wherein said porous inorganic particles have an average particle dimension of from about 30 µm to about 120 µm, preferably from about 50 µm to about 90 µm, more preferred of about 70 µm.

10. The chromatography media of any one of claims 1 to 9, wherein said porous inorganic particles comprise silica, alumina, zirconia, or mixtures thereof, preferably comprise silica, and more preferred silica having at least 97% by weight SiO_2 based upon a total weight of said porous inorganic particles.

11. The chromatography media of any one of claims 1 to 10, wherein said functionalized surface comprises a reaction product resulting from a reaction between (i) hydroxyl groups on said porous inorganic particles and (ii) a silane, preferably an epoxy silane, more preferred (3-glycidyloxypropyl) trimethoxysilane.

12. The chromatography media of claim 1, wherein each of said linker molecules comprises a diol and/or wherein said functionalized surface comprises (i) a diol group and (ii) unreacted hydroxyl groups on said porous inorganic particles.

13. The chromatography media of claim 12, wherein said diol is present in an amount ranging from about 30 to about 150 µmol/g of said porous inorganic particles, preferably from about 50 to about 100 µmol/g of said porous inorganic particles.

14. The chromatography media of claim 1, wherein each of said linker molecules comprises an aldehyde.

15. The chromatography media of any one of claims 1 and 5 to 14, wherein said functionalized surface comprises a protein covalently linked to surfaces of said porous inorganic particles via at least some of said linker molecules.

16. The chromatography media of any one of claims 2 to 15, wherein said functionalized surface comprises (i) said protein covalently linked to surface portions of said porous inorganic particles and (ii) unreacted hydroxyl groups on said porous inorganic particles.

17. The chromatography media of any one of claims 2 to 11 and 15 to 16, wherein said protein comprises Protein A, preferably a recombinant Protein A (rProA), wherein said protein preferably is present in an amount ranging from about 4.0 to about 16 mg/ml of said porous inorganic particles, more preferred from about 5.0 to about 12 mg/ml of said porous inorganic particles.

18. The chromatography media of any one of claims 1 to 17, wherein said chromatography media, when used in an affinity column, has a non-specific protein binding level of less than about 20.0 ng/ml, preferably of less than about 5.0 ng/ml, and/or has a dynamic binding capacity of at least 30 mg/ml, preferably from about 30 to about 90 mg/ml.

19. A method for making the chromatography media of any one of claims 1 to 18, said method comprising:

forming the porous inorganic particles; and

reacting surface portions of the porous inorganic particles with at least one reactant so as to form the functionalized surface.

20. The method of claim 19, wherein said forming step comprises forming porous inorganic particles via a particle-forming process selected from the group consisting of gelation, precipitation, aggregation, or combinations thereof, preferably via a gelation process.

21. The method of any one of claims 19 to 20, wherein the at least one reactant comprises a silane, preferably an epoxy silane, more preferred (3-glycidyloxypropyl) trimethoxysilane.

22. The method of any one of claims 22 to 23, further comprising:

converting at least one functional group on the silane to a hydroxyl group so as to form a diol, wherein preferably the functionalized surface comprises (i) a diol and (ii) unreacted hydroxyl groups on the porous inorganic particles.

23. The method of claim 22, wherein the diol is present on the surface in an amount ranging from about 30 to about 150 µmol/g of the porous inorganic particles, preferably from about 50 to about 100 µmol/g of the porous inorganic particles.

24. The method of any one of claims 22 to 23, further comprising:

converting at least one diol to an aldehyde group, preferably further comprising reacting at least one aldehyde group with at least one free amino group on the desired protein to form an imine group and, optionally, reducing the imine group to an amine, and more preferred further comprising covalently bonding a protein to the functionalized surface via an imino or amino group.

25. The method of any one of claims 19 to 24, wherein the functionalized surface comprises a protein covalently linked to surfaces of the porous inorganic particles and preferably also comprises unreacted hydroxyl groups on the porous inorganic particles.

26. A chromatography device comprising:

a device housing; and

chromatography media positioned within said device housing, said

chromatography media comprising the chromatography media of any one of claims 1 to 18.

27. The chromatography device of claim 26, wherein said device housing comprises a tubular housing member, and at least one separate and attachable tubular housing member end cap.

28. The chromatography device of claim 26 or 27, wherein said device housing comprises a polymeric material, a metal material, a glass material, a ceramic material, or a composite thereof, preferably a biodegradable polymeric material, or a metal material, preferably stainless steel.

29. The chromatography device of any one of claims 26 to 28, wherein said chromatography device comprises an affinity column, and/or wherein said chromatography device has a device back pressure of less than 5.0 bar when said chromatography media is run at a linear velocity of about 1000 cm/h.

30. Chromatography media comprising:

porous inorganic particles having a median pore diameter of from about 600 Å to about 1600 Å; a pore size distribution relative span of at least about 0.75 and a pore size distribution such that at least about 20% of the total pore volume have pores in a diameter ranging from about 1000 Å to about 1600 Å.

31. The chromatography media of claim 30, wherein the porous inorganic particles have a functionalized surface comprising an average of from greater than 1 to about 3 linker molecules per square nanometer of surface area of said porous inorganic particles.

32. The chromatography media of any one of claims 30 to 31, wherein at least 40% of the total pore volume is in pores having a diameter between about 600 Å to about 1600 Å, preferably from about 40% to about 90 % of the total pore volume, and/or wherein at least 20% to about 60% of the total pore volume have pores in a diameter ranging from about 1000 Å to about 1600 Å, and/or wherein at least 15% of the total

pore volume have pores in a diameter ranging from about 1200 Å to about 1500 Å, preferably from about 15% to about 30% of the total pore volume.