AFFINITY CHROMATOGRAPHY DEVICES CONTAINING A HEAT TREATED FIBRILLATED POLYMER MEMBRANE AND MANIFOLDS CONTAINING THE SAME

FIELD

[0001] The present disclosure relates generally to affinity chromatography, and more specifically, to an affinity chromatography device that includes a fibrillated heat treated polymer membrane containing therein spherical particles, a particle size distribution that has a D90/D10 less than or equal to 3, and which enables the separation of a targeted molecule from an aqueous mixture. Manifolds containing multiple affinity chromatography devices and manifolds in a parallel configuration are also disclosed.

BACKGROUND

[0002] Chromatographic methods generally are used to separate and/or purify molecules of interest such as proteins, nucleic acids, and polysaccharides from a mixture. Affinity chromatography specifically involves passing the mixture over a matrix having a ligand specific (*i.e*. a specific binding partner) for the molecule of interest bound to it. Upon contacting the ligand, the molecule of interest is bound to the matrix and is therefore retained from the mixture. Affinity chromatography provides certain advantages over other types of chromatography. For example, affinity chromatography provides a purification method that can isolate a target protein from a mixture of the target protein and other biomolecules in a single step in high yield.

[0003] Despite the advantages of current affinity chromatography devices, there exists a need in the art for a chromatography device that can be used at shorter residence times than conventional devices while providing the same binding capacity or better binding capacities than current offerings and that is re-useable.

SUMMARY

[0003a] In a first aspect of the present disclosure, there is provided an article comprising:

an affinity chromatography device including:

a fluid inlet;

a fluid outlet fluidly connected to the fluid inlet;

a fibrillated heat treated polymer membrane positioned between the fluid inlet and fluid outlet and containing therein inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns;

a housing encompassing the fluid inlet, the fluid outlet and the fibrillated heat treated polymer membrane,

wherein a particle size distribution has a D90/D10 less than or equal to 3, and

wherein at least one of the fibrillated heat treated polymer membrane and the inorganic particles has covalently bonded thereto an affinity ligand that reversibly binds to a targeted molecule.

[0003b] In another aspect of the present disclosure, there is provided a manifold comprising at least two of the affinity chromatography devices as disclosed herein arranged in a parallel configuration; and optionally

wherein the manifold is contained within a housing.

[0003c] In yet another aspect of the present disclosure, there is provided a use of the article as disclosed herein to separate the targeted molecule from a fluid stream.

[0003d] In a further aspect of the present disclosure, there is provided a device comprising a first manifold and a second manifold in a parallel configuration, wherein each of the first manifold and the second manifold includes at least two of the affinity chromatography devices as disclosed herein; and optionally

wherein the first manifold and the second manifold are enclosed within a housing.

[0004] In one ~~Aspect~~Example (“~~Aspect~~Example 1”), an affinity chromatography device includes a fluid inlet, a fluid outlet connected to the fluid inlet, a fibrillated heat treated polymer membrane positioned between the fluid inlet and fluid outlet and containing therein inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns, a housing encompassing the fluid inlet, the fluid outlet

and the fibrillated heat treated polymer membrane, where a particle size distribution has a D90/D10 less than or equal to 3, and where at least one of the fibrillated heat treated polymer membrane and the inorganic particles has covalently bonded thereto an affinity ligand that reversibly binds to a targeted molecule.

[0005] According to another ~~Aspect~~Example ("~~Aspect~~Example 2") further to ~~Aspect~~Example 1, where the targeted molecule is a protein, antibody, viral vector, and combinations thereof.

[0006] According to another ~~Aspect~~Example ("~~Aspect~~Example 3") further to ~~Aspect~~Example 1 or ~~Aspect~~Example 2, a hydraulic permeability from about 200 (X 10^{-12} cm^2) to about 700 (X 10^{-12} cm^2).

[0007] According to another ~~Aspect~~Example ("~~Aspect~~Example 4") further to any one of ~~Aspect~~Examples 1 to 3, the inorganic particles having a spherical shape are selected from silica, zeolites, hydroxyapatite, metal oxides and combinations thereof.

[0008] According to another ~~Aspect~~Example ("~~Aspect~~Example 5") further to any one of ~~Aspect~~Examples 1 to 4, where the fibrillated polymer membrane comprises an expanded polytetrafluoroethylene membrane, an expanded modified polytetrafluoroethylene membrane, an expanded tetrafluoroethylene copolymer membrane, or an expanded polyethylene membrane.

[0009] According to another ~~Aspect~~Example ("~~Aspect~~Example 6") further to any one of ~~Aspect~~Examples 1 to 5, where the fibrillated heat treated polymer membrane is an expanded polytetrafluoroethylene membrane.

[00010] According to another ~~Aspect~~Example ("~~Aspect~~Example 7") further to any one of ~~Aspect~~Examples 1 to 6, where the affinity ligand is selected from Protein A, Protein G, Protein L, human Fc receptor protein, antibodies, polysaccharides and combinations thereof.

[00011] According to another ~~Aspect~~Example ("~~Aspect~~Example 8") further to any one of ~~Aspect~~Examples 1 to 7, where the inorganic particles comprise at least a first inorganic particle having a spherical shape and a first nominal particle size and a second inorganic particle having a spherical shape and a second nominal particle size, the first and second nominal particle sizes being different from each other.

[00012] According to another ~~Aspect~~Example ("~~Aspect~~Example 9") further to any one of ~~Aspect~~Examples 1 to 8, where the nominal particle size is selected from about 5 microns, about 10 microns, about 15 microns, about 20 microns, and combinations thereof.

[00013] According to another ~~Aspect~~Example ("~~Aspect~~Example 10") further to any one of ~~Aspect~~Examples 1 to 9 where the inorganic particles having a spherical shape comprise a blend of 10 micron spherical particles and 20 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00014] According to another ~~Aspect~~Example (“~~Aspect~~Example 11”) further to any one of ~~Aspect~~Examples 1 to 9, where the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 10 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00015] According to another ~~Aspect~~Example (“~~Aspect~~Example 12”) further to any one of ~~Aspect~~Examples 1 to 9, where the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 20 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00016] According to another ~~Aspect~~Example (“~~Aspect~~Example 13”) further to any one of ~~Aspect~~Examples 1 to 12, including a dynamic binding capacity (DBC) of at least 35 mg/ml at a residence time of 20 seconds.

[00017] According to another ~~Aspect~~Example (“~~Aspect~~Example 14”) further to any one of ~~Aspect~~Examples 1 to 13, including a cycling durability of at least 100 cycles at an operating pressure less than 0.3 MPa.

[00018] According to another ~~Aspect~~Example (“~~Aspect~~Example 15”) further to any one of ~~Aspect~~Examples 1 to 14, where the fibrillated heat treated polymer membrane has a wound configuration.

[00019] According to another ~~Aspect~~Example (“~~Aspect~~Example 16”) further to any one of ~~Aspect~~Examples 1 to 15, where the fibrillated polymer membrane has a stacked configuration.

[00020] According to another ~~Aspect~~Example (“~~Aspect~~Example 17”) further to any one of ~~Aspect~~Examples 1 to 16, where the fibrillated polymer membrane has a wound configuration, a stacked configuration, and a combination thereof.

[00021] According to another ~~Aspect~~Example (“~~Aspect~~Example 18”) further to any one of ~~Aspect~~Examples 1 to 17, where an inner intermediate material is circumferentially positioned on an outer surface of a core and where the fibrillated polymer membrane is circumferentially positioned on the inner intermediate material.

[00022] According to another ~~Aspect~~Example (“~~Aspect~~Example 19”) further to any one of ~~Aspect~~Examples 1 to 18, including an outer intermediate material circumferentially positioned on the heat treated fibrillated polymer membrane.

[00023] According to another ~~Aspect~~Example (“~~Aspect~~Example 20”) further to any one of ~~Aspect~~Examples 1 to 19, where the inner intermediate material and outer intermediate material are selected from a porous fluoropolymer film, a porous non-fluoropolymer film, a porous non-woven material and a porous woven material.

[00024] According to another ~~Aspect~~Example (“~~Aspect~~Example 21”) further to any one of ~~Aspect~~Examples 1 to 20, where at least one of the inner intermediate material and outer intermediate material is a polypropylene non-woven material.

[00025] In one ~~Aspect~~Example (“~~Aspect~~Example 22”) a manifold includes at least two of the affinity chromatography devices of any one of claims 1 to 21 are arranged in a parallel configuration.

[00026] According to another ~~Aspect~~Example (“~~Aspect~~Example 23”) further to ~~Aspect~~Example 22, where the manifold is enclosed within a housing.

[00027] According to another ~~Aspect~~Example (“~~Aspect~~Example 24”) where the article of any one of ~~Aspect~~Examples 1 to 21 is used to separate the targeted substance from a biological sample.

[00028] In one ~~Aspect~~Example (“~~Aspect~~Example 25”) a device includes a first manifold and a second manifold in a parallel configuration and where each of the first manifold and the second manifold includes a plurality of the affinity chromatography device of any one of ~~Aspect~~Examples 1 to 21.

[00029] In another ~~Aspect~~Example (“~~Aspect~~Example 26”) further to ~~Aspect~~Example 25, where the first manifold and the second manifold are enclosed within a housing.

[00030] According to one ~~Aspect~~Example (“~~Aspect~~Example 27”), an article includes a centrally located core, a fibrillated heat treated polymer membrane containing therein spherical inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns wound around the core, a housing surrounding both the core and the fibrillated heat treated polymer membrane, a first end cap positioned at a first end of the housing, and a second end cap positioned at a second end of the housing, a particle size distribution has a D90/D10 less than 3, and where at least one of the fibrillated heat treated polymer membrane and the spherical inorganic particles has covalently bonded thereto an affinity ligand that reversibly binds to a targeted molecule.

[00031] According to another ~~Aspect~~Example (“~~Aspect~~Example 28”) further to ~~Aspect~~Example 27, where the targeted molecule is a protein, antibody, viral vector, and combinations thereof.

[00032] According to another ~~Aspect~~Example (“~~Aspect~~Example 29”) further to ~~Aspect~~Example 27 or ~~Aspect~~Example 28, including a hydraulic permeability from about 200 (X 10^{12} cm^2) to about 700 (X 10^{12} cm^2).

[00033] According to another ~~Aspect~~Example (“~~Aspect~~Example 30”) further to any one of ~~Aspect~~Examples 27 to 29, where the inorganic particles having a spherical shape are selected from silica, zeolites, hydroxyapatite, metal oxides and combinations thereof.

[00034] According to another ~~Aspect~~Example (“~~Aspect~~Example 31”) further to any one of ~~Aspect~~Examples 27 to 30, where the fibrillated polymer membrane includes at least one of an expanded polytetrafluoroethylene membrane, an expanded modified polytetrafluoroethylene membrane, an expanded tetrafluoroethylene copolymer membrane, or an expanded polyethylene membrane.

[00035] According to another ~~Aspect~~Example (“~~Aspect~~Example 32”) further to any one of ~~Aspect~~Examples 27 to 31, where the fibrillated heat treated polymer membrane is a fibrillated heat treated expanded polytetrafluoroethylene membrane.

[00036] According to another ~~Aspect~~Example (“~~Aspect~~Example 33”) further to any one of ~~Aspect~~Examples 27 to 32, where the affinity ligand is selected from Protein A, Protein G, Protein L, human Fc receptor protein, antibodies, polysaccharides and combinations thereof.

[00037] According to another ~~Aspect~~Example (“~~Aspect~~Example 34”) further to any one of ~~Aspect~~Examples 27 to 33, where the inorganic particles comprise at least a first inorganic particle having a spherical shape and a first nominal particle size and a second inorganic particle having a spherical shape and a second nominal particle size, and where the first and second nominal particle sizes are different from each other.

[00038] According to another ~~Aspect~~Example (“~~Aspect~~Example 35”) further to any one of ~~Aspect~~Examples 27 to 34, where the nominal particle size is selected from about 5 microns, about 10 microns, about 15 microns, about 20 microns, and combinations thereof.

[00039] According to another ~~Aspect~~Example (“~~Aspect~~Example 36”) further to any one of ~~Aspect~~Examples 27 to 35, the inorganic particles having a spherical shape comprise a blend of 10 micron spherical particles and 20 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00040] According to another ~~Aspect~~Example (“~~Aspect~~Example 37”) further to any one of ~~Aspect~~Examples 27 to 35, where the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 10 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00041] According to another ~~Aspect~~Example (“~~Aspect~~Example 38”) further to any one of ~~Aspect~~Examples 27 to 35, where the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 20 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00042] According to another ~~Aspect~~Example (“~~Aspect~~Example 39”) further to any one of ~~Aspect~~Examples 27 to 38, including a dynamic binding capacity (DBC) of at least 35 mg/ml at a residence time of 20 seconds.

[00043] According to another ~~Aspect~~Example (“~~Aspect~~Example 40”) further to any one of ~~Aspect~~Examples 27 to 39, including a cycling durability of at least 100 cycles and an operating pressure less than 0.3 MPa.

[00044] According to another ~~Aspect~~Example (“~~Aspect~~Example 41”) further to any one of ~~Aspect~~Examples 27 to 40, where an inner intermediate material is circumferentially positioned on an outer surface of a core and the fibrillated heat treated polymer membrane is circumferentially positioned on the inner intermediate material.

[00045] According to another ~~Aspect~~Example (“~~Aspect~~Example 42”) further to any one of ~~Aspect~~Examples 27 to 41, including an outer intermediate material circumferentially positioned on the fibrillated heat treated polymer membrane

[00046] According to another ~~Aspect~~Example (“~~Aspect~~Example 43”) further to any one of ~~Aspect~~Examples 27 to 42, where the inner intermediate material and the outer intermediate material are selected from a porous fluoropolymer film, a porous non-fluoropolymer film, a porous non-woven material and a porous woven material.

[00047] According to another ~~Aspect~~Example (“~~Aspect~~Example 44”) further to any one of ~~Aspect~~Example 27 to 43, where at least one of the inner intermediate material and the outer intermediate material is a polypropylene non-woven material.

[00048] In one ~~Aspect~~Example (“~~Aspect~~Example 45”) a manifold includes at least two of the affinity chromatography devices of any one of ~~Aspect~~Examples 27 to 44 arranged in a parallel configuration.

[00049] According to another ~~Aspect~~Example (“~~Aspect~~Example 46”) further to ~~Aspect~~Example 45, where the manifold is enclosed within a housing.

[00050] In one ~~Aspect~~Example (“~~Aspect~~Example 47”) a device includes a first manifold and a second manifold in a parallel configuration where each of the first manifold and the second manifold includes at least two of the affinity chromatography device of any one of ~~Aspect~~Examples 27 to 44.

[00051] According to another ~~Aspect~~Example (“~~Aspect~~Example 48”) further to ~~Aspect~~Example 47, the first manifold and the second manifold are enclosed within a housing.

[00052] According to another ~~Aspect~~Example (“~~Aspect~~Example 49”) where the article of any one of ~~Aspect~~Examples 27 to 44 are used to separate the targeted molecule from a fluid stream.

[00053] According to one ~~Aspect~~Example ("~~Aspect~~Example 50"), an affinity chromatography device includes a housing, an inlet to permit fluid flow into the housing, first and second flow distributors, said first flow distributor and said second flow distributor positioned at opposing ends of said housing, an outlet to permit fluid flow out of said housing, a stacked membrane assembly disposed within said housing between the fluid inlet and fluid outlet, said stacked membrane assembly, where the stacked membrane assembly includes two or more fibrillated heat treated polymer membranes in a stacked configuration, where the fibrillated heat treated polymer membrane contains therein inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns, where a particle size distribution has a D90/D10 less than 3, and where at least one of the fibrillated heat treated polymer membrane and the spherical inorganic particles has covalently bonded thereto an affinity ligand that reversibly binds to a targeted molecule.

[00054] According to another ~~Aspect~~Example ("~~Aspect~~Example 51") further to ~~Aspect~~Example 50, where the targeted molecule is a protein, antibody, viral vector, and combinations thereof.

[00055] According to another ~~Aspect~~Example ("~~Aspect~~Example 52") further to ~~Aspect~~Example 50 or ~~Aspect~~Example 51, including first and second flow distributors, said first flow distributor and said second flow distributor positioned at opposing ends of the housing.

[00056] According to another ~~Aspect~~Example ("~~Aspect~~Example 53") further to any one of ~~Aspect~~Examples 50 to 52 including a hydraulic permeability from about 200 (X 10^{-12} cm^2) to about 700 (X 10^{-12} cm^2).

[00057] According to another ~~Aspect~~Example ("~~Aspect~~Example 54") further to any one of ~~Aspect~~Examples 50 to 53, where the inorganic particles having a spherical shape are selected from silica, zeolites, hydroxyapatite, metal oxides and combinations thereof.

[00058] According to another ~~Aspect~~Example ("~~Aspect~~Example 55") further to any one of ~~Aspect~~Examples 50 to 54, where the fibrillated polymer membrane includes an expanded polytetrafluoroethylene membrane, an expanded modified polytetrafluoroethylene membrane, an expanded tetrafluoroethylene copolymer membrane, or an expanded polyethylene membrane.

[00059] According to another ~~Aspect~~Example ("~~Aspect~~Example 56") further to any one of ~~Aspect~~Examples 50 to 55, where the fibrillated heat treated polymer membrane is a fibrillated heat treated expanded polytetrafluoroethylene membrane.

[00060] According to another ~~Aspect~~Example (“~~Aspect~~Example 57”) further to any one of ~~Aspect~~Examples 50 to 56, the affinity ligand is selected from Protein A, Protein G, Protein L, human Fc receptor protein, antibodies, polysaccharides and combinations thereof.

[00061] According to another ~~Aspect~~Example (“~~Aspect~~Example 58”) further to any one of ~~Aspect~~Examples 50 to 57, where the inorganic particles comprise at least a first inorganic particle having a spherical shape and a first nominal particle size and a second inorganic particle having a spherical shape and a second nominal particle size, where the first and second nominal particle sizes are different from each other.

[00062] According to another ~~Aspect~~Example (“~~Aspect~~Example 59”) further to any one of ~~Aspect~~Examples 50 to 58, where the nominal particle size is selected from about 5 microns, about 10 microns, about 15 microns, about 20 microns, and combinations thereof.

[00063] According to another ~~Aspect~~Example (“~~Aspect~~Example 60”) further to any one of ~~Aspect~~Examples 50 to 59, where the inorganic particles having a spherical shape comprises a blend of10 micron spherical particles and 20 micron spherical particles, and where the blend is from 90:10 to 10:90.

[00064] According to another ~~Aspect~~Example (“~~Aspect~~Example 61”) further to any one of ~~Aspect~~Examples 50 to 59, where the inorganic particles having a spherical shape comprises a blend of 5 micron spherical particles and 10 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00065] According to another ~~Aspect~~Example (“~~Aspect~~Example 62”) further to any one of ~~Aspect~~Examples 50 to 59, the inorganic particles having a spherical shape comprises a blend of 5 micron spherical particles and 20 micron spherical particles, and where the blend is from 10:90 to 90:10.

[00066] According to another ~~Aspect~~Example (“~~Aspect~~Example 63”) further to any one of ~~Aspect~~Examples 50 to 62, including a dynamic binding capacity (DBC) of at least 35 mg/ml at a residence time of 20 seconds.

[00067] According to another ~~Aspect~~Example (“~~Aspect~~Example 64”) further to any one of ~~Aspect~~Examples 50 to 63, where a cycling durability of at least 100 cycles and an operating pressure less than 0.3 MPa.

[00068] According to another ~~Aspect~~Example (“~~Aspect~~Example 65”) further to any one of ~~Aspect~~Examples 50 to 64, where at least one upper intermediate material is positioned on a first side of the stacked membrane assembly and a lower intermediate material is positioned on a second side of the stacked membrane assembly, where the second side opposes the first side.

[00069] According to another ~~Aspect~~Example (“~~Aspect~~Example 66”) further to ~~Aspect~~Example 65, where the first intermediate material and the second intermediate material are selected from a porous fluoropolymer film, a porous non-fluoropolymer film, a porous non-woven material and a porous woven material.

[00070] According to another ~~Aspect~~Example (“~~Aspect~~Example 67”) further to ~~Aspect~~Example 66, where at least one of the first intermediate material and the second intermediate material is a polypropylene non-woven material.

[00071] In one ~~Aspect~~Example (“~~Aspect~~Example 68”) a manifold includes at least two of the affinity chromatography devices of any one of ~~Aspect~~Examples 50 to 67 arranged in a parallel configuration.

[00072] According to another ~~Aspect~~Example (“~~Aspect~~Example 69”) further to ~~Aspect~~Example 68, where the manifold is contained within a housing.

[00073] In one ~~Aspect~~Example (“~~Aspect~~Example 70”) a device includes a first manifold and a second manifold in a parallel configuration and where each of the first manifold and the second manifold includes at least two of the affinity chromatography devices of any one of ~~Aspect~~Examples 50 to 69.

[00074] In another ~~Aspect~~Example (“~~Aspect~~Example 71”) further to ~~Aspect~~Example 70, where the first manifold and the second manifold are enclosed within a housing.

[00075] In one ~~Aspect~~Example (“~~Aspect~~Example 72”) an article includes a diagnostic device that includes a fibrillated polymer membrane positioned between the fluid inlet and fluid outlet and containing therein inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns, where a particle size distribution has a D90/D10 less than or equal to 3, and where at least one of the fibrillated polymer membrane and the inorganic particles has covalently bonded thereto a ligand that reversibly binds to a targeted substance within a biological sample.

[00076] According to another ~~Aspect~~Example (“~~Aspect~~Example 73”) further to ~~Aspect~~Example 72, including a fluid inlet and a fluid outlet fluidly connected to the fluid inlet.

[00077] According to another ~~Aspect~~Example (“~~Aspect~~Example 74”) further to ~~Aspect~~Example 72 or ~~Aspect~~Example 73, including a housing member encompassing the fluid inlet, the fluid outlet and the fibrillated polymer membrane

WHAT IS CLAIMED IS:

1. An article comprising:

an affinity chromatography device including:

a fluid inlet;

a fluid outlet fluidly connected to the fluid inlet;

a fibrillated heat treated polymer membrane positioned between the fluid inlet and fluid outlet and containing therein inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns;

a housing encompassing the fluid inlet, the fluid outlet and the fibrillated heat treated polymer membrane,

wherein a particle size distribution has a D90/D10 less than or equal to 3, and

wherein at least one of the fibrillated heat treated polymer membrane and the inorganic particles has covalently bonded thereto an affinity ligand that reversibly binds to a targeted molecule.

2. The article of claim 1, wherein the targeted molecule is a protein, antibody, viral vector and combinations thereof.

3. The article of claim 1 or claim 2, comprising a hydraulic permeability from about 200 (X 10^{-12} cm^2) to about 700 (X 10^{-12} cm^2).

4. The article of any one of claims 1 to 3, wherein the inorganic particles having a spherical shape are selected from silica, zeolites, hydroxyapatite, metal oxides and combinations thereof.

5. The article of any one of claims 1 to 4, wherein the fibrillated heat treated polymer membrane comprises an expanded polytetrafluoroethylene membrane, an expanded modified polytetrafluoroethylene membrane, an expanded tetrafluoroethylene copolymer membrane, or an expanded polyethylene membrane.

~~6. The article of any one of claims 1 to 5, wherein the fibrillated polymer membrane is an expanded polytetrafluoroethylene membrane.~~

6~~7~~. The article of any one of claims 1 to 5~~6~~, wherein the affinity ligand is selected from Protein A, Protein G, Protein L, human Fc receptor protein, antibodies, polysaccharides and combinations thereof.

7~~8~~. The article of any one of claims 1 to ~~7~~6, wherein the inorganic particles comprise at least a first inorganic particle having a spherical shape and a first nominal particle size and a second inorganic particle having a spherical shape and a second nominal particle size, the first and second nominal particle sizes being different from each other.

8~~9~~. The article of any one of claims 1 to 7~~8~~, wherein the nominal particle size is selected from about 5 microns, about 10 microns, about 15 microns, about 20 microns, and combinations thereof.

9~~10~~. The article of any one of claims 1 to 8~~9~~, wherein the inorganic particles having a spherical shape comprise a blend of 10 micron spherical particles and 20 micron spherical particles, and wherein the blend is from 10:90 to 90:10; or~~.~~

~~11. The article of any one of claims 1 to 9,~~ wherein the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 10 micron spherical particles, and wherein the blend is from 10:90 to 90:10; or~~.~~

~~12. The article of any one of claims 1 to 9,~~ wherein the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 20 micron spherical particles, and wherein the blend is from 10:90 to 90:10.

10~~13~~. The article of any one of claims 1 to 9~~12~~, comprising a dynamic binding capacity (DBC) of at least 35 mg/ml at a residence time of 20 seconds.

11~~14~~. The article of any one of claims 1 to 10~~13~~, comprising a cycling durability of at least 100 cycles at an operating pressure less than 0.3 MPa.

12~~15~~. The article of any one of claims 1 to 11~~14,~~ wherein the fibrillated heat treated heat treated polymer membrane has a wound configuration; or~~.~~

~~16. The article of any one of claims 1 to 15,~~ wherein the fibrillated polymer membrane has a stacked configuration.

~~17. The article of any one of claims 1 to 16, wherein the fibrillated polymer membrane has a wound configuration, a stacked configuration, and a combination thereof.~~

13~~18~~. The article of any one of claims 1 to 12~~17~~, wherein an inner intermediate material is circumferentially positioned on an outer surface of a core and wherein the fibrillated heat treated polymer membrane is circumferentially positioned on the inner intermediate material.

14~~19~~. The article of any one of claims 1 to 13~~18~~, comprising an outer intermediate material circumferentially positioned on the heat treated fibrillated polymer membrane.

15~~20~~. The article of any one of claims 1 to 14~~19~~, wherein the inner intermediate material and the outer intermediate material are selected from a porous fluoropolymer film, a porous non-fluoropolymer film, a porous non-woven material and a porous woven material.

~~21. The article of any one of claims 1 to 20, wherein at least one of the inner intermediate material and the outer intermediate material is a polypropylene non-woven material.~~

16~~22~~. A manifold comprising at least two of the affinity chromatography devices of any one of claims 1 to 15~~21~~ arranged in a parallel configuration; and optionally~~.~~

~~23. The manifold of claim 22,~~ wherein the manifold is contained within a housing.

17~~24~~. Use of the article of any one of claims 1 to 16~~21~~ to separate the targeted molecule from a fluid stream.

18~~25~~. A device comprising a first manifold and a second manifold in a parallel configuration, wherein each of the first manifold and the second manifold includes at least two of the affinity chromatography devices of any one of claims 1 to 16~~21.~~; and optionally

~~26. The device of claim 25,~~ wherein the first manifold and the second manifold are enclosed within a housing.

~~27. An article comprising:~~

~~a centrally located core;~~

~~a fibrillated heat treated polymer membrane containing therein spherical inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns wound around the core;~~

~~a housing surrounding both the core and the fibrillated heat treated polymer membrane,~~

~~a first end cap positioned at a first end of the housing, and~~

~~a second end cap positioned at a second end of the housing,~~

~~wherein a particle size distribution has a D90/D10 less than 3, and~~

~~wherein at least one of the fibrillated heat treated polymer membrane and the spherical inorganic particles has covalently bonded thereto an affinity ligand that reversibly binds to a targeted molecule.~~

~~28. The article of claim 27, wherein the targeted molecule is a protein, antibody, viral vector and combinations thereof.~~

~~29. The article of claim 27 or claim 28 comprising a hydraulic permeability from about 200 (X 10^{12} cm^2) to about 700 (X 10^{12} cm^2).~~

~~30. The article of any one of claims 27 to 29, wherein the inorganic particles having a spherical shape are selected from silica, zeolites, hydroxyapatite, metal oxides and combinations thereof.~~

~~31. The article of any one of claims 27 to 30, wherein the fibrillated heat treated polymer membrane includes at least one of an expanded polytetrafluoroethylene membrane, an expanded modified polytetrafluoroethylene membrane, an expanded tetrafluoroethylene copolymer membrane, or an expanded polyethylene membrane.~~

~~32. The article of any one of claims 27 to 31, wherein the fibrillated heat treated polymer membrane is a fibrillated heat treated expanded polytetrafluoroethylene membrane.~~

~~33. The article of any one of claims 27 to 32, wherein the affinity ligand is selected from Protein A, Protein G, Protein L, human Fc receptor protein, antibodies, polysaccharides and combinations thereof.~~

~~34. The article of any one of claims 27 to 33, wherein the inorganic particles comprise at least a first inorganic particle having a spherical shape and a first nominal particle size and a second inorganic particle having a spherical shape and a second nominal particle size, the first and second nominal particle sizes being different from each other.~~

~~35. The article of any one of claims 27 to 33, wherein the nominal particle size is selected from about 5 microns, about 10 microns, about 15 microns, about 20 microns, and combinations thereof.~~

~~36. The article of any one of claims 27 to 33, wherein the inorganic particles having a spherical shape comprise a blend of 10 micron spherical particles and 20 micron spherical particles, and wherein the blend is from 10:90 to 90:10.~~

~~37. The article of any one of claims 27 to 31, wherein the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 10 micron spherical particles, and wherein the blend is from 10:90 to 90:10.~~

~~38. The article of any one of claims 27 to 33, wherein the inorganic particles having a spherical shape comprise a blend of 5 micron spherical particles and 20 micron spherical particles, and wherein the blend is from 10:90 to 90:10.~~

~~39. The article of any one of claims 27 to 38, comprising a dynamic binding capacity (DBC) of at least 35 mg/ml at a residence time of 20 seconds.~~

~~40. The article of any one of claims 27 to 39, comprising a cycling durability of at least 100 cycles and an operating pressure less than 0.3 MPa.~~

~~41. The article of any one of claims 27 to 40, wherein an inner intermediate material is circumferentially positioned on an outer surface of a core and the fibrillated heat treated polymer membrane is circumferentially positioned on the inner intermediate material.~~

~~42. The article of any one of claims 27 to 41, comprising an outer intermediate material circumferentially positioned on the fibrillated heat treated polymer membrane.~~

~~43. The article of any one of claims 27 to 42, wherein the inner intermediate material and the outer intermediate material are selected from a porous fluoropolymer film, a porous non-fluoropolymer film, a porous non-woven material and a porous woven material.~~

~~44. The article of any one of claims 27 to 43, wherein at least one of the inner intermediate material and the outer intermediate material is a polypropylene non-woven material.~~

~~45. A manifold comprising at least two of the affinity chromatography devices of any one of claims 27 to 44 arranged in a parallel configuration.~~

~~46. The manifold of claim 45, wherein the manifold is enclosed within a housing.~~

~~47. A device comprising a first manifold and a second manifold in a parallel configuration, wherein each of the first manifold and the second manifold includes at least two of the affinity chromatography devices of any one of claims 27 to 44.~~

48. The device of claim 47, wherein the first manifold and the second manifold are enclosed within a housing.

49. Use of the article of any one of claims 27 to 44 to separate the targeted molecule from a fluid stream.

50. An article comprising:

an affinity chromatography device including:

a housing member;

an inlet to permit fluid flow into said housing;

an outlet to permit fluid flow out of said housing, and

a stacked membrane assembly disposed within said housing between the fluid inlet and fluid outlet, said stacked membrane assembly comprising:

two or more fibrillated heat treated polymer membranes in a stacked configuration, each said fibrillated polymer membrane containing therein inorganic particles having a spherical shape and a blend of nominal particle sizes, the nominal particle sizes being from about 5 microns to about 20 microns,

wherein a particle size distribution has a D90/D10 less than 3, and

wherein at least one of the fibrillated heat treated polymer membrane and the spherical inorganic particles has covalently bonded thereto an affinity ligand that reversibly binds to a targeted molecule.

51. The article of claim 50, wherein the targeted molecule is a protein, antibody, viral vector and combinations thereof.

52. The article of claim 50 or claim 51, comprising first and second flow distributors, said first flow distributor and said second flow distributor positioned at opposing ends of said housing.

53. The article of any one of claims 50 to 52, comprising a hydraulic permeability from about 200 (X 10^{-12} cm^2) to about 700 (X 10^{-12} cm^2).

54. The article of any one of claims 50 to 53 wherein the inorganic particles having a spherical shape are selected from silica, zeolites, hydroxyapatite, metal oxides and combinations thereof.

55. The article of any one of claims 50 to 54, wherein the fibrillated heat treated polymer membrane includes an expanded polytetrafluoroethylene membrane, an expanded modified polytetrafluoroethylene membrane, an expanded tetrafluoroethylene copolymer membrane, or an expanded polyethylene membrane.

56. The article of any one of claims 50 to 55, wherein the fibrillated heat treated polymer membrane is a fibrillated heat treated expanded polytetrafluoroethylene membrane.

57. The article of any one of claims 50 to 56, wherein the affinity ligand is selected from Protein A, Protein G, Protein L, human Fc receptor protein, antibodies, polysaccharides and combinations thereof.

58. The article of any one of claims 50 to 57, wherein the inorganic particles comprise at least a first inorganic particle having a spherical shape and a first nominal particle size and a second inorganic particle having a spherical shape and a second nominal particle size, the first and second nominal particle sizes being different from each other.

59. The article of any one of claims 50 to 58, wherein the nominal particle size is selected from about 5 microns, about 10 microns, about 15 microns, about 20 microns, and combinations thereof.

60. The article of any one of claims 50 to 59, wherein the inorganic particles having a spherical shape comprises a blend of 10 micron spherical particles and 20 micron spherical particles, and wherein the blend is from 90:10 to 10:90.

61. The article of any one of claims 50 to 59, wherein the inorganic particles having a spherical shape comprises a blend of 5 micron spherical particles and 10 micron spherical particles, and wherein the blend is from 10:90 to 90:10.

62. The article of any one of claims 50 to 59, wherein the inorganic particles having a spherical shape comprises a blend of 5 micron spherical particles and 20 micron spherical particles, and wherein the blend is from 10:90 to 90:10.

63. The article of any one of claims 50 to 62, comprising a dynamic binding capacity (DBC) of at least 35 mg/ml at a residence time of 20 seconds.

64. The article of any one of claims 50 to 63, comprising a cycling durability of at least 100 cycles an operating pressure less than 0.3 MPa.

65. The article of any one of claims 50 to 64, wherein at least one first intermediate material is positioned on a first side of the stacked membrane assembly and a second intermediate material is positioned on a second side of the stacked membrane assembly, the second side opposing the first side.

66. The article of claim 65, wherein the first intermediate material and the second intermediate material are selected from a porous fluoropolymer film, a porous non-fluoropolymer film, a porous non-woven material and a porous woven material.

67. The article of claim 67, wherein at least one of the first intermediate material and the second intermediate material is a polypropylene non-woven material.

68. A manifold comprising at least two of the affinity chromatography devices of any one of claims 50 to 67 arranged in a parallel configuration.

69. The manifold of claim 68, wherein the manifold is enclosed within a housing.

70. A device comprising a first manifold and a second manifold in a parallel configuration, wherein each of the first manifold and the second manifold includes at least two of the affinity chromatography devices of any one of claims 50 to 69.

71. The device of claim 70, wherein the first manifold and second manifold are enclosed within a housing.

~~72. An article comprising:~~

~~A diagnostic device including:~~

~~a fibrillated polymer membrane positioned between the fluid inlet and fluid outlet and containing therein inorganic particles having a spherical shape and a nominal particle size from about 5 microns to about 20 microns,~~

~~wherein a particle size distribution has a D90/D10 less than or equal to 3, and~~

~~wherein at least one of the fibrillated polymer membrane and the inorganic particles has covalently bonded thereto a ligand that reversibly binds to a targeted substance within a biological sample.~~

~~73. The article of claim 72, comprising a fluid inlet and a fluid outlet fluidly connected to the fluid inlet.~~

~~74. The article of claim 72 or claim 73, comprising a housing member encompassing the fluid inlet, the fluid outlet and the fibrillated polymer membrane.~~