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(54) Title: FLUID PURIFICATION COMPOSITIONS AND METHODS OF FLUID PURIFICATION USING THE SAME

(57) Abstract: Described herein is a composition comprising porous particles, wherein the porous particles comprise an organic polymer and further comprise functional groups that selectively and reversibly bind blood components. Also described herein is method of dispersing a medical composition in a filtration unit, the method comprising the steps of: providing a vessel comprising a medical composition: securing the vessel to a filtration unit; and depositing the composition into the filtration unit; wherein the medical composition comprises porous particles comprising at least one organic polymer; the filtration unit comprises a filtration membrane having hollow fiber pores; and the average diameter of the porous particles is larger than the hollow fiber pores of the filtration membrane. Also described herein is a method of synthesizing polymer beads.



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/31697

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. B01J 20/24, B01J 20/26, B01J 20/28 (2023.01)
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CPC - INV. B01J 20/24, B01J 20/26, B01J 20/28, B01J 20/28016, B01J 20/28021

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Wang et al., "Selective potassium uptake via biocompatible zeolite-polymer hybrid microbeads as promising binders for hyperkalemia" 24 August 2020 (24.08.2020) entire document especially Page 543, Para 1; Page 544, Para 6; Page 553, Para 6; Figure 3E	1-13
A	US 2010/0029545 A1 (Sumerlin et al.) 04 February 2010 (04.02.2010) entire document	1-13
A	US 2021/0154322 A1 (UNIVERSITY OF NOTRE DAME DU LAC) 27 May 2021 (27.05.2021) entire document	1-13
A	US 2016/0022180 A1 (Thomas Jefferson University) 28 January 2016 (28.01.2016) entire document	1-13

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/31697

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-13, directed to a composition comprising porous particles, wherein the porous particles comprise an organic polymer and further comprise functional groups that selectively and reversibly bind blood components; wherein the porous particles have a core and a shell; and wherein the core and the shell have different porosity.

Group II: Claims 14, directed to a method of removing potassium or phosphate from the blood of a subject, the method comprising the steps of: providing the dialyzer of claim 12; and dialyzing the blood of the subject using the dialyzer.

***** Continued on Supplemental Page *****

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-13

- Remark on Protest**
- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
 - The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
 - No protest accompanied the payment of additional search fees.

Box III Continued

Group III: Claims 15-17, directed to a method of dispersing a medical composition in a filtration unit, the method comprising the steps of: providing a vessel comprising a medical composition; securing the vessel to a filtration unit; and depositing the composition into the filtration unit; wherein the medical composition comprises porous particles comprising at least one organic polymer; the filtration unit comprises a filtration membrane having hollow fiber pores; and the average diameter of the porous particles is larger than the hollow fiber pores of the filtration membrane.

Groups IV: Claims 18 and 19, directed to a system for the removal of a blood component from the blood of a patient, the system comprising: a dialyzer unit having a blood inlet, a blood outlet, and dialysate inlet, and a dialysate outlet; wherein the blood inlet and blood outlet are fluidly connected, and the dialysate inlet and the dialysate outlet are fluidly connected; a dialysate containment vessel which is fluidly connected to the dialysate inlet port via a filtration line and a bypass line; wherein the bypass line includes a bypass valve between the dialyzer unit and the dialysate vessel; wherein the filtration line includes a filtration cartridge fluidly connected to the dialysate containment vessel and the dialysate inlet and a valve between the purification cartridge and the dialysate containment vessel; and wherein the filtration cartridge comprises the composition of any of claims 1-9.

Groups V: Claims 20, directed to a method of synthesizing polymer beads, the method comprising the steps of: dispersing a polymer in a solvent to give a polymer solution; adding a blowing agent to the polymer solution; and treating the polymer solution with a base, acid, or microwaves, to form polymer beads.

The group of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features:

Group II requires the special technical feature of a method of removing potassium or phosphate from the blood of a subject, the method comprising the steps of: providing the dialyzer of claim 12; and dialyzing the blood of the subject using the dialyzer not required by Groups I and III-V.

Group III requires the special technical feature of a method of dispersing a medical composition in a filtration unit, the method comprising the steps of: providing a vessel comprising a medical composition; securing the vessel to a filtration unit; and depositing the composition into the filtration unit; wherein the medical composition comprises porous particles comprising at least one organic polymer; the filtration unit comprises a filtration membrane having hollow fiber pores; and the average diameter of the porous particles is larger than the hollow fiber pores of the filtration membrane, not required by Groups I, II, IV and V.

Group IV requires the special technical feature of a system for the removal of a blood component from the blood of a patient, the system comprising: a dialyzer unit having a blood inlet, a blood outlet, and dialysate inlet, and a dialysate outlet; wherein the blood inlet and blood outlet are fluidly connected, and the dialysate inlet and the dialysate outlet are fluidly connected; a dialysate containment vessel which is fluidly connected to the dialysate inlet port via a filtration line and a bypass line; wherein the bypass line includes a bypass valve between the dialyzer unit and the dialysate vessel; wherein the filtration line includes a filtration cartridge fluidly connected to the dialysate containment vessel and the dialysate inlet and a valve between the purification cartridge and the dialysate containment vessel; and wherein the filtration cartridge comprises the composition of any of claims 1-9, not required by Groups I-III and V.

Group V requires the special technical feature of a method of synthesizing polymer beads, the method comprising the steps of: dispersing a polymer in a solvent to give a polymer solution; adding a blowing agent to the polymer solution; and treating the polymer solution with a base, acid, or microwaves, to form polymer beads, not required by Groups I-IV.

Common technical features:

Groups I, II, and IV share the technical feature of a composition comprising porous particles, wherein the porous particles comprise an organic polymer and further comprise functional groups that selectively and reversibly bind blood components; wherein the porous particles have a core and a shell; and wherein the core and the shell have different porosity.

These shared technical features, however, do not provide a contribution over the prior art, as being anticipated by "Selective potassium uptake via biocompatible zeolite-polymer hybrid microbeads as promising binders for hyperkalemia" to Wang et al. (hereinafter "Wang").

***** Continued on Supplemental Page *****

Box III Continued

Wang teaches a composition comprising porous particles (Page 543, Para 1 "Treatments primarily rely on orally administered potassium binding agents, along with low curative effects and various side effects. Herein, direct serum potassium uptake was realized via zeolite-heparin-mimicking-polymer hybrid microbeads. The preparation process involved the synthesis of the heparin-mimicking polymer via the in situ cross-linking polymerization of acrylic acid and N-vinylpyrrolidone in polyethersulfone solution, the fabrication of microbeads via zeolite-mixing, electro-spraying and phase-inversion, and the subsequent aqueous-phase modifications based on ion-exchange and metal-leaching. An ultra-high (about 88%) amount of zeolite could be incorporated and well locked inside the polymer matrix. Potassium uptake capability was verified in water, normal saline and human serum, showing high selectivity and fast adsorption. The microbeads exhibited satisfying blood compatibility, negligible hemolysis ratio, prolonged clotting time, inhibited contact activation, and enhanced antifouling property toward serum proteins and cells. The proposed approach toward zeolite-heparin-mimicking-polymer hybrid microbeads provided a cheap, efficient and safe treatment protocol of hyperkalemia for the high-risk patients"), wherein the porous particles comprise an organic polymer (Page 543, Para 1 "The preparation process involved the synthesis of the heparin-mimicking polymer via the in situ cross-linking polymerization of acrylic acid and N-vinylpyrrolidone in polyethersulfone solution, the fabrication of microbeads via zeolite-mixing, electro-spraying and phase-inversion, and the subsequent aqueous-phase modifications based on ion-exchange and metal-leaching", this is an appropriate polymer see instant claim 3) and further comprise functional groups that selectively and reversibly bind blood components (Page 543, Para 1 "Treatments primarily rely on orally administered potassium binding agents, along with low curative effects and various side effects. Herein, direct serum potassium uptake was realized via zeolite-heparin-mimicking-polymer hybrid microbeads. The preparation process involved the synthesis of the heparin-mimicking polymer via the in situ cross-linking polymerization of acrylic acid and N-vinylpyrrolidone in polyethersulfone solution, the fabrication of microbeads via zeolite-mixing, electro-spraying and phase-inversion, and the subsequent aqueous-phase modifications based on ion-exchange and metal-leaching. An ultra-high (about 88%) amount of zeolite could be incorporated and well locked inside the polymer matrix. Potassium uptake capability was verified in water, normal saline and human serum, showing high selectivity and fast adsorption. The microbeads exhibited satisfying blood compatibility, negligible hemolysis ratio, prolonged clotting time, inhibited contact activation, and enhanced antifouling property toward serum proteins and cells. The proposed approach toward zeolite-heparin-mimicking-polymer hybrid microbeads provided a cheap, efficient and safe treatment protocol of hyperkalemia for the high-risk patients", potassium is a blood component); wherein the porous particles have a core and a shell (Figure 3E, see item "the multilayered structure with hierarchical porosity"); and wherein the core and the shell have different porosity (Figure 3E, see item "the multilayered structure with hierarchical porosity").

As the technical features were known in the art at the time of the invention, they cannot be considered a special technical feature that would otherwise unify the groups. Groups I-V therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.