Claims

1. A sorbent for removing metabolic waste products from a dialysis liquid, the sorbent comprising a homogeneous mixture of: (a) uremic toxin-treating enzyme particles comprising a uremic toxin-treating enzyme immobilized on a solid support; (b) cation exchange particles configured to exchange ammonium ions for predominantly hydrogen ions and to exchange essential cations predominantly for sodium ions; and (c) anion exchange particles, and further comprising a soluble source of sodium ions, wherein the cation exchange particles are set to a pH range of from 3.5 to 5.0.

2. A sorbent as claimed in claim 1 wherein the soluble source of sodium ions is a soluble salt.

3. A sorbent as claimed in claim 2 wherein the soluble salt is a basic salt.

4. A sorbent as claimed in claim 3 wherein the soluble salt is selected from one or more of the group consisting of sodium carbonate, sodium bicarbonate and sodium hydroxide.

5. A sorbent as claimed in claim 4 wherein the soluble salt is sodium bicarbonate.

6. A sorbent as claimed in claim 2 wherein the soluble salt is a neutral salt or a salt of a weak acid.

7. A sorbent as claimed in any one of claims 1 to 6 comprising particles of the soluble source of sodium ions.

8. A sorbent as claimed in any one of claims 1 to 7 wherein said cation exchange particles are set to a pH of 4.5.

9. A sorbent as claimed in any one of claims 1 to 8 wherein said cation exchange particles comprise an amorphous, water-insoluble metal phosphate in protonated form.

10. A sorbent as claimed in claim 9 wherein the metal is selected from the group consisting of titanium, zirconium, hafnium and combinations thereof.

11. A sorbent as claimed in claim 10 wherein the metal is zirconium.

12. A sorbent as claimed in any one of claims 1 to 11 wherein said anion exchange particles are set to a pH in the range of from 7 to 14, preferably from 12 to 13.

13. A sorbent as claimed in any one of claims 1 to 12, wherein said anion exchange particles comprise an amorphous and partly hydrated, water-insoluble metal oxide in its hydroxide-, carbonate-, acetate-, and/or lactate- counter-ion form, wherein the metal may be selected from the group consisting of titanium, zirconium, hafnium and combinations thereof.

14. A sorbent as claimed in claim 13 wherein the anion exchange particles are hydrous zirconium oxide particles.

15. A sorbent as claimed in any one of claims 1 to 14 wherein the ratio of cation exchange particle to anion exchange particle is in the range of from 1:1 to 5:1, preferably in the range of 2:1 to 3:1, more preferably about 2.4:1.

16. A sorbent as claimed in any one of claims 1 to 15, wherein said uremic toxin-treating enzyme particles comprise a urease.

17. A sorbent as claimed in any one of claims 1 to 16, further comprising organic compounds absorber particles.

18. A sorbent as claimed in any one of claims 1 to 17 further comprising a carbonic anhydrase.

19. A process of preparing a sorbent comprising mixing particles of a soluble source of sodium ions and: (a) uremic toxin-treating enzyme particles comprising a uremic toxin-treating enzyme immobilized on a solid support; (b) cation exchange particles configured to exchange ammonium ions for predominantly hydrogen ions and to exchange essential cations for sodium ions; (c) anion exchange particles; and (d) organic compounds absorber particles, wherein the cation exchange particles are set to a pH range of from 3.5 to 5.0.

20. A sorbent for removing metabolic waste products from a dialysis liquid, wherein the sorbent hydrolyses urea to ammonium and bicarbonate, and comprises cation exchange particles set to a pH range of from 3.5 to 5.0, such that said sorbent binds ammonium predominantly in exchange for protons.

21. A sorbent for removing metabolic waste products from a dialysis liquid, wherein the sorbent (a) hydrolyses urea to ammonium and bicarbonate, and (b) binds ammonium predominantly in exchange for protons and binds essential cations predominantly in exchange for sodium ions, wherein the sorbent comprises cation exchange particles set to a pH range of from 3.5 to 5.0.

22. A sorbent cartridge comprising a sorbent as claimed in any one of claims 1 to 18 and 20 to 21 contained within a cartridge.

23. A dialysis system for treating and recycling dialysate, the system comprising a sorbent cartridge that comprises a sorbent as described in any one of claims 1 to 18 and 20 to 21, or a sorbent cartridge as described in claim 22, which releases a predicted amount of sodium following ion exchange in the sorbent, a conduit for conveying spent dialysate from a source of spent dialysate to the sorbent cartridge, a conduit for conveying regenerated dialysate from the sorbent cartridge to the source of spent dialysate, and an infusate system for dosing an infusate solution comprising essential cations to the regenerated dialysate such that the solution combines with the predicted release of sodium ions from the sorbent cartridge to generate a predetermined dialysate sodium concentration.

24. A dialysis system as claimed in claim 23 further comprising a source of salts other than calcium, magnesium and potassium salts for addition to the regenerated dialysate, typically sodium chloride.

25. A dialysis system as claimed in either one of claims 23 or 24 wherein pH of the regenerated dialysate is maintained within a range of 6 to 8.

26. A dialysis system as claimed in claim 23 wherein the concentration of cation equivalents in the infusate solution is approximately equal to a predetermined dialysate sodium ion concentration so that ion exchange in the sorbent, followed by addition of the infusate solution provides a target dialysate sodium concentration.

27. A process for regenerating dialysate in a dialysis process, comprising repeating the steps of:

(a) conveying spent dialysate from a source of spent dialysate to a sorbent which (i) hydrolyses urea to ammonium and bicarbonate, and (ii) binds ammonium predominantly in exchange for protons and binds essential cations predominantly in exchange for sodium ions, to produce regenerated dialysate;

(b) introducing essential cations to the regenerated dialysate to reconstitute the dialysate; and

(c) conveying reconstituted dialysate from the sorbent to the source of spent dialysate;

characterised in that a predetermined concentration of sodium ions is generated following ion exchange in the sorbent and that the sorbent comprises cation exchange particles set to a pH range of from 3.5 to 5.0.

28. A process as claimed in claim 27 wherein the essential cations are introduced as infusate solution and the concentration of cation equivalents in the infusate solution is approximately equal to a predetermined dialysate sodium ion concentration so that ion exchange in the sorbent, followed by addition of the infusate solution provides a target dialysate sodium concentration.

29. A sorbent which (a) hydrolyses urea to ammonium and bicarbonate, and (b) binds ammonium predominantly in exchange for protons and binds essential cations predominantly in exchange for sodium ions, to produce regenerated dialysate for use in regenerating dialysate in a dialysis process, wherein the sorbent comprises cation exchange particles set to a pH range of from 3.5 to 5.0.

30. A kit comprising a sorbent as claimed in any one of claims 1 to 18 or 20 to 21 or a sorbent cartridge as claimed in claim 22 and an infusate comprising salts of essential ions.

31. A kit as claimed in claim 30 wherein the infusate is in the form of an infusate solution in which the concentration of essential cations is approximately equal to a target sodium ion concentration or the kit includes instructions to prepare an infusate solution in which the concentration of essential cations is approximately equal to a target sodium ion concentration.