CLAIMS

1. A method of making an anion exchange membrane, comprising:

mixing a tertiary amine monomer with a quaternization agent to produce a functional monomer;

mixing a cross-linking agent and a solvent with the functional monomer to form a monomeric solution; and

casting the monomeric solution on a polymeric microporous substrate to form the anion exchange membrane.

2. The method of claim 1, wherein the tertiary amine monomer is selected from the group consisting of 1-vinylimidazole, 2-methyl-1-vinylimidazole, 9-vinylcarbazole, N-ethyl-2-vinylcarbazole, 2-vinylpyridine, 3-vinylpyridine, 4-vinylpyridine, and mixtures thereof.

3. The method of claim 2, wherein the quaternization agent is selected from the group consisting of benzyl chloride, benzyl bromide, benzyl iodide, p-dichlorobenzene, m-dichlorobenzene, 1,4-dichloro-2-nitrobenzene, 3-(Benzyloxy)benzyl chloride, 4-(Benzyloxy)benzyl chloride 2-(Trifluoromethyl)- benzyl chloride, 3-(Trifluoromethyl)benzyl chloride, 4-(Trifluoromethyl)benzyl chloride, 1-chlorohexane, 1-chloropentane, 1-chlorobutane, 1-chloropropane, 1,6 dichlorohexane, 1,5-dichloropentane, 1,4-dichlorobutane, 1,3-dichloropropane, 1-bromohexane, 1-bromopentane, 1-bromobutane, 1-bromopropane, 1,6- dibromohexane, 1,5-dibromopentane, 1,4-dibromobutane, 1,3-dibromopropane, 1-iodohexane, 1-iodopentane, 1-iodobutane, 1-iodoopropane, 1-iodideethane, 1-iodidemethane,1,6-diiodohexane, 1,5-diiodorpentane, 1,4-diiodobutane,1,3-diiodopropane, and mixtures thereof.

4. The method of claim 3, wherein the cross-linking agent is selected from the group consisting of vinylbenzyl chloride, m-divinylbenzene, ethyleneglycol-dimethacrylate, p-dichlorobenzene, m-dichlorobenzene, 1,4-dichloro-2-nitrobenzene, 1,6 dichlorohexane, 1,5-dichloropentane, 1,4-dichlorobutane, 1,3-dichloropropane, 1,6- dibromohexane, 1,5-dibromopentane, 1,4-dibromobutane, 1,3-dibromopropane, 1,6- dibromohexane, 1,5-dibromopentane, 1,4-dibromobutane, 1,3-dibromopropane, 1,4-butanediol dimethacrylate, 1,4-butanediol diacrylate, 1,6-hexanediol diacrylate, Pentaerythritol triacrylate, divinyl benzene, (m- and p-mixture), trimethylolpropane triacrylate, trimethylolpropane

trimethacrylate, ethoxylated (n) bisphenol A di(meth)acrylate (n=1.5, 2, 4, 6, 10, 30), ethoxylated (n) trimethylolpropanetri(meth)Acrylate (n= 3,6,9,10,15,20), propoxylated(n) trimethylolpropane triacrylate (n =3,6), and mixtures thereof.

5. The method of claim 4, wherein the solvent comprises dipropyleneglycol, n-propanol, 2-propanol, 1-methyl-2-pyrrolidinone, 1-butanol, and mixtures thereof.

6. The method of claim 5, further comprising mixing a polymerization initiator with the monomer solution.

7. The method of claim 6, wherein the polymerization initiator is selected from the group consisting of organic peroxides, 2,2' azobis[2,[2-imdazolin-2-yl]-propane] dihydrochloride, α,α'-azoisobutyronitrile, 2,2'-azobis[2-methylpropioaminidine] dihydrochloride , 2,2'-azobis [2, [2 -imdazolin-2-yl]-propane], dimethyl2,2'azobis[2-methylpropionate] and benzoyl peroxide.

8. The method of claim 7, further comprising controlling polymerization with an inhibitor.

9. The method of claim 8, wherein the polymerization inhibitor is selected from the group consisting of 4-methoxyphenol and 4-tert-butyl catechol.

10. The method of claim 9, wherein the polymeric microporous substrate comprises at least one of polypropylene, high molecular weight polyethylene, ultrahigh molecular weight polyethylene, polyvinyl chloride, polyvinylidene difluoride, and polytetrafluoroethylene.

11. The method of claim 10, wherein casting comprises applying heat at a temperature of about 0°C to about 100°C, ultraviolet light at a wavelength of about 100 nm to about 400 nm, or ionizing radiation.

12. An anion exchange membrane, comprising:

a polymeric microporous substrate; and

a cross-linked anion exchange polymeric layer on the substrate,

the membrane having a resistivity of less than about 1.5 Ohm-cm^2 and an apparent permselectivity of at least about 95%.

13. The anion exchange membrane of claim 12, wherein the cross-linked anion exchange polymeric layer comprises a copolymerization product of at least one quaternized tertiary amine monomer and at least one cross-linking agent.

14. The anion exchange membrane of claim 12, wherein the cross-linked anion exchange polymeric layer comprises a copolymerization product of a two-step fabrication process.

15. The ion exchange membrane of claim 14, wherein a thickness of the polymeric microporous substrate is between about 20 microns and about 255 microns.

16. The ion exchange membrane of claim 15, wherein the thickness of the polymeric microporous substrate is less than about 155 microns.

17. The ion exchange membrane of claim 16, wherein the thickness of the polymeric microporous substrate is less than about 55 microns.

18. A fuel cell including at least one anion exchange membrane of claim 12.

19. An electrochemical separation device, comprising:

at least one anion exchange membrane having a resistivity of less than about 1.5 Ohm-cm^2 and an apparent permselectivity of at least about 95%.

20. The electrochemical separation device of claim 19, wherein the electrochemical separation device comprises an electrodialysis cell.

21. The electrochemical separation device of claim 19, wherein the electrochemical separation device comprises an electrodeionization cell.

22. A desalination system, wastewater treatment system, onsite acid/base generation system, or water treatment system for the food and beverage industry including at least one electrochemical separation device of claim 19.

23. The electrochemical separation device of claim 19, wherein the at least one anion exchange membrane is configured for ion selective removal of nitrate, sulfate, perchlorate, boron, silica or anionic selenium.

CLAIMS

1. An invention not claimed in any divisional application.