CLAIMS

What is claimed is:

1. A method of separating a charged biological molecule from a liquid using a porous ion-exchange membrane sheet, the method comprising contacting liquid that contains the charged biological molecule with a porous ion-exchange membrane comprising a porous polymeric sheet and imidazole ion-exchange groups at surfaces of the porous polymeric sheet, at an adsorption condition that causes the charged biological molecule to adsorb onto the ion-exchange membrane.

2. The method of claim 1, wherein the charged biological molecule is plasmid DNA.

3. The method of claim 1, wherein the adsorption condition includes a pH below about 6.

4. The method of claim 1 further comprising eluting the adsorbed biological molecule from the ion-exchange membrane at an eluting condition.

5. The method of claim 4, wherein the eluting condition includes a pH of above about 7.

6. The method of claim 1, wherein the ion-exchange membrane has a porosity of from 20 to 95 percent (volume).

7. The method of claim 1, wherein the ion-exchange membrane has a thickness in a range of from 5 to 300 microns.

8. The method of claim 1, wherein the ion-exchange membrane contains pores having an average pore size in a range from 0.2 to 10 microns.

9. The method of claim 1, wherein the porous polymeric sheet comprises a base polymer selected from the group consisting of a polyolefin, a polysulfone, a polyvinylidenefluoride, a polyolefin, polypropylene, a cellulose acetate, a nylon, and a polytetrafluoroethylene.

10. The method of claim 9, wherein the porous polymer sheet comprises two or more of the base polymers.

11. The method of claim 9, wherein the base polymer comprises ultra high molecular weight polyethylene.

12. A porous ion-exchange membrane comprising imidazole ion-exchange groups at surfaces of the membrane, wherein charges of the imidazole ion-exchange groups are pH-dependent and exhibit a positive charge at a pH in a range below 5.2 and a negative charge at a pH in a range above 5.2.

13. The membrane of claim 12 comprising a polymeric porous membrane base having imidazole ion-exchange groups chemically bonded to the polymeric porous membrane base.

14. The membrane of claim 13, wherein the imidazole ion-exchange groups are bonded to carbon atoms of carbon-to-carbon linkages of the polymeric base, through a divalent alkylene linking group.

15. The membrane of claim 14, wherein the divalent alkylene linking group is $-CH_2-$.

16. The membrane of claim 13 comprising a polymeric sidechain comprising imidazole ion-exchange groups extending as a branch of the base polymer.

17. The membrane of claim 16, wherein the polymeric sidechain is derived from polymerized vinylimidazole monomers and optional co-monomer.

18. The membrane of claim 12 comprising a polymeric porous membrane base, and a crosslinked polymer network that contains the imidazole ion-exchange groups at a surface of the base.

19. The membrane of claim 18, wherein the crosslinked polymer network comprises:
polymer backbone,
imidazole groups bonded to carbon atoms of the polymer backbone, and
divalent crosslinking groups bonded to carbon atoms of the polymer backbone.

20. The membrane of claim 19, wherein the polymer backbone comprises polymerized vinylimidazole monomers.

~~21. The membrane of claim 19, wherein the divalent crosslinking groups are derived from di-functional acrylamide crosslinking monomer.~~

~~22. The membrane of claim 21, wherein the di-functional acrylamide crosslinking monomer is N,N-dimethyl acrylamide.~~

~~23. The membrane of claim 12 having a porosity of from 20 to 95 percent (volume).~~

~~24. The membrane of claim 12 having a thickness in a range of from 5 to 300 microns.~~

~~25. The membrane of claim 12 having pores of an average pore size in a range from 0.2 to 10 microns.~~

~~26. The membrane of claim 13, wherein the base polymer comprises one or more of a polyolefin, polypropylene, a polysulfone, a polyvinylidenefluoride, a polypropylene, a cellulose acetate, a nylon, or polytetrafluoroethylene.~~

~~27. The membrane of claim 13, wherein the base polymer is ultra high molecular weight polyethylene.~~

~~28. A method of preparing a porous ion-exchange membrane that contains imidazole ion-exchange groups, the method comprising chemically bonding imidazole ion-exchange groups to a surface of a porous polymeric membrane base.~~

~~29. The method of claim 28, wherein chemically bonding comprises grafting imidazole ion-exchange groups to the surface of the porous polymeric membrane base.~~

~~30. The method of claim 29, wherein grafting comprises reacting the polymeric porous membrane base with vinylimidazole monomer and optional co-monomers to form a polymeric sidechain comprising imidazole ion exchange groups extending from the base.~~

31. The method of claim 30, wherein the comonomer is N [2 (dimethylamino)ethyl]acrylamide and N [2 (diethylamino)ethyl]acrylamide.

32. The method of claim 28, wherein the imidazole ion-exchange groups of the membrane exhibit a positive charge at a pH in a range below 5.2 and a negative charge at a pH in a range above 5.2.

33. The method of claim 28, wherein the ion-exchange membrane has a porosity of from 20 to 95 percent (volume).

34. The method of claim 28, wherein the ion-exchange membrane has a thickness in a range from 5 to 300 microns.

35. The method of claim 28, wherein the ion-exchange membrane contains pores having an average pore size in a range from 0.2 to 10 microns.

36. The method of claim 28, wherein the base polymer comprises one or more of a polyolefin, polypropylene, a polysulfone, a polyvinylidenefluoride, a polypropylene, a cellulose acetate, a nylon, or polytetrafluoroethylene.

37. The method of claim 28, wherein the base polymer is ultra high molecular weight polyethylene.

38. The method of claim 28, wherein chemically bonding comprises:

placing a coating composition at a surface of the base, the coating composition comprising vinylimidazole and crosslinker, and

reacting the vinylimidazole and crosslinker to form a crosslinked polymer network on the surface.

39. The method of claim 38, wherein the porous ion-exchange membrane contains a polymeric porous membrane base and a crosslinked polymer network that contains imidazole ion-exchange groups at a surface of the base.