CLAIMS

What is claimed is:

1. A method of treating a feed stream comprising a liquid and a solute, comprising:

transporting a first membrane separator retentate inlet stream to a retentate side of a first membrane separator such that:

a first membrane separator retentate outlet stream exits the retentate side of the first membrane separator, the first membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the first membrane separator retentate inlet stream, and

at least a portion of liquid from the first membrane separator retentate inlet stream is transported from the retentate side of the first membrane separator, through a semi-permeable membrane of the first membrane separator, to a permeate side of the first membrane separator; and

transporting a second membrane separator retentate inlet stream to a retentate side of a second membrane separator such that:

a second membrane separator retentate outlet stream exits the retentate side of the second membrane separator, the second membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the second membrane separator retentate inlet stream, and

at least a portion of liquid and solute from the second membrane separator retentate inlet stream is transported from the retentate side of the second membrane separator, through a semi-permeable membrane of the second membrane separator, to a permeate side of the second membrane separator where the portion of the liquid and solute forms some or all of a second membrane separator permeate outlet stream that is transported out of the permeate side of the second membrane separator;

wherein:

the first membrane separator retentate inlet stream comprises at least a portion of the feed stream;

the second membrane separator retentate inlet stream comprises at least a portion of the first membrane separator retentate outlet stream;

a salt passage percentage at standard conditions of the first membrane separator is different than a salt passage percentage at standard conditions of the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

the first membrane separator has a solute enhancement factor during the step of transporting the first membrane separator retentate inlet stream to the retentate side of the first membrane separator, the second membrane separator has a solute enhancement factor during the step of transporting the second membrane separator retentate inlet stream to the retentate side of the second membrane separator, and the arithmetic average of the solute enhancement factor of the first membrane separator and the solute enhancement factor of the second membrane separator is greater than or equal to 1.005.

2. A method of treating a feed stream comprising a liquid and a solute, comprising:

transporting a first membrane separator retentate inlet stream to a retentate side of a first membrane separator such that:

a first membrane separator retentate outlet stream exits the retentate side of the first membrane separator, the first membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the first membrane separator retentate inlet stream, and

at least a portion of liquid from the first membrane separator retentate inlet stream is transported from the retentate side of the first membrane separator, through a semi-permeable membrane of the first membrane separator, to a permeate side of the first membrane separator; and

transporting a second membrane separator retentate inlet stream to a retentate side of a second membrane separator such that:

a second membrane separator retentate outlet stream exits the retentate side of the second membrane separator, the second membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the second membrane separator retentate inlet stream, and

at least a portion of liquid and solute from the second membrane separator retentate inlet stream is transported from the retentate side of the second membrane separator, through a semi-permeable membrane of the second

membrane separator, to a permeate side of the second membrane separator where the portion of the liquid and solute forms some or all of a second membrane separator permeate outlet stream that is transported out of the permeate side of the second membrane separator;

wherein:

the first membrane separator retentate inlet stream comprises at least a portion of the feed stream;

the second membrane separator retentate inlet stream comprises at least a portion of the first membrane separator retentate outlet stream;

a salt passage percentage at standard conditions of the first membrane separator is different than a salt passage percentage at standard conditions of the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

the first membrane separator has a mass flow ratio during the step of transporting the first membrane separator retentate inlet stream to the retentate side of the first membrane separator, the second membrane separator has a mass flow ratio during the step of transporting the second membrane separator retentate inlet stream to the retentate side of the second membrane separator, and the arithmetic average of the mass flow ratio of the first membrane separator and the mass flow ratio of the second membrane separator is greater than or equal to 1.005.

3. A method of treating a feed stream comprising a liquid and a solute, comprising:

transporting a first membrane separator retentate inlet stream to a retentate side of a first membrane separator such that:

a first membrane separator retentate outlet stream exits the retentate side of the first membrane separator, the first membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the first membrane separator retentate inlet stream, and

at least a portion of liquid from the first membrane separator retentate inlet stream is transported from the retentate side of the first membrane separator, through a semi-permeable membrane of the first membrane separator, to a permeate side of the first membrane separator;

transporting a second membrane separator retentate inlet stream to a retentate side of a second membrane separator such that:

a second membrane separator retentate outlet stream exits the retentate side of the second membrane separator, the second membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the second membrane separator retentate inlet stream, and

at least a portion of liquid and solute from the second membrane separator retentate inlet stream is transported from the retentate side of the second membrane separator, through a semi-permeable membrane of the second membrane separator, to a permeate side of the second membrane separator where the portion of the liquid and solute forms some or all of a second membrane separator permeate outlet stream that is transported out of the permeate side of the second membrane separator; and

transporting a third membrane separator retentate inlet stream to a retentate side of a third membrane separator such that:

a third membrane separator retentate outlet stream exits the retentate side of the third membrane separator, the third membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the third membrane separator retentate inlet stream, and

at least a portion of liquid and solute from the third membrane separator retentate inlet stream is transported from the retentate side of the third membrane separator, through a semi-permeable membrane of the third membrane separator, to a permeate side of the third membrane separator where the portion of the liquid and solute forms some or all of a third membrane separator permeate outlet stream that is transported out of the permeate side of the third membrane separator;

wherein:

the first membrane separator retentate inlet stream comprises at least a portion of the second membrane separator permeate outlet stream and/or at least a portion of the third membrane separator permeate outlet stream;

the second membrane separator retentate inlet stream and/or the third membrane separator retentate inlet stream comprises at least a portion of the feed stream;

the second membrane separator retentate inlet stream comprises at least a portion of the first membrane separator retentate outlet stream;

the third membrane separator retentate inlet stream comprises at least a portion of the second membrane separator retentate outlet stream;

a salt passage percentage at standard conditions of the first membrane separator is different than a salt passage percentage at standard conditions of the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

the first membrane separator has a solute enhancement factor during the step of transporting the first membrane separator retentate inlet stream to the retentate side of the first membrane separator, the second membrane separator has a solute enhancement factor during the step of transporting the second membrane separator retentate inlet stream to the retentate side of the second membrane separator, and the arithmetic average of the solute enhancement factor of the first membrane separator and the solute enhancement factor of the second membrane separator is greater than or equal to 1.005.

4. A method of treating a feed stream comprising a liquid and a solute, comprising:

transporting a first membrane separator retentate inlet stream to a retentate side of a first membrane separator such that:

a first membrane separator retentate outlet stream exits the retentate side of the first membrane separator, the first membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the first membrane separator retentate inlet stream, and

at least a portion of liquid from the first membrane separator retentate inlet stream is transported from the retentate side of the first membrane separator, through a semi-permeable membrane of the first membrane separator, to a permeate side of the first membrane separator;

transporting a second membrane separator retentate inlet stream to a retentate side of a second membrane separator such that:

a second membrane separator retentate outlet stream exits the retentate side of the second membrane separator, the second membrane separator retentate

outlet stream having an osmotic pressure that is greater than an osmotic pressure of the second membrane separator retentate inlet stream, and

at least a portion of liquid and solute from the second membrane separator retentate inlet stream is transported from the retentate side of the second membrane separator, through a semi-permeable membrane of the second membrane separator, to a permeate side of the second membrane separator where the portion of the liquid and solute forms some or all of a second membrane separator permeate outlet stream that is transported out of the permeate side of the second membrane separator; and

transporting a third membrane separator retentate inlet stream to a retentate side of a third membrane separator such that:

a third membrane separator retentate outlet stream exits the retentate side of the third membrane separator, the third membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the third membrane separator retentate inlet stream, and

at least a portion of liquid and solute from the third membrane separator retentate inlet stream is transported from the retentate side of the third membrane separator, through a semi-permeable membrane of the third membrane separator, to a permeate side of the third membrane separator where the portion of the liquid and solute forms some or all of a third membrane separator permeate outlet stream that is transported out of the permeate side of the third membrane separator;

wherein:

the first membrane separator retentate inlet stream comprises at least a portion of the second membrane separator permeate outlet stream and/or at least a portion of the third membrane separator permeate outlet stream;

the second membrane separator retentate inlet stream and/or the third membrane separator retentate inlet stream comprises at least a portion of the feed stream;

the second membrane separator retentate inlet stream comprises at least a portion of the first membrane separator retentate outlet stream;

the third membrane separator retentate inlet stream comprises at least a portion of the second membrane separator retentate outlet stream;

a salt passage percentage at standard conditions of the first membrane separator is different than a salt passage percentage at standard conditions of the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

the first membrane separator has a mass flow ratio during the step of transporting the first membrane separator retentate inlet stream to the retentate side of the first membrane separator, the second membrane separator has a mass flow ratio during the step of transporting the second membrane separator retentate inlet stream to the retentate side of the second membrane separator, and the arithmetic average of the mass flow ratio of the first membrane separator and the mass flow ratio of the second membrane separator is greater than or equal to 1.005.

5. The method of any one of claims 1-4, wherein the portion of the liquid transported from the retentate side of the first membrane separator, through the semi-permeable membrane of the first membrane separator, to the permeate side of the first membrane separator forms some or all of a first membrane separator permeate outlet stream.

6. The method of claim 5, wherein the first membrane separator retentate inlet stream comprises at least a portion of the first membrane separator permeate outlet stream.

7. The method of any one of claims 1-6, wherein a solute permeability of the first membrane separator during the step of transporting the first membrane separator retentate inlet stream to the retentate side of the first membrane separator is different than a solute permeability of the second membrane separator during the step of transporting the second membrane separator retentate inlet stream to the retentate side of the second membrane separator.

8. The method of any one of claims 1-7, wherein a solute permeability of the first membrane separator during the step of transporting the first membrane separator retentate inlet stream to the retentate side of the first membrane separator and the solute

permeability of the second membrane separator during the step of transporting the second membrane separator retentate inlet stream to the retentate side of the second membrane separator are at least 5% different from each other.

9. The method of any one of claims 1-8, wherein the salt passage percentage at standard conditions of the first membrane separator and the salt passage percentage at standard conditions of the second membrane separator are at least 5% different from each other.

10. The method of any one of claims 1-9, wherein the second membrane separator has a salt passage percentage at standard conditions that is greater than that of the first membrane separator.

11. The method of any one of claims 1-10, wherein the second membrane separator has a salt passage percentage at standard conditions that is greater than that of first membrane separator by a factor of at least 1.05.

12. The method of any one of claims 1-11, wherein the solute enhancement factor of the first membrane separator is within 40% of the solute enhancement factor of the second membrane separator.

13. The method of any one of claims 1-12, wherein the mass flow ratio of the first membrane separator is within 40% of the mass flow ratio of the second membrane separator.

14. The method of any one of claims 1-13, wherein the second membrane separator has a rejection for the solute on the retentate side that is less than that of the first membrane separator.

15. The method of any one of claims 1-14, wherein the second membrane separator has a rejection for the solute on the retentate side that is less than that of the first membrane separator by at least 5%.

16. The method of any one of claims 1-15, wherein the semi-permeable membrane of the second membrane separator has an average molecular weight cutoff (MWCO) that is greater than that of the semi-permeable membrane of the first membrane separator.

17. The method of any one of claims 1-16, wherein the semi-permeable membrane of the second membrane separator has an average molecular weight cutoff (MWCO) that is greater than that of the semi-permeable membrane of the first membrane separator by a factor of at least 1.05.

18. The method of any one of claims 1-17, wherein the semi-permeable membrane of the first membrane separator and/or the semi-permeable membrane of the second membrane separator has an average MWCO of less than or equal to 400 Daltons.

19. The method of any one of claims 1-18, wherein the semi-permeable membrane of the first membrane separator and/or the semi-permeable membrane of the second membrane separator has an average MWCO of greater than or equal to 50 Daltons.

20. The method of any one of claims 1-19, wherein the first membrane separator and/or the second membrane separator has a rejection for the solute of less than or equal to 95%.

21. The method of any one of claims 1-20, wherein the first membrane separator and/or the second membrane separator has a rejection for the solute of greater than or equal to 10%.

22. The method of any one of claims 1-21, wherein the first membrane separator has a total membrane surface area that is different than a total membrane surface area of the second membrane separator.

23. The method of any one of claims 1-22, wherein the semi-permeable membrane of the first membrane separator and/or the semi-permeable membrane of the second membrane separator has cross-links, with at least some of the cross-links being disrupted.

24. The method of any one of claims 1-23, wherein the semi-permeable membrane of the first membrane separator and/or the semi-permeable membrane of the second membrane separator has cross-links, with at least some of the cross-links being chemically disrupted.

25 The method of any one of claims 1-24, wherein the semi-permeable membrane of the first membrane separator and/or the semi-permeable membrane of the second membrane separator comprises an active layer comprising a cross-linked polymeric material derived from monomers, and wherein fewer than or equal to 99.9 mol% of the monomers participate in cross-link.

26. The method of any one of claims 1-25, wherein the first membrane separator and/or the second membrane separator comprises a plurality of semi-permeable membranes.

27. The method of claim 26, wherein the plurality of semi-permeable membranes is connected in series.

28. The method of claim 26, wherein the plurality of semi-permeable membranes is connected in parallel.

29. The method of any one of claims 1-2 and 5-28, wherein the method further comprises transporting a third membrane separator retentate inlet stream to a retentate side of a third membrane separator such that:

a third membrane separator retentate outlet stream exits the retentate side of the third membrane separator, the third membrane separator retentate outlet stream having an osmotic pressure that is greater than an osmotic pressure of the third membrane separator retentate inlet stream, and

at least a portion of liquid and solute from the third membrane separator retentate inlet stream is transported from the retentate side of the third membrane separator, through a semi-permeable membrane of the third membrane separator, to a permeate side of the third membrane separator where the portion of the liquid

and solute forms some or all of a third membrane separator permeate outlet stream that is transported out of the permeate side of the third membrane separator;

wherein:

the third membrane separator retentate inlet stream comprises at least a portion of the second membrane separator retentate outlet stream.

30. The method of any one of claims 1-29, wherein the first membrane separator retentate inlet stream comprises at least a portion of the second membrane separator permeate outlet stream.

31. The method of any one of claims 3-30, wherein the first membrane separator retentate inlet stream comprises at least a portion of the third membrane separator permeate outlet stream.

32. The method of any one of claims 3-31, wherein the second membrane separator retentate inlet stream comprises at least a portion of the feed stream.

33. The method of any one of claims 3-32, wherein the third membrane separator retentate inlet stream comprises at least a portion of the feed stream.

34. The method of any one of claims 1-33, wherein at least a portion of solute from the first membrane separator retentate inlet stream is transported from the retentate side of the first membrane separator, through a semi-permeable membrane of the first membrane separator, to a permeate side of the first membrane separator.

35. A system, comprising:

a plurality of membrane separators comprising:

a first membrane separator comprising at least one semi-permeable membrane defining a retentate side of the first membrane separator and a permeate side of the first membrane separator; and

a second membrane separator comprising at least one semi-permeable membrane defining a retentate side of the second membrane separator and a permeate side of the second membrane separator;

wherein:

the retentate side of the first membrane separator is fluidically connected to the retentate side of the second membrane separator;

the first membrane separator has a different salt passage percentage at standard conditions than the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

for an initial feed stream containing NaCl as the only solute and water as the only liquid, and having a salinity of 7%, at a temperature of 298 K, each of the plurality of membrane separators has a solute enhancement factor, and the arithmetic average of the solute enhancement factors of the plurality of membrane separators is greater than or equal to 1.005.

36. A system, comprising:

a plurality of membrane separators comprising:

a first membrane separator comprising at least one semi-permeable membrane defining a retentate side of the first membrane separator and a permeate side of the first membrane separator; and

a second membrane separator comprising at least one semi-permeable membrane defining a retentate side of the second membrane separator and a permeate side of the second membrane separator;

wherein:

the retentate side of the first membrane separator is fluidically connected to the retentate side of the second membrane separator;

the first membrane separator has a different salt passage percentage at standard conditions than the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

for an initial feed stream containing NaCl as the only solute and water as the only liquid, and having a salinity of 20%, at a temperature of 298 K, each of the plurality of membrane separators has a solute enhancement factor, and the arithmetic average of the solute enhancement factors of the plurality of membrane separators is greater than or equal to 1.005.

37. A system, comprising:

a plurality of membrane separators comprising:

a first membrane separator comprising at least one semi-permeable membrane defining a retentate side of the first membrane separator and a permeate side of the first membrane separator; and

a second membrane separator comprising at least one semi-permeable membrane defining a retentate side of the second membrane separator and a permeate side of the second membrane separator;

wherein:

the retentate side of the first membrane separator is fluidically connected to the retentate side of the second membrane separator;

the first membrane separator has a different salt passage percentage at standard conditions than the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

for an initial feed stream containing NaCl as the only solute and water as the only liquid, and having a salinity of 7%, at a temperature of 298 K, each of the plurality of membrane separator has a mass flow ratio, and the arithmetic average of the mass flow ratios of the plurality of membrane separators is greater than or equal to 1.005.

38. A system, comprising:

a plurality of membrane separators comprising:

a first membrane separator comprising at least one semi-permeable membrane defining a retentate side of the first membrane separator and a permeate side of the first membrane separator; and

a second membrane separator comprising at least one semi-permeable membrane defining a retentate side of the second membrane separator and a permeate side of the second membrane separator;

wherein:

the retentate side of the first membrane separator is fluidically connected to the retentate side of the second membrane separator;

the first membrane separator has a different salt passage percentage at standard conditions than the second membrane separator, wherein the salt passage percentage at standard conditions is determined using ASTM D4516-19a; and

for an initial feed stream containing NaCl as the only solute and water as the only liquid, and having a salinity of 20%, at a temperature of 298 K, each of the plurality of membrane separator has a mass flow ratio, and the arithmetic average of the mass flow ratios of the plurality of membrane separators is greater than or equal to 1.005.

39. A membrane separator comprising at least one semi-permeable membrane defining a retentate side of the membrane separator and a permeate side of the membrane separator, wherein for an initial feed stream containing NaCl as the only solute and water as the only liquid, and having salinity of 7%, at a temperature of 298 K, the membrane separator has a solute enhancement factor and/or mass flow ratio of greater than or equal to 1.005.

40. A membrane separator comprising at least one semi-permeable membrane defining a retentate side of the membrane separator and a permeate side of the membrane separator, wherein for an initial feed stream containing NaCl as the only solute and water as the only liquid, and having salinity of 20%, at a temperature of 298 K, the membrane separator has a solute enhancement factor and/or mass flow ratio of greater than or equal to 1.005.

41. The system of any one of claims 35-38, wherein the salt passage percentage at standard conditions of the first membrane separator and the salt passage percentage at

standard conditions of the second membrane separator are at least 5% different from each other.

42. The system of any one of claims 35-38 and 41, wherein the second membrane separator has a salt passage percentage at standard conditions that is greater than that of the first membrane separator.

43. The system of any one of claims 35-38 and 41-42, wherein the second membrane separator has a salt passage percentage at standard conditions that is greater than that of first membrane separator by a factor of at least 1.05.

44. The system of any one of claims 35-38 and 41-43, wherein at least two thirds of the membrane separators of the plurality of membrane separators have a solute enhancement factor within 40% of the arithmetic average of the solute enhancement factors of the plurality of membrane separators.

45. The system of any one of claims 35-38 and 41-44, wherein each of the membrane separators of the plurality of membrane separators has a solute enhancement factor within 40% of the arithmetic average of the solute enhancement factors of the plurality of membrane separators.

46. The system of any one of claims 35-38 and 41-45, wherein at least two thirds of the membrane separators of the plurality of membrane separators have a mass flow ratio within 40% of the arithmetic average of the mass flow ratios of the plurality of membrane separators.

47. The system of any one of claims 35-38 and 41-46, wherein each of the membrane separators of the plurality of membrane separators has a mass flow ratio within 40% of the arithmetic average of the mass flow ratio of the plurality of membrane separators.

48. The system of any one of claims 35-38 and 41-47, wherein the system is configured to transport a liquid stream from the retentate side of the first membrane separator to the retentate side of the second membrane separator.

49. The system of any one of claims 35-38 and 41-48, wherein the permeate side of the second membrane separator is fluidically connected to the retentate side of the first membrane separator.

50. The system of any one of claims 35-38 and 41-49, wherein the system is configured to transport a liquid stream from the permeate side of the second membrane separator to the retentate side of the first membrane separator.

51. The system of any one of claims 35-38 and 41-50, wherein the second membrane separator has a rejection for at least one solute at a given solute concentration on the retentate side that is less than that of the first membrane separator.

52. The system of any one of claims 35-38 and 41-51, wherein the second membrane separator has a rejection for at least one solute on the retentate side that is less than that of the first membrane separator by at least 5%.

53. The system of any one of claims 35-38 and 41-52, wherein the at least one semi-permeable membrane of the second membrane separator has an average molecular weight cutoff (MWCO) that is greater than that of the at least one semi-permeable membrane of the first membrane separator.

54. The system of any one of claims 35-38 and 41-53, wherein the at least one semi-permeable membrane of the second membrane separator has an average molecular weight cutoff (MWCO) that is greater than that of the at least one semi-permeable membrane of the first membrane separator by a factor of at least 1.05.

55. The system of any one of claims 35-38 and 41-54, wherein the at least one semi-permeable membrane of the first membrane separator and/or the at least one semi-permeable membrane of the second membrane separator has an average MWCO of less than or equal to 400 Daltons.

56. The system of any one of claims 35-38 and 41-55, wherein the at least one semi-permeable membrane of the first membrane separator and/or the at least one semi-permeable membrane of the second membrane separator has an average MWCO of greater than or equal to 50 Daltons.

57. The system of any one of claims 35-38 and 41-56, wherein the first membrane separator and/or the second membrane separator has a rejection for at least one solute of less than or equal to 95%.

58. The system of any one of claims 35-38 and 41-57, wherein the first membrane separator and/or the second membrane separator has a rejection for at least one solute of greater than or equal to 10%.

59. The system of any one of claims 35-38 and 41-58, wherein the first membrane separator has a total membrane surface area that is different than a total membrane surface area of the second membrane separator.

60. The system of any one of claims 35-38 and 41-59, wherein the at least one semi-permeable membrane of the first membrane separator and/or the at least one semi-permeable membrane of the second membrane separator has cross-links, with at least some of the cross-links being disrupted.

61. The system of any one of claims 35-38 and 41-60, wherein the at least one semi-permeable membrane of the first membrane separator and/or the at least one semi-permeable membrane of the second membrane separator has cross-links, with at least some of the cross-links being chemically disrupted.

62. The system of any one of claims 35-38 and 41-61, wherein the at least one semi-permeable membrane of the first membrane separator and/or the at least one semi-permeable membrane of the second membrane separator comprises an active layer comprising a cross-linked polymeric material derived from monomers, and wherein fewer than or equal to 99.9 mol% of the monomers participate in at least one cross-link.

63. The system of any one of claims 35-38 and 41-62, wherein the first membrane separator and/or the second membrane separator comprises a plurality of semi-permeable membranes.

64. The system of claim 63, wherein the plurality of semi-permeable membranes is connected in series.

65. The system of claim 63, wherein the plurality of semi-permeable membranes is connected in parallel.

66. The system of any one of claims 35-38 and 41-65, wherein the plurality of membrane separators further comprises a third membrane separator comprising at least one semi-permeable membrane defining a retentate side of the third membrane separator and a permeate side of the third membrane separator.

67. The system of claim 66, wherein the system is configured to transport a liquid stream from the retentate side of the second membrane separator to the retentate side of the third membrane separator.

68. The system of any one of claims 66-67, wherein the permeate side of the third membrane separator is fluidically connected to the retentate side of the second membrane separator.