CLAIMS

1. An electrochemical separation modular unit, comprising:

a cell stack defining a plurality of alternating depleting compartments and concentrating compartments; and

a frame surrounding the cell stack and including a manifold system configured to facilitate fluid flow through the cell stack.

2. The modular unit of claim 1, wherein the frame is configured to maintain vertical alignment of the cell stack.

3. The modular unit of claim 2, wherein the manifold system comprises an inlet manifold in fluid communication with an inlet of each depleting compartment and with an inlet of each concentrating compartment.

4. The modular unit of claim 3, wherein the manifold system further comprises an outlet manifold in fluid communication with an outlet of each depleting compartment and with an outlet of each concentrating compartment.

5. The modular unit of claim 3, wherein the frame includes a flow distribution system in fluid communication with the manifold system.

6. The modular unit of claim 5, wherein the flow distribution system is in fluid communication with an inlet of each depleting compartment and with an inlet of each concentrating compartment.

7. The modular unit of claim 5, wherein the flow distribution system comprises at least one bypass path configured to reduce current loss.

8. The modular unit of claim 6, wherein the flow distribution system comprises a plurality of first fluid passages oriented in a first direction.

9. The modular unit of claim 8, wherein the flow distribution system further comprises a plurality of second fluid passages oriented in a second direction and in fluid communication with the plurality of first fluid passages.

10. The modular unit of claim 9, wherein the first and second directions are substantially perpendicular.

11. The modular unit of claim 5, wherein the flow distribution system comprises an insert, and wherein the frame defines a recess configured to receive the insert.

12. The modular unit of claim 11, wherein the insert defines a lattice structure configured to promote uniform flow distribution to the cell stack.

13. The modular unit of claim 11, wherein the insert has a first side proximate the cell stack, and a second side opposite the first side, and wherein the insert comprises a plurality of ports on at least one of the first and second sides.

14. The modular unit of claim 13, wherein each port on the first side of the insert is oriented substantially perpendicular to ion exchange membranes of the cell stack, and wherein each port on the second side of the insert is oriented substantially parallel to ion exchange membranes of the cell stack.

15. The modular unit of claim 14, wherein at least one port on the first side is in fluid communication with two or more compartments of the cell stack.

16. The modular unit of claim 14, wherein the plurality of ports on the first side are staggered.

17. The modular unit of claim 1, wherein the cell stack is constructed and arranged to achieve at least about 85% fluid contact with respect to surface area of ion exchange membranes defining the cell stack.

18. The modular unit of claim 1, wherein at least one of the depleting compartments and concentrating compartments comprises a blocking spacer or flow redistributor.

19. The modular unit of claim 1, wherein the cell stack is configured such that a direction of flow through the depleting compartments is different than a direction of flow through the concentrating compartments.

5

20. The modular unit of claim 1, wherein the cell stack is configured such that the direction of flow through the depleting compartment is substantially perpendicular to the direction of flow through the concentrating compartments.

Claims:

1. An electrochemical separation modular unit, comprising:

a cell stack defining a plurality of alternating depleting compartments and concentrating compartments; and

a frame surrounding the cell stack and including a manifold system configured to facilitate fluid flow through the cell stack;

wherein the frame includes a flow distribution system comprising an insert and a recess defined by the frame, the frame configured to receive the insert; and

wherein the insert has a first side proximate the cell stack, and a second side opposite the first side, and the insert comprises a plurality of ports on at least one of the first and second sides, each port on the first side of the insert being oriented substantially perpendicular to ion exchange membranes of the cell stack, and each port on the second side of the insert being oriented substantially parallel to ion exchange membranes of the cell stack.

2. The modular unit of claim 1, wherein the frame is configured to maintain vertical alignment of the cell stack.

3. The modular unit of claim 2, wherein the manifold system is in fluid communication with an inlet of each depleting compartment and with an inlet of each concentrating compartment.

4. The modular unit of claim 3, wherein the manifold system is further in fluid communication with an outlet of each depleting compartment and with an outlet of each concentrating compartment.

5. The modular unit of claim 3, wherein the frame includes a flow distribution system in fluid communication with the manifold system.

6. The modular unit of claim 5, wherein the flow distribution system is in fluid communication with an inlet of each depleting compartment and with an inlet of each concentrating compartment.

7. The modular unit of claim 5, wherein the flow distribution system comprises at least one bypass path configured to reduce current loss.

8. The modular unit of claim 6, wherein the flow distribution system comprises a plurality of first fluid passages oriented in a first direction.

9. The modular unit of claim 8, wherein the flow distribution system further comprises a plurality of second fluid passages oriented in a second direction.

10. The modular unit of claim 9, wherein the first and second directions are substantially perpendicular.

11. The modular unit of claim 1, wherein the insert defines a lattice structure configured to promote uniform flow distribution to the cell stack.

12. The modular unit of claim 1, wherein at least one port on the first side is in fluid communication with two or more compartments of the cell stack.

13. The modular unit of claim 1, wherein the plurality of ports on the first side are staggered.

14. The modular unit of claim 1, wherein the cell stack is constructed and arranged to achieve at least about 85% fluid contact with respect to surface area of ion exchange membranes defining the cell stack.

15. The modular unit of claim 1, wherein at least one of the depleting compartments and concentrating compartments comprises a blocking spacer or flow redistributor.

16. The modular unit of claim 1, wherein the cell stack is configured such that a direction of flow through the depleting compartments is different than a direction of flow through the concentrating compartments.

17. The modular unit of claim 1, wherein the cell stack is configured such that the direction of flow through the depleting compartment is substantially perpendicular to the direction of flow through the concentrating compartments.