favor of membrane reactors. This is due to health and environmental concerns relating to the use of asbestos and mercury, respectively. Key challenges with membrane electrolyzers include the high cost of the ion-selective membranes and their susceptibility to fouling. Further, electrodialysis cells typically rely on multiple membranes and operate at low current densities. Various approaches have been pursued in order to improve the yield, energy efficiency, economics, and environmental impacts of the membrane process.

SUMMARY

[0004] Accordingly, some embodiments of the present disclosure relates to a system for treatment of brines including one or more electrolyzers, each electrolyzer including an influent flow chamber including an influent stream; at least one anode effluent flow chamber including an anode effluent stream; at least one cathode effluent flow chamber including a cathode effluent stream, wherein the cathode effluent stream includes a basic effluent stream and a hydrogen gas stream; at least one porous anode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one anode effluent flow chamber; and at least one porous cathode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one cathode effluent flow chamber, wherein the at least one anode and at least one cathode are positioned obliquely to each other. In some embodiments, the system includes an anode effluent processing unit in fluid communication with the at least one anode effluent flow chamber; a cathode effluent processing unit in fluid communication with the at least one cathode effluent flow chamber; a neutralization unit producing a system effluent stream, the neutralization unit positioned in fluid communication with the anode effluent processing unit, the cathode effluent processing unit, or combination thereof; a brine inlet stream in fluid communication with the one or more electrolyzers, the anode effluent processing unit, the cathode effluent processing unit, or combinations thereof, and configured to provide a source of brine to the one or more electrolyzers; and a separation unit configured to separate the basic effluent stream into an alkaline product stream and an alkaline salt water stream, the separation unit in fluid communication with the cathode effluent processing unit, one or more electrolyzers, and the neutralization unit. In some embodiments, the at least one porous anode and the at least one porous cathode include a

catalyst layer and a semi-permeable layer disposed on the catalyst layer, the semi-permeable layer being selectively permeable to one or more components of the influent stream.

[0005] In some embodiments, the anode effluent stream includes an acid effluent stream and the cathode effluent stream includes a basic effluent stream and a hydrogen

CLAIMS

What is claimed is:

1. A system for treatment of brines, comprising:

one or more electrolyzers, each electrolyzer including:

an influent flow chamber including an influent stream;

at least one anode effluent flow chamber including an anode effluent stream;

at least one cathode effluent flow chamber including a cathode effluent stream, wherein the cathode effluent stream includes a basic effluent stream and a hydrogen gas stream;

at least one porous anode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one anode effluent flow chamber; and

at least one porous cathode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one cathode effluent flow chamber,

wherein the at least one anode and at least one cathode are positioned obliquely to each other;

an anode effluent processing unit in fluid communication with the at least one anode effluent flow chamber;

a cathode effluent processing unit in fluid communication with the at least one cathode effluent flow chamber;

a neutralization unit producing a system effluent stream, the neutralization unit positioned in fluid communication with the anode effluent processing unit, the cathode effluent processing unit, or combination thereof;

a brine inlet stream in fluid communication with the one or more electrolyzers, the anode effluent processing unit, the cathode effluent processing unit, or combinations thereof, and configured to provide a source of brine to the one or more electrolyzers, and

a separation unit configured to separate the basic effluent stream into an alkaline product stream and an alkaline salt water stream, the separation unit in fluid communication with the cathode effluent processing unit, one or more electrolyzers, and the neutralization unit.

2. The system according to claim 1, wherein the anode effluent stream includes an acid effluent stream.

3. The system according to claim 2, wherein the at least one anode effluent flow chamber and at least one cathode effluent flow chamber each include a fluid effluent outlet and a gas effluent outlet.

4. The system according to claim 1, wherein the at least one anode includes a plurality of anode fingers and the at least one cathode includes a plurality of cathode fingers, wherein the plurality of anode fingers and the plurality of cathode fingers are interdigitated.

5. The system according to claim 1, wherein the one or more electrolyzers include a plurality of electrolyzers arranged in series, wherein:

the influent flow chambers of the plurality of electrolyzers are in fluid communication;

the anode effluent flow chambers of the plurality of electrolyzers are in fluid communication; and

the cathode effluent flow chambers of the plurality of electrolyzers are in fluid communication.

6. The system according to claim 5, further comprising one or more recycle flow chambers configured to recycle at least a portion of the anode effluent stream, the

cathode effluent stream, or combinations thereof, to a previous electrolyzer in the plurality of electrolyzers.

7. The system according to claim 2, wherein the cathode effluent processing unit is in fluid communication with the brine inlet stream, a carbon dioxide inlet stream, or combinations thereof.

8. The system according to claim 1, wherein the influent stream includes at least a portion of the alkaline salt water stream.

9. The system according to claim 1, wherein the alkaline product stream includes alkali earth metal carbonates, alkali earth metal hydroxides, or combinations thereof.

10. The system according to claim 7, wherein the system effluent stream includes concentrated carbon dioxide, demineralized salt water, sterilized salt water, neutralized salt water, or combinations thereof.

11. The system according to claim 2, wherein the acid effluent stream includes a chlorine gas stream and the anode effluent processing unit includes a fuel cell, wherein the fuel cell is in fluid communication with the chlorine gas stream and the hydrogen gas stream.

12. The system according to claim 1, wherein the influent stream includes at least a portion of the system effluent stream.

13. The system according to claim 12, wherein the influent stream includes neutralized salt water from the neutralization unit.

14. The system according to claim 1, wherein the at least one porous anode and the at least one porous cathode include:

a catalyst layer; and

a semi-permeable layer disposed on the catalyst layer, the semi-permeable layer being selectively permeable to one or more components of the influent stream.

15. A method for treatment of brines, comprising:

providing one or more electrolyzers, each electrolyzer including:

an influent flow chamber;

at least one anode effluent flow chamber;

at least one cathode effluent flow chamber;

at least one porous anode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one anode effluent flow chamber; and

at least one porous cathode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one cathode effluent flow chamber,

wherein the at least one anode and at least one cathode are positioned obliquely to each other;

providing an influent stream to the influent flow chamber, the influent stream including at least one reactant;

applying a voltage across the at least one porous anode and the at least one porous cathode;

flowing the influent stream through the at least one porous anode and the at least one porous cathode;

isolating an anode effluent stream in the at least one anode effluent flow chamber and a cathode effluent stream in the at least one cathode effluent flow chamber, wherein the anode effluent stream includes an acid effluent

stream and the cathode effluent stream includes a basic effluent stream and a hydrogen gas stream;

providing at least a portion of the anode effluent stream to an anode effluent processing unit;

providing at least a portion of the cathode effluent stream to a cathode effluent processing unit;

flowing a brine inlet stream, a carbon dioxide inlet stream, or combinations thereof into the cathode effluent processing unit;

providing a stream from the anode effluent processing unit and the cathode effluent processing unit to a neutralization unit; and

producing a system effluent stream from the neutralization unit.

16. The method according to claim 15, wherein the system effluent stream includes concentrated carbon dioxide, demineralized salt water, sterilized salt water, neutralized salt water, or combinations thereof.

17. The method according to claim 15, further comprising:

separating the cathode effluent stream from the cathode effluent processing unit into an alkaline product stream and an alkaline salt water stream, wherein the alkaline product stream includes alkali earth metal carbonates, alkali earth metal hydroxides, or combinations thereof; and

recycling at least a portion of the alkaline salt water stream in the influent stream.

18. A method for treatment of brines, comprising:

providing one or more electrolyzers, each electrolyzer including:

an influent flow chamber;

at least one anode effluent flow chamber;

at least one cathode effluent flow chamber;

at least one porous anode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one anode effluent flow chamber; and

at least one porous cathode positioned at a location within and extending longitudinally along the influent flow chamber, and further positioned to separate the influent flow chamber from the at least one cathode effluent flow chamber,

wherein the at least one anode and at least one cathode are positioned obliquely to each other, and the at least one anode effluent flow chamber and at least one cathode effluent flow chamber each include a fluid effluent outlet and a gas effluent outlet;

providing an influent stream to the influent flow chamber, the influent stream including at least one reactant;

applying a voltage across the at least one porous anode and the at least one porous cathode;

flowing the influent stream through the at least one porous anode and the at least one porous cathode;

isolating an anode effluent stream in the at least one anode effluent flow chamber and a cathode effluent stream in the at least one cathode effluent flow chamber, wherein the anode effluent stream includes an acid effluent stream and an oxygen gas stream and the cathode effluent stream includes a basic effluent stream and a hydrogen gas stream;

providing one or more recycle flow chambers configured to recycle at least a portion of the anode effluent stream, the cathode effluent stream, or combinations thereof, to the one or more electrolyzers;

providing at least a portion of the acid effluent stream to an anode effluent processing unit;

providing at least a portion of the basic effluent stream to a cathode effluent processing unit;

flowing a brine inlet stream, a carbon dioxide inlet stream, or combinations thereof into the cathode effluent processing unit

providing a stream from the anode effluent processing unit to a neutralization unit;

separating the cathode effluent stream from the cathode effluent processing unit into an alkaline product stream and an alkaline salt water stream, wherein the alkaline product stream includes alkali earth metal carbonates, alkali earth metal hydroxides, or combinations thereof;

recycling a first portion of the alkaline salt water stream in the influent stream;

flowing a second portion the alkaline salt water stream to the neutralization unit; and

producing a system effluent stream from the neutralization unit.

19. The method according to claim 18, wherein the system effluent stream includes concentrated carbon dioxide, demineralized salt water, sterilized salt water, neutralized salt water, or combinations thereof.