CLAIMS

1. A flow redox battery system comprising an electrochemical cell, an anolyte tank, a catholyte tank, a first anolyte carrier slurry, a second anolyte carrier slurry, a first catholyte carrier slurry, a second catholyte carrier slurry, and a power generation circuit, wherein:

the electrochemical cell comprises an ion-exchange membrane positioned between and electrochemically engaged with an anode and a cathode;

the power generation circuit is electrically coupled to the anode and the cathode;

the anolyte tank comprises an anolyte upper end fluidly coupled to the anode and an anolyte lower end fluidly coupled to the anode;

the catholyte tank comprises a catholyte upper end fluidly coupled to the cathode and a catholyte lower end fluidly coupled to the cathode;

the first anolyte carrier slurry comprises a density that is less than a density of the second anolyte carrier slurry and an electronegativity that is different than an electronegativity of the second anolyte carrier slurry, wherein the first and second anolyte carrier slurries each comprise a plurality of slurry grains, each slurry grain comprising an inert core and one or more active particles chemically engaged with the inert core; and

the first catholyte carrier slurry comprises a density that is less than a density of the second catholyte carrier slurry and an electronegativity that is different than an electronegativity of the second catholyte carrier slurry, wherein the first and second catholyte carrier slurries each comprise a plurality of slurry grains, each slurry grain comprising an inert core and one or more active particles chemically engaged with the inert core.

2. The flow redox battery system of claim 1, wherein the first anolyte carrier slurry floats above the second anolyte carrier slurry when the first and second anolyte carrier slurries are housed within the anolyte tank.

3. The flow redox battery system of claim 1, wherein the electronegativity of the first anolyte carrier slurry is greater than the electronegativity of the second

anolyte carrier slurry such that the first anolyte carrier slurry electrochemically attracts a discharged anolyte active material and the second anolyte carrier slurry electrochemically attracts a charged anolyte active material.

4. The flow redox battery system of claim 1, wherein the electronegativity of the first anolyte carrier slurry is less than the electronegativity of the second anolyte carrier slurry such that the first anolyte carrier slurry electrochemically attracts a charged anolyte active material and the second anolyte carrier slurry electrochemically attracts a discharged anolyte active material.

5. The flow redox battery system of claim 1, wherein the first catholyte carrier slurry floats above the second catholyte carrier slurry when the first and second catholyte carrier slurries are housed within the catholyte tank.

6. The flow redox battery system of claim 1, wherein the electronegativity of the first catholyte carrier slurry is greater than the electronegativity of the second catholyte carrier slurry such that the first catholyte carrier slurry electrochemically attracts a charged catholyte active material and the second catholyte carrier slurry electrochemically attracts a discharged catholyte.

7. The flow redox battery system of claim 1, wherein the electronegativity of the first catholyte carrier slurry is less than the electronegativity of the second catholyte carrier slurry such that the first catholyte carrier slurry electrochemically attracts a discharged catholyte and the second catholyte carrier slurry electrochemically attracts a charged catholyte active material.

8. The flow redox battery system of claim 1, wherein the inert core comprises one or more functionalized surface regions and the one or more active particles are chemically engaged with the inert core at the one or more functionalized surface regions.

9. The flow redox battery system of claim 1, further comprising a low density anolyte pathway that extends between and fluidly couples the anolyte upper end of the anolyte tank and the anode and a high density anolyte pathway that extends between and fluidly couples the anolyte lower end of the anolyte tank and the anode.

10. The flow redox battery system of claim 1, further comprising a low density catholyte pathway that extends between and fluidly couples the catholyte upper end of the catholyte tank and the cathode and a high density catholyte pathway that extends between and fluidly couples the catholyte lower end of the catholyte tank and the cathode.

11. The flow redox battery system of claim 1, further comprising an anolyte solution chemically engageable with the first anolyte carrier slurry and the second anolyte carrier slurry.

12. The flow redox battery system of claim 11, wherein one or more active materials of the anolyte solution comprises vanadium, chromium, zinc, sulfur, neptunium, uranium, or a combination thereof.

13. The flow redox battery system of claim 11, wherein the anode is electrochemically configured to:

chemically separate a charged anolyte active material from the first or second anolyte carrier slurry and oxidize the charged anolyte active material such that the charged anolyte active material outputs an electron receivable by the power generation circuit upon receiving both the charged anolyte active material chemically engaged with the first or second anolyte carrier slurry and a proton from the ion-exchange membrane; and

chemically separate a discharged anolyte active material from the first or second anolyte carrier slurry and reduce the discharged anolyte active material such that the discharged anolyte active material outputs a proton receivable by the ion-exchange membrane upon receiving both the discharged anolyte active material chemically

engaged with the first or second anolyte carrier slurry and an electron from the power generation circuit.

14. The flow redox battery system of claim 1, further comprising a catholyte solution chemically engageable with the first catholyte carrier slurry and the second catholyte carrier slurry.

15. The flow redox battery system of claim 14, wherein one or more active materials of the catholyte solution comprises vanadium, bromine, cerium, chlorine, ferricyanide, ferrocyanide, manganese, neptunium oxide, uranium oxide, or a combination thereof.

16. The flow redox battery system of claim 14, wherein the cathode is electrochemically configured to:

chemically separate a charged catholyte active material from the first or second catholyte carrier slurry and reduce the charged catholyte active material such that the charged catholyte active material outputs a proton receivable by the ion-exchange membrane upon receiving both the charged catholyte active material chemically engaged with the first or second catholyte carrier slurry and an electron from the power generation circuit; and

chemically separate a discharged catholyte active material from the first or second catholyte carrier slurry and oxidize the discharged catholyte active material such that the discharged catholyte active material outputs an electron receivable by the power generation circuit upon receiving both the discharged catholyte active material chemically engaged with the first or second catholyte carrier slurry and a proton from the ion-exchange membrane.

17. The flow redox battery system of claim 1, wherein the ion-exchange membrane comprises a solid state proton conducting material structurally configured to provide a proton pathway between the anode and the cathode.

18. A flow redox battery system comprising an electrochemical cell, an anolyte tank, a catholyte tank, a first anolyte carrier slurry, a second anolyte carrier slurry, a first catholyte carrier slurry, a second catholyte carrier slurry, an anolyte solution, a catholyte solution, and a power generation circuit, wherein:

the electrochemical cell comprises an ion-exchange membrane positioned between and electrochemically engaged with an anode and a cathode;

the power generation circuit is electrically coupled to the anode and the cathode;

the anolyte tank comprises an anolyte upper end fluidly coupled to the anode and an anolyte lower end fluidly coupled to the anode;

the catholyte tank comprises a catholyte upper end fluidly coupled to the cathode and a catholyte lower end fluidly coupled to the cathode;

the anolyte solution is chemically engageable with the first anolyte carrier slurry and the second anolyte carrier slurry;

the catholyte solution is chemically engageable with the first catholyte carrier slurry and the second catholyte carrier slurry;

the first anolyte carrier slurry comprises a density that is less than a density of the second anolyte carrier slurry and an electronegativity that is different than an electronegativity of the second anolyte carrier slurry;

the first catholyte carrier slurry comprises a density that is less than a density of the second catholyte carrier slurry and an electronegativity that is different than an electronegativity of the second catholyte carrier slurry; and

the first and second anolyte carrier slurries and the first and second catholyte carrier slurries each comprise a plurality of slurry grains, each slurry grain comprising an inert core and one or more active particles chemically engaged with the inert core.

19. A flow redox battery system comprising an electrochemical cell, an anolyte tank, a catholyte tank, a first anolyte carrier slurry, a second anolyte carrier slurry, a first catholyte carrier slurry, a second catholyte carrier slurry, and a power generation circuit, wherein:

the electrochemical cell comprises an ion-exchange membrane positioned between and electrochemically engaged with an anode and a cathode;

the power generation circuit is electrically coupled to the anode and the cathode;

the anolyte tank comprises an anolyte upper end fluidly coupled to the anode and an anolyte lower end fluidly coupled to the anode;

the catholyte tank comprises a catholyte upper end fluidly coupled to the cathode and a catholyte lower end fluidly coupled to the cathode;

the first anolyte carrier slurry comprises a density that is less than a density of the second anolyte carrier slurry such that the first anolyte carrier slurry floats above the second anolyte carrier slurry when the first and second anolyte carrier slurries are housed within the anolyte tank;

the first anolyte carrier slurry comprises an electronegativity that is greater than an electronegativity of the second anolyte carrier slurry such that the first anolyte carrier slurry electrochemically attracts a discharged anolyte active material and the second anolyte carrier slurry electrochemically attracts a charged anolyte active material, wherein the first and second anolyte carrier slurries each comprise a plurality of slurry grains, each slurry grain comprising an inert core and one or more active particles chemically engaged with the inert core;

the first catholyte carrier slurry comprises a density that is less than a density of the second catholyte carrier slurry such that the first catholyte carrier slurry floats above the second catholyte carrier slurry when the first and second catholyte carrier slurries are housed within the catholyte tank, wherein the first and second catholyte carrier slurries each comprise a plurality of slurry grains, each slurry grain comprising an inert core and one or more active particles chemically engaged with the inert core; and

the first catholyte carrier slurry comprises an electronegativity that is less than the electronegativity of the second catholyte carrier slurry such that the first catholyte carrier slurry electrochemically attracts a discharged catholyte and the second catholyte carrier slurry electrochemically attracts a charged catholyte active material.