WHAT IS CLAIMED IS:

1. A method for manufacturing a functional electrode, the method comprising:

providing and stirring a mixture comprising a solvent and at least one of one or more carbon materials and one or more conductive polymers to form a dispersion of the at least one of the one or more carbon materials and the one or more conductive polymers in the solvent;

adding at least one binder into the dispersion to provide a resultant mixture and stirring the resultant mixture;

processing the resultant mixture to form a plurality of electrode sheets; and

attaching the electrode sheets on opposite surfaces of an intermediate layer,

wherein the intermediate layer is electron conductive and ion non-conductive.

2. The method of claim 1, wherein the functional electrode comprises a bipolar electrode.

3. The method of claim 1, wherein the mixture further comprises one or more of carbon fibers, conductive carbon black, and carbon nanotubes.

4. The method of claim 1, wherein the solvent comprises water, ethanol, and combinations thereof.

5. The method of claim 1, wherein processing the resultant mixture comprises mixing one or more pore-forming agents with different particles sizes and the resultant mixture with another solvent to form a mixed paste and processing the mixed paste to form the electrode sheets.

6. The method of claim 5, wherein the one or more pore-forming agent are selected from the group consisting of sodium chloride, ammonium chloride, potassium chloride, calcium chloride, sodium carbonate, potassium carbonate, calcium carbonate, ammonium carbonate, ammonium acid carbonate, titanium oxide, zinc oxide, and combinations thereof.

7. The method of claim 5, wherein processing the mixed paste comprises calendering the mixed paste to form a calendered sheet, immersing the calendered sheet into deionized water to remove the one or more pore-forming agents, drying the calendered sheet after removal of the one or more pore-forming agents, and shaping the calendered sheet into the electrode sheets after drying.

8. The method of claim 1, further comprising attaching one or more reinforcement layers disposed on at least one of the electrode sheets, wherein the one or more reinforcement layers are selected from the group consisting of polyethylene terephthalate (PET), polyethene (PE), polypropylene (PP), poly(vinylidenechloride) (PVC), and combinations thereof.

9. The method of claim 1, further comprising disposing one or more anion selective materials and one or more cation selective materials on the respective electrode sheets.

10. The method of claim 9, wherein the one or more cation selective materials are selected from the group consisting of an amine group, a pyridinium group and combinations thereof, wherein the amine group comprises one or more of a primary amine, secondary amine, tertiary amine, and quaternary amine, and wherein the one or more anion selective materials are selected from the group consisting of a sulfonic group, carboxylic group, phosphate group, and combinations thereof.

11. The method of claim 1, wherein the one or more carbon materials are selected from the group consisting of activated carbon particles, carbon aerogels, carbon nanotubes, carbon cages, carbon fibers, porous carbon particles, porous mesocarbon microbeads, and combinations thereof, and wherein the one or more conductive polymers are selected from the group consisting of polyaniline, polypyrrole, and combinations thereof.

12. The method of claim 1, wherein the intermediate layer comprises one or more of carbon black, graphite, and a polymer, and wherein the polymer is selected from the group consisting of polyethylene terephthalate, polyethene, polypropylene, poly(vinylidenechloride), and combinations thereof.

13. The method of claim 1, wherein the binder comprises non-fibrillated polytetrafluoroethylene.

14. The method of claim 1, further comprising introducing one or more of vapor grown carbon fibers and conductive carbon blacks into the mixture comprising the solvent and the at least one of the one or more carbon materials and the one or more conductive polymers.

15. The method of claim 2, wherein the electrode sheets comprise a first and a second electrode sheet, wherein the first and second electrode sheets act as a first and a second layer of the bipolar electrode, and wherein the first and second layers of the bipolar electrode are configured to function as an anode and a cathode, respectively.

16. The method of claim 15, further comprising disposing a plurality of adhesive layers between the first layer and the intermediate layer, and between the second layer and the intermediate layer respectively, and wherein the adhesive layers comprise at least one of carbon-based polymer films and carbon conductive adhesives.