CLAIMS

What is claimed is:

1. A method for recycling lithium-ion batteries, comprising the steps of:

a) discharging the lithium-ion batteries;

b) chopping the lithium-ion batteries into pieces to provide a mixture of a structural part, a first conductive metal part coated with a cathode layer, and a second conductive metal part coated with an anode layer;

c) immersing the pieces of the chopped lithium-ion batteries into a polar solvent to form a heterogeneous mixture;

d) processing the heterogeneous mixture with mechanical agitation for a time period from about 15 minutes to about 2 hours to dissolve a binder material in the cathode and anode layers;

e) screening the processed heterogeneous mixture to separate the structural part, first conductive metal part, and second conductive metal part from finer electrode materials comprising cathode and anode materials to provide a suspension comprising the polar solvent and the finer electrode materials; and

f) isolating the finer electrode materials in the suspension from the polar solvent;

wherein the polar solvent is a buffer solution having a pH from about 6 to about 8.

2. The method of claim 1, wherein step d) is performed at room temperature.

3. The method of claim 1, wherein the heterogeneous mixture in step d) is heated at a temperature from about 35 ˚C to about 100 ˚C, or from about 55 ˚C to about 75 ˚C.

4. The method of claim 1, wherein the binder material comprises a water-based binder material selected from the group consisting of unsaturated polymer, conjugated diene polymer, styrene-butadiene rubber, acrylated styrene-butadiene rubber, acrylonitrile-butadiene rubber, acryl rubber, butyl rubber, fluorine rubber,

polyvinylpyrrolidone, polyolefin, polyethylene, polypropylene, ethylene/propylene copolymers, polybutadiene, polyethylene oxide, chlorosulfonated polyethylene, polyvinylpyrrolidone, polyvinylpyridine, polyvinyl compound, polyvinyl alcohol, polyvinyl acetate, polyepichlorohydrin, polyphosphazene, polyacrylonitrile, polystyrene, latex, acrylic resins, phenolic resins, epoxy resins, cellulose, carboxymethyl cellulose, hydroxypropyl cellulose, cellulose acetate, cellulose acetate butyrate, cellulose acetate propionate, cyanoethylcellulose, cyanoethylsucrose, polyester, polyamide, polyether, polyimide, polycarboxylate, polycarboxylic acid, polyacrylic acid, polyacrylate, polymethacrylic acid, polymethacrylate, polyacrylamide, polyurethane, halogenated polymer, fluorinated polymer, chlorinated polymer, a salt of alginic acid, and combinations thereof.

5. The method of claim 4, wherein the salt of alginic acid comprises a cation selected from Na, Li, K, Ca, NH_4, Mg, Al, or a combination thereof.

6. The method of claim 1, wherein the binder material comprises a water-based binder that is a monomer containing a carboxylic acid group, a sulfonic acid group, or a combination thereof.

7. The method of claim 1, wherein the lithium-ion batteries are chopped by a water jet cutting machine or a cutting device with teeth or blades.

8. The method of claim 1, wherein the pieces of the chopped lithium-ion batteries have an average length from about 0.5 inches to about 4.0 inches.

9. The method of claim 1, wherein the pieces of the chopped lithium-ion batteries have an average length of about one quarter inch or less.

10. The method of claim 1, wherein each of the first and second conductive metal parts is independently selected from the group consisting of an aluminum thin plate, a copper thin plate, a gold thin plate, a silver thin plate, and a platinum thin plate.

11. The method of claim 1, wherein the buffer solution comprises a salt selected from the group consisting of lithium carbonate, lithium bicarbonate, lithium phosphate, sodium carbonate, sodium bicarbonate, sodium phosphate, potassium carbonate, potassium bicarbonate, potassium phosphate, ammonium carbonate, ammonium bicarbonate, ammonium phosphate, and combinations thereof.

12. The method of claim 1, wherein the mechanical agitation of the processing step is performed by stirring, shaking, ultrasonication, vortexing, or a combination thereof.

13. The method of claim 1, wherein the binder material further comprises an organic-based binder material.

14. The method of claim 13, wherein the organic-based binder material is selected from the group consisting of polytetrafluoroethylene, perfluoroalkoxy polymer, polyvinylidene fluoride, copolymer of tetrafluoroethylene and hexafluoropropylene, fluorinated ethylene-propylene copolymer, terpolymer of tetrafluoroethylene, hexafluoropropylene and vinylidene fluoride, and combinations thereof.

15. The method of claim 1, wherein the finer electrode materials further comprise a conductive agent.

16. The method of claim 1, wherein the cathode material is a lithium metal oxide selected from the group consisting of $LiNiO_2$, $LiNi_xMn_yO_2$, $Li_{1+z}Ni_xMn_yCo_{1-x-y}O_2$, $LiNi_xCo_yAl_zO_2$, LiV_2O_5, $LiTiS_2$, $LiMoS_2$, $LiMnO_2$, $LiCoO_2$, $LiCrO_2$, $LiMn_2O_4$, $LiFePO_4$, and combinations thereof, wherein each x is independently from 0.3 to 0.8; each y is independently from 0.1 to 0.45; and each z is independently from 0 to 0.2; and wherein the anode material is a carbonaceous material.

17. The method of claim 1, wherein the finer electrode materials are screened by passing through a sieve having a mesh width between 2 mm and 4 mm, or between 0.5 mm and 1.0 mm.

18. The method of claim 1, wherein isolation of the finer electrode materials is performed by filtration, decanting, settling, centrifugation, or a combination thereof.