increased amounts of binder material. It would also be desirable to provide related treated electrodes.

SUMMARY OF THE INVENTION

[0004] In certain embodiments, the invention is directed to a cathode of a lithium-ion battery comprising a conductive substrate, a first layer covering at least a portion of the conductive substrate comprising a pretreatment composition comprising a Group IIIB and/or Group IVB metal, and a second layer covering at least a portion of the first layer, the second layer comprising a coating composition comprising a lithium-containing compound.

[0005] In certain other embodiments, the invention is directed to a battery comprising a cathode comprising a conductive substrate, a first layer covering at least a portion of the conductive substrate comprising a pretreatment composition comprising a Group IIIB and/or Group IVB metal, and a second layer covering at least a portion of the first layer, the second layer comprising a coating composition comprising a lithium-containing compound. The battery also comprises an anode, a separator between the anode and the cathode, and an electrolyte in contact with the anode and the cathode.

[0006] In certain other embodiments, the invention is directed to a method for treating a battery cathode, comprising contacting a conductive substrate of the battery cathode with a pretreatment composition comprising a Group IIIB and/or Group IVB metal, and depositing a coating composition comprising lithium-containing compounds over at least a portion of the pretreated conductive substrate.

[0007] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate some non-limiting embodiments of the invention and together with the description, serve to explain the invention.

[0021] In certain embodiments, the cathode 10 may be prepared by mixing a positive active material, a conductive material, and a binder by any method known to those skilled in the art, as described, for example, in Lithium-Ion Batteries: Science and Technologies, Yoshio et al., 2009. In certain embodiments, the cathode may be prepared by mixing about 90 wt% LiNiCoMnO2 as the lithium active material, about 5 wt% of conductive carbon (e.g., acetylene black), and about 5 wt% of a binder, such as PVDF, and using an aluminum collector foil, typically of 10-15 μm thickness.

[0022] In certain embodiments, and as illustrated in FIG. 1, the anode 20 and the cathode 10 (described below) may be separated by a separator 40. In certain embodiments, the separator may be formed of a polymer film, such as polyethylene or polypropylene, having micro pores may be laminated. In certain embodiments, the anode 20, the cathode 10, and the separator 40 may be spirally wound to produce a spiral type electrode element. In certain embodiment, the roll may have an oblong shape.

[0023] In accordance with embodiments of the invention, and as schematically illustrated in FIG. 2, the cathode 10 comprises a conductive substrate 12, a first layer 14 covering at least a portion of the conductive substrate 12 comprising a pretreatment composition comprising a Group IIIB and/or Group IVB metal, and a second layer 16 covering at least a portion of the first layer 14, the second layer 16 comprising a coating composition comprising a lithium-containing compound.

[0024] The conductive substrate 12 to be treated in accordance with the methods of the present invention may first be cleaned to remove grease, dirt, or other extraneous matter. This is often done by employing mild or strong alkaline cleaners, such as are commercially available and conventionally used in metal pretreatment processes. Examples of alkaline cleaners suitable for use in the present invention

CLAIMS

1. A cathode of a lithium-ion battery comprising:

   a conductive substrate;

   a first layer covering at least a portion of the conductive substrate comprising a pretreatment composition comprising a Group IIIB and/or Group IVB metal and an electropositive metal; and

   a second layer covering at least a portion of the first layer, the second layer comprising a coating composition comprising a lithium-containing compound.

2. The cathode of Claim 1, wherein the Group IIIB and/or Group IVB metal comprises zirconium.

3. The cathode of Claim 1, wherein the Group IIIB and/or Group IVB metal is present in the pretreatment composition in an amount of at least 20 ppm metal.

4. The cathode of Claim 1, wherein the electropositive metal is present in an amount of at least 2 ppm metal.

5. The cathode of Claim 1, wherein the electropositive metal comprises tin, indium, gallium, cobalt, nickel, copper, silver, gold, or a combination thereof.

6. The cathode of Claim 1, wherein the pretreatment composition further comprises a free fluoride source, preferably present in an amount of at least 2 ppm.

7. The cathode of Claim 6, wherein the free fluoride source comprises fluorides or bifluorides of ammonium, phosphonium, Group IA metals, Group IIA metals, Group IIIA metals, or a combination thereof.

8. The cathode of Claim 1, wherein the lithium-containing compound comprises lithium nickel cobalt manganese dioxide, lithium iron phosphate, carbon-coated lithium iron phosphate, or a combination thereof.

9. The cathode of Claim 1, wherein the lithium-containing compound comprises from 80 to 90 weight percent, based on a total weight of the coating, and wherein the coating composition further comprises a conductive agent comprising from 5 to 10 weight percent and a binder comprising from 5 to 10 weight percent, based on the total weight of the coating.

10. The cathode of Claim 1, wherein the cathode has a 180° peel adhesion strength of greater than 1.5 N.

11. The cathode of Claim 1, wherein the first layer has a thickness of 5 to 500 nm.

12. The cathode of Claim 1, wherein the cathode comprises aluminum.

13. A battery comprising:

a cathode according to any of claims 1-9,12;

an anode;

a separator between the anode and the cathode; and

an electrolyte in contact with the anode and the cathode.

14. A method for treating a battery cathode, comprising:

contacting a conductive substrate of the battery cathode with a pretreatment composition comprising a Group IIIB and/or Group IVB metal; and

depositing a coating composition comprising lithium-containing compounds over at least a portion of the pretreated conductive substrate.

15. The method of Claim 14, further comprising contacting the conductive substrate with a fluoride solution prior to contacting the conductive substrate with the pretreatment composition.

We claim:

1. A cathode of a lithium-ion battery comprising:

a conductive substrate;

a first layer covering at least a portion of the conductive substrate comprising a pretreatment composition comprising a Group IIIB and/or Group IV metal; and

a second layer covering at least a portion of the first layer, the second layer comprising a coating composition comprising a lithium-containing compound.

2. The cathode of Claim 1, wherein the Group IIIB and/or Group IVB metal comprises zirconium.

3. The cathode of Claim 1, wherein the Group IIIB and/or Group IVB metal is present in the pretreatment composition in an amount of at least 20 ppm metal.

4. The cathode of Claim 1, wherein the pretreatment composition further comprises an electropositive metal present in an amount of at least 2 ppm metal.

5. The cathode of Claim 4, wherein the electropositive metal comprises tin, indium, gallium, cobalt, nickel, copper, silver, gold, or a combination thereof.

6. The cathode of Claim 1, wherein the pretreatment composition further comprises a free fluoride source present in an amount of at least 2 ppm.

7. The cathode of Claim 6, wherein the free fluoride source comprises fluorides or bifluorides of ammonium, phosphonium, Group IA metals, Group IIA metals, Group IIIA metals, or a combination thereof.

8. The cathode of Claim 1, wherein the lithium-containing compound comprises lithium nickel cobalt manganese dioxide, lithium iron phosphate, carbon-coated lithium iron phosphate, or a combination thereof.

9. The cathode of Claim 1, wherein the lithium-containing compound comprises from 80 to 90 weight percent, based on a total weight of the coating, and wherein the coating composition further comprises a conductive agent comprising from 5 to 10 weight percent and a binder comprising from 5 to 10 weight percent, based on the total weight of the coating.

10. The cathode of Claim 1, wherein the cathode has a 180° peel adhesion strength of greater than 1.5 N.

11. The cathode of Claim 1, wherein the first layer has a thickness of 5 to 500 nm.

12. The cathode of Claim 1, wherein the cathode comprises aluminum.

13. A battery comprising:

a cathode comprising:

a conductive substrate;

a first layer covering at least a portion of the conductive substrate comprising a pretreatment composition comprising a Group IIIB and/or Group IV metal; and

a second layer covering at least a portion of the first layer, the second layer comprising a coating composition comprising a lithium-containing compound;

an anode;

a separator between the anode and the cathode; and

an electrolyte in contact with the anode and the cathode.

14. The battery of Claim 13, wherein the Group IIIB and/or Group IVB metal comprises zirconium.

15. The battery of Claim 13, wherein the pretreatment composition further comprises an electropositive metal.

16. The battery of Claim 13, wherein the pretreatment composition further comprises a free fluoride source.

17. The battery of Claim 13, wherein the lithium-containing compound comprises from 80 to 90 weight percent, based on a total weight of the coating, and wherein the coating composition further comprises a conductive agent comprising from 5 to 10 weight percent and a binder comprising from 5 to 10 weight percent, based on the total weight of the coating.

18. The battery of Claim 13, wherein the conductive substrate comprises aluminum.

19. A method for treating a battery cathode, comprising:

contacting a conductive substrate of the battery cathode with a pretreatment composition comprising a Group IIIB and/or Group IV metal; and

depositing a coating composition comprising lithium-containing compounds over at least a portion of the pretreated conductive substrate.

20. The method of Claim 19, further comprising contacting the conductive substrate with a fluoride solution prior to contacting the conductive substrate with the pretreatment composition.