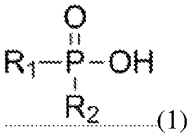
CLAIMS

What is claimed is:

1. A coated cathode active material comprising a cathode active material and a coating layer; wherein the coating layer of the coated cathode active material is derived from a phosphorus-containing compound, and wherein the phosphorus-containing compound has a chemical structure that satisfies general formula (1).



.....(1)

2. The coated cathode active material according to claim 1, wherein R_1 is alkyl, alkenyl, alkynyl, enynyl, cycloalkyl, or alkylcarbonylalkyl, and R_2 is alkyl, alkenyl, alkynyl, enynyl, cycloalkyl, alkoxy, alkylcarbonylalkyl, or hydroxyl; wherein each of the alkyl, alkenyl, alkynyl, enynyl, cycloalkyl, alkoxy, and alkylcarbonylalkyl is optionally substituted with one or more substituents independently selected from F, Cl, Br, I, cyano, hydroxyl, N_3, NO_2, NH_2, ester, amide, aldehyde, acyl, alkyl, alkoxy, alkylthio or alkylamino.

3. The coated cathode active material according to claim 1, wherein R_1 is C_1-C_{40} alkyl, and wherein R_2 is hydroxyl, C_1-C_{40} alkyl, or C_1-C_{40} alkoxy.

4. The coated cathode active material according to claim 1, wherein R_1 of the phosphorus-containing compound is selected from the group consisting of methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, nonadecyl, and icosyl, and wherein R_2 of the phosphorus-containing compound is selected from the group consisting of hydroxyl, methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, nonadecyl, icosyl, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, nonoxy, decoxy, undecoxy, dodecoxy, tridecoxy, tetradecoxy, pentadecoxy, hexadecoxy, heptadecoxy, octadecoxy, nonadecoxy, and icosoxy.

5. The coated cathode active material according to claim 1, wherein the amount of phosphorus-containing compound coated per unit surface area of cathode active material particles is from about 0.1 $\mu mol/m^2$ to about 30 $\mu mol/m^2$.

6. The coated cathode active material according to claim 1, wherein the thickness of the coating layer is less than 10 nm.

7. The coated cathode active material according to claim 1, wherein the cathode active material is selected from the group consisting of $LiCoO_2$, $LiNiO_2$, $LiNi_{1-x}(M_a)_xO_2$, $LiNi_xMn_yO_2$, $LiCo_xNi_yO_2$, $Li_{1+z}Ni_xMn_yCo_{1-x-y}O_2$, $LiNi_xCo_yAl_zO_2$, LiV_2O_5, $LiTiS_2$, $LiMoS_2$, $LiMnO_2$, $LiCrO_2$, $LiMn_2O_4$, Li_2MnO_3, $LiFeO_2$, LiM_bPO_4, $Li_{1+a}Ni_bMn_cCo_dAl_{(1-b-c-d)}O_2$, $Li_3V_2(PO_4)_3$, $LiVPO_4F$, $LiNi_xMn_eO_4$, $LiNi_{0.92}Mn_{0.04}Co_{0.04}O_2$, and combinations thereof, wherein $0.1\leq x\leq 0.9$; $0\leq y\leq 0.9$; $0\leq z\leq 0.4$; $-0.2\leq a\leq 0.2$; $0\leq b<1$; $0\leq c<1$; $0\leq d<1$; $0\leq e\leq 2$; and $b+c+d\leq 1$; M_a is selected from the group consisting of Co, Mn, Al, Fe, Ti, Ga, Mg, and combinations thereof; and M_b is selected from the group consisting of Fe, Co, Ni, Mn, Al, Mg, Zn, Ti, La, Ce, Sn, Zr, Ru, Si, Ge, and combinations thereof.

8. The coated cathode active material according to claim 1, wherein the cathode active material comprises or is a core-shell composite having a core and shell structure, wherein the shell comprises a lithium transition metal oxide selected from the group consisting of $Li_{1+x}Ni_aMn_bCo_cAl_{(1-a-b-c)}O_2$, $LiCoO_2$, $LiNiO_2$, $LiMnO_2$, $LiMn_2O_4$, Li_2MnO_3, $LiCrO_2$, $Li_4Ti_5O_{12}$, LiV_2O_5, $LiTiS_2$, $LiMoS_2$, $LiCo_aNi_bO_2$, $LiMn_aNi_bO_2$, and combinations thereof; wherein $-0.2\leq x\leq 0.2$, $0\leq a<1$, $0\leq b<1$, $0\leq c<1$, and $a+b+c\leq 1$.

9. The coated cathode active material according to claim 1, wherein the cathode active material comprises or is a core-shell composite having a core and shell structure, wherein the shell comprises one or more transition metal oxides selected from the group consisting of Fe_2O_3, MnO_2, Al_2O_3, MgO, ZnO, TiO_2, La_2O_3, CeO_2, SnO_2, ZrO_2, RuO_2, and combinations thereof.

10. The coated cathode active material according to claim 1, 7 or 8, wherein the cathode active material is doped with a dopant selected from the group consisting of Co, Cr, V, Mo, Nb, Pd, F, Na, Fe, Ni, Mn, Al, Mg, Zn, Ti, La, Ce, Sn, Zr, Ru, Si, Ge, and combinations thereof.

11. A cathode slurry for a secondary battery, comprising the coated cathode active material according claim 1, a binder material, and an aqueous solvent.

12. The cathode slurry according to claim 11, wherein the binder material comprises a binder copolymer, wherein the binder copolymer comprises a structural unit (a) that is derived from an acid-group containing monomer, and wherein the acid group is selected from the group consisting of carboxylic acid, sulfonic acid, phosphonic acid, phosphoric acid, salts of these acids, derivatives of these acids, and combinations thereof.

13. The cathode slurry according to claim 12, wherein the binder copolymer further comprises a structural unit (b) that is derived from a monomer selected from the group consisting of an amide group-containing monomer, a hydroxyl group-containing monomer, and combinations thereof; and a structural unit (c) that is derived from a monomer selected from the group consisting of a nitrile group-containing monomer, an ester group-containing monomer, an epoxy group-containing monomer, a fluorine-containing monomer, and combinations thereof.

14. The cathode slurry according to claim 11, wherein the aqueous solvent is water.

15. The cathode slurry according to claim 14, wherein the aqueous solvent additionally comprises a miscible minor component in addition to water, and wherein the miscible minor component is selected from the group consisting of methanol, ethanol, isopropanol, n-propanol, tert-butanol, n-butanol, 1,2-butanediol, 1,3-butanediol, 1,4-butanediol, 2,3 butanediol, ethylene glycol, propylene glycol, glycerol, acetone, dimethyl ketone, methyl ethyl ketone, ethyl acetate, isopropyl acetate, propyl acetate, butyl acetate, 1,4-dioxane, diethyl ether, tetrahydrofuran, chloroform, dichloromethane, acetonitrile, dimethyl sulfoxide, nitromethane, propylene carbonate, ethylene carbonate, dimethyl carbonate, pyridine, acetaldehyde, acetic acid, propanoic acid, butyric acid, furfuryl alcohol, diethanolamine, dimethylacetamide, dimethylformamide, and combinations thereof; and wherein the volume ratio of water and the miscible minor component is from about 51:49 to about 99:1.

16. The cathode slurry according to claim 11, wherein the cathode slurry further comprises a conductive agent selected from the group consisting of carbon, carbon black, graphite, expanded graphite, graphene, graphene nanoplatelets, carbon fibers, carbon nano-fibers, graphitized carbon flake, carbon tubes, carbon nanotubes, activated carbon, mesoporous carbon, and combinations thereof.

17. The cathode slurry according to claim 11, wherein the proportion of the coated cathode active material in the cathode slurry is from about 60% to about 99% by weight, based on the total weight of the solid portion of the cathode slurry.

18. The cathode slurry according to claim 11, wherein the degradation of cathode active material in water is inhibited by a percentage from about 1 percent to about 40 percent.

19. The cathode slurry according to claim 11, wherein the concentration of lithium ions in the cathode slurry is from about 0.05M to about 1.25M.

20. A cathode for a secondary battery, comprising the coated cathode active material

according to claim 1.