CLAIMS

1. A core-shell electrode active material, comprising:

a core capable of intercalating and deintercalating lithium; and

a coating layer formed on at least a portion of an outer surface of the core, wherein the coating layer comprises a lithium oxofluorometallate, wherein the lithium oxofluorometallate comprises a general formula:

$$Li_mMO_xF_y$$

wherein M is a metal capable of forming an oxofluorometallate, selected from aluminum (Al), iron (Fe), titanium (Ti), Zirconium (Zr), scandium (Sc), vanadium (V), chromium (Cr), manganese (Mn), cobalt (Co), nickel (Ni), copper (Cu), Zinc (Zn), molybdenum (Mo), ruthenium (Ru), lanthanum (La), Hafnium (Hf), Niobium (Nb), tungsten (W), gallium (Ga), indium (In), tin (Sn), thallium (Tl), and lead (Pb), and M may further comprise one or more additional metal, one or more metalloid, and one or more of phosphorus (P), sulfur (S), selenium (Se), iodine (I) or arsenic (As), or a combination of two or more of the additional metal, metalloid, P, S, Se, I, and As, and

$x > 0$, $y > 0$, and $m \geq 1$ ,

wherein for all metals M bonded to O and all metals M bonded to F in the coating, there is a ratio of M-F:M-O, and wherein the ratio of M-F:M-O is in the range from 30:70 to 70:30.

2. The core-shell electrode active material of claim 1 wherein the core comprises one or a combination of two or more of lithium cobalt oxide, lithium manganese oxide, lithium nickel manganese oxide, lithium nickel manganese cobalt oxide (NMC), lithium nickel cobalt aluminum oxide, lithium-rich cathode material and nickel-rich NMC material.

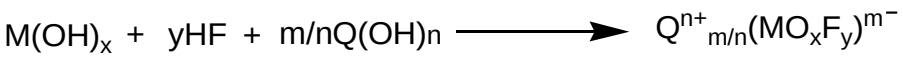
3. The core-shell electrode active material of claim 1 ~~or claim 2~~ wherein the metal capable of forming an oxofluorometallate is selected from Al, Ti, V, Zn, Ni, Co, Mn, Zr, In, Si, and Cu.

4. The core-shell electrode active material of ~~any one of claims 1-3~~claim 1 wherein M comprises a combination of two or more of the metals capable of forming oxofluorometallates.

5. A process for coating a shell onto a ceramic substrate, wherein the ceramic substrate is a cathode material, comprising:

a. providing a ceramic substrate;

b. preparing a precursor having a general formula $Q_{m/n}MO_xF_y$ by the following reaction:



$$M(OH)_x + yHF + m/nQ(OH)_n \longrightarrow Q^{n+}{}_{m/n}(MO_xF_y)^{m-}$$

wherein

Q is an onium ion, selected from quaternary alkyl ammonium, quaternary alkyl phosphonium and trialkylsulfonium, wherein the alkyl groups are independently selected from $C_1$-$C_{18}$ alkyl, branched or unbranched;

M is a metal capable of forming an oxofluorometallate, selected from aluminum (Al), iron (Fe), titanium (Ti), Zirconium (Zr), scandium (Sc), vanadium (V), chromium (Cr), manganese (Mn), cobalt (Co), nickel (Ni), copper (Cu), Zinc (Zn), molybdenum (Mo), ruthenium (Ru), lanthanum (La),Hafnium (Hf), Niobium (Nb), tungsten (W),gallium (Ga), indium (In), tin (Sn), thallium (Tl), and lead (Pb), and may further comprise one or more additional metal, one or more metalloid, and one or more of phosphorus (P), sulfur (S), selenium (Se), iodine (I) or arsenic (As), or a combination of two or more of the additional metal, metalloid, P, S, Se, I, and As, and

$x > 0$, $y > 0$, $m \geq 1$ and $n \geq 1$; and

c. combining the $Q_{m/n}MO_xF_y$ precursor with a lithium ion source and with the ceramic substrate, and mixing to form a coating composition comprising a lithium oxofluorometallate having a general formula $Li_mMO_xF_y$ on the ceramic substrate.

6. The process of claim 5, further comprising calcining the coated ceramic substrate at a temperature in the range from 200°C to 700°C for a time in the range from 1 to 24 hours.

7. The process of claim 5 ~~or claim 6~~, wherein the ceramic substrate comprises ceramic particles suitable for active electrode material in a lithium-ion battery.

8. The process of claim 7, wherein the ceramic particles comprise one or a combination of two or more of lithium cobalt oxide, lithium manganese oxide, lithium nickel manganese oxide, lithium nickel manganese cobalt oxide (NMC), lithium nickel cobalt aluminum oxide, lithium-rich cathode material and nickel-rich NMC material.

9. The process of ~~any one of claims 5-8~~ claim 5 wherein the metal capable of forming an oxofluorometallate is selected from Al, Ti, V, Zn, Ni, Co, Mn, Zr, In, Si, and Cu.

10. The process of ~~any one of claims 5-9~~ claim 5 wherein M comprises a combination of two or more of the metals capable of forming oxofluorometallates.

11. The process of ~~any one of claims 5-10~~ claim 5 wherein the quaternary ammonium is one or more selected from tetramethylammonium hydroxide, 1,3-bis (trimethylammonium)-2-propanol dihydroxide (BTA(OH)2), trimethyladmantylammonium hydroxide, and benzyltrimethylammonium hydroxide.

12. The process of ~~any one of claims 5-11~~ claim 5 wherein the lithium ion source is one or more selected from lithium hydroxide, lithium acetate, or a lithium halide.