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Composite Electrodes for Rechargeable Lithium-ion Batteries

Electrodes that offer superior cost and safety features over state-of-the-art $LiCoO_2$ electrodes.

The Invention

Electrodes having composite $xLi_2M'O_3 \cdot (1-x)LiMO_2$ structures in which an electrochemically inactive $Li_2M'O_3$ component is integrated with an electrochemically active $LiMO_2$ component to provide improved structural and electrochemical stability. The preferred M' ions are manganese, titanium and zirconium, whereas the preferred M ions are manganese and nickel, which can be used in combination with other metals such as cobalt. For example, the composite electrode $^{0.10}Li_2MnO_3 \cdot 0.90LiMn_{0.26}Ni_{0.37}Co_{0.37}O_2$, which can also be represented in conventional layered notation as $Li[Li_{0.0475}Mn_{0.3175}Ni_{0.3175}Co_{0.3175}]O_2$, shows outstanding electrochemical properties. The structural compatibility between the two components, both of which have layered configurations (Fig. 1), allows integration to occur at the atomic level.

During charge and discharge of a lithium-ion cell, Li^+ ions are electrochemically removed from and reinserted into the $LiMO_2$ component, respectively, as shown schematically in a compositional phase diagram of a $Li_2M'O_3$ - $LiMO_2$ - MO_2 - Li_2MO_2 electrode system (Fig. 2). An additional advantage of using electrode structures with manganese and nickel ions in the $LiMO_2$ component is that these structures can accommodate additional lithium; they form layered Li_2MO_2 structures without compromising the reversibility of the reaction, thereby providing additional capacity to the electrode. The $Li_2M'O_3$ component not only provides structural stability but also ensures, with its high lithium content, that the lithium layers in the composite electrodes are not contaminated by small amounts of transition metal ions, such as Ni^{2+} ions.

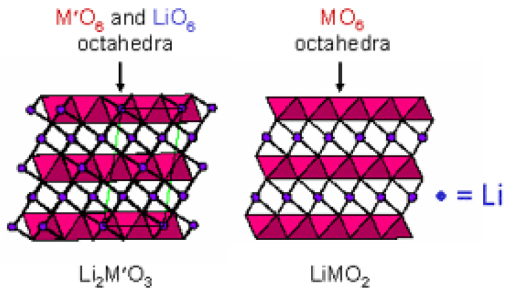

Fig. 1. Structural illustrations of the components of $xLi_2MO_3 \cdot (1-x)LiMO_2$

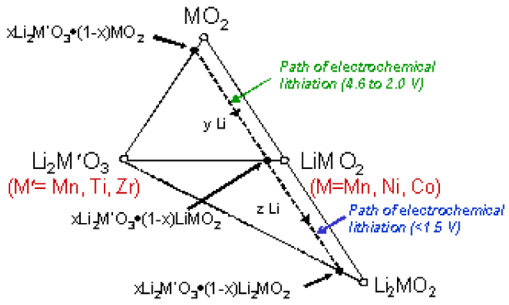

Fig. 2. The compositional phase diagram of a Li_2MO_3 - $LiMO_2$ - MO_2 - Li_2MO_2 electrode

Benefits

- Superior cost and safety features over state-of-the-art $LiCoO_2$ electrodes
- Can be charged and discharged at high rates

Applications and Industries

Electrodes used in batteries for

- Electric and plug-in hybrid electric vehicles;
- Portable electronic devices;
- Medical devices; and
- Space, aeronautical, and defense-related devices.

Developmental Stage

Ready for commercialization

Availability

Available for licensing

Patent Information

US Patents 6,677,082 and 6,680,143

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Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC

June 2012
cse-6677082 -0612