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Synthesis and electrical characterization of Fe and Al doped $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ for lithium ion rechargeable battery cathodes

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Li-ion batteries (LIB) undeniably represent the most promising energy storage system among the portable sources of energy and certain aspects of its principles of operation deserve particular attention. Though $LiCoO_2$ has most widely been used for the cathode of Li-ion batteries, now $Li(Ni_yCo_{1-2y}Mn_y)O_2$ material systems (R3*m* layered structure) are extensively being studied to replace costly $LiCoO_2$. In this system, $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ has extensively been investigated, because of its superior electrochemical performance and safety with compared to $LiCoO_2$. This abstract presents a study of synthesis and electrical characterization of new material compositions prepared by substituting Co, in $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ with Al and Fe.

New material compositions in two systems, $Li(Ni_{1/3}Co_{(1/3-x)}Mn_{1/3}Fe_x)O_2$, (x=0.00, 0.11, 0.22, 0.33) and $Li(Ni_{1/3}Co_{(1/3-x)}Mn_{1/3}Al_x)O_2$, (x=0.00, 0.11, 0.22, 0.33) were synthesized in the form of fine powders by Pechini method by calcining at 900 °C for 4 h. The calcined powders were then pelletized and sintered at 1000 °C for 4 h. The phase and particle size analyses were carried out on calcined powders with X-ray diffractometry and a particle size analyzer, respectively. The a.c. impedance, Seebeck and d.c. (four probe method) electrical characterizations were performed on the sintered pellets.

The phase analysis revealed the formation of solid solutions of appropriate $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ phase (R3*m* layered structure) in the materials doped with Fe and Al content up to 0.11. The electrical conductivity of most of these materials is in the order of $1x10^{-4}$ S/cm at 25 °C and $1x10^{-2}$ S/cm at 200 °C, and much better than that reported for $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$. The electrical conductivity of Fe doped system increases with Fe content up to x=0.11, then decreases significantly, but even at x = 0.22, the conductivity is still higher than that of $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$. Conversely, conductivity of Al doped system decreases with Al content, indicating that the Al doping in $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ has adversely affected the electrical conductivity. All these materials prepared by Pechini method show of having appropriate particle size for LIB cathodes. Altogether, this study shows potentiality of, specially Fe doped $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ materials prepared by Pechini method, for Li-ion battery cathode application.

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