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Synthesis and electrical characterization of $Li(Ni_{1/3}Co_{1/3-x}Mn_{1/3}\ Mg_x)O_2$ and $Li(Ni_{1/3}Co_{1/3}Mn_{1/3-x}\ Mg_x)O_2$ for lithium ion rechargeable battery positive electrode

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$Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ which is commonly known as 333 material, is an important member of the $Li(Ni_yCo_{1-2y}Mn_y)O_2$ system (y = 1/3), hence, has recently been investigated as a promising candidate for positive electrode materials in lithium ion rechargeable battery (LIB). It is believed that presence of Mg^{2+} prevents occupancy of the Li^+ layers by Ni^{2+} in these layered materials and does not cause local structural collapse and is beneficial for the thermal and electrochemical stability

New material compositions of two systems, $Li(Ni_{1/3}Co_{1/3}Mn_{(1/3-x)}Mg_x)O_2$ and $Li(Ni_{1/3}Co_{(1/3-x)}Mn_{1/3}Mg_x)O_2$(x=0, 0.11, 0.22, 0.33) were synthesized in the form of fine powders by the Pechini method. Subsequently powders were calcined at 900 °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 and d.c.(four probe method) electrical characterizations were performed on the pellets sintered at 1000 °C for 4 h.

The phase analysis revealed the formation of solid solutions of appropriate 333 phase (R3m layered structure) in the materials doped with Mg content up to 0.11. The electrical conductivity of 333 (i.e.x=0.0), at 25 °C is about $1x10^{-4}$ S/cm and $2x10^{-3}$ S/cm at 200 °C. For the new compositions prepared substituting Co and Mn by Mg , the electrical conductivity is almost $7x10^{-4}$ S/cm and $4x10^{-2}$ S/cm at 25 °C and 200 °C, respectively. The d.c electrical conductivity increases in an exponential way for all the materials with temperature, indicating semiconductor behaviour of the materials. The electrical conductivity of $Li(Ni_{1/3}Co_{1/3}Mn_{(1/3-x)}Mg_x)O_2$ system increases with Mg content up to x=0.22, then decreases significantly. But the conductivity is still higher than that of 333 material even at x = 0.33. Quite interestingly in the system where the Co was substituted with Mg, electrical conductivity increases with Mg content then decreases almost to the same value of 333 material. However again the conductivity increase in the cobalt free system (i.e. x=0.33) unexpectedly. All these materials prepared by Pechini method show of having appropriate particle size for LIB positive electrode. Altogether, this study shows potentiality of, Mg doped $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ materials prepared by Pechini method, for LIB positive electrode application.

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