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Synthesis and electrical characterization of $Li(Ni_{1/3}Co_{1/3-x}Mn_{1/3}Zn_x)O_2$, (x= 0.00, 0.11, 0.22, 0.33) for lithium ion rechargeable battery cathodes

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This abstract presents a study of synthesis and electrical characterization of $Li(Ni_{1/3}Co_{1/3-x}Mn_{1/3}Zn_x)O_2$ (X = 0.00, 0.11, 0.22, 0.33) materials synthesized by the Pechini method. The Pechini method is a low cost technique which results in powders with high purity, homogeneity and particle morphology that are greatly preferred for Li-ion battery cathodes. Subsequently powders were calcined at 900 °C for 4 hrs in air. The phase analysis was carried out on calcined powders with X-ray diffractometry. The a.c. impedance and d.c. (four probe method) electrical characterizations were performed on the pellets sintered at 1000 °C for 4 hrs in static air.

The phase analysis of the materials revealed the formation of a solid solution of $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ phase (R3*m* structure), only in the materials with x=0.00 and 0.11. With the increase of the Zn content, at 0.22 and 0.33 substitutional levels, formation of secondary phases is quite evident, resulting in a drastic change in the structure. The electrical conductivity at 25 °C is about $1x10^{-4}$ S/cm and $2x10^{-3}$ S/cm at 200 °C for $Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$ (x=0.00). For the other investigated materials, electrical conductivity is in the range of $2.5x10^{-2}$ S/cm to $4.6x10^{-3}$ S/cm at room temperature and $2.4x10^{-2}$ S/cm to $2.9x10^{-3}$ S/cm at 200 °C, respectively. To 0.11 substitutional level, the materials showed an increase of the conductivity and also a possible semiconducting behaviour. However, the conductivity variation with the temperature at 0.22 and 0.33 Zn substitutional levels is quite abnormal, unexpectedly the conductivity slightly decreased with temperature, which is an indication of metallic behavior for the materials. This change could be attributed to the presence of structural changes that can be observed in the x-ray diffractograms. As a result, the materials above 0.11 Zn substitutional level could not be used for conventional lithium ion battery cathode applications.

As a whole, this study shows the potentiality of preparing Zn doped $Li(Ni_{1/3}Co_{1/3-x}Mn_{1/3}Zn_x)O_2$ materials up to x=0.11, by Pechini method, with appropriate structural and electrochemical properties suitable for Li-ion battery cathode application.

Key words: Lithium ion battery, Pechini method, cathode material.