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Synthesis and electrical characterization of $Na_xM_{1-x}O$, M=Co and Mn, compositions

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From the viewpoint of cost and efficiency, semi-conductive oxide ceramics are the best practical electrode materials for rechargeable batteries. This work is based on the synthesis and electrical characterization of $Na_xMn_{1-x}O$ with x = 0 - 0.5 and $Na_xCo_{1-x}O$ with x = 0 - 0.75 oxide ceramics for rechargeable Na-ion battery (NIB) cathode application. For this study, Pechini wet chemical powder preparation technique was employed to synthesize oxide powders having appropriate characteristics for the cathode preparation. The powder synthesis process was completed by calcining the ash product at 800 °C for two hours in air. This revealed the possibility of successful synthesis of $Na_xM_{1-x}O$, M = Co, Mn compositions by the Pechini technique. The synthesized powders were uni-axially pressed at 150 MPa and the green pellets were subsequently sintered at 800 °C for two hours in static air.

The d.c. electrical conductivity measurements were performed by the four-probe technique from room temperature to 200 °C. All the materials prepared in this study showed an increase in conductivity in an exponential manner with increase in ambient temperature. This is a good indication of the semiconducting nature, which is a prime requirement to be an electrode material. In the $Na_xMn_{1-x}O$ system, the x=0 base composition showed an electrical conductivity of $3.9x10^{-6}$ S/cm. However, the increase of Na content has increased the conductivity considerably to a maximum of $4.1x10^{-5}$ S/cm at x=0.25. This indicates the need of further investigations, especially with suitable conductive additives for enhancing electrical conductivity of these $Na_xMn_{1-x}O$ materials. Interestingly, in the $Na_xCo_{1-x}O$ system, the increase of the Na content has drastically increased the conductivity and the composition with x=0.75 showing an electrical conductivity close to 1 S/cm at room temperature. This is a significant achievement in electrical conductivity and this material can directly be used without any other additional conductivity enhancer, for NIB cathode preparation. Altogether this study indicated the potential of $Na_xM_{1x}O$, M=Co and Mn, compositions, specially the $Na_xCo_{1-x}O$ with x>0.5 compositions, for the Na-ion battery cathode application.

Keywords: Cathode materials, electrical conductivity, Pechini method, semi-conductive oxide ceramics, sodium-ion battery

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