Structural, Electrical, and Electrochemical Characterization of $Li_{1.2}Ni_{0.6-x}Mg_xCo_{0.3}O_2$ Cathode Materials for Application in Lithium-Ion Batteries

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Abstract

Lithium-rich nickel cobalt magnesium oxide cathode materials with varying concentrations of nickel and magnesium have been synthesized using a solid-state reaction (SSR) method. The structural properties of the as-synthesized cathode materials were analyzed by x-ray diffraction (XRD), confirming their α-$NaFeO_2$ layered structure in space group *R3m*. Scanning electron microscopy (SEM) study revealed the cube-like hexagonal structure of the prepared materials. Electrochemical impedance spectroscopy (EIS) was carried out in the frequency range from 1 Hz to 7 MHz with a voltage amplitude of 10 mV. At ambient temperature, the direct-current (DC) conductivity was found to be the highest for the $Li_{1.2}Ni_{0.6}Co_{0.3}O_2$ cathode material with a value of 3.64×10^{-4} S/cm. Various conducting mechanisms are proposed for the prepared cathode materials based on Jonscher's power law. The activation energy is seen to increase with increasing Mg concentration, which helps to produce a defect-less or ordered homogeneous structure. Furthermore, the value of the power-law exponent *n* is found to decrease with increasing Mg concentration. For the $Li_{1.2}Ni_{0.3}Mg_{0.3}Co_{0.3}O_2$ sample, the *n* value decreases with increasing temperature and is found to be less than 1 at higher temperatures, indicating the orderliness of the system. Cyclic voltammetry (CV) measurements confirmed that Mg substitution delayed the oxidation and reduction processes, thus enhancing the operating voltage of the electrochemical cell.