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Influence of CuO Concentration on the Electrical Conductivity and Structural Properties of Lithium Borate Glasses

Borate glasses are notable for their unique combination of properties, including a low melting point, high transparency, large refractive index, and good thermal stability. Lithium borate glasses have attracted considerable attention due to their significant ionic conductivity and potential applications in solid-state batteries and electrochemical devices. Incorporating transition metal oxides such as CuO into the lithium borate matrix can significantly influence the glass structure and ionic transport properties.
The physical, structural, electrical, and optical properties of the (60-x)Li2O-40B2O3-xCuO glasses with x = 0, 5, 10, and 15 mol% were investigated. The glasses were prepared by the melt-quenching method. Samples were characterized by X-ray diffraction, density, Raman, FTIR, EPR, and impedance measurements. No sharp Bragg peaks were observed in the X-ray diffractograms of the prepared samples. The density of the prepared samples monotonically increases with increasing concentration of CuO. The molar volume, on the other hand, increases with an increase in CuO concentration till 10 mol% and decreases with further increase in CuO in the glasses. FTIR and Raman measurements were done in 400 to 4000 cm-1 to 50 to 2000 cm-1, respectively. The deconvolution of the Raman and FTIR spectra was carried out for all the samples to get the Gaussian peaks from which structural information was retrieved. Electrical conductivity measurements were done in the frequency range 100 Hz to 5 MHz at room temperature. The results show that increasing the copper ions in the glasses at the expense of lithium ions decreases the electrical conductivity due to the ion blocking effect. The Nyquist plots, electric modulus spectra of all the samples were used for finding the relaxation mechanism.

Keywords: Copper doping, electric modulus, Nyquist analysis, energy storage applications

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