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Structural and Optical investigations of sodium zinc-manganese borate glasses

The physical, structural, and optical properties of sodium borate glasses doped with zinc and manganese, with the composition xNa2O-(100-x-y) B2O3 –yM (where x=30, 40, 50 mol%; y=0, 5 mol%; M=Zn, Mn, Zn + Mn) were studied. The samples were prepared using the melt-quenching method. Physical properties of the prepared samples were determined through density measurements, which were performed using the Archimedes method. Structural analysis was conducted using Raman spectroscopy in the range of 50 to 2000 cm-1 at room temperature. UV-Vis-NIR measurements were taken in the range of 190 to 2000 nm, at room temperature. In all the studied samples, it was observed that density increases while the molar volume decreases with an increasing concentration of Na. Various structural units were identified through Raman spectral deconvolution. For example, in borate-based glasses containing Na_2O, ZnO, and MnO_2, Raman peaks between 400–1600 cm^{-1} reveal structural changes in the glass network. Bands near 495–505 cm^{-1} indicate B–O–B bending, while peaks at 720–760 cm^{-1} and 1020–1100 cm^{-1} correspond to BO_4 unit formation and non-bridging oxygens. ZnO and MnO2 contribute sharp peaks at 400 cm^{-1} to 550 cm^{-1}. These Raman features provide insights into glass structure, modifier effects with doping ZnO and MnO2. In the UV analysis, as the Na concentration increases from 30 to 40 mol%, a decrease in the energy bandgap was observed. However, with a further increase in the Na concentration from 40 to 50 mol%, an increase in the energy bandgap was observed. This behavior can be attributed to the formation of different structural units in the borate glasses with changing Na concentration, which acts as a glass modifier. Additionally, in the manganese-doped sodium borate glasses, a continuous decrease in the energy bandgap was observed.

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