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Comprehensive study on the effect of Gd2O3 NPs on elastic properties of zinc borotellurite glass system using non-destructive ultrasonic technique

ABSTRACT

Quaternary Gd2O3 NPs doped zinc borotellurite (TeO2-B2O3-ZnO-Gd2O3 NPs) glass system were fabricated using conventional melt-quenching method with composition {[(TeO2)70(B2O3)30]70(ZnO)30}1-x(Gd2O3 NPs)x (x = 1.0, 2.0, 3.0, 4.0 and 5.0 mol%). The physical, structural and elastic properties of the glass samples were investigated. X-ray diffraction (XRD) were used to confirm the amorphousity of the samples. Fourier Transform Infrared (FTIR) spectroscopy indicated the presence of TeO3, TeO4, BO3 and BO4 structural units within the glass matrix. The presence of Gd2O3 NPs was proven from Transmission Electron Microscopy (TEM). The density and molar volume showed anomalous behavior. The elastic properties of the glass system were characterized by using pulse-echo technique. The longitudinal and shear ultrasonic velocities vary from 3883 to 4042 m/s and 2265 to 2282 m/s, respectively. The observed change in the ultrasonic velocities imply that there are substantial change in the structure of the vitreous network. The experimental elastic moduli (longitudinal modulus (L), shear modulus (G), bulk modulus (K) and Young's modulus (E)) increases from 68.77 to 79.45 GPa, 23.40 to 26.68 GPa, 37.56 to 48.25 GPa and 58.13 to 66.55 GPa, respectively. The increase in elastic moduli of the glass system indicates that the strength and rigidity of the glass increase. The experimental elastic moduli were correlated and compared with the theoretically calculated elastic moduli using Makishima-Mackenzie and Bond Compression model.

Keyword: Gadolinium oxide; Nanoparticles; Borotellurite glass; Makishima-Mackenzie model; Bond compression model