STUDYING PHYSICAL AND MECHANICAL PROPERTIES OF HEAVY METAL OXIDES DOPED GLASS

By

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Abstract

Glass composed of heavy metal oxides (HMO) which have atomic weights larger than 100 have sparked a lot of interest due to their intriguing physical and optical properties. Among the many HMO glasses, boro-tellurite-based glasses have received the most interest and research because of their beneficial properties, including ease of fabrication, low melting point, high density, and broad optical range. Moreover, boro-tellurite former-based glasses have gained considerable attention as potential materials for optoelectronic, photonic, and radiation shielding applications.

The goal of the thesis is to develop and investigate the characteristics of a novel glass composition ($60B_2O_3$ -(10-x) CaO - $10Na_2O$ - $20TeO_2$ - $xZrO_2$), where x is varied from 0.0 to 3.0 mol.% prepared using the melt-quenching method. The prepared glass samples were subjected to testing using X-ray diffraction (XRD). The lack of crystalline peaks in (XRD) patterns demonstrated the glassy nature of all glass samples. Using a scanning electron microscope (SEM), the surface characteristics of the glass samples were examined. Moreover, element distribution maps were obtained using the energy dispersive x-ray spectroscopy method (EDX).

A Differential Scanning Calorimeter (DSC) test was used to assess the thermal transition temperatures as well as the thermal stability of the glass. Glass stability was shown to deteriorate when ZrO_2 level increase. An ultraviolet-visible (UV-Vis/NIR) spectrophotometer was used to evaluate optical properties. Optical measurements show that raising the ZrO_2 concentration decreases the indirect optical bandgap and Urbach energy while increasing the indirect refractive index. The theoretical elastic moduli were calculated using Makishima and Mackenzie's approach, while Vickers microhardness was found experimentally. It was found that raising the ZrO_2 concentration improved the microhardness and elastic properties.

Radiation shielding characteristics were calculated theoretically using the Phy-X/PSD and WinXCom databases in the energy range of (0.015MeV –15 MeV). Theoretical gamma shielding characteristics such as the mean free path (MFP), half-value layer thickness (HVL), Energy buildup factor (EBF), effective atomic number (Z_{eff}), the effective electron density (N_{eff}) and Fast neutron removal cross section (FNRC), were estimated. It was shown that, the addition of zirconia to our glass system has considerable effect on both the mean free path (MFP) and half value layer (HVL) , in the sense that HVL and MFP levels both fell as the zirconia concentration increased, indicating that samples with higher zirconia content may absorb more radiation. Our glass system has better results of gamma ray shielding as compared with RS-253-G18 glass, Barite concrete and ordinary concrete.

Moreover, compared with ordinary concrete, hematite Serpentine concrete, ilmenite limonite concrete, graphite, and water, our glass system calculated fast neutron removal cross-section (FNRC) showed marked improvement. The shielding results show that light-weight transparent ZrO_2-doped boro-tellurite glasses compositions might be a promising candidate for a variety of shielding applications. The optimum proportion of ZrO_2 additive is determined by the balance between greater shielding and glass stability qualities, which varies depending on the application. These results suggest that doping borotellurite glass with ZrO_2 would improve glass properties, so that it is a good candidate for useful applications in the field of optoelectronics, fiber optics, and/or gamma and neutron radiation shielding.