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Development of Boro-Tellurite Glasses Enhanced with HfO2 for Radiation Shielding: Examination of Optical and Physical Characteristics

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Abstract : Due to their transparency, various types of glass are utilized in numerous applications where clear visibility is essential. One such application involves environments where radiography, radiotherapy, and X-ray devices are used, all of which involve exposure to radiation. As is well-known, radiation can be lethal to humans. Consequently, there is a need for glass that can absorb and block these harmful rays in such settings. Effective protection from radiation typically requires materials with high atomic numbers and densities. Currently, lead oxide-infused glasses are commonly used for this purpose, but due to the toxicity of lead oxide, there is a demand for safer alternatives. HfO2 has been selected as an additive for boro-tellurite (M1-M2-M3) glasses intended for radiation shielding because it has a high atomic number, high density, and is non-toxic. In this study, new glasses will be developed as alternatives to leaded glasses by incorporating x mol% HfO2 into the boro-tellurite glass structure. The glass compositions will be melted and quenched using the traditional method in an alumina crucible at temperatures between 900–1100°C. The resulting glasses will be evaluated for their elastic properties (including elastic modulus, shear modulus, bulk modulus, and Poisson ratio), density, hardness, and fracture toughness. X-ray diffraction (XRD) will be used to examine the amorphous nature of the glasses, while Differential Thermal Analysis (DTA) will provide thermal analysis. Optical properties will be assessed through UV-Vis and Photoluminescence Spectroscopy, and structural properties will be studied using Raman spectroscopy and FTIR spectroscopy. Additionally, the radiation shielding capabilities will be investigated by measuring parameters such as mass attenuation coefficient, half-value thickness, mean free path, effective atomic number (Z_{eff}), and effective electron density (N_e). The aim of this study is to develop new, lead-free glasses with excellent optical properties and high mechanical strength to replace the leaded glasses currently used for radiation shielding.

Keywords : boro-tellurite glasses, hfo2, radiation shielding, mechanical properties, elastic properties, optical properties
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