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Optical properties and radiation protection applications of B_2O_3:Na_2O:PbO:Tb_2O_3:Bi_2O_3 glass system

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Abstract

Glass is a versatile material with diverse structures and technological applications depending on composition and attributes. In the present study, the optical, physical, and radiation-interaction-response parameters of $70B_2O_3$: $10Na_2O$: 15PbO: (5-x)Tb_2O_3: xBi_2O_3, with x = 2, 3, 4, 1nd 5 mol% glasses prepared using the melt-and-rapidly cool method were assessed and studied. The mass attenuation coefficients (μ/ρ) were evaluated for 0.2, 0.662, and 1.25 MeV photons with the aid of XCOM. The density of the glass system increased from 3.61 g/cm^3 to 3.70 g/cm^3 as the molar ratio of Bi_2O_3 relative to Tb_2O_3 increased from 0.67 to 5. Also, the molar volume of the glasses increased from 29.958 cm^3/mol to 35.973 cm^3/mol for the same molar ratio increase. The refractive index of the BNPBTx glasses increased from about 2.22 to 2.5. The molar refractivity and polarizability increased with Bi_2O_3 content within the range of 16.98–20.69 cm^3/mol and $6{,}74\times10^{-24}$–8.21×10^{-24} cm^3, respectively. Other estimated optical parameters showed variations in contrast to glass chemical content. The μ/ρ vary within the range 0.0566–0.4720 for BNPBT1; 0.0568–0.4898 for BNPBT2; 0.0570–0.5074 for BNPBT3; and 0.0572–0.5246 cm^2/g for BNPBT4. The increase in the Bi_2O_3/Tb_2O_3 concentration ratio improved the gamma photon and neutron interaction prowess of BNPBT glasses. The investigated glasses showed better radiation shielding abilities compared to existing shielding glasses. They are thus recommended for radiation control and optical applications.

Keywords Borate glasses · Radiation · Optical parameters · Neutrons · Photons

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