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Investigation of X-rays and Gamma-ray Shielding Properties of Heavy Metal Oxide Glass Materials

As technology advances, ionizing radiation has become an essential tool in various fields such as medicine, industry, and research. However, excessive exposure poses serious health risks, including cancer. This study investigates the radiation shielding properties of heavy metal oxide (HMO) glasses to provide safer, lead-free alternatives for X-ray and gamma-ray protection. A series of glasses with the chemical composition xBi_2O_3–$(55–x)B_2O_3$–15BaO–10ZnO–$18SiO_2$–$2Nd_2O_3$ (x = 15, 20, 25, 30, and 35 mol%) were synthesized using the melt quenching technique at the University of Johannesburg. The radiation shielding capabilities of these glasses were tested at the University of Zululand, utilizing the facilities in the Modern African Nuclear DEtector LAboratory (MANDELA). The radiation attenuation performance of the investigated glasses was evaluated by calculating mass attenuation coefficients (μ/ρ) using XCOM and Phy-X/PSD software programs and further validated through Monte Carlo simulations with Geant4 and MCNP6. Key shielding parameters such as linear attenuation coefficient (LAC), mean free path (MFP), effective atomic number (Z_eff), effective electron density (N_eff), half-value layer (HVL), tenth-value layer (TVL), effective atomic mass (A_eff), exposure buildup factors (EBF), and energy absorption buildup factors (EABF) were also analyzed over the photon energy range of 0.03–0.3 MeV.

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