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A comprehensive investigation on the role of PbO in the structural and radiation shielding attribute of P_2O_5–CaO–Na_2O–K_2O–PbO glass system

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ABSTRACT

This study presents the synthesis, physical, structural and gamma-ray shielding characteristics of $40P_2O_5$–$20CaO$–$(30-x)Na_2O-10K_2O$–$xPbO$ (x = 0, 5, 10, 15, 20 mol%) glasses. The glass samples coded as PbCKNP1, PbCKNP2, PbCKNP3, PbCKNP4, and PbCKNP5 were prepared using the melt quench method. Na_2O substitution by PbO influenced the molar volume and mass density of the glasses. Structural analysis of the glasses using the X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy confirmed amorphous structure. The photon shielding parameters of the glasses examined via the Monte Carlo simulation code (MCNP-5) revealed that the glasses' shielding ability improved as PbO content increased. The highest simulated linear attenuation coefficient (LAC) achieved at 0.015 MeV increased from 21.46 to 159.07 cm^{-1} as the PbO concentration increased from 0 and 20 mol%. The LAC for all fabricated glass samples showed an exponential reduction trend with gamma photon energy. Based on the simulated LAC values, calculated mass attenuation coefficient (MAC), half-value layer (HVL), transmission factor (TF), and radiation shielding capacity (RSC), PbCKNP5 possessed the best gamma-ray protection ability among the investigated glasses. Furthermore, the calculated shielding

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