



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

Nuha Al-Harbi^{1,2}, M. I. Sayyed^{3,4,*} , Ashok Kumar^{5,6}, K. A. Mahmoud^{7,8}, O. I. Olarinoye⁹, Abdullah M. S. Alhuthali¹⁰, and Yas Al-Hadeethi¹

¹Department of Physics, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia

²Department of Physics, Umm AL-Qura University, Makkah, Saudi Arabia

³Department of Physics, Faculty of Science, Isra University, Amman, Jordan

⁴Department of Nuclear Medicine Research, Institute for Research and Medical Consultations (IRMC), Imam Abdulrahman bin Faisal University (IAU), PO Box 1982, Dammam 31441, Saudi Arabia

⁵University College, Benra- Dhuri, Punjab, India

⁶Department of Physics, Punjabi University, Patiala, Punjab, India

⁷Ural Federal University, St. Mira, 19, 620002 Yekaterinburg, Russia

⁸Nuclear Materials Authority, Maadi, Cairo, Egypt

⁹Department of Physics, Federal University of Technology, Minna, Nigeria

¹⁰Department of Physics College of Sciences, Taif University, PO Box 11099, Taif 21944, Saudi Arabia

Received: 12 February 2021

Accepted: 29 March 2021

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2021

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

Address correspondence to E-mail: mabualssayed@ut.edu.sa

<https://doi.org/10.1007/s10854-021-05868-9>

Published online: 20 April 2021

 Springer