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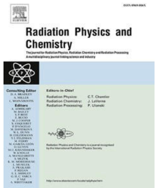

Photon, proton, and neutron shielding capacity of optical tellurite-vanadate glass systems: Theoretical investigation

Yasser S. Rammah [a,*], I.O. Olarinoye [b], Fouad I. El-Agawany [a], Amin El-Adawy [a], El Sayed Yousef [c,d]

[a] Department of Physics, Faculty of Science, Menoufia University, 32511 Shebin El Koom, Egypt
[b] Department of Physics, School of Physical Sciences, Federal University of Technology, Minna, Nigeria
[c] Research Center for Advanced Materials Science (RCAMS), King Khalid University, P. O. Box 9004, Abha 61413, Saudi Arabia
[d] Department of Physics, Faculty of Science, King Khalid University, P. O. Box 9004, Abha 61413, Saudi Arabia

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ABSTRACT

The influence of density and molar concentration of Ag_2O on photon, proton, neutron, and alpha particle shielding capacity of tellurite-vanadate-silver glass systems with the form $40TeO_2+(60\text{-}x)V_2O_5+xAg_2O$: x = 0–50 mol% (encoded as TVAg0- TVAg50) was evaluated and analyzed in a wide range of energy (0.015–15 MeV). Linear and mass attenuation coefficients (μ, μ_m), half value thickness (HVT), mean free path (MFP), and effective atomic number (Z_{eff}) were evaluated via the free online program–Phy-X/PSD, while EBF and EABF were computed via EXABCal software. The maximum μ_m was obtained at the least photon energy (15 keV) with values equal to 29.702, 31.371, 32.949, 34.443, 35.86, and 37.205 cm^2g^{-1} for TVAg0, TVAg10, TVAg20, TVAg30, TVAg40, and TVAg50, respectively. Generally, The μ_m of the glass's trends in the order: $(\mu_m)_{TVAg0} < (\mu_m)_{TVAg10} < (\mu_m)_{TVAg20} < (\mu_m)_{TVAg30} < (\mu_m)_{TVAg40} < (\mu_m)_{TVAg50}$. The trend of μ amongst the glasses is like that of the mass attenuation coefficient. The values of the maximum MFP varied from 9.757 to 4.53 cm for TVAg0 and TVAg50, respectively. The HVT trend of TVAg-glasses obeys the order: $(HVT)_{TVAg0} > (HVT)_{TVAg10} > (HVT)_{TVAg20} > (HVT)_{TVAg30} > (HVT)_{TVAg40} > (HVT)_{TVAg50}$. The range of Z_{eff} for the glasses varied from: 14.8 to 42.38 for TVAg0 glass and from 26.06 to 47.63 for TVAg50 glass. The *f*-factor of the TVAg-glasses were lower than unity except that of TVAg50 at 5 MeV. The variations in buildup factors with photon energy is alike for all glass materials and depth of penetration (mfp). The projected range (PR) followed the order: $(PR)_{TVAg0} > (PR)_{TVAg10} > (PR)_{TVAg20} > (PR)_{TVAg30} > (PR)_{TVAg40} > (PR)_{TVAg50}$ for both proton and α-particle. Mass stopping power (MSP) is inversely proportional to the atomic number of the target (TAVg-glasses). Results confirmed that density and molar concentration of Ag_2O plays an important role for improving the radiation shielding capacity of the investigated TAVg-glasses.

1. Introduction

The use of glass materials as radiation shields has been made attractive due to their superior functionality compared to traditional shields such as concrete (Gaikwad et al., 2018; Rammah et al., 2020a; Singh et al., 2018). For example, in applications where a shield is required to be transparent at room temperature, hard, non-corrosive, non-toxic and environmentally friendly, glass shields are preferred (Issa et al., 2017). Today, glass systems have been applied for radiation absorption in X-ray examination rooms in hospitals, security X-ray screening room in airports, nuclear facilities across the world, and with the potential to expand to other areas (Rammah, 2020). As the frontiers of radiation application expands, new demand would be placed on existing radiation shields in order for them to fit into these emerging applications. Consequently, more materials would have to be synthesized and investigated for their shielding potentials. The ability to easily alter the composition and hence, the general properties of glass places them in a pivot position among materials that would be major players in the quest to find novel shielding materials (Bootjomchai et al., 2012; Darwish et al., 2016; Elbashir et al., 2018; Issa et al., 2018a). This explains the reason why many glass systems have been investigated for their radiation shielding competence with amazing results. These

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* Corresponding author.
E-mail address: dr_yasser1974@yahoo.com (Y.S. Rammah).

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