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Radiation Shielding Properties of Tin-PDMS-Based Composite Enriched with Bismuth and Tungsten Carbide Against Gamma Rays

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ABSTRACT

In radiation shielding, metal-polymer-based composites offer an alternative to lead. Therefore, a mix-mixing process of the nano-mix-micro method (NMaM) was used to fabricate tin-PDMS-based composites for radiation shielding against gamma rays. In this work, a micro tin particle is used as a base component in the composites, with polydimethylsiloxane (PDMS) polymer, which serves as a binder matrix. The base composite is then enriched with tin, bismuth, and tungsten carbide nanoparticles to increase the radiation effect and is evaluated using gamma energy between 160 keV to 834 keV. The metal compositions vary by 10 % of their weight percentage. Sample characterisation was carried out using FESEM/EDX, FTIR, and NaI Scintillation Spectroscopy, respectively, to examine and characterise the composites' morphological, structural, and radiation properties. To measure LAC, MAC, HVL, TVL, and RPE appropriately, three radionuclides were used in radiation characterisation: Ba-133 (160, 276.2, 302.7, 356, 384 keV), Cs-137 (661.7 keV), and Mn-54 (834.8 keV). The results show that the increasing metal-filler content led to enhancements in shielding properties. Particularly at low energy of 160 keV, the PDMS(SnBi) composite, which has a high atomic number, demonstrated higher absorption than PDMS(SnWC) and PDMS(Sn). PDMS(SnBi)7 documented the most remarkable attenuation out of all composites, followed by PDMS(SnWC)6. By 70% concentration, the linear and mass attenuation coefficients of the PDMS(SnBi)7 are 8.289 cm-2 and 1.311 cm2/g (at 160 keV), respectively. The MAC and LAC of the PDMS(SnBi)7 decrease (0.243-0.070 cm2/g, 1.538- 0.442 cm-2) as energy increases from 276 keV to 834 keV. The RPE recorded for PDMS(SnBi)7 is 96.3 % compared with PDMS(SnWC)6 (94.0%) and lead (99.7 %). Therefore, the tin-PDMS-based composites enriched with bismuth nanoparticles (PDMS(SnBi)7) demonstrated remarkable efficacy, safety, and lightweight as X-ray and gamma-ray shielding materials, making them attractive for a range of medical applications, particularly those involving low energy levels.

Keywords: *Metal-Polymer Composite; Tin-Polydimethylsiloxane; Radiation Absorber; Micro-Nano Particles; Gamma-Rays*