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The impact of PbF_2 on the ionizing radiation shielding competence and mechanical properties of TeO_2–PbF_2 glasses and glass-ceramics

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ABSTRACT

The influence of adding PbF_2 on the elastic properties and radiation shielding competences of nine different samples labelled as TPb10-TPb90 with the form of (100-X)TeO_2-XPbF_2: (where X = 10–90 in steps of 10 mol%) glasses and glass-ceramics was investigated via the bond compression model and WinXcom software. The average cross-link density ($\overline{n}_c$) increased from 2.2 to 3.8 and the average atomic ring size (l) decreases from 0.390 to 0.356 nm with the increase of Pb ions content in the TPb10-TPb90 samples. The K_{BC} increased from 84.47 GPa to 111.09 GPa and Young's modulus (E_{BC}) increased from 136.89 GPa to 199.60 GPa for TPb10 to TPb90 samples. Poisson's ratio (σ_{BC}) decreased from 0.229 to 0.200, while the hardness (H) increased from 10.02 GPa to 16.59 GPa. The MAC of the glasses follows the order throughout the energy spectrum: TPb10 < TPb20 < TPb30 < TPb40 < TPb50 < TPb60 < TPb70 < TPb80 <TPb90. The maximum value of LAC obtained at 15 keV were: 290, 348, 405, 462, 519, 575, 632, 688, and 744 cm^{-1} for TPb10, TPb20, TPb30, TPb40, TPb50, TPb60, TPb70, TPb80, and TPb90, respectively. HVT and MFP are inversely proportional to LAC, hence, the highest and the lowest values of HVT and MFP were obtained for TPb10 and TPb90 samples at all energies. The TPb90 had the highest Z_{eff} while TPb10 had the least. The buildup factors of TPb10 was highest at all depths while TPb90 had the least buildup factors. The obtained results showed that the addition of Pb to the proposed samples improves their mechanical and radiation shielding properties. Therefore, TPb90 sample has a better photon, fast neutron, proton, and alpha particle absorber compared to the other eight glass species in this study.