Borotellurite glasses for gamma-ray shielding: an exploration of photon attenuation coefficients, structural, and thermal properties

ABSTRACT

Gamma-ray attenuation characteristics and vibrational and thermal features have been studied for singly doped erbium (Er), dysprosium (Dy), and Er/Dycodoped sodium lithium zinc lead borotellurite glasses. For all glasses, the amorphous nature was confirmed from the x-ray diffraction profiles, and BO3, BO4, TeO4, TeO3 +1, and TeO3 structural units were identified by both Fourier transform infrared spectroscopy and Raman spectroscopy. Glass transition (Tg), onset crystallization (Tx), peak crystallization (Tc), and melting (Tm) temperatures including thermal stabilities (DT) were evaluated following the glass differential scanning calorimetry profiles. An enhancement in Tg (359 fi 399C) and DT variation at 131–169C with Er2O3, Dy2O3, and Er2O3/ Dy2O3 incorporation suggested that the prepared glasses possess good thermal stability. The radiation shielding properties within the 0.356–1.33-MeV photon energy range were assessed for all the glasses. The mass attenuation coefficient (l/q) values have been calculated using Monte Carlo simulation code. Further, photon interaction parameters like effective atomic number (Zeff), half-value layer (HVL), and mean free path (MFP) were also computed. The host and 1.0 Er/1.0 Dy (mol.%)-codoped glasses possess the lowest and highest Zeff values and their magnitudes are varied within the range 11.40–15.99 and 12.14–17.26, respectively. For the host glass, exposure buildup factor values were calculated by the geometric progression (GP) fitting method within the 0.015–15-MeV energy range and up to a penetration depth of 40 MFP. The removal cross sections RR (cm1) for fast neutrons were calculated to evaluate the attenuation of neutrons through the prepared glasses.

Keyword: Borotellurite glass; FTIR; Raman; DSC; Mass attenuation coefficient; Radiation shielding