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B_2O_3/PbO/Na_2O/MgO/Nb_2O_5 glasses: fabrication, physical, optical characteristics as well as photons/neutrons/beta particles attenuation capacities

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Abstract

Physical, optical characteristics, and radiation attenuation capacities of the prepared (50-x) $B_2O_3 + 30PbO + 10Na_2O + 10MgO + xNb_2O_5$ glasses with various doping ratios x = 0, 2, 4, 6, and 8 mol% have been investigated. Glasses were prepared using the well-known melt quenching process and named as their corresponding x value. The density and molar volume of the prepared glasses were increased from 4.71 g/cm^3 and 23.76 cm^3/mol for the sample with free Nb_2O_5 to 4.91 g/cm^3 and 25.99 cm^3/mol for the rich sample with x = 8 mol% of Nb_2O_5. With increasing Nb_2O_5 concentration, the broad near-visible band centered was moved towards higher wavelength. The direct band gap energies of glass samples felt from 3.728 to 2.939 eV, while the indirect band gap energies from 3.032 to 1.822 eV as the Nb_2O_5 substitution ratio increased. Urbach's energies of the prepared samples were increased with the increasing of Nb_2O_5. For photons, the maximum values of mass attenuation coefficient (MAC) were 32.67, 33.02, 33.38, 33.74, and 34.10 cm^2/g for x = 0 – x = 8, respectively at 0.015 MeV, while the least corresponding MAC value of 0.0286, 0.0288, 0.0291, 0.0293, and 0.0295 cm^2/g was obtained at 10 MeV. For neutrons, the fast $(MAC)_{FN}$ was decreased from 0.0185 – 0.0161 cm^2/g, while the thermal $(MAC)_{TN}$ was decayed from 6.6538 – 5.5903 cm^2/g. Analysis of the TSP and CSDA range of the glasses emphasize the fact that there is no significant difference in the charged particle of the glasses irrespective of the weight fraction of Nb_2O_5 relative B_2O_3. Results confirm that the current glasses are superior for radiation shielding materials compared to some commercial concrete and glasses.

Keywords Glasses · Optical properties · Photons · Neutron attenuation

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