PAPER

Effect of Ag_2O/V_2O_5 substitution on the radiation shielding ability of tellurite glass system via XCOM approach and FLUKA simulations

Physica Scripta

PAPER

Effect of Ag_2O/V_2O_5 substitution on the radiation shielding ability of tellurite glass system via XCOM approach and FLUKA simulations

RECEIVED
22 January 2021

REVISED
19 March 2021

ACCEPTED FOR PUBLICATION
26 March 2021

PUBLISHED
9 April 2021

I O Olarinoye[1], Sultan Alomairy[2], Chahkrit Sriwunkum[3] and M S Al-Buriahi[4,*]

[1] Department of Physics, School of Physical Sciences, Federal University of Technology, Minna, Nigeria
[2] Department of Physics, College of Science, Taif University, PO Box 11099, Taif 21944, Saudi Arabia
[3] Department of Physics, Ubon Ratchathani University, Ubon Ratchathani, Thailand
[4] Department of Physics, Sakarya University, Sakarya, Turkey
[*] Author to whom any correspondence should be addressed.

E-mail: mburiahi@gstd.sci.cu.edu.eg

Keywords: TeO_2 glass, attenuation, shielding, gamma, neutron, Geant4

Abstract

This study focuses on the effect of Ag_2O/V_2O_5 substitution on the radiation shielding ability of tellurite glass system with the chemical composition of $xAg_2O + 40TeO_2 + (60 - x)V_2O_5$ with $0 < x < 50$ mol%. FLUKA code was successfully employed for simulation the radiation interaction parameters of the glass systems. The results of the simulations were comparable with the predications of theory. Thereafter, several empirical equations were used to study the shielding ability of the glass systems against neutrons and charged particles. The results indicate that linear attenuation coefficient changes with energy and reaches maximum at 0.6 MeV (minimum at 10 MeV) with the values of 0.2806 (0.109), 0.3181 (0.121), 0.3771 (0.1498), 0.409 (0.168), 0.4588 (0.1911), and 0.5162 (0.2180) for x = 0, 10, 20, 30, 40, and 50 mol%, respectively. Beyond 5 MeV, the gamma ray constant was found in the order of $(\Gamma)_{x=50} > (\Gamma)_{x=40} > (\Gamma)_{x=30} > (\Gamma)_{x=20} > (\Gamma)_{x=10} > (\Gamma)_{x=0}$. For all the charged particles, the projectile range was noted in the order of $(R)_{x=0} > (R)_{x=10} > (R)_{x=20} > (R)_{x=30} > (R)_{x=40} > (R)_{x=50}$. Finally, we provide an extensive comparative study between AVT-glass systems and standard traditional materials. The obtained results suggest the sample of x = 50 mol% as the best photon, fast neutron and charged particle shield amongst the present glass systems. Hence, AVT6 could be used in radiation safety applications as a shield.

1. Introduction

Radiation glass shields have become attractive in diverse areas of nuclear technology in recent times based on many advantages they provide over other (contemporary) shielding materials. Research into different glasses for their shielding competence has thus continued to soar. One major point of attraction that has influenced this increase is the flexibility offered by the properties of many glass matrices. Generally, the properties of a glass can be tuned by altering its chemical composition. The importance of this is the ability to produce glasses with novel properties and potential to function in a wide spectrum of applications such as radiation shielding. For shielding glasses in radiation protection applications, the composition of the glasses is a fundamental parameter that usually influence their competence in absorbing different types of ionizing radiation.

For providing superior shielding for ionizing radiations, a glass system has to possess different features depending on the type of radiation involved and energy. Heavy metals such as Sr, Mo, Ba, Pb, Bi, because of their higher atomic number and density possess higher photon cross section and hence have a potential of effectively absorbing photons better. In fact, glasses containing higher concentration of heavy metal oxides (HMO) such as MoO_3, BaO, SrO, WO_3, PbO, Bi_2O_3 have been confirmed to possess better photon and charged particle shielding ability compared to those with lower concentrations or without HMO [1–21]. The influence of HMO (PbO, BaO, and SrO) on the photon, shielding ability of borosilicate glasses was studied experimentally for ^{137}Cs photon source by Aly *et al* [1]. The study revealed that the shielding ability of the glasses improved with the proportion of HMO in the glasses' compositions. The study also revealed that glass samples with heavier HMO are better photon absorbers than those with less dense