International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 10-No.2 (2024) pp. 141-145
http://www.ijcesen.com

ISSN: 2149-9144

Research Article

Gamma ray Shielding Properties of the 57.6TeO$_2$-38.4ZnO-4NiO system

Nuray KUTU*

Süleyman Demirel Üniversity, Isparta-Turkiye
* **Corresponding Author Email:** nuraykutu@gmail.com - **ORCID:** 0000-0002-8095-0051

Article Info:

DOI: 10.22399/ijcesen.310
Received : 02 April 2024
Accepted : 02 May 2024

Keywords :

Gamma rays
Radiation shielding
Phy-X/PSD

Abstract:

The radiation shielding is important for human health as it is hazardous for cell. New material development is under research for alternative shielding materials. Thus 57.6TeO2–38.4ZnO–4NiO system was developed and its shielding capacity were inspected in terms of some parameters of the linear attenuation coefficient (LAC), half value length (HVL), mean free path (mfp), effective atomic number (Zeff) and Effective electron density (Neff).

1. Introduction

With the development of technology, the radiation started to be used in a variety of applications and this required protection processes from its hazardous effect. The protection processes are namely time-distance and shielding. The latest one is important and lead and lead based materials have been conventional materials for this purpose. On the other hand because of negative effect of lead and lead based materials, alternative non-conventional materials started to be investigated [1-10]. This made researcher to focus on this subject for several years and many different types of materials have been tested for this purpose [11-26]. In this study 57.6TeO2–38.4ZnO–4NiO system were inspected their radiation defensive mechanism. To assess the radiation-protective characteristics of sample, the LAC, mfp, HVL, Zeff and Neff have been obtained.

2. Material and Methods

A glass sample formulated as 57.6TeO2–38.4ZnO–4NiO was the material to be investigated.
The chemical formulation and density of glass sample are given as follow [27]:
57.6TeO2–38.4ZnO – 4NiO, density=5.43 g.cm^{-3}

The Phy-X/PSD program was used in to test LAC and related other parameters. The program is a friendly software to calculate parameters [28].

3. Results and Discussions

The LAC and other related parameters are calculated at various energies for 57.6TeO2–38.4ZnO–4NiO system. The obtained LAC results as a function of gamma ray energies for sample is displayed in Fig.1. As can be seen from this figure that the distribution of LAC values decreases with increasing energy. This is consistence with the previous works done on this subject [29-34]. The HVL and mfp have been displayed in Fig. 2 and 3 as a function of gamma ray energies respectively. The Z_{eff} and N_{eff} of the tested glass sample as a function of gamma ray energies are graphed in Fig.4 and Fig.5 respectively. It can be seen from these figure that HVL and mfp are similar to each other. In the same time the Z_{eff} and N_{eff} are similar shape too.

4. Conclusions

The present work is about radiation shielding properties of glass sample formulated as 57.6TeO2–38.4ZnO–4NiO. The changes LAC, HVL, mfp, Zeff

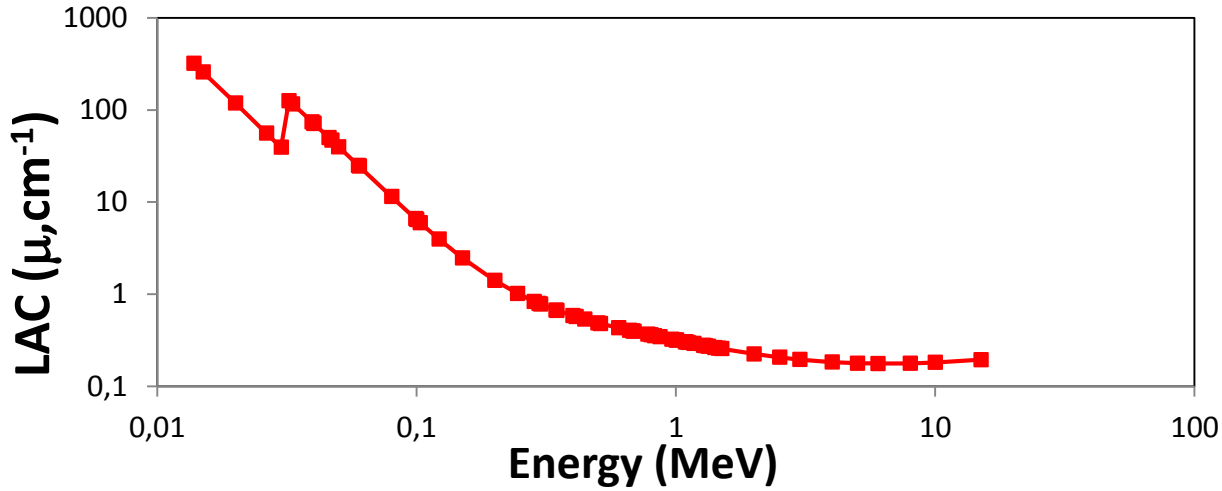

Figure 1. *The LAC value obtained for the glass sample.*

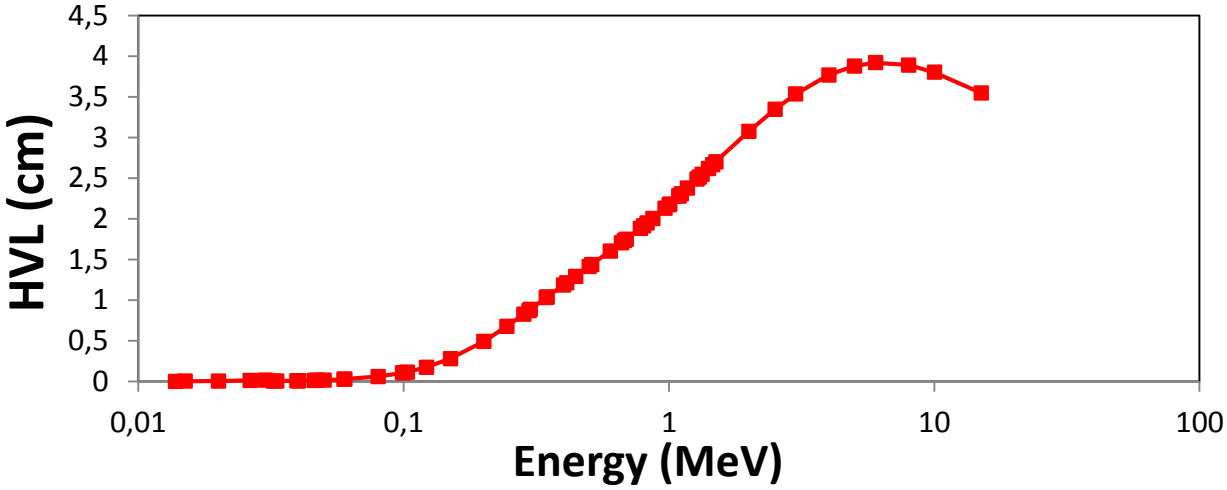

Figure 2. *The HVL value obtained for glass sample.*

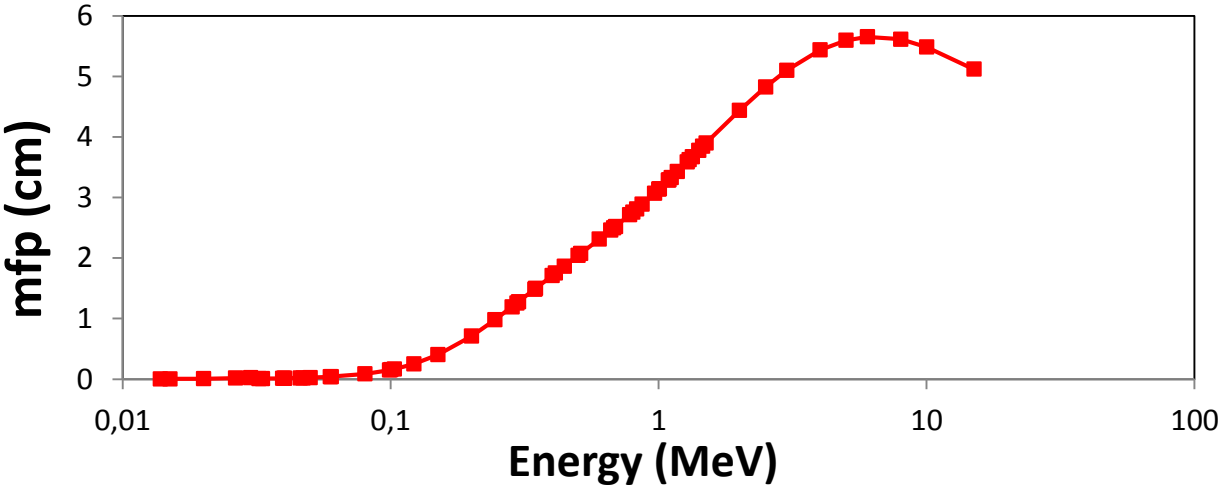

Figure 3. *The mfp values obtained for the glass sample.*

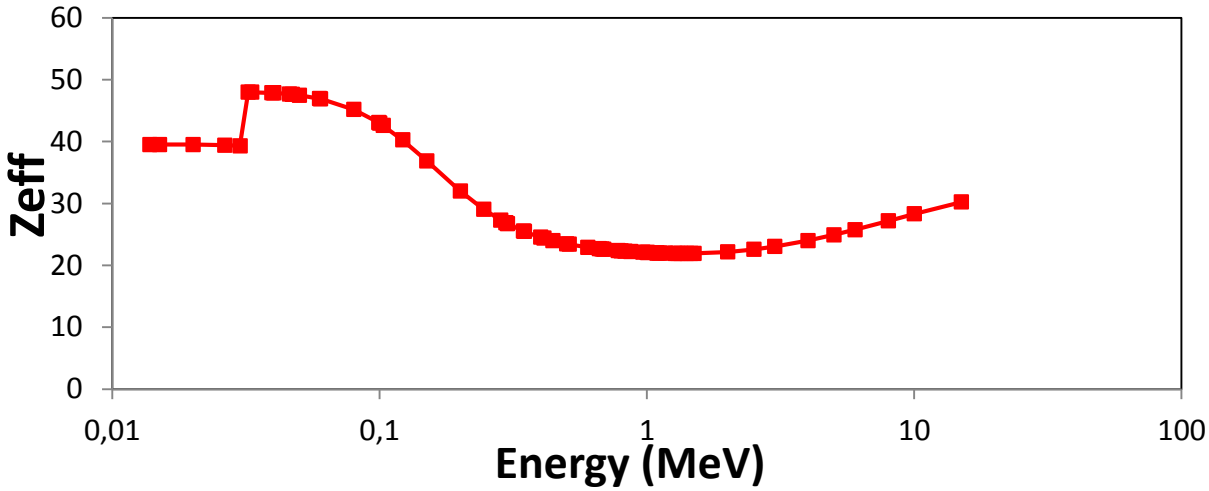

Figure 4. *The Zeff values for the glass sample.*

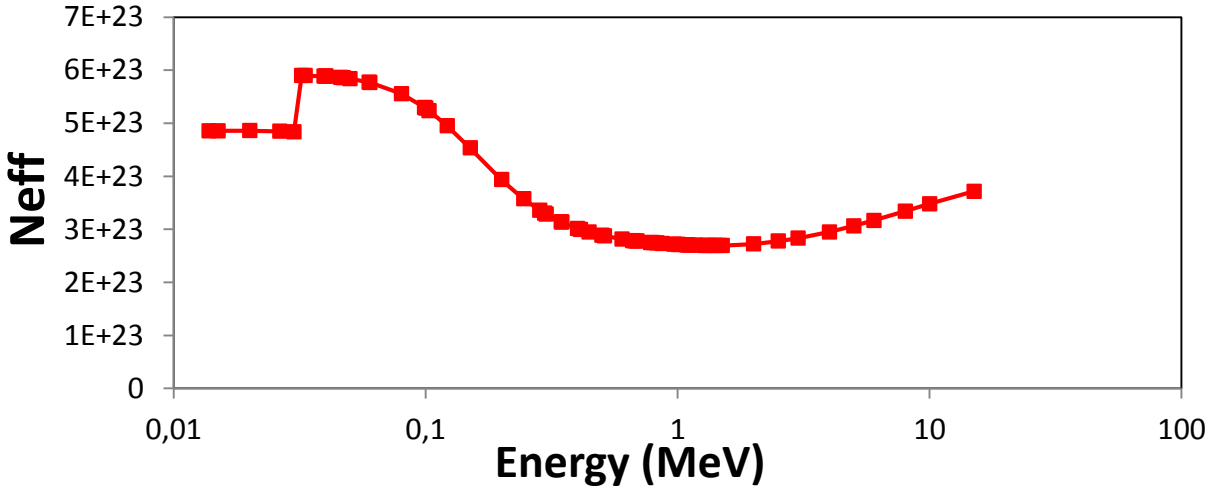

Figure 5. *The N_{eff} values for the glass sample.*

and Neff were studied. It can be concluded that the LAC values decreased with the increasing gamma ray energies.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

[1]Jawad, A.A., Demirkol, N., Gunoğlu, K., Akkurt I. (2019). Radiation shielding properties of some ceramic wasted samples. *Int. J. Environ. Sci. Technol.* 16;5039–5042. https://doi.org/10.1007/s13762-019-02240-7

[2] Boodaghi Malidarre R., Khabaz R., Benam M. R., and Zanganeh V., (2019) A feasibility study to reduce the contamination of photoneutrons and photons in organs/tissues during radiotherapy. *Iran. J. Med. Phys*. 17;366-373. http://doi.org 10.22038/ijmp.2019.40879.1579.

[3]Akkurt I. (2007). Effective atomic numbers for Fe–Mn alloy using transmission experiment *Chinese Phys. Lett.* 24;2812. https://doi.org/10.1088/0256-307X/24/10/027

[4]Akkurt I.;El-Khayatt A.M. (2013). Effective atomic number and electron density of marble concrete. *Journal of Radioanalytical and Nuclear Chemistry*. 295(1);633 – 638. DOI: 10.1007/s10967-012-2111-5

[5]Aygun, Z. & Aygün, M. (2023). An Analysis on Radiation Protection Abilities of Different Colored Obsidians. *International Journal of Computational and Experimental Science and Engineering*, 9 (2); 170-176 . DOI: 10.22399/ijcesen.1076556

[6]Rwashdi, Q. A. A. D. , Waheed, F. , Gunoglu, K. & Akkurt, İ. (2022) Experimental Testing of the Radiation Shielding Properties for Steel . *International Journal of Computational and Experimental Science and Engineering* , 8 (3), 74-76. DOI: 10.22399/ijcesen.1067028

[7] Akkurt I., Boodaghi Malidarre R. (2022). Physical, structural, and mechanical properties of the concrete by FLUKA code and phy-X/PSD software. *Radiation Physics and Chemistry* 193;109958. https://doi.org/10.1016/j.radphyschem.2021.109958

[8] Waheed, F. , İmamoğlu, M. , Karpuz, N. & Ovalıoğlu, (2022). H. Simulation of Neutrons Shielding Properties for Some Medical Materials. *International Journal of Computational and Experimental Science and Engineering*, 8(1), 5-8. DOI: 10.22399/ijcesen.1032359

[9]Boodaghi Malidarre, R. , Akkurt, İ. , Gunoglu, K. & Akyıldırım, H. (2021). Fast Neutrons Shielding Properties for HAP-Fe2O3 Composite Materials . *International Journal of Computational and Experimental Science and Engineering*, 7(3),143-145. DOI: 10.22399/ijcesen.1012039

[10]Demir, N., Tarim, U.A., Popovici, MA. Demirci ZN, Gurler O., Akkurt I. (2013). Investigation of mass attenuation coefficients of water, concrete and bakelite at different energies using the FLUKA Monte Carlo code. *J Radioanal Nucl Chem* 298, 1303–1307 https://doi.org/10.1007/s10967-013-2494-y

[11] Tekin H.O., Cavli B., Altunsoy E.E, Manici T., Ozturk C., Karakas H.M. (2018). An Investigation on Radiation Protection and Shielding Properties of 16 Slice Computed Tomography (CT) Facilities *International Journal of Computational and Experimental Science and Engineering* 4(2);37 – 40. https://doi.org/10.22399/ijcesen.408231

[12]Biswas R, Sahadath H, Mollah AS, Huq Md F (2016) Calculation of gamma-ray attenuation parameters for locally developed shielding material: Polyboron. *Journal of Radiation Research and Applied Sciences* 9:26–34

[13]Aycan Şengül (2023). Gamma-ray attenuation properties of polymer biomaterials: Experiment, XCOM and GAMOS results. *Journal of Radiation Research and Applied Sciences* 16(4);100702 https://doi.org/10.1016/j.jrras.2023.100702

[14]ALMisned G., Sen Baykal D., Susoy G. ,Kilic G., M.H. Zakaly H. Ene A., Tekin H.O. (2022). Determination of gamma-ray transmission factors of WO3–TeO2–B2O3 glasses using MCPX Monte Carlo code for shielding and protection purposes *Applied Rheology*, 32(1);166-177, DOI: 10.1515/arh-2022-0132

[15] Boodaghi Malidarre, R., Akkurt, I. (2021).Monte Carlo simulation study on TeO2–Bi2O–PbO–MgO–B2O3 glass for neutron-gamma 252Cf source. *J Mater Sci: Mater Electron* 32,11666–11682 https://doi.org/10.1007/s10854-021-05776-y

[16] Shams A.M. Issa, Y. B. Saddeek, M. I. Sayyed, H. O. Tekin, O. Kilicoglu, (2019) Radiation shielding features using MCNPX code and mechanical properties of the PbO Na2O B2O3 CaO Al2O3 SiO2 glass systems, *Composites Part B* 167;231-240, https:// doi.org/10.1016/j.compositesb.2018.12.029.

[17]Ahmet Bozkurt, Aycan Sengul. (2021). Monte Carlo approach for calculation of mass energy absorption coefficients of some amino acids *Nuclear Engineering and Technology* 53(9);3044-3050. https://doi.org/10.1016/j.net.2021.04.004

[18]I.Akkurt, A.M.El-Khayatt. (2013). The effect of barite proportion on neutron and gamma-ray shielding. *Annals of Nuclear Energy* 51;5-9 https://doi.org/10.1016/j.anucene.2012.08.026

[19] Tekin, H.O., ALMisned, Susoy G., Zakaly G., Issa H. M. H., Shams A. M., Kilic, G., Rammah, Y.S., Lakshminarayana, G. and Ene, A. (2022). A detailed investigation on highly dense CuZr bulk metallic glasses for shielding purposes. *Open Chemistry*, 20(1);69-80. https://doi.org/10.1515/chem-2022-0127

[20]Şen Baykal, D , Tekin, H , Çakırlı Mutlu, R . (2021). An Investigation on Radiation Shielding Properties of Borosilicate Glass Systems . *International Journal of Computational and Experimental Science and Engineering*, 7(2),99-108.DOI: 10.22399/ijcesen.960151

[21] ALMisned G., Sen Baykal D., Kilic G., Susoy G., M.H. Zakaly H., Ene A., Tekin H.O. (2022). Assessment of the usability conditions of Sb2O3-PbO-B2O3 glasses for shielding purposes in some medical radioisotope and a wide gamma-ray energy spectrum *Applied Rheology*, vol. 32(1) https://doi.org/10.1515/arh-2022-0133

[22]Kurtulus R., Kavas T., Akkurt I, Gunoglu K. (2021) Theoretical and experimental gamma-rays attenuation characteristics of waste soda-lime glass doped with La2O3 and Gd2O3. *Ceramics International.* 47(6);8424-8432. https://doi.org/10.1016/j.ceramint.2020.11.207.

[23]M. Y. Hanfi, M. I. Sayyed, E. K. Lacomme, K. A. Mahmoud, I. Akkurt, (2021). The influence of MgO on the radiation protection and mechanical roperties of tellurite Glasses, *Nucl. Eng. Technol.*, 53(6);2000-2010 doi.org/10.1016/j.net.2020.12.012.

[24]Akkurt I. (2009). Effective atomic and electron numbers of some steels at different energies" *Ann. Nucl. En.* 36(11,12);1702-1705 DOI: 10.1016/j.anucene.2009.09.005

[25]Oruncak, B. (2023). Computation of Neutron Coefficients for B2O3 reinforced Composite. *International Journal of Computational and Experimental Science and Engineering*, 9 (2), 50-53 . DOI: 10.22399/ijcesen.1290497

[26]El-bashir B O, Sayyed M I, Zaid M H M, Matori K A, (2017). Comprehensive study on physical, elastic and shielding properties of ternary BaO-Bi2O3-P2O5

glasses as a potent radiation shielding material, *J. Non. Cryst. Solids* 468, 92–99.

[27] O.A. Zamyatin, M.F. Churbanov, J.A. Medvedeva, S.A. Gavrin, E.V. Zamyatina, A.D. Plekhovich (2018). Glass-forming region and optical properties of the TeO2 – ZnO – NiO system. *Journal of Non-Crystalline Solids* 479; 29–41 http://dx.doi.org/10.1016/j.jnoncrysol.2017.10.005

[28]E. Şakar, Ö. Fırat Özpolat, B.Alım, M.I.Sayyed, M. Kurudirek, (2020). Phy-X / PSD: Development of a user friendly online software for calculation of parameters relevant to radiation shielding and dosimetry, *Radiation Physics and Chemistry.* 166;108496. https://doi.org/10.1016/j.radphyschem.2019.108496

[29]Tekin, H.O., ALMisned, G., Zakaly, H.M. H., Zamil, A., Khoucheich, D., Bilal G., Al-Sammarraie, L., Issa, Shams A. M., Al-Buriahi, M. and Ene, A.. (2022). Gamma, neutron, and heavy charged ion shielding properties of Er3+-doped and Sm3+-doped zinc borate glasses *Open Chemistry*, 20(1),130-145. https://doi.org/10.1515/chem-2022-0128

[30]Kadir Gunoglu, Hatice Varol Özkavak, İskender Akkurt (2021). Evaluation of gamma ray attenuation properties of boron carbide (B4C) doped AISI 316 stainless steel: Experimental, XCOM and Phy-X/PSD database software" *Materials Today Communications.* 29;102793. https://doi.org/10.1016/j.mtcomm.2021.102793

[31]Bashter II (1997) Calculation of radiation attenuation coefficient for shielding concretes. *Ann Nucl Energy* 24(17):1389–1401

[32]Makarious AS, Bashter II, El-Sayed Abdo A, Samir Abdel Azim M,Kansouh WA (1996) On the utilization of heavy concrete for radiation shielding. *Ann Nucl Energy* 23(3):195–206

[33]Malidarre, R. B. , Ozan Tekin, H. , Gunoglu, K. & Akyıldırım, H. (2023). Assessment of Gamma Ray Shielding Properties for Skin . *International Journal of Computational and Experimental Science and Engineering*, 9(1),6-10. DOI: 10.22399/ijcesen.1247867

[34]A.M. Reda, A.A. El-Daly, (2020). Gamma ray shielding characteristics of Sn-20Bi and Sn-20Bi-0.4Cu lead-free alloys, *Progress in Nuclear Energy* 123; 103304. https://doi.org/10.1016/j.pnucene.2020.103304