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Energy Dependence Of Mass Attenuation For Sodium Based Silicate Glasses

Rajinder Singh Kaundal[1*], Romi Bharol [2]

[1] *Physics Department, School of Chemical Engineering and Physical Sciences, Lovely Professional University, Phagwara, Punjab (India).*
[2] *Physics Department , British Olivia School Jalandhar, Punjab India.*
**Corresponding author: e-mail: rajinder.17099@lpu.co.in*

ABSTRACT: The theoretical studies are carried out to get the idea of the mass attenuation values at varying energies of gamma ray photons. For this purpose sodium basesd silicate glasses are studied with the NIST XCOM, further the density values are analysed to see the impact of varying sodium composition. To understand the effect of varying composition of metal cation in altering the structure of glass, molar volume values are evaluated and analysed.
Keywords: Silicate Glasses, Density, Molar Volume, Attenuation coefficient, Gamm ray-Photon Energy

1 Introduction

Alpha (□□, beta (□□ & gamma (□□□□□the gamma radiations are commonly emitted by different radioactive sources which can contaminate the environment. Out of these radiations the gamma radiations can travel maximum distance in air and posseses large value of energy [1]. To prevent these radiations in penetrating into the environment many researchers have suggested that the glasses can be used as promising candidates. But to reduce the cost related issue and due to fact that these can absorb moisture resulting in week structure, alternative materials are proposed [2]. Lead based glasses are suggested by many researchers a alternate to concretes. But again due to fact the lead is highly toxic and can have considerable effect in the contamination of the environment more work is required to find lead free glasses. In the present work the author have tried to estimate the gamma ray shielding properties of sodium based silicate glasses. [3, 4]

2. Preparation and computing techniques

2.1 1 Glass synthesis and density value

Five glass samples NS1, NS2, NS3, NS4 and NS5 of formula x Na_2O (100-x) SiO_2 , where x=10, 15, 20, 25, 30 were synthesized by melt and quench technique. Analytical reagent (AR) grade with purity 99.9% were utilized for the synthesis of glasses.

Glass densities at ambient temperature, were estimated by utilizing the Archmede's rule using Benzene medium. Weighing of glasses were done in benzene as well as air at room temperature. The densities were determined by utilizing equation:

$$□□ (w_a / w_{a-} w_b) \text{ X } 0.787 \qquad (1)$$

w_a denotes weight of sample taken in air, □ density of glass sample & w_b is weight of glass sample in the medium in which the glass was immersed. The density of immersing medium was taken as 0.787 at room temperature. The various materials along with their mole fraction along with densities and value of molar volume values are listed in table 1.

X-ray diffraction studies were conducted for detecting the non-crystalline nature of the glass samples. For this powder form of synthesized glasses was studied with the diffractometer (Philips PW 1710). CuKa radiations were used for scanning the powder. The scanning was conducted at rate of (2θ/s) of 0.030 for the initial value (2θ) at 5.010^0 to final value of (2θ) at 60.0^0. No peak in X-ray diffraction data confirms the synthesizes glasses are non crystalline.

For estimating the linear attenuation coefficient of synthesized glasses WIN XCOM [5-8] software is employed. The values half value layer (HVL) are estimated with the help of following equation:

$$HVL=0.693/\mu \quad (2)$$

3. Result & Discussion

3.1 Densities & Values of Molar volume

Densities & Molar volumes for synthesized glasses are listed in table I The density value for the NS5 is maximum and is minimum for NS1. Molar volume of the glass samples is mimimum for NS5 showing that the glass structure is more compact as compared to the other prepared glass systems gtlass sample. The compactness shows that there is increase in the bridged oxygen atoms in the glass structure. [9-12] compact structure.

Table I. Mole fraction, density (□), molar volume (V_m)

Sr. No.	Sample	Density	Molar Volume
1	NS1	2.39	25.21715481
2	NS2	2.44	24.73913934
3	NS3	2.48	24.37822581
4	NS4	2.52	24.02876984
5	NS5	2.56	23.69023438

3.2 Z_{eff} (effective atomic- number) and Linear Attenuation- coefficients

Estimated values of mass- attenuation coefficient listed in table -2 from the 1.0 kev value - 10^2 GeV value.

Table II. Estimation of Mass attenuation (□□□ (cm^2g^{-1})) coefficients for investigated samples, at various values of energy in MeV values

Mass attenuation (□□□ (cm^2g^{-1})) coefficients									
Energy (MeV)	1.00E-03	1.00E-02	1.00E-01	1.00E+00	1.00E+01	1.00E+02	1.00E+03	1.00E+04	1.00E+05
NS1	3.02E+03	1.84E+01	1.67E-01	6.35E-02	2.25E-02	2.23E-02	2.68E-02	2.79E-02	2.81E-02
NS2	2.95E+03	1.81E+01	1.67E-01	6.34E-02	2.25E-02	2.22E-02	2.67E-02	2.78E-02	2.80E-02
NS3	2.87E+03	1.78E+01	1.66E-01	6.33E-02	2.24E-02	2.22E-02	2.65E-02	2.77E-02	2.79E-02
NS4	2.79E+03	1.75E+01	1.66E-01	6.32E-02	2.24E-02	2.21E-02	2.64E-02	2.76E-02	2.78E-02
NS5	2.72E+03	1.72E+01	1.65E-01	6.31E-02	2.23E-02	2.20E-02	2.63E-02	2.75E-02	2.77E-02

As clear from the table mass attenuation coefficient are having very large value corresponding to less energy values where dominating mechanism is photoelectric. For intermediate energies range attenuation coefficients show fast decrease and is minimum in the intermediate values of the energy. With the change in energy region to the intermediate energy values which is associated with the Compton scattering range to more energy value range associated with the pair- production mass attenuation -coefficient shows increment and at elevated energy values become almost steady.[13-15]

3.3 Half value layer

The values of half value layers as estimated from mass attenuation coefficients are given as below

Table III. Values of HVL for prepared glass samples for distinct energies (in units of MeV):

Half Value Layer (cm)									
Energy (MeV)	0.001	0.01	0.1	1	10	100	1000	10000	100000
NS1	9.8E-05	0.016095	1.770196	4.66678	13.1507	13.27449	11.07117	10.59964	10.5243
NS2	9.97E-05	0.016223	1.760456	4.634534	13.06827	13.20936	11.01854	10.55135	10.4798
NS3	0.000101	0.016299	1.744634	4.583594	12.93878	13.09066	10.92533	10.46025	10.38904
NS4	0.000103	0.016441	1.735376	4.552753	12.8601	13.02908	10.87564	10.41855	10.34359
NS5	0.000105	0.01659	1.727348	4.522442	12.78284	12.96886	10.83119	10.37414	10.29921

As seen, that HVL for the glass NS5 is minimum for the glass samples . From the table it can be concluded that out of the the glass sustem NS5 requires minimum thickness for reducing the intensity of incident gamma ray photons to one half of its initial value. HVL is not the function of the composition only but also is a function of the density value and the packing of the atoms of the material also. Above mentioned parameter has been significant for identification of materials which can be utilized as the radiation-shielding.

The glass sample, NS5 i.e. 30Na_2O 70 SiO_2 shows better shielding properties among all the prepared glass samples as its half value layer value is least, among all the prepared glasses.

4. Conclusion

For the work undertaken, we analyzed the the silicate glasses containing oxides of Sodium for gamma radiation shielding properties with respect to attenuation and HVL value. It is concluded that the glass sample NS5 corresponding to 30 mole percent of Li_2O, 70 mole percentage of silicate has highest mass attenuation □□□□coefficients & least half layer values values. The minimum HVL value suggests system corresponding to this composition has the potential for radiation shielding applications among all the prepared glass samples.

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Conflict of Interest

There is no conflict of interest.

REFERENCES

[1] Donald I.W. Crystallization kinetics of a lithium zinc silicate glass studied by DTA and DSC. Journal of Non- Crystalline Solids. 2004: 345:120-126.

[2] Yousef S. Heat effect on the shielding and strength properties of local concrete. Progress in Nuclear Energy. 2008: 50: 22-26.

[3] Singh H, Singh K, Gerward L, Singh K, Sahota HS, Nathuram R. ZnO–PbO–B_2O_3 glasses as gamma-ray shielding materials. Nuclear Instruments and Methods in Physics Research B: 2003: 207:257-262.

[4] Singh H, Singh K, Sharma G, Nathuram R, Sahota HS. Photon Interaction Studies with Some Glasses and Building Materials. Nuclear Science and Engineering: 2002:142:342-348.

[5] Singh K, Singh H. Singh, Sharma G, Gerward L, Khanna A, Kumar R, Nathuram R, Sahota HS. Gamma-ray shielding properties of CaO–SrO–B_2O_3 glasses. Radiation Physics and Chemistry.2005:72: 225-228.

[6] Singh K, Goel A, Mohan S, Arora A, Sharma G. Lead- and Bismuth-Borate Fly-Ash Glasses as Gamma-Ray-Shielding Materials. Nuclear Science and Engineering. 2006:154: 233-240.

[7] Singh KJ, Singh N, Kaundal RS, Singh K. Gamma-ray shielding and structural properties of PbO–SiO_2 glasses. Nuclear Instruments and Methods in Physics Research B.2008:266(6): 944-948.

[8] Singh N, Singh KJ, Singh K, Singh H. Gamma-ray attenuation studies of PbO–BaO–B_2O_3 glass system. Radiation Measurements. 2006:41(1):.84-88.

[9] Kant, N., Wani, M. A., & Kumar, A. (2012). Self-focusing of Hermite–Gaussian laser beams in plasma under plasma density ramp. *Optics Communications*, *285*(21-22), 4483-4487.

[10] Mukherjee, R. (2020). Electrical, thermal and elastic properties of methylammonium lead bromide single crystal. Bulletin of Materials Science, *43*(1), 1-5.

[11] Mukherjee, R., Lawes, G., & Nadgorny, B. (2014). Enhancement of high dielectric permittivity in CaCu3Ti4O12/RuO2 composites in the vicinity of the percolation threshold. Applied Physics Letters, *105*(7), 072901.

[11] Singh N, Singh R, Singh KJ. □−ray shielding properties of lead and bismuth borosilicate glasses. Glass Technol. 2005: 46 (4): 311-314.

[12] Wu J M, Huang H L. Microwave properties of zinc, barium and lead borosilicate glasses. Journal of Non- Crystalline Solids: 1999: 260(1-2):116-124.

[13] Singh, S., Kumar, V., Upadhyay, N., Singh, J., Singla, S., & Datta, S. (2017). Efficient biodegradation of acephate by Pseudomonas pseudoalcaligenes PS-5 in the presence and absence of heavy metal ions [Cu (II) and Fe (III)], and humic acid. *3 Biotech*, *7*(4), 262.

[14] Singh, S., Kumar, V., Upadhyay, N., Singh, J., Singla, S., & Datta, S. (2017). Efficient biodegradation of acephate by Pseudomonas pseudoalcaligenes PS-5 in the presence and absence of heavy metal ions [Cu (II) and Fe (III)], and humic acid. *3 Biotech*, *7*(4), 262.

[15] Verma, P., Chauhan, D. S., & Singh, P. (2007, October). Effects on tensile strength of transformer insulation paper under accelerated thermal and electrical stress. In *2007 Annual Report-Conference on Electrical Insulation and Dielectric Phenomena* (pp. 619-622). IEEE.