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AN ANALYTIC ANALYSIS OF Z-EFFECTIVE FOR THE SERIES OF GLASS [LI2O – B2O3 – SIO2 – XO] WITH SECOND (4D) D-BLOCK (Y–CD) TRANSITION METALS ELEMENTS(X)

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Abstract: In this paper a analytic analysis of the Z-effective calculations made through manual calculations and direct from the Auto Z-effective over the series of glass with Second (4d) d-block Series (Y–Cd) transition metals(X= Y, Zr, Nb, Mo, ……..,Ag, Cd) in series of glass [Li2O – B2O3 – SiO2 – XO] at the given energy levels. Z-effective calculated through manually calculations of Glass mass Attenuation Coefficient, Total cross section and cross section per atom. With Increase in energy(0.01MeV- 1MeV) Z-effective decreases consistently for all the Second (4d) d-block Series (Y–Cd) transition metals in given series of Boro-Silicate Glass. However for higher energy ranges (1 MeV – 100 MeV) slight increase observed in Z-effective.
Keywords: Z-effective, Auto Z-effective software, Transition metals, Boro-Silicate Glass.

1. INTRODUCTION

Z – Effective is a phenomenon for studding the glass structure. It used in measurement of the interaction of radiation with matter (Glasses). Z effective calculates the interaction of the radiation with matter; it describes the range of the frequencies of the radiation absorbed by the glasses at different energy levels. It is the screening off the core nucleus by the cloud of the electron around it in given compound of the series of glass. In Glasses structure we analyse the interaction of the X-rays and γ- rays with given series [1][2]. The amount of radiation absorbed by the given glass is influenced by Z-effective of the glass[3][4]. Z-Effective is the electron cloud interaction with radiation. It is the effective atomic number per unit mass and provide the packing of the atoms in compound [5][6]. To calculate Z-effective various methods various methods used widely. These methods basically characterised into three main categories.

Transition metals are defined as the elements which have incompletely filled d orbitals in its ground state either in any one of its oxidation states. For example in this paper we chose (I) oxidation state.

2. Z-EFFECTIVE CALCULATION

Compound has been used for evaluation of Z-effective

Compound $Li_2O – B_2O_3 – SiO_2 – XO$

Mole fraction (0.1) (0.5) (0.3) (0.1)

Initially we have to find out the following basic parameters A, Z, W, n_i, f_i & M are Atomic Weight, Atomic Number, Weight Percentage, Formula Units, Fraction, Molecular Weight of individual atoms respectively. Fraction calculated by dividing formula unit of the individual atom by sum of formula units of all atoms[7]

At last Molecular Weight evaluated by multiple formula unit of with respective atomic weight e.g Ag(Z = 47) = n× A [8] . Similarly for other atoms the above parameters calculated and drawn the table1

Table no.1: Calculation of formula units and fraction

Elements	A	W	Z	$\sum n_i$	f_i	M
B	10.81	0.16	5	1	0.256	10.8
O	15.99	0.58	8	2.3	0.6	36.8
Li	6.941	0.046	3	0.2	0.051	1.4
			1			
Si	28.1	0.14	4	0.3	0.077	8.43
	107.8		4			10.7
Ag	6	0.087	7	0.1	0.025	8
						68.2
Total		1		3.9		1

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Next step is to evaluate the given values for individual atoms for different energy levels. **μm** Total attenuation with coherent scattering, to evaluate **μm** NIST XCOM database had been used on given **NIST**[9][10]. Then **f(A)m** & **∑f(A/Z)m** is the total weighing factor & weighing factor per atoms in compound respectively calculated using following formulae[2][7][8]

$$f(A)m = W \times f_i \times \mu m \quad (1)$$

$$f(A/Z)m = \frac{f(A)m}{\text{Atomic No.}(Z)} \quad (2)$$

Table no. 2: Calculations of f(A)m & ∑f(A/Z)m for Boron(Z=5)

	B		
Energy	μm	fAm	f(A/Z)m
1.17	1.26	3.48	0.70

Similarly above these values calculated for rest of atoms

Last step we have to calculate values of **μg, σt , σa, Zeff**. Where **μg** is Glass mass Attenuation Coefficient, **σt** is Total cross section and σa is cross section per atom

$$\mu g = \sum_{\text{all atoms}} [W \times \mu m] \quad (3)$$

$$\sigma t = \sum_{\text{all atoms}} [M \times \mu g] \quad (4)$$

$$\sigma a = \frac{\sigma t}{\sum ni} \quad (5)$$

$$\text{Z-effective} = \frac{\boldsymbol{\sigma a}}{\boldsymbol{\sum f(A/Z)m}} \quad (6)$$

Table no. 3: Table of calculation of Z-effective

Energy (MeV)	∑f(A/Z)m	μg	σt	σa	Z-Eff
0.01	0.117	0.057	3.91	1.01	8.51
0.1	20.01	18.74	1278.9	327.9	16.39
1	0.39	0.26	18.4	4.72	12.09
10	0.13	0.062	4.24	1.087	8.52
100	0.04	0.022	1.51	0.38	9.19

3. DATA ANALYSIS

Graph plotted Z-effective verses energy in MeV(fig 1.1). Where trends show 4d transition metals show highest values of Z-effective at very low energy 0.01 MeV. These values suddenly dropped with average values from 15 to 9 for 0.1 MeV to 1 MeV. Among all the metals used in series Cd(z=43) having minimum value of Z-effective and Y(z=39) at 1 MeV. Variation in Z-effective with energy range .01 to 100 MeV is in parabolic shape for all 4d transition metals used in the given boro-silicate glass series.

For energy variation from 1 MeV to 100 MeV slightly increase observed for given glass series with all 4d transition metals. If we study within the group of 4d transition metals Z-effective consistently going on increasing with increase in atomic number lowest energy range (0.01 MeV to 1 MeV). With Increase in energy range (1MeV- 100MeV) Z-effective Increases consistently for all the First (3d) d-block Series (Sc–Zn) transition metals in given series of Boro-Silicate Glass.

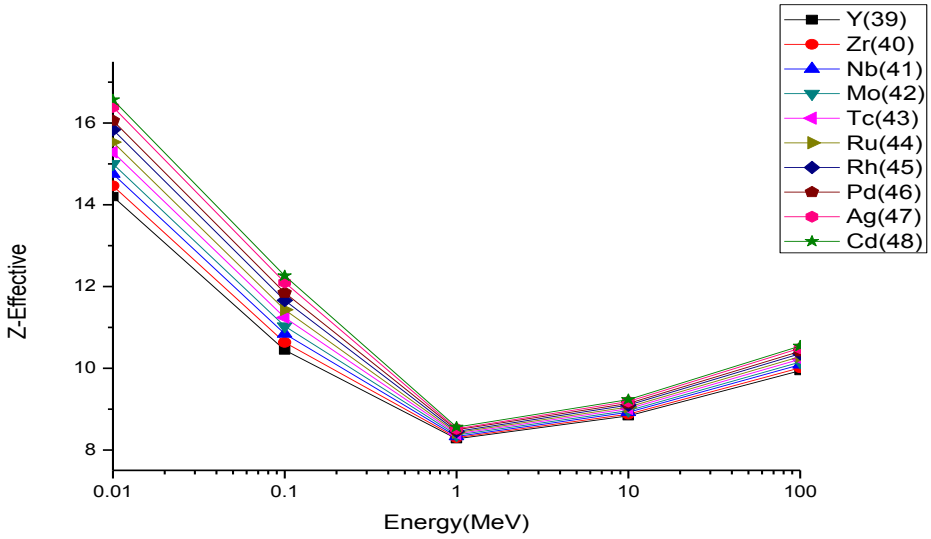

Fig1.1. Graph plotted Z-effective verses energy in MeV

4. CONCLUSIONS

Variations in Z-effective are high with increase in energy for all 4d metals used in given series of glass. From 1 to 100 MeV a small variation observed in data as it ranges 9 to 10 (Z-effective). All over variation is symmetrical within the 4d transition metals for given boro-silicate glass series. Calculated Data applications are for experimental references and for preparation of protecting glass from radiation. Also these values refect the influence and behaviour of the 4d transition metals in boro-silicate glass series with alkaline earth metals with their individual variations in it.

5. REFERENCES:

[1] A. M. Ali, A. M. El-Khayatt & I. Akkurt (2016): Determination of effective atomic number and electron density of heavy metal oxide glasses, Radiation Effects andDefects in Solids, 1042-0150 (Print)

[2] Singh, H., Singh, K., Gerward, L., Singh, K., Sahota, H. S., & Nathuram, R. (2003). ZnO–PbO–B 2 O 3 glasses as gamma-ray shielding materials. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 207(3), 257-262.

[3] Manohara, S. R., Hanagodimath, S. M., Thind, K. S., & Gerward, L. (2008). On the effective atomic number and electron density: a comprehensive set of formulas for all types of materials and energies above 1keV. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 266(18), 3906-3912.

[4] Singh, K., Singh, H., Sharma, V., Nathuram, R., Khanna, A., Kumar & Sahota, H. S. (2002). Gamma-ray attenuation coefficients in bismuth borate glasses. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 194(1), 1-6.

[5] Sheng, H. W., Luo, W. K., Alamgir, F. M., Bai, J. M., & Ma, E. (2006). Atomic packing and short-to-medium-range order in metallic glasses. Nature, 439(7075), 419-425.

[6] Kaewkhao, J., & Limsuwan, P. (2010). Mass attenuation coefficients and effective atomic numbers in phosphate glass containing Bi 2 O 3, PbO and BaO at 662keV. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 619(1), 295-297.

[7] Singh, K., Singh, H., Sharma, G., Gerward, L., Khanna, A., Kumar, R., ... & Sahota, H. S. (2005). Gamma-ray shielding properties of CaO–SrO–B2O3 glasses. Radiation Physics and Chemistry, 72(2), 225-228.

[8] Singh, S., Kumar, A., Singh, D., Thind, K. S., & Mudahar, G. S. (2008). Barium–borate–flyash glasses: as radiation shielding materials. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 266(1), 140-146.

[9] M. J. Berger and J. H. Hubbell, XCOM: Photon Cross Sections Database, NBSIR, 1987

[10] Singh, V. P., Badiger, N. M., & Kucuk, N. (2014). Determination of effective atomic numbers using different methods for some low-Z materials. Journal of Nuclear Chemistry, 2014.

[11] Hossain I., Shekaili N. K. & Wagiran H. (2013). Dopant Concentration and Effective Atomic Number of Copper-Doped Potassium Borate Glasses. Hindawi Publishing Corporation Advances in Materials Science and Engineering, Article ID 278934, 1-4

[12] M. L. Taylor (2012), Robust calculation of effective atomic numbers: The Auto-Zeff software, Medical Physics 39, 1769-1778

[13] M. L. Taylor (2011), Robust determination of effective atomic numbers for electron interactions with TLD-100 and TLD-100H thermoluminescent detectors, Nuclear Instruments and Methods B, 269 770-773

[14] Yang, Z., Yu, X., & Holmes, G. (2011, August). Evaluating impact of plug-in hybrid electric vehicle charging on power quality. In Electrical Machines and Systems (ICEMS), 2011 International Conference on ,1-4. IEEE.

[15] Wong Julia, (2012), SAS ZIP Auto Zeff Distribution software [Online] , RMIT University, Melbourne, Vic, Available from: /browse; http://mams.rmit.edu.au/hhwsx58somwoz.zip