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AN ANALYTIC ANALYSIS OF Z-EFFECTIVE FOR THE SERIES OF GLASS [LI2O – B2O3 – SIO2 – XO] WITH FIRST (3D) D-BLOCK (SC–ZN) 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 First (3d) d-block Series (Sc–Zn) transition metals(X= Cd, Ti, V, Cr, ……..,Cu, Zn) in series of glass [$Li_2O – B_2O_3 – SiO_2 – XO$] at the given energy levels. Z-effective calculated through manually calculations of Glass mass Attenuation Coefficient, Total cross section and cross section per atom. Z-effective consistently going on increasing with increase in atomic number except for Cu(z=29) and Zn(z=30) at lowest energy levels(0.01 MeV). With Increase in energy(0.01MeV- 100MeV) Z-effective decreases consistently for all the First (3d) d-block Series (Sc–Zn) transition metals in given series of Boro-Silicate Glass.

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 Mn(Z = 25) = 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
Si	28.1	0.14	14	0.3	0.077	8.43
Mn	54.94	0.077	25	0.1	0.026	5.5
Total		1		3.9		62.92

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]

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

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

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	21.5	20.1	1267.4	325	15.1
0.1	0.323	0.17	10.66	2.73	8.47
1	0.127	0.0619	3.89	0.999	7.85
10	0.0412	0.0207	1.31	0.34	8.13
100	0.0353	0.0197	1.24	0.327	8.99

3. DATA ANALYSIS

Graph plotted Z-effective verses energy in MeV(fig 1.1). Where trends show 3d transition metals show highest values of Z-effective at very low energy 0.01 MeV. These values suddenly dropped to 7-9 values for 0.1 MeV. Among all the metals used in series Ti(z=22) shows larger variation with minimum dip in Z-effective at 0.1 MeV.

Further decrease observed in Z-effective for the given series except the Ti(z=22) having the minimum value of Z-effective 7.62145 at 1 MeV. For energy variation from 1 MeV to 100 MeV slightly increase observed for given glass series with all 3d transition metals. If we study within the group of 3d transition metals Z-effective consistently going on increasing with increase in atomic number except for Cu(z=29) and Zn(z=30) at lowest energy levels(0.01 MeV). With Increase in energy(0.01MeV- 100MeV) Z-effective decreases consistently for all the First (3d) d-block Series (Sc–Zn) transition metals in given series of Boro-Silicate Glass.

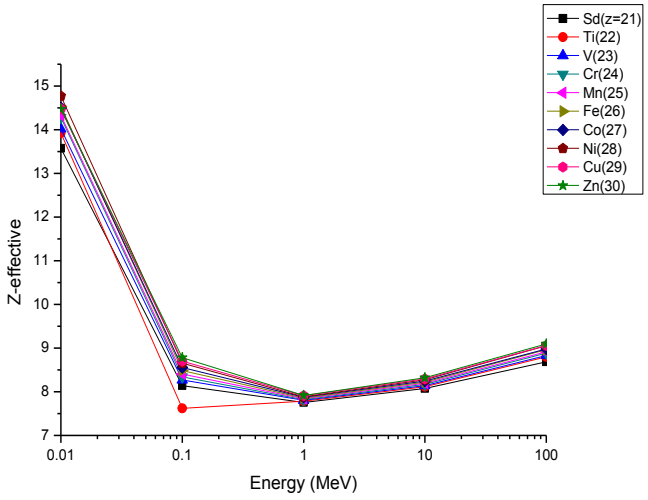

Fig 1.1. Graph plotted Z-effective verses energy in MeV

4. CONCLUSIONS

Variations in Z-effective are high with increase in energy for all 3d metals used in given series of glass. From 0.1 to 100 MeV a small variation observed in data as it ranges 7 to 9 (Z-effective). These values of Z-effective resembles with Z-effective of human skin. Given data having applications for experimental references and preparation for skin protecting glass for energy absorption ranges from 0.1 to 100 MeV. Also these values refect the influence and behaviour of the 3d transition metals in boro silicate glass series with alkaline earth metals with their individual variations in it.

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