

Mass Attenuation Coefficient Of Low Energy Beta Particles In Aluminium

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ABSTRACT

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The mass attenuation coefficient (MAC) is a critical parameter in understanding the interaction of beta particles with materials, particularly in shielding and dosimetry applications. This study investigates the attenuation properties of low-energy beta particles using sources Ti^{204} , Pb^{210} - Bi^{210} , Sr^{90} - Y^{90} for the aluminium. Experimental measurements were conducted using a GM Counter, with aluminium absorbers of varying thicknesses. The results were analysed to determine the mass attenuation coefficients, which were compared to theoretical values obtained from simulation tools or tabulated data. The findings demonstrate a strong correlation between experimental and theoretical values, highlighting the reliability of aluminium as a shielding material for low-energy beta radiation. The study also discusses the influence of particle energy and absorber density on attenuation, offering insights for practical applications in radiation protection and nuclear science.

1 Introduction

Beta particles or electrons are widely used dosimetry and medicine. The various interaction of beta particles with matter is of almost importance in practical consideration. Mass absorption coefficient measures the penetration power of Beta particles which is dependent on the concentration and atomic number of constituent element in the mixture. Measurement of mass attenuation coefficient of elements plays an important role in particle Physics. The measurements of mass attenuation coefficient of pure elements require accuracy and precision which is difficult. The measurements are to be done indirectly by using the attenuation of different thickness metal foils. The method of measuring the total mass attenuation coefficient of the foils are done through attenuation with good geometry set up Teli et al.⁽²¹⁾ The mass attenuation coefficient of a compound in linear region is given by Bragg's mixture rule.

2 METHOD & MATERIAL

The mass attenuation coefficient of low energy beta particle is measured with the help of Geiger Muller counter (GM Counter). The GM tubes have been made in Great variety of size and ships from 1 cm to 100 cm in length and from 0.3 cm to 10 cm in diameter. The GM Counting system is shown by the block diagram given below in figure 1.0

2.1 Experimental Arrangements for measuring linear attenuation coefficient

Experimental arrangement is shown in Fig. 1.0 to measure the mass attenuation coefficient for the compounds by performing a beta particle transmission experiment in narrow beam geometry. Geometry is designed to stop the secondary rays from secondary scattering. These secondary scattered particles must be stopped by using lead collimator of thickness of 0.2 cm was placed upper the source. A cylindrical thin glass container of internal diameter 1.592 cm was placed upper the source at a distance 2 cm and 6 cm below the detector. To prevent liquid chemicals from evaporation a burette is directly connected to the glass container. The burette and glass container are sealed with butter paper and interconnected through 1.2 mm polyethylene micro tube to bypass air. The stand is made up of prefix sheet of suitable size. The source, absorber and detector are placed along the axis of stand. The whole system is enclosed in a lead castle. The G.M. tube with high voltage and filter circuit along with analog to digital converter is interfaced with microcontroller counting system manufactured by Nucleonix system. The counts for 500 seconds are used for calculations.

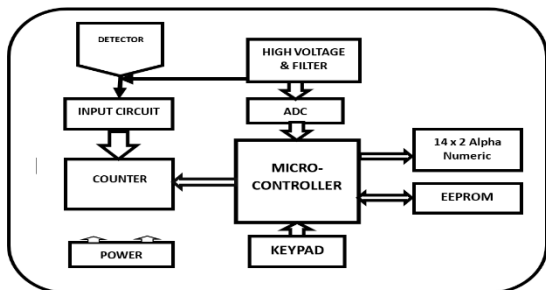


Figure 1.0

3 Results And Discussion

3.1 Computation of Dead Time for Ti^{204} , Pb^{210} - Bi^{210} , Sr^{90} - Y^{90} Sources

The dead time is calculated for Ti^{204} , Pb^{210} - Bi^{210} , Sr^{90} - Y^{90} Sources By methods double source method and various area method are given below,

Sr.No	Sources Used	Energy in Mev	Dead time by Various Area Method	Dead time by Double Source Method
1.	Ti204	0.763 Mev	1.75×10^{-4}	0.449×10^{-4}
2.	Pb210-Bi210	1.16 Mev	1.3×10^{-4}	0.4×10^{-4}
3.	Sr90-Y90	2.27 Mev	0.20×10^{-4}	0.1128×10^{-4}

3.2 Computation of Mass Attenuation Coefficient for Aluminum

If I and I₀ are the measured count rates through the container respectively with or without the absorber of density ρ (gm/cm³), thickness and total linear attenuation coefficient μ (cm-1) and mass attenuation coefficient μ/ρ (cm²/gm) of the absorber are related by the standard exponential law.

$$I = I_0 e^{-\mu h} \quad 1.1$$

And

$$I = I_0 \exp\left(-\frac{\mu}{\rho} (\rho h)\right) \quad 1.2$$

Since I₀ and I are proportional to gross counts for 1800 seconds in the interest, if the absorber is a homogeneous liquid or solution. its density can be eliminated from equation 1.2 by containing it in a cylindrical container of internal radius r cm. the density of solution of mass m and height h cm in the container is given by $\rho = \frac{m}{\pi r^2 h}$ and it simplifies equation 1.1 to

$$I = I_0 \exp\left(-\frac{\mu}{\rho} \frac{m}{\pi r^2 h}\right) \quad 1.3$$

Thus equation 1.3 directly gives μ/ρ values for elements in a single experiment without obtaining the density of solutions separately.

The measurements of mass attenuation coefficient of pure elements requires accuracy and precision which is difficult. The measurements are to be done indirectly by using the attenuation of different thickness metal foils. the method of measuring the total attenuation coefficient of the foils are done through attenuation with good geometry setup Teli et al. the mass attenuation coefficient of a compound in linear region is given by Bragg's mixture rule.

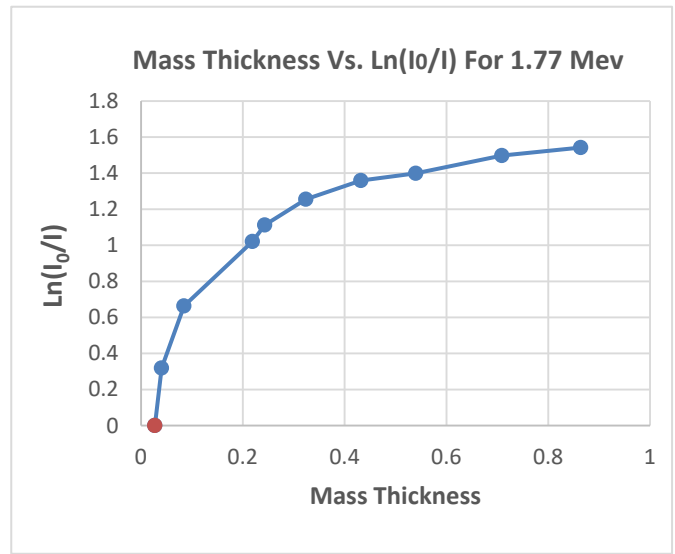
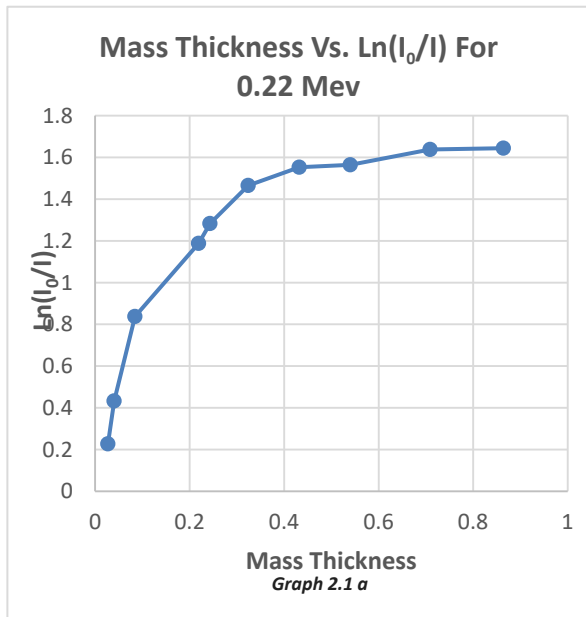
$$\left(\frac{\mu}{\rho}\right)_{comp} = \sum_{i=1}^N w_i \left(\frac{\mu}{\rho}\right)_i \quad 1.4$$

Where w_i and $\left(\frac{\mu}{\rho}\right)_i$ are weighing factor and total attenuation coefficient respectively of the constituent elements of the compound.

3.3 Experimental data for Aluminum

Beta Energy 0.77 MeV, Density = 2.7 gm/cm³

Mass thickness	I, I ₀ 200 Sec	Corrected I	I/I ₀	Ln(I ₀ /I)
0.0000	11578	13094		
0.0270	9228	10166	0.7764	0.2269
0.0405	7509	8119	0.6200	0.433
0.0845	5010	5274	0.4028	0.8377
0.2190	3530	3659	0.2795	1.1878
0.2430	3208	3314	0.2531	1.2835
0.3240	2674	2747	0.2098	1.4655
0.4320	2450	2512	0.1918	1.553
0.5400	2421	2481	0.1895	1.5649
0.7090	2250	2302	0.1758	1.6382
0.8640	2237	2288	0.1748	1.644



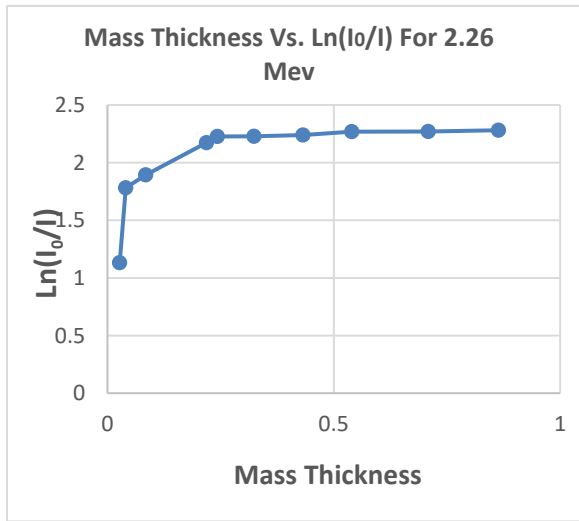
Beta energy 1.77 MeV

Mass thickness	I, I_0 200 Sec	Corrected I	I/I_0	$\ln(I_0/I)$
0.0000	38059	23574		
0.0270	22178	28498	1.2089	-0.1897
0.0405	14628	17134	0.7268	0.3191
0.0845	10829	12144	0.5151	0.6633
0.2190	7827	8492	0.3602	1.0211
0.2430	8852	9712	0.4120	0.8868
0.3240	8052	8757	0.3715	0.9903
0.4320	7554	8171	0.3466	1.0595
0.5400	7032	7564	0.3209	1.1368
0.7090	5010	5274	0.2237	1.4973
0.8640	4800	5042	0.2139	1.5423

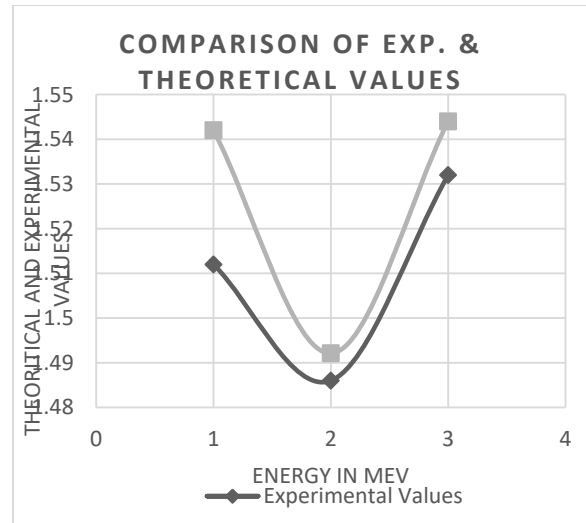
Beta energy 2.26 MeV

Mass thickness	I, I_0 200 Sec	Corrected I	I/I_0	$\ln(I_0/I)$
0.0000	51042	104257		
0.0270	25161	33620	0.3225	1.1317
0.0405	14936	17559	0.1684	1.7813
0.0845	13565	15694	0.1505	1.8936
0.2190	10611	11871	0.1139	2.1728
0.2430	10110	11247	0.1079	2.2267
0.3240	10100	11235	0.1078	2.2278
0.4320	9999	11110	0.1066	2.2390
0.5400	9732	10781	0.1034	2.2690
0.7090	9726	10774	0.1033	2.2697
0.8640	9629	10655	0.1022	2.2808

Table 2.5



Graph 2.3 a



4 CONCLUSION

The work presented here has been carried out for compound with view of major mass and linear attenuation coefficient of elements in beta particle energies ranging from 0.77 to 2.26 Mev by using the technique of Teli et al. this work pertains to the experimental verification of theoretical values calculated by Berger and Seltzer.

Because of accessing struggling and the large statistical fluctuations in the result of their collision in the absorber and low activity sources give more differences in the experiment result than normal. our investigation of interesting method of elemental measurement of mass attenuation coefficient has proved very efficient and useful it skilfully avoids the extra measurement of the density of compound solution.

Table 2.4 & 2.5 Who represents comparative statements between experimental and theoretical values of mass attenuation coefficient of range of 0.77 to 2.26 Mev electrons in aluminium respectively. The above result shows that the deviation between the experimental and theoretical values are less than 3% in entire region for electrons. The deviation are due to the multiple scattering with the target atoms which is important only near the end of tracks for electrons from the table and the figure it is clear that the range of particles increases with the energy of electron as well as atomic number of absorber the calculations may be used for medical science particularly X ray passing through human body which creates electrons the range of bit political at low energy can be useful in determining the impurities present in the material.

5 REFERENCES

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Mass Attenuation Coefficient for Aluminium

Isotpes	Energy in Mev	Experimental Values	Theoretical Values	% Error
Ti204	0.77 Mev	1.5120	1.5420	- 1.9841
Pb210- Bi210	1.16 Mev	1.4860	1.4921	- 0.4105
Sr90- Y90	2.27 Mev	1.5320	1.5440	- 0.7833

Table 2.4

Range of Beta Particle for Aluminum

Isotopes	Energy in Mev	Experimental Values	Theoretical Values	% Error
Ti204	0.77 Mev	0.3989	0.3900	2.2311
Pb210- Bi210	1.16 Mev	0.6521	0.6530	- 0.1380
Sr90- Y90	2.27 Mev	0.1335	0.1320	1.1236

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