Measurement of Mass and Linear Attenuation Coefficients of Gamma-Rays of Alanine for 0.662, 1.170, 1.280 and 1.330 Mev Photons

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ABSTRACT

Gamma –ray transmission methods have been used accurately for the study of the properties of biological sample such as alanine. In this study mass and linear attenuation coefficients of gamma-rays of Alanine for 0.662, 1.170, 1.280 and 1.330 MeV photons are determined by using NaI (Tl) scintillation detector. The radioactive sources used in the experiment were Cs^{13}, Co^{60} and Na^{22}. Mass (μ/ρ) and linear attenuation coefficients (μ) of alanine for 0.662, 1.170, 1.280 and 1.330 MeV gamma-rays photons have been measured using the well-type scintillation spectrometer. Measurements have been made to determine gamma ray attenuation coefficients very accurately by using a narrow-collimated-beam method which effectively excluded corrections due to small-angle and multiple scattering of photons. The values of μ and μ/ρ thus obtained are found to be in good agreement with the theory.

Keywords: Mass attenuation coefficients, Linear attenuation coefficients, Gamma rays, Alanine.
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INTRODUCTION

Amino acids are the building blocks of proteins. Proteins are the most abundant macro molecules in the living cells and constitute the largest fraction of living matter in all types of cells. Ionizing radiation and radioactive materials play a major role as effective tools in the field of medicine, biological studies and industry. Photons of energy in the range 10-1500keV are found to be suitable for medical and biological applications. The mass attenuation coefficient μ/ρ is a

measure of probability of interaction that occurs between incident photons and matter of unit mass per unit area. The knowledge of mass attenuation coefficients of X-rays and gamma photons in biological and other important materials is of significant interest for industrial, biological, agricultural and medical applications [1].Data on the mass (μ/ρ) and linear attenuation coefficients (μ) of amino acids for, Cs^{137} (0.662), Co^{60} (1.170), Na^{22} (1.280) and Co^{60} (1.330) MeV are quite useful, especially since these are the building blocks of proteins which are essential to all living matter.

Radioactive sources are increasingly used in biological studies, radiation sterilization and industry [1-2].Mass attenuation coefficients of gamma-rays in some compounds and mixtures of dosimetric and biological importance have been compiled by Hubbel [3] in the energy range 1keV to 20 MeV. Since photons of energy from 1500 keV down to about 5keV are widely used in medical and biological applications [4], a thorough knowledge of the nature of interaction of samples such as sugars and amino acids is desirable over this energy region. Hence, in recent years, several investigators have studied the nature of interaction of such biologically important molecules with such photons in this energy regime.[5-20] Gopinathan et al [21-22] have studied the total attenuation cross sections for several amino acids and sugars in the solid form for limited energies.

The photoelectric effect, the Compton scattering and the pair production processes are the predominant interactions between the photons and atoms apart from other types over a wide range of energies. A series of accurate and consistent measurements of γ-ray mass attenuation coefficients was undertaken by author. The results of these measurements covering alanine sample at four photon energies. A possible effect due to multiply scattered photons from thick attenuators on the measurements has been minimized to a great extent by using extremely – narrow-beam collimation and selected attenuator thicknesses. With this end in view, author measured photon interaction cross sections of alanine sample at four photon energies using a NaI (Tl) detector. The measured mass (μ/ρ) and linear attenuation coefficients (μ) of alanine for 0.662, 1.170, 1.280 and 1.330 MeV gamma-rays photons have been compared with the values calculated based on the data of Hubbell [23] and found to be in good agreement.

THEORY

When I and I_0 are the intensities of gamma radiation of energy E traversed through the container respectively with and without the absorber of thickness t then the linear (μ) and mass (μ/ρ) attenuation coefficients are given from the exponential law viz:

$$I = I_0 \, e^{-\mu t}$$

$$I = I_0 \, e^{-\mu/\rho(\rho t)} \qquad\qquad ....(1)$$

as $\mu = 1/t \, \ln(I_0/I)$ ....(2)

and $\mu/\rho = 1/\rho t \, \ln(I_0/I)$ ....(3)

For the container of the absorber in cylindrical form of inner cross-section Πr^2,

$\rho= m/ \Pi r^2 t$ where r is the inner radius of the container and m is the absorber mass of thickness t. Eq. (3) then simplifies to

$$\mu/\rho = \Pi r^2/m \, \ln(I_0/I) \qquad\qquad ....(4)$$

MATERIALS AND METHODS

The authors measured the linear attenuation coefficient of the alanine sample by performing vertical narrow beam geometry. The diameter of the collimator is1.18cm. Alanine foils of uniform thicknesses was placed below the source at a distance of 12.3 cm and 9.0 cm above the detector .To increase the thickness of alanine absorber foil, place the alanine absorber foils of

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known thickness (0.33 cm) one by one between the source and the detector. The Sodium Iodided detector [0.75"x2"] was connected to PC based 8k-MCA.The authors measured (μ/ρ) for alanine foils at four photon energies 0.662, 1.170, 1.280 and 1.330 MeV. Three standard gamma sources Cs^{137} (0.662), Co^{60} (1.170, 1.330) and Na^{22} (1.280) MeV are used. The results are shown in table 1.

The alanine samples under investigation were confined in cylindrical plastic containers or inner diameter 2.5 cm. It was found that the attenuation of the photon beam by the material of the empty containers was negligible. Each sample thus prepared was weighed in an electrical balance exactly to the third decimal place. The weighings were repeated a number of times to obtain concordant values of the mass. A mean of this set of concordant values was taken to be the mass of the sample. The inner diameter of each container was determined separately with the help of a traveling microscope by the usual method. Using the mean values of the mass and the inner diameter, the mass per unit area of each sample was determined. The thickness of the samples (mass per unit area) was chosen such that a $\mu t < 0.6$ [24] criterion was satisfied at each energy, in order to minimize the effects due to multiple scattering.

Table 1: Linear attenuation coefficient μ (cm^{-1}) and mass attenuation coefficient μ/ρ (cm^2/g) of Alanine absorber at Photon energies 0.662, 1.170, 1.280 and 1.330 MeV

S. No.	Energy MeV	μ (cm^{-1})	μ/ρ (cm^2/g)
1	0.662	0.121 a	0.084 a
		0.119 b	0.083 b
		-1.256 c	-1.205 c
2	1.170	0.088 a	0.061 a
		0.091 b	0.063 b
		3.297 c	3.174 c
3	1.280	0.087 a	0.061 a
		0.086 b	0.060 b
		-1.162 c	-1.666 c
4	1.330	0.085 a	0.059 a
		0.085 b	0.059 b
		0.000 c	0.000 c

a (experimental)
b (Hubbell and Seltzer) values.
c (Percentage deviation)

RESULTS AND DISCUSSION

The comparison of their measurements with the theoretical values [23] is done by calculating the Percentage deviation as:

$$\% \text{ deviation} = \frac{(\mu/\rho)_{theo} - (\mu/\rho)_{exp}}{(\mu/\rho)_{theo}} \times 100$$

These are also presented in the table 1 and the author found the deviation mostly below 2%

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indicating thereby excellent agreement of the author's measurements with theory. The linear attenuation coefficient is obtained by multiplying the mass attenuation coefficient of the sample by its density. Figure 1-4 shows plot of I_0/I Vs thickness t for alanine at 0.662, 1.170, 1.280 and 1.330 MeV .Using this graphs, slope can be calculated and these slope is nothing but the (μ/ρ) mass attenuation coefficient of alanine at that particular energy.
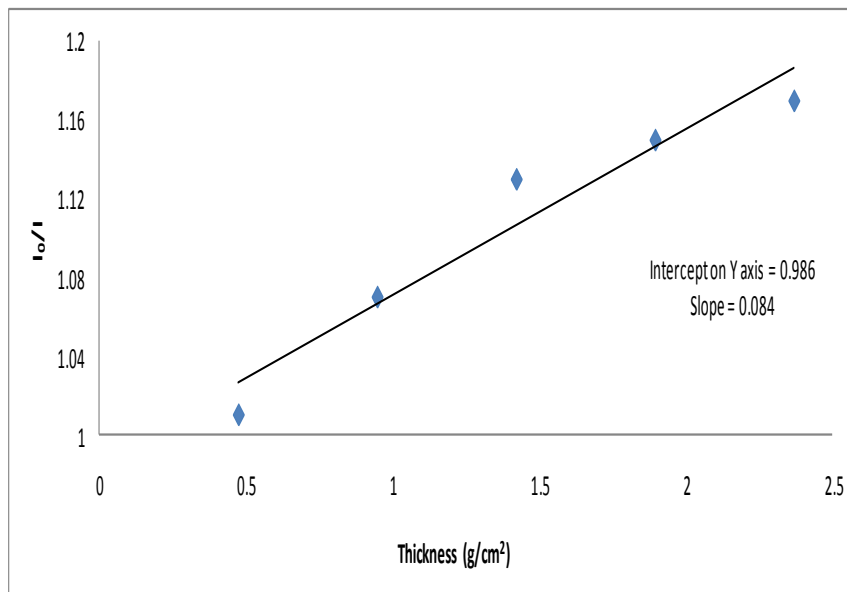

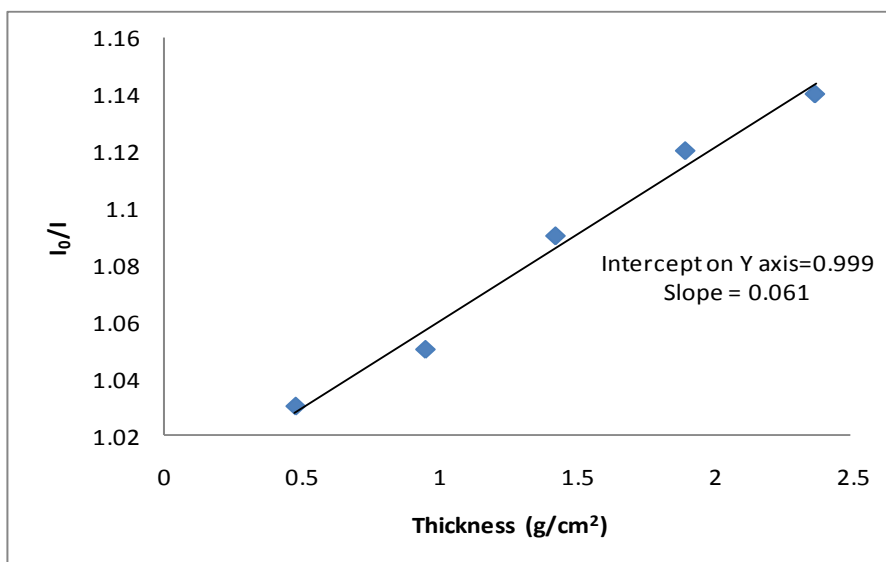**Figure 1.Plot of I_0/I Vs thickness t for Alanine at 0.662 MeV.**

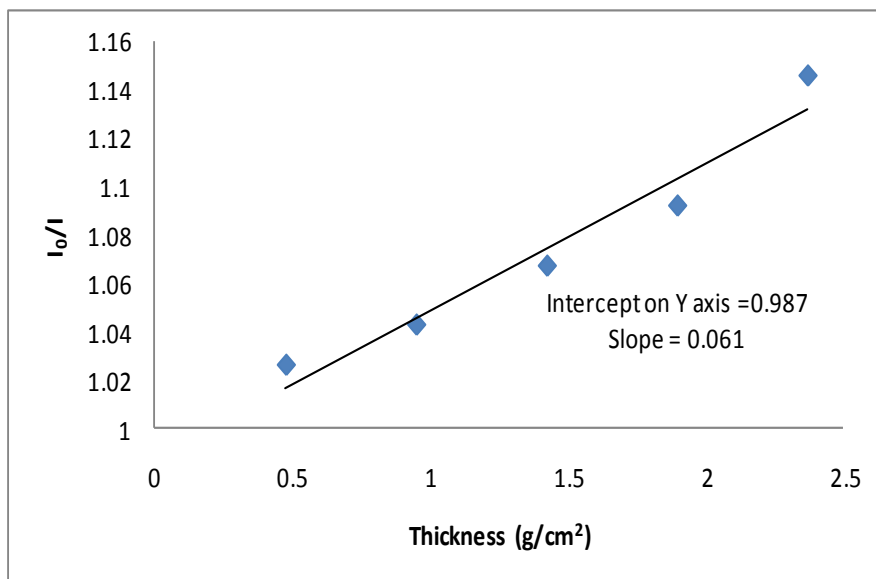**Figure 2.Plot of I_0/I Vs thickness t for Alanine at 1.17 MeV.**

Figure 3 .Plot of I_0/I Vs thickness t for Alanine at 1.280 MeV.
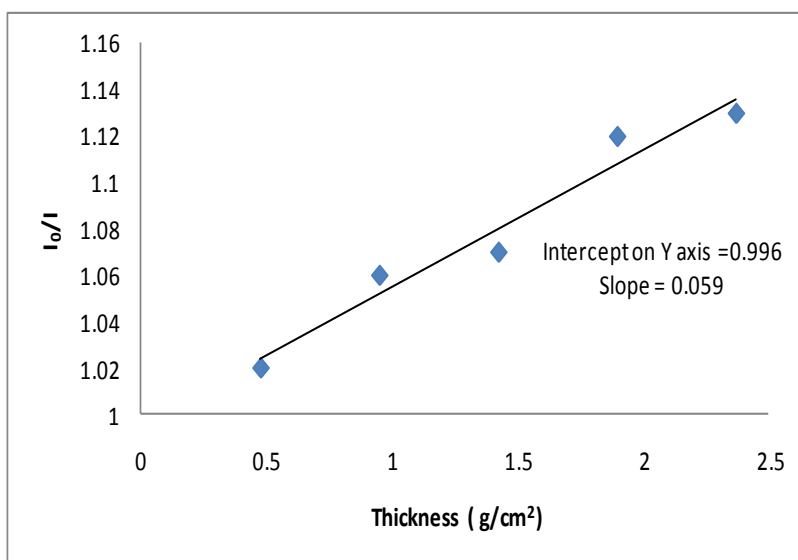

Figure 4.Plot of I_0/I Vs thickness t for Alanine at 1.33 MeV.

APPLICATIONS

The measured mass and linear attenuation coefficients of alanine are useful in medical field. The data is useful in radiation dosimetry and other fields.

CONCLUSION

The theoretical values of mass attenuation coefficient for Alanine are available from [23] and the author carried out the work of their experimental measurement with excellent accuracy. The agreement of the author so measured values with theory confirms the theoretical considerations

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of the contribution of various processes such as photoelectric effect, the Compton scattering and the pair production. To decide the radiation to be delivered without any harm to normal cells it is necessary to have a precise knowledge of gamma ray photon attenuation and consequent absorption.

ACKNOWLEDGMENT

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