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Measurement of Mass and Linear Attenuation Coefficients of Gamma-Rays of Elastin protein for 0.122-1.330 MeV Photons

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ABSTRACT

Photon attenuation coefficients methods have been used accurately for the study of the properties of biological sample such as Elastin protein. In this study mass and linear attenuation coefficients of gamma-rays of Elastin protein for 0.122, 0.356, 0.511, 0.662, 1.170, 1.275 and 1.330 MeV photons are determined by using NaI (Tl) scintillation detector. The radioactive sources used in the experiment were Co^{57}, Ba^{133}, Na^{22}, Cs^{137} *and* Co^{60}. *Mass* (μ/ρ) *and linear attenuation coefficients* (μ) *of Elastin protein 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: Linear Attenuation Coefficients, Mass Attenuation Coefficients, Elastin protein.

INTRODUCTION

Elastin protein is an essential part of various human tissues that depend on elasticity. These connective tissues include the skin, lung and arteries. Elastin provides these elastic tissues with the ability to stretch and recoil and plays a critical role in supporting and maintaining healthy cells [1]. 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 [2]. Data on the mass (μ/ρ) and linear attenuation coefficients (μ) of Elastin for, Co^{57}, Ba^{133}, Na^{22}, Cs^{137} and Co^{60} are 0.122, 0.356, 0.511, 0.662, 1.170, 1.275 and 1.330 MeV are quite useful. The interaction of radiation and tissue is governed by the energy of the incident radiation [3]. The attenuation of gamma radiation (photons) by an absorber is qualitatively different from that of either alpha or beta radiation. Whereas both these corpuscular radiations have definite ranges in matter and therefore can be completely stopped, gamma radiation can only be reduced in intensity by increasingly thicker absorbers; it cannot be completely absorbed. With this end in view, author measured linear and mass attenuation coefficients of Elastin protein sample at different photon energies using a NaI (Tl) detector. The measured mass (μ/ρ) and linear attenuation coefficients (μ) of Elastin protein for 0.122, 0.356, 0.511, 0.662, 1.170, 1.275 and 1.330 MeV gamma-rays photons have been compared with the values calculated based on the data of Hubbell [4] and found to be in good agreement and theory is included.

MATERIALS AND METHODS

The authors measured the linear attenuation coefficient of the Elastin protein sample by performing vertical narrow beam geometry. The diameter of the collimator is1.18cm. The sodium iodide detector [0.75"x2"] was connected to PC based 8k-MCA.The authors measured (μ/ρ) for Elastin protein foils at seven photon energies and five standard gamma sources Co^{57}(0.122) ,Ba^{133}(0.356),Cs^{137} (0.662), Co^{60} (1.170, 1.330) and Na^{22} (0.511,1.275) MeV are used. The results are shown in table 1.

Table1: Linear attenuation coefficient μ (cm^{-1}) and mass attenuation coefficient μ/ρ (cm2/g) of Elastin protein from 0.122 to1.330 MeV.

Sr.No	Energy MeV	μ/ρ exp.	μ/ρ theo.	μ exp	μ theo.	% deviation
1	0.122	0.156	0.157	0.175656	0.176782	0.636943
2	0.356	0.107	0.108	0.120482	0.121608	0.925926
3	0.511	0.094	0.095	0.105844	0.10697	1.052632
4	0.662	0.084	0.085	0.094584	0.09571	1.176471
5	1.170	0.062	0.063	0.069812	0.070938	1.587302
6	1.275	0.061	0.062	0.068686	0.069812	1.612903
7	1.330	0.059	0.060	0.066434	0.06756	1.666667

The Elastin protein samples under investigation were confined in cylindrical plastic containers of 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 $t < 0.6$ [5] criterion was satisfied at each energy, in order to minimize the effects due to multiple scattering [6-10].

RESULTS AND DISCUSSION

The comparison of experimental measurements with the theoretical values [4] is done by calculating the Percentage deviation as:

$$\% \text{ deviation}=[\{(\mu/\rho)\text{ theo}-(\mu/\rho)\text{ exp}\} /(\mu/\rho)\text{ theo}]*100\%$$

These are also presented in the table 1 and the deviation is found to be mostly below 2% indicating thereby excellent agreement of the experimental measurements with theory. The linear attenuation coefficient is obtained by multiplying the mass attenuation coefficient of the sample by its density. Figures 1-7 are the plots of ln I_0/I Vs thickness t for Elastin protein at 0.122, 0.356, 0.511, 0.662, 1.170, 1.275 and 1.330 MeV. Using these graphs, slope can be calculated and this slope is nothing but the (μ/ρ) mass attenuation coefficient of Elastin protein at that particular energy[11-13].

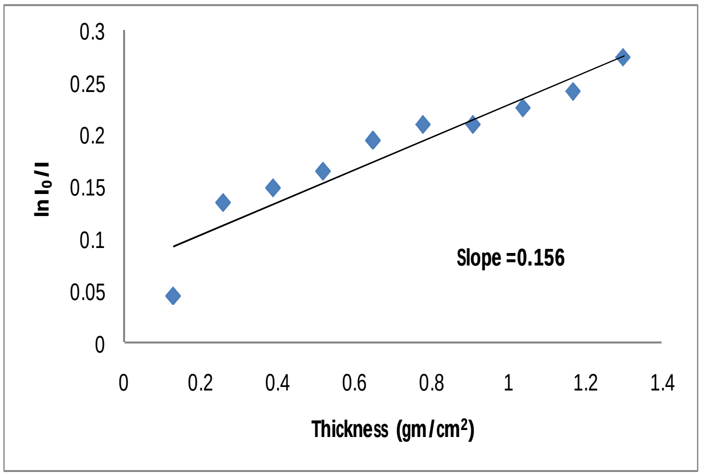

Figure 1. Plot of ln I_0/I Vs thickness T in gm/cm^2 for Elastin protein at 0.122 MeV.

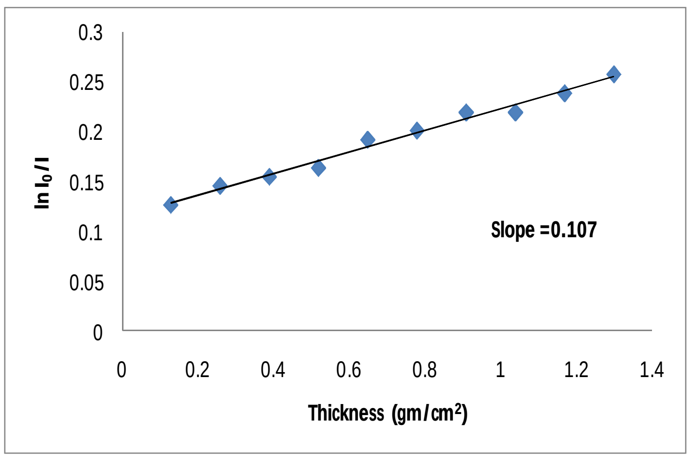

Figure 2. Plot of ln I_0/I Vs thickness T in gm/cm^2 for Elastin protein at 0.356 MeV.

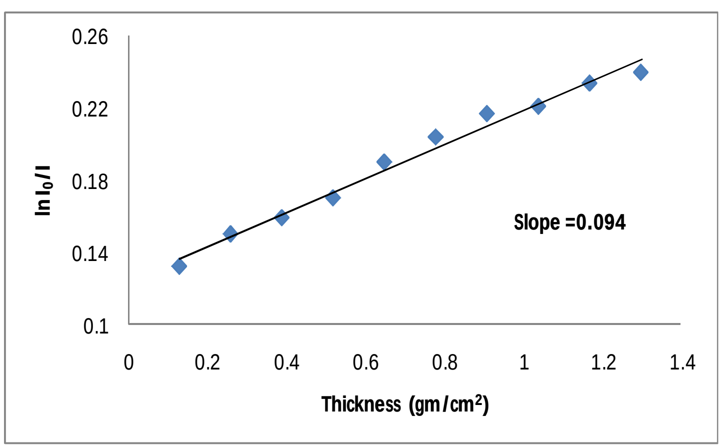

Figure 3. Plot of ln I_0/I Vs thickness T in gm/cm^2 for Elastin protein at 0.511 MeV.

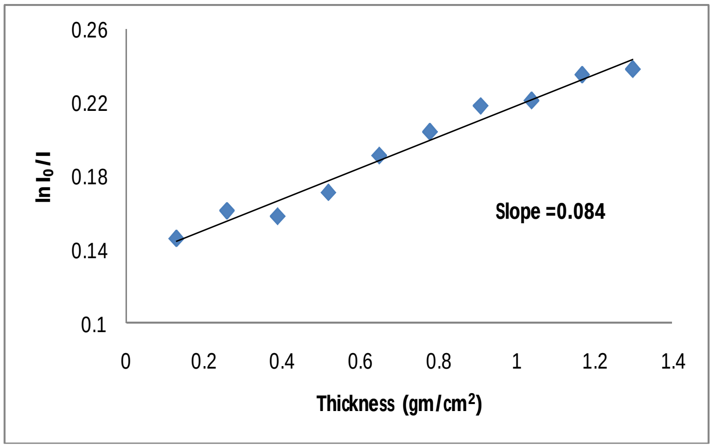

Figure 4. Plot of ln I_0/I Vs thickness T in gm/cm^2 for Elastin protein at 0.662 MeV.

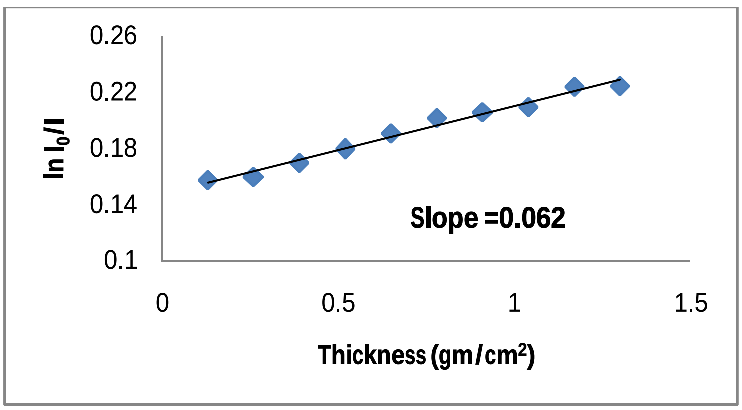

Figure 5. Plot of ln I_0/I Vs thickness T in gm/cm^2 for Elastin protein at 1.170 MeV.

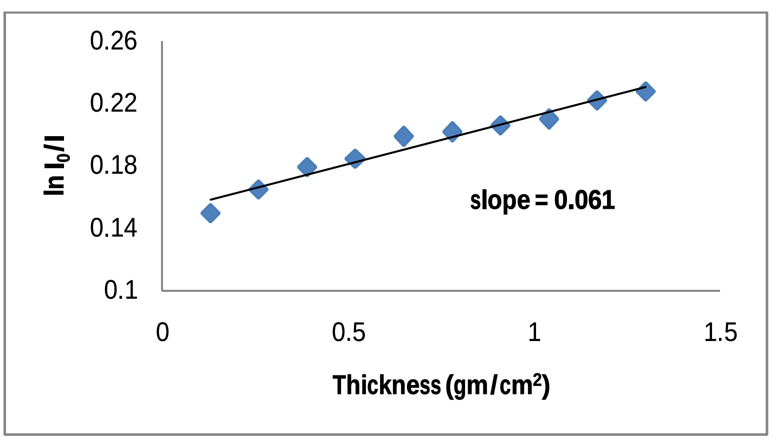

Figure 6. Plot of ln I_0/I Vs thickness T in gm/cm^2 for Elastin protein at 1.275 MeV.

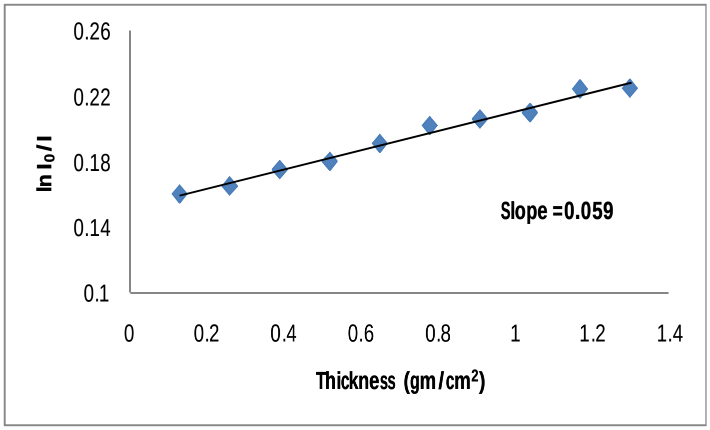

Figure 7. Plot of ln I_0/I Vs thickness T in gm/cm^2 for Elastin protein at 1.330 MeV.

APPLICATIONS

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

CONCLUSIONS

The theoretical values of mass attenuation coefficient for Elastin protein are available from [4] 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 of the contribution of various processes such as photoelectric effect, the Compton scattering and the pair production[14-24]. 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.

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