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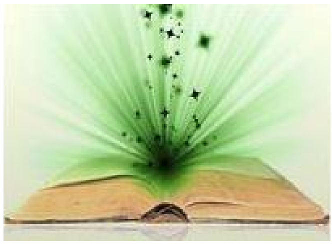

Measurement of Mass and Linear Attenuation Coefficients of Gamma-Rays of L Arginine LR from 122 to 1330 Kev Photons

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ABSTRACT

Gamma –ray transmission methods have been used accurately for the study of the properties of biological sample such as L Arginine LR. In this study mass and linear attenuation coefficients of gamma-rays of L Arginine LR from 122 to 1330 keV 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 L Arginine LR have been measured for gamma-rays from 122 to 1330 keV photons 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, L-Arginine LR.

INTRODUCTION

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. 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. 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, Co^{57} (0.122) , Ba^{133} (0.356), Na^{22}(0.511) Cs^{137} (0.662),Co^{60} (1.170), Na^{22}(1.275) 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.

Arginine is one of the twenty amino acids that constitute protein. It exists as L- Arginine and D-Arginine form. However, the L Arginine is the more compatible form to human body. Since L Arginine can be synthesized in the body, it is called nonessential amino acid. L Arginine is a precursor of nitric oxide and other metabolites, a component of collagen, enzymes and hormones (eg.vasopressin), ejaculate (seminal fluid and sperm), skin and connective tissues. L-arginine plays important roles in the synthesis of various protein molecules (creatine and insulin).Other L Arginine benefits include regulation of platelet aggregation and lowering of blood pressure. It may also have antioxidant property. Additional L Arginine benefits include removal of excess ammonia and maintenance of nitrogen balance. It reduces accumulation of compounds such as ammonia and plasma lactate, byproducts of physical exercise. It helps in liver detoxification, reduction of alcohol toxicity effects, and wound healing.[23-25]

In the present work a series of accurate and consistent measurements of gamma ray mass attenuation coefficients for L Arginine LR samples were undertaken by authors.

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 were undertaken by author. The results of these measurements covering L Arginine LR sample at seven 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 mass and linear attenuation coefficients of L Arginine LR sample at seven photon energies using a NaI (Tl) detector. The measured mass (μ/ρ) and linear attenuation coefficients (μ) of L Arginine LR 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 [26] and found to be in good agreement.

MATERIALS AND METHODS

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:

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

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

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

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

Experimental Section: The authors measured the linear attenuation coefficient of the L Arginine LR sample by performing vertical narrow beam geometry. The diameter of the collimator is1.18cm. L Arginine LR 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 L Arginine LR absorber foil, place the L Arginine LR absorber foils of known thickness (0.13 gm/cm^2) 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 L Arginine LR foils at seven photon energies 0.122,0.356,0.511,0.662, 1.170, 1.275 and 1.330 MeV. 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, 1.280) MeV are used. The results are shown in table 1.

The L Arginine LR 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 weighing was 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 $\mu t < 0.6$ [27] criterion was satisfied at each energy, in order to minimize the effects due to multiple scattering.

Table 1: Linear and mass attenuation coefficient of L Arginine LR sample from 122 to 1330 keV

S.no	Energy keV	μ/ρ exp.	μ/ρ theo.	μ exp	μ theo	% deviation
1	122	0.156	0.155	0.2028	0.2015	-0.645
2	356	0.108	0.108	0.1404	0.1404	0
3	511	0.095	0.094	0.1235	0.1222	-1.06382
4	662	0.083	0.084	0.1079	0.1092	1.1904
5	1170	0.063	0.064	0.0819	0.0832	1.5625
6	1275	0.061	0.060	0.0793	0.078	-1.6666
7	1330	0.058	0.059	0.0754	0.0767	1.6949

RESULTS AND DISCUSSION

The comparison of these measurements with the theoretical values [26] 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% 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 1-7 shows plot of $\ln I_0/I$ Vs thickness t for L Arginine LR at 0.122,0.356,0.511, 0.662, 1.170, 1.275 and 1.330 MeV .Using this graphs, slope can be calculated and these slope is nothing but the (μ/ρ) mass attenuation coefficient of L Arginine LR at that particular energy.

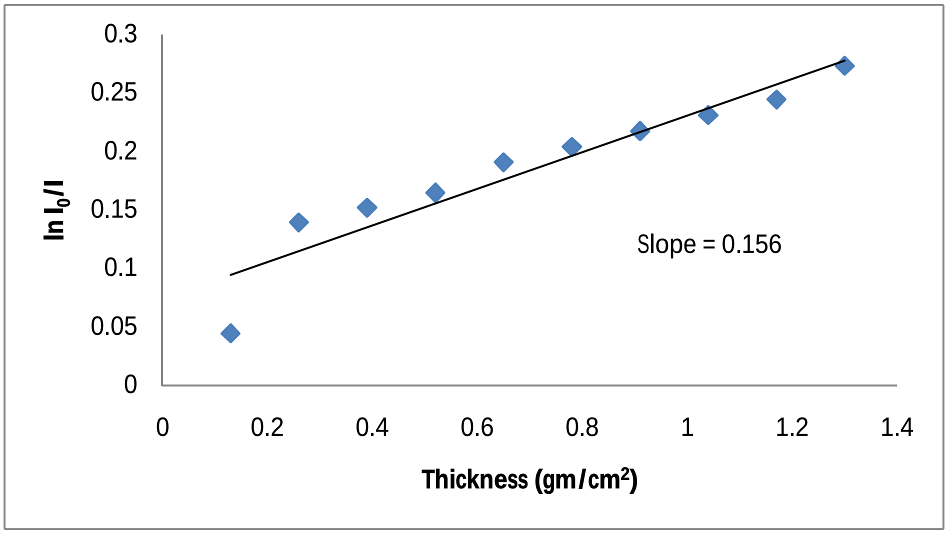

Fig .1 Plot of Thickness in gm/cm^2 vs.ln I_0/I for L Arginine LR at energy 0.122 MeV.

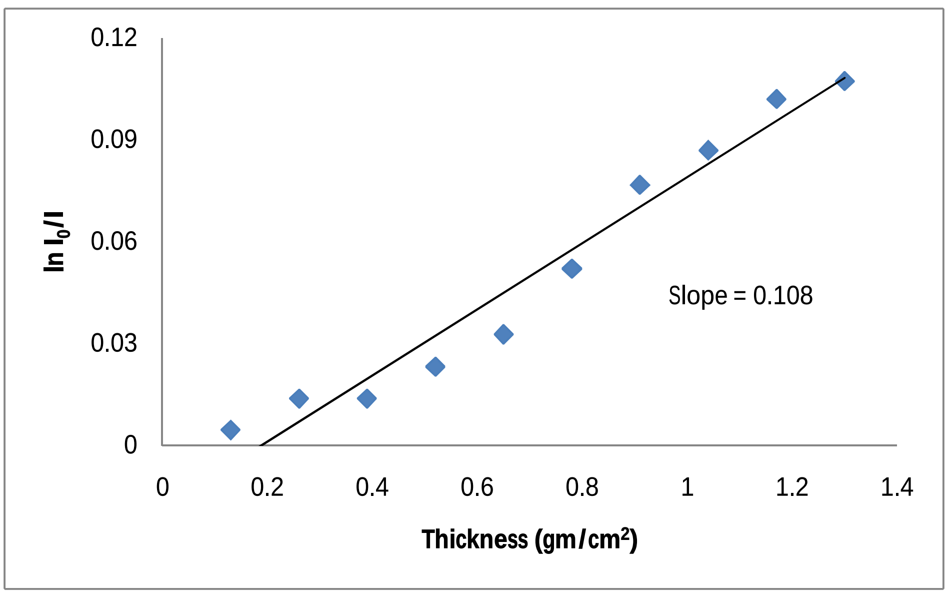

Fig .2 Thickness in gm/cm^2 vs.ln I_0/I for L Arginine LR at energy 0.356 MeV.

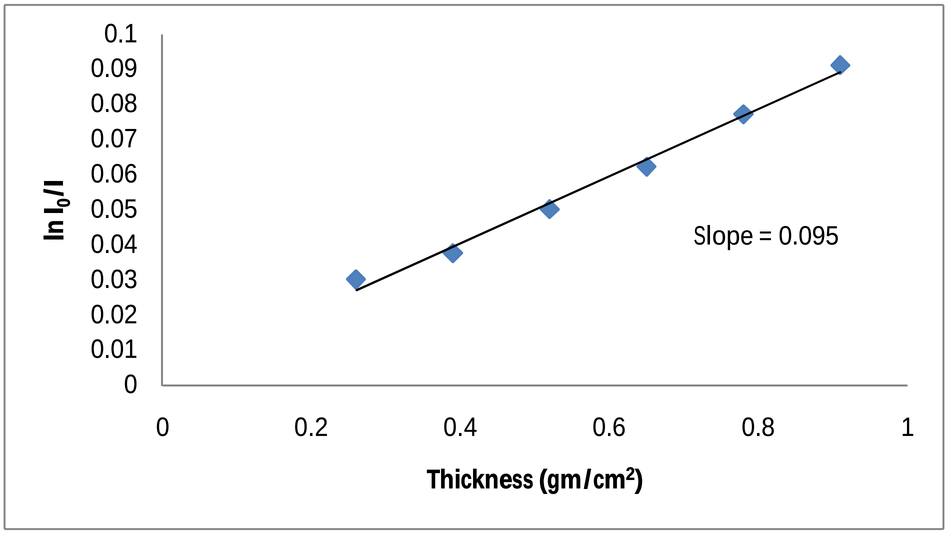

Fig.3 Thickness in gm/cm^2 vs.ln I_0/I for L Arginine LR at energy 0.511 MeV.

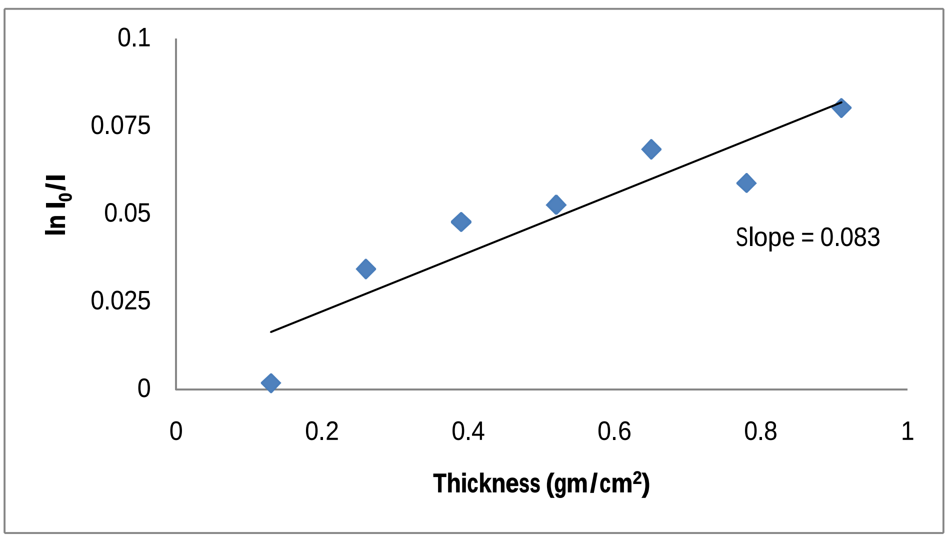

Fig.4 Thickness in gm/cm^2 vs.ln I_0/I for L Arginine LR at energy 0.662 MeV.

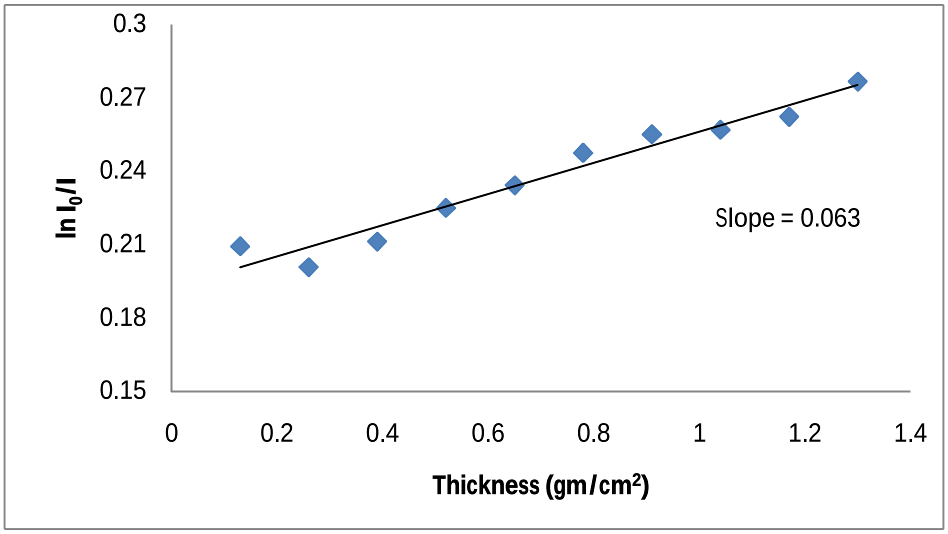

Fig.5 Thickness in gm/cm^2 vs.ln I_0/I for L Arginine LR at energy 1.170 MeV.

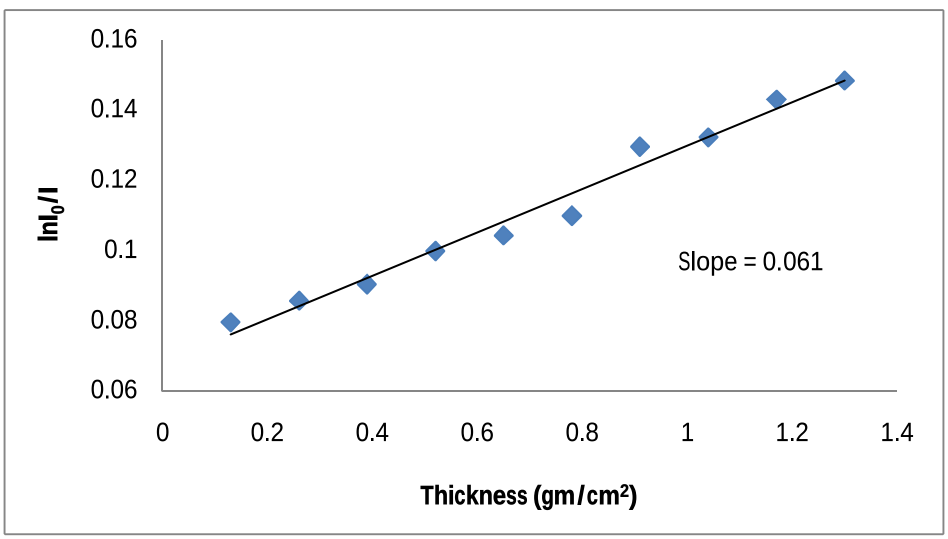

Fig.6 Thickness in gm/cm^2 vs.ln I_0/I for L Arginine LR at energy 1.275 MeV

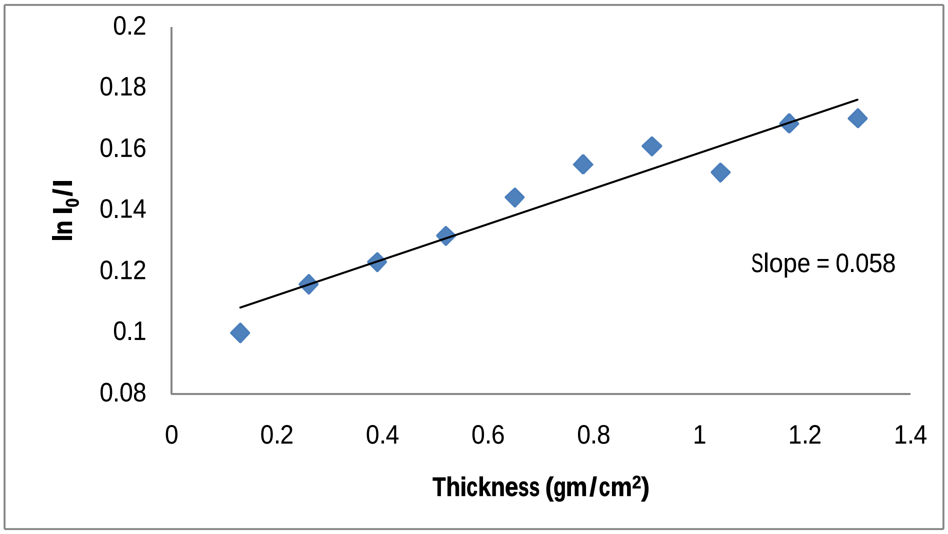

Fig. 7 Thickness in gm/cm^2 vs.ln I_0/I for L Arginine LR at energy 1.330 MeV.

APPLICATIONS

This Method is useful in Medical field. To decide the radiation to be delivered without any harm to normal cell it is necessary to have a precise knowledge of gamma ray photon attenuation coefficient studies.

CONCLUSION

The theoretical values of mass attenuation coefficient for L Arginine LR are available from [26] 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. The measured mass and linear attenuation coefficients of L Arginine LR are useful in medical field. The data is useful in radiation dosimetry and other fields. 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.

ACKNOWLEDGMENTS

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