Available online at www.joac.info

ISSN: 2278-1862

Journal of Applicable Chemistry

2013, 2 (5):1355-1361

(International Peer Reviewed Journal)

Measurement of Mass and Linear Attenuation Coefficients of Gamma-Rays of protein (Collagen sample) from 10 keV to 1500keV Photons

Muataz Dheyaa. S, Pravina P. Pawar*, Essam Anwer. k, Muhsin.k. Ali, Bibifatima M.Ladhaf

*Department of physics Dr. Babasaheb Ambedkar Marathwada University, Aurangabad-431004, **INDIA**

Email: pravina.pawar@yahoo.com

Received on 10th September and finalized on 11th September 2013.

ABSTRACT

Gamma ray transmission methods have been used accurately for the study of the properties of biological sample such as Collagen sample of protein. In this study mass and linear attenuation coefficients of gamma-rays of Collagen sample of protein for 122, 356, 511, 662, 1170, 1275 and 1330 keV photons are determined by using NaI (Tl) scintillation well-type detector. The radioactive sources used in the experiment were Co^{57}, Ba^{133}, Na^{22}, Cs^{137} and Co^{60}. 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, proteins, Collagen.

INTRODUCTION

Collagen sample is a simple protein made up of amino-acids. Amino acids are built from carbon, oxygen, nitrogen and hydrogen. In fact collagen sample makes up approximately 30% of the protein within the body. As a structure Collagen sample is intensely strong and is a vital protein that is found all over the body: In tendons and ligaments. It plays an important role in the protection function of the skin in that it helps limit the absorption and spreading of pathogenic substances, environmental toxins, micro - organisms and cancerous cells.

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 [1,4]. Data on the mass (μ/ρ) and linear attenuation coefficients (μ) of Collagen for, 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) are 122, 356, 511, 662, 1170, 1275 and 1330 KeV are quite useful. Radioactive sources are increasingly used in biological studies, radiation sterilization and industry [2]. The biological effect of radiation can be understood in terms of the transfer of energy from the radiation (photons and particles) to the tissue. When the radiation of energy is deposited in the body, it can disrupt the chemical bonds and alter tissue. It is important to understand some of the details of this transfer. The interaction of radiation and tissue is governed by the energy and mass of the incident radiation. Mass attenuation coefficients of gamma-rays in some compounds and mixtures of dosimetric and biological importance have been compiled by Hubbell [3]. A thorough knowledge of the nature of interaction of samples such as proteins 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 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 photon interaction cross sections of Collagen protein sample at different photon energies using a NaI (Tl) detector. The measured mass (μ/ρ) and linear attenuation coefficients (μ) of Collagen protein for 122, 356, 511, 662, 1170, 1275 and 1330 keV 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 incident a narrow beam of gamma-rays at different intensities on container without absorber is denote by incident intensity I_0, and the intensity of the radiation which gets through the thickness t as the transmitted intensity I, so the linear Attenuation Coefficient (μ) and mass Attenuation Coefficient (μ/ρ) are given from the exponential law-

$$I = I_0\, e^{-\mu t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$I = I_0\, e^{-\mu/\rho(\rho t)} \quad \ldots\ldots\ldots\ldots (2)$$

as

$$\mu = 1/t \ln(I_0/I) \quad \ldots\ldots\ldots\ldots (3)$$

and

$$\mu/\rho = 1/\rho t \ln(I_0/I) \ldots\ldots\ldots (4)$$

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. (4) then simplifies to

$$\mu/\rho = \pi r^2/m \ln(I_0/I) \ldots\ldots\ldots\ldots (5)$$

MATERIALS AND METHODS

The authors measured the linear attenuation coefficient of the Collagen 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 Collagen sample at seven photon energies 122, 356, 511, 662, 1170, 1275 and 1330 KeV. Five standard gamma sources Co^{57}, Ba^{133}, Cs^{137}, Co^{60} and Na^{22} are used
The results are shown in table 1.

Table 1. Linear and mass attenuation coefficient of Collagen protein sample from 122 to1330 keV.

Sr.No	Energy keV	μ/ρ exp.	μ/ρ theo.	μ exp	μ theo.	% deviation
1	122	0.156	0.157	0.22308	0.22451	0.636943
2	356	0.107	0.108	0.15301	0.15444	0.925926
3	511	0.09	0.091	0.1287	0.13013	1.098901
4	662	0.081	0.082	0.11583	0.11726	1.219512
5	1170	0.066	0.065	0.09438	0.09295	-1.53846
6	1275	0.059	0.059	0.08437	0.08437	0
7	1330	0.057	0.058	0.08151	0.08294	1.724138

The Collagen protein 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 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 $t < 0.6$ [24] criterion was satisfied at each energy, in order to minimize the effects due to multiple scattering.

RESULTS AND DISCUSSION

The comparison of experimental measurements with the theoretical values [23] 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 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 Collagen protein at 122, 356, 511, 662, 1170, 1275 and 1330 keV. Using this graphs, slope can be calculated and these slope is nothing but the (μ/ρ) mass attenuation coefficient of Collagen sample protein at that particular energy.

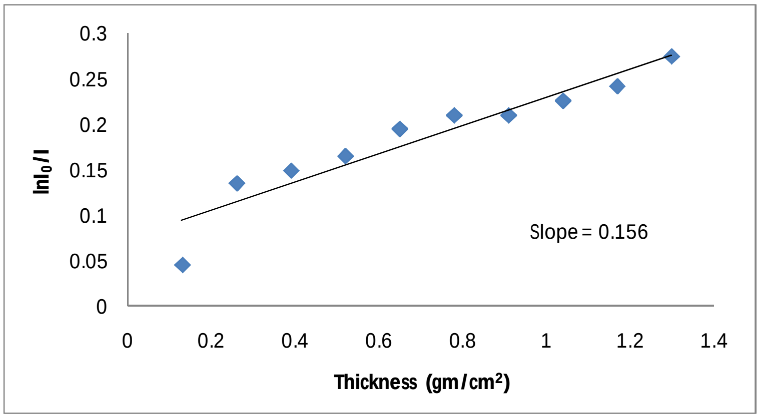

Fig 1 . Plot of Thickness in gm/cm^2 vs ln I_0/I for Collagen protein at energy 0.122 MeV.

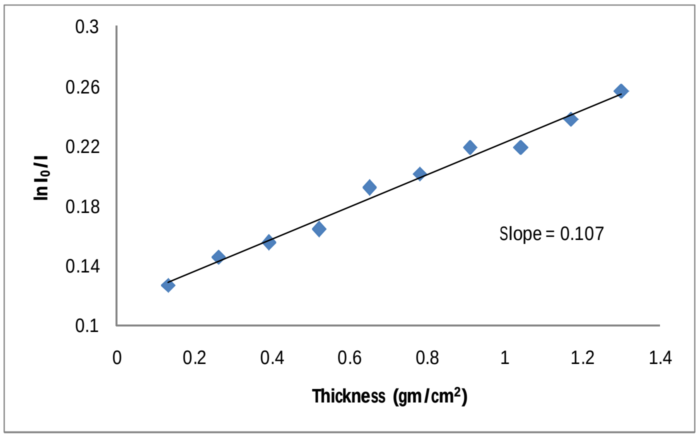

Fig.**2** Plot of Thickness in gm/cm^{2}vs.ln I_0/I for Collagen protein at energy 0.356 MeV**.**

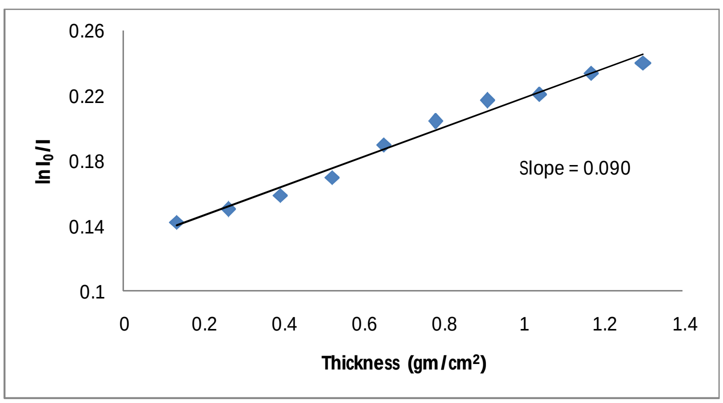

Fig .3 Plot of Thickness in gm/cm^2 vs.ln I_0/I for Collagen protein at energy 0.511 MeV**.**

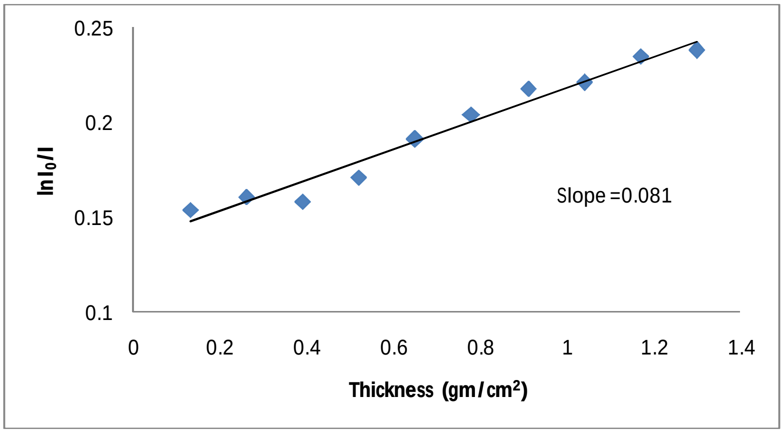

Fig .4 Plot of Thickness in gm/cm^2 vs.ln I_0/I for Collagen protein at energy 0.662 MeV.

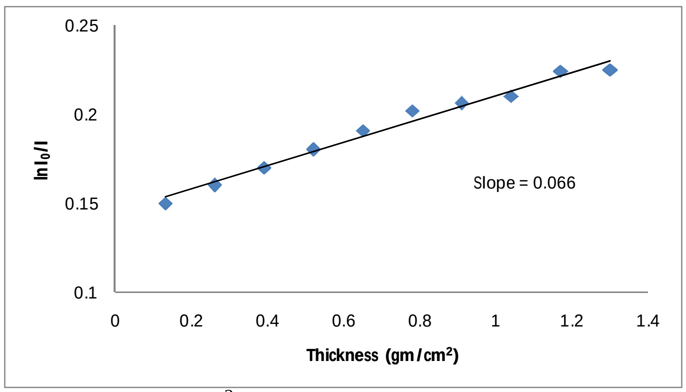

Fig .5 Plot of Thickness in gm/cm^2 vs.ln I_0/I for Collagen protein at energy 1.170 MeV.

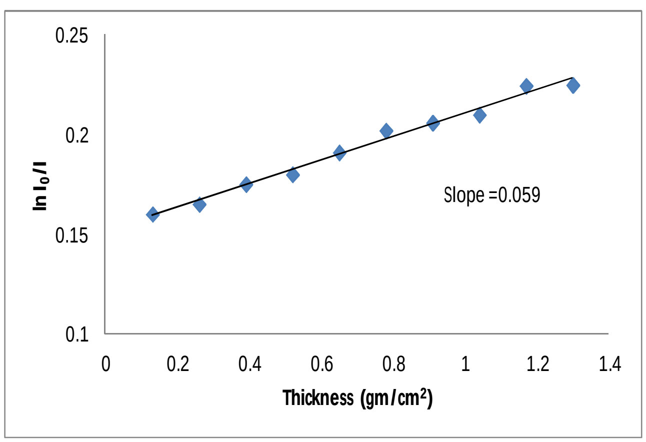

Fig .6 Plot of Thickness in gm/cm^2 vs.ln I_0/I for Collagen protein at energy 1.275 MeV.

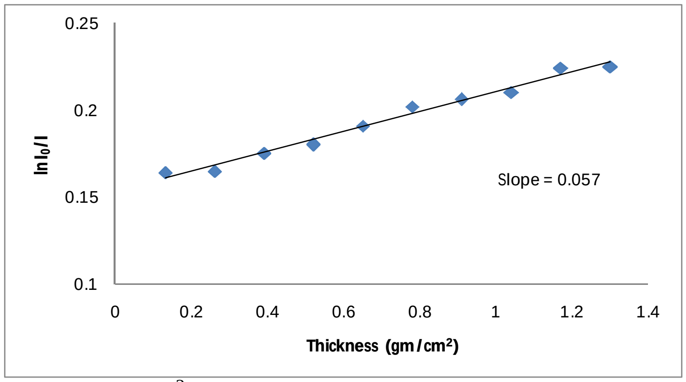

Fig .7 Plot of Thickness in gm/cm^2 vs.ln I_0/I for Gollagen protein at energy 1.330 MeV**.**

APPLICATIONS

The measured mass and linear attenuation coefficients of Collagen 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 Collagen protein 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 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.

ACKNOWLEDGMENTS

The author is very much thankful to UGC for giving financial support for Major Research Project on doing work on attenuation coefficient studies of biologically important compounds.

REFERENCES

[1] D F Jackson and D J Hawkes, *Phys. Rep.*, **1981**, 70, 169-233.
[2] E J Hall, Radiation and Life, Pergamon Press, New York, **1978**, 55.
[3] J H Hubbell, *Intern. J Appl.Radiation Isotopes*, **1982**, 33, 1269.
[4] J H Hubbell, *Phys.Med. Biol.*44 R1-R22.
[5] D.F. Jackson and D.Hawkes, *J Phys.Rep.* **1981**, 70, 169-233.
[6] S.M. Midgley, *Phys. Med.Biol*. **2005**, 50(41), 39-57.
[7] S.M.Midgley, *Phys. Med .Biol.*, **2004**, 49, 307-25.
[8] B.J. Kirby, J.R.Davis, J.A.Grant and M.J.Morgan, *Phys. Med. Biol.*, **2003**, 48, 3389-409.
[9] Shivaramu, R.Amutha and V. Ramprasath, *Nucl.Sci.Eng.* **1999**, 132, 148-53.
[10] Shivaramu, R.Vijay Kumar, L.Rjasekaran and N.Ramamurthy, *Radiat. Phys. Chem.*, **2001**, 62, 371-7.
[11] S. Gowda , S.Krishnaveni and R Gowda, *Nucl.Instrum. Methods Phys. Res. B* **2005**, 239, 361-9.
[12] G.K. Sandhu , Kulwant Singh, B.S.Lark and L.Gerward, *Radiat. Phys. Chem.*, **2002**, 65, 211-5.
[13] S. Gowda,S. Krishnaveni, T.Yashoda, T.K. Umesh and R.Gowda, *Pramana–J .Phys.* **2004**, 63, 529-41.
[14] Shivaramu, *Med. Dosim*, **2001**, 27, 1-9.

[15] V. Manjunathaguru and T.K.Umesh, *J.Phys. B: At. Mol. Opt. Phys,* **2006**, 39, 3969-81.
[16] P Pawar and G K Bichile, *Archives of Physics Research*, **2011**, 2(3), 146-152.
[17] A.H. El-Kateb and A.S. Abdul-Hamid, *Appl. Radiat.Isot*., **1991**, 42,303-7.
[18] P P Pawar and G K Bichile, *J. Chem. Pharm. Res.,* **2011**, 3(5), 41-50.
[19] S.R.Manohara and S.M.Hanagodimath, *Nucl. Instrum. Methods Phys.Res. b* **2007**, 258,321-8.
[20] P. P. Pawar and G .K .Bichile, *Archives of Physics Research,* **2011**, 2(4), 94-103.
[21] K. P. Gopinathan Nair, T. K. Umesh and R. K. Gowda, *Radiat.Phys.Chem.,* **1995**, 45, 231-233.
[22] K. P. Gopinathan Nair, C. Gowda, J. Shylaja Kumari, S. J. Anasuya, T. K. Umesh and R. K. Gowda, *Radiat.Phys.Chem.,* **1994**, 43, 581-584.
[23] M. J .Berger and J. H. Hubbell, XCOM Photon cross sections Database, Web Version 1.2, National Institute of Standards and Technology, Gaithersburg, MD 20899-8460,USA (1990.1987/99
[24] R. Gowda, K.S. Puttaswamy and B. Sanjeevaiah, *Can.J.Phys.*, **1976**, 54, 2170.