Science Research Reporter 3(1):53-56, April 2013 **ISSN: 2249-2321 (Print)**

Measurement of mass and linear attenuation coefficients of gamma-rays of Glycine for 0.360, 0.662, 1.170 and 1.330 MeV photons.

Pravina P. Pawar[1], Chandrakant S. Mahajan[2]

[1]Department of Physics, Dr. Babasaheb Ambedkar Marathwada University,
Aurangabad: 431 004. India
[2] Post Graduate Department of Physics , R. G. Bagdia Arts, S. B. Lakhotia Commerce and R. Bezonji Science College, Jalna - 431203 (MS) India.
csmahajan_jes@rediffmail.com

ABSTRACT

Mass (μ/ρ) and linear attenuation coefficients (μ) of glycine for 0.360, 0.662, 1.170 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.

Key words: Gamma-rays, Glycine, Mass attenuation coefficients, Linear attenuation, coefficients.

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 (Jackson *et al.,* 1981). Data on the mass (μ/ρ) and linear attenuation coefficients (μ) of amino acids for Ba^{133} (0.360), Cs^{137} (0.662) and Co^{60} (1.170,1.330) 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 (Jackson *et al.,* 1981 and Hall, 1978). Mass attenuation coefficients of gamma-rays in some compounds and mixtures of dosimetric and biological importance have been compiled by (Hubbell 1982) 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 (Hubbell, 1999), 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. (Gopinathan *et al.,* 1994, 1995) 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 glycine sample at three 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 glycine sample at three photon energies using a NaI (Tl) detector. The measured mass (μ/ρ) and linear attenuation coefficients (μ) of glycine for 0.360, 0.662, 1.170 and 1.330 MeV gamma-rays photons have been compared with the values calculated based on the data of (M.J. Berger et al. 1990) 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:

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

$I = I_0 e^{-\mu/\rho(\rho t)}$ (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 equation (3) then simplifies to

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

Experimental section: The authors measured the linear attenuation coefficient of the glycine sample by performing vertical narrow beam geometry. The diameter of the collimator is 1.18cm .Glycine 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 glycine absorber foil ,place the glycine absorber foils of 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 glycine foils at three photon energies 0.360, 0.662, 1.170 and 1.330 MeV. Three standard gamma sources Ba^{133} (0.360), Cs^{137} (0.662) and Co^{60} (1.170, 1.330) MeV are used. The results are shown in table 1.

The glycine 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 μt<0.4 criterion was satisfied at each energy, in order to minimize the effects due to multiple scattering.

RESULTS AND DISCUSSION

The comparison of their measurements with the theoretical values (M.J. Berger et al. 1990) 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 1-4 shows plot of I_0/I Vs thickness t for glycine at 0.360, 0.662 ,1.170 and 1.330 MeV.Using this graphs, slope can be calculated and these slope is nothing but the (μ/ρ) mass attenuation coefficient of glycine at that particular energy.

The theoretical values of mass attenuation coefficient for Glycine are available from (M.J. Berger et al. 1990) 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 glycine 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.

Table1: Linear attenuation coefficient μ (cm^{-1}) and mass attenuation coefficient μ/ρ (cm^2/g) of Glycine absorber at Photon energies 0.360, 0.662, 1.170 and 1.330 MeV

Sr.No.	Energy MeV	μ (cm^{-1})	μ/ρ (cm^2/g)
1	0.360	0.124 a	0.107 a
	0.124 b	0.107 b	
	0.000 c	0.000 c	
2	0.662	0.097 a	0.084 a
	0.096 b	0.083 b	
	-1.042 c	-1.205 c	
3	1.170	0.069 a	0.060 a
	0.070 b	0.061 b	
	1.420 c	1.630 c	
4	1.330	0.066 a	0.057a
	0.065 b	0.056 b	
	-1.538 c	-1.786 c	

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

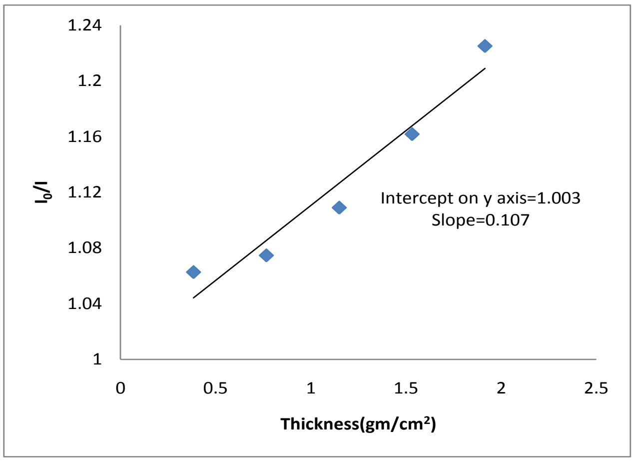

Fig. 1: Plot of I_0/I Vs thickness t for Glycine at 0.360 MeV.

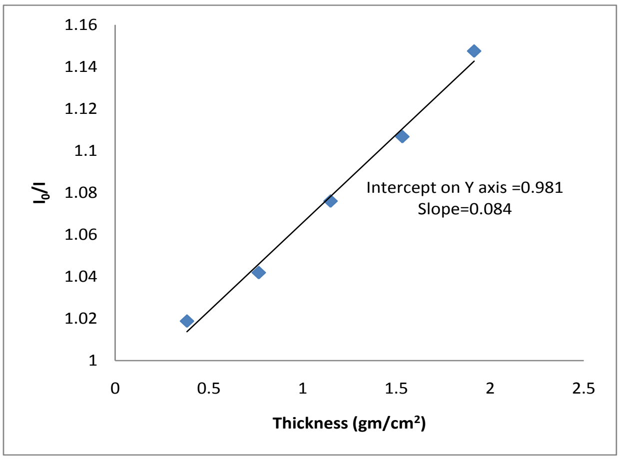

Fig. 2: Plot of I_0/I Vs thickness t for Glycine at 0.662 MeV.

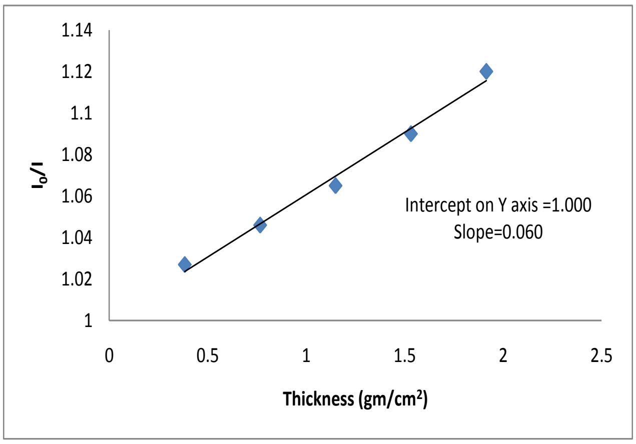

Fig. 3: Plot of I_0/I Vs thickness t for Glycine at 1.170 MeV.

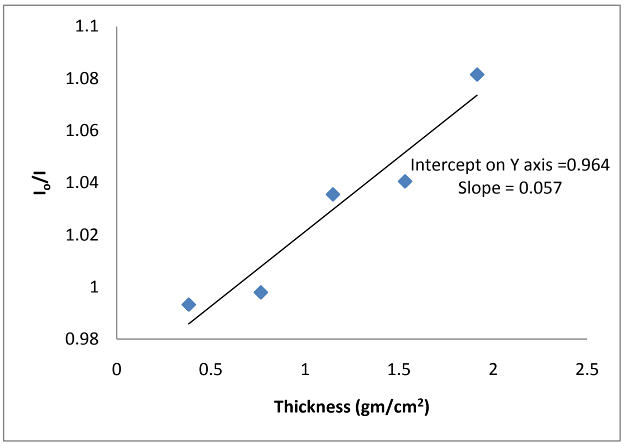

Fig. 4: Plot of I_0/I Vs thickness t for Glycine at 1.330 MeV

Acknowledgment

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.

LITERATURE CITED

Berger MJ and Hubbell JH, 1990, 1987/99. XCOM Photon cross sections Database, Web Version 1.2, *National Institute of Standards and Technology, Gaithersburg, MD* 20899-8460,USA.

Gopinathan Nair KP, Gowda C, Shylaja Kumari J, Anasuya S J, Umesh TK and Gowda RK, 1994-a. Photon interaction cross sections for some Amino acids in the range 30-385 keV. *Radiat.Phys.Chem.* **43:**581-584.

Gopinathan Nair KP, Umesh TK and Gowda RK, 1995. Total attenuation cross sections of several amino acids at 661.6, 1173 and 1332.5keV. *Radiat. Phys. Chem.* **45**: 31-233.

Gowda S, Krishnaveni S and Gowda R, 2005. Studies on effective atomic numbers and electron densities in amino acids and sugars in the energy range 30-1333keV *Nucl.Instrum.and Methods in Phys. Res.* **B-239**:361-369.

Hall EJ, 1978. Radiation and Life *Pergamon Press, New York* 55.

Hubbell JH, 1982. Mass attenuation and energy absorption coefficients from 1 keV to 20 MeV *Intern. J Appl.Radiation Isotopes* **33** :1269-1290.

Hubbell JH, 1999. Review of photon interaction cross section data in the medical and biological context *Phys.Med. Biol.* 44 : R1-R22.

Jackson DF and Hawkes DJ, 1981. X ray attenuation coefficients of elements and mixtures *Phys. Rep.***70 :** 169-233.

Kirby BJ, Davis JR, Grant JA and Morgan M, 2003 Extracting material parameters from x-ray attenuation: a CT feasibility study using kilovoltage synchrotron x-rays incident upon low atomic number absorbers *J Phys. Med. Biol*. **48**:3389-3409.

Manjunathaguru V and Umesh TK, 2006 Effective atomic numbers and electron densities of some biologically important compounds containing H, C, N and O in the energy range 145-1330keV. *J.Phys. B: At. Mol. Opt. Phys.* **39**:3969-3981.

Manohara SR and Hanagodimath SM, 2007. Studies on effective atomic numbers and electron densities of essential amino acids in the energy range 1keV-100 GeV *Nucl. Instrum.and Methods in Phys.Res.* **B 258**: 321-328.

Midgley SM, 2004. A parameterization scheme for the x-ray linear attenuation coefficient and energy absorption coefficient *Phys. Med .Biol.* **49:** 307-325.

Midgley SM, 2005 Materials analysis using X-ray linear attenuation coefficient measurements at four photon energies. *Phys. Med. Biol.* **50:** 4139-4157.

Pawar PP and Bichile GK, 2011. Effective atomic numbers and electron densities of amino acids containing H, C, N and O. *Archives of Physics Research*, **2**(4): 94-103.

Pawar PP and Bichile GK, 2011. Effect of weight fraction of different constituent elements on the total attenuation coefficients of some amino acids in the energy range 10 KeV to 1500 KeV *Archives of Physics Research* **2**(3):146-152.

Pawar PP and Bichile GK, 2011 Molar extinction coefficients of some amino acids *J. Chem. Pharm. Res;* **3**(5): 41-50.

Shivaramu, Vijaykumar R., Rjasekaran L.and Ramamurthy N, 2001. Effective atomic numbers for photon energy absorption of some low –Z substances of dosimetric interest *Radiat. Phys.and Chem.***62:** 371-377.

How to Cite this Article:

Pravina P Pawar, Chandrakant S Mahajan, 2013. Measurement of mass and linear attenuation coefficients of gamma-rays of Glycine for 0.360, 0.662, 1.170 and 1.330 MeV photons. *Sci. Res. Rept,* **3**(1):53-56.