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PHOTON INTERACTION STUDY OF C-H-N-O BASED MATERIALS

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ABSTRACT

Mass attenuation coefficients of C-H-N-O materials based materials such as Crotonic acid, Sapinic acid and Oleic acid were measured in the energy range 0.122-1.330 MeV. NaI (Tl) scintillation detection system was used to detect gamma rays with a resolution of 8.2% at 0.662 MeV. The measured attenuation coefficient values were then used to determine the mass energy-absorption coefficients (μ_{en}/ρ) and average atomic energy-absorption cross sections ($\sigma_{a,en}$) of the C-H-N-O materials based materials. Theoretical values were calculated based on XCOM data. Theoretical and experimental values are found to be in good agreement.

INTRODUCTION

The Biochemical such as carbohydrates, proteins, lipids, enzymes, vitamins, nucleotides and hormones are involved in a variety of physiological functions of living systems. C-H-N-O materials based materials are the building blocks of proteins which are the most abundant macro molecules in the living cells and constitute the largest function of living matter in all types of cells. Interaction of photons with biological molecules plays an important role in radiation biology, nuclear technology and space research since radio-isotopes such as Co^{57} (122keV), Ba^{133} (356 keV), Na^{22} (511 and 1275 keV), Cs^{137} (662 keV), Mn^{54} (840 keV) and

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Co^{60} (1170 and 1330 keV) are used in biological studies, radiation sterilization and industry (E.J. Hall, 1978). Mass attenuation coefficient, μ_m is a measure of the average number of interactions between incident photons and matter that occur in a given mass per unit area thickness of the substance under investigation (J.H. Hubbell, 1999). Related parameters such as mass energy-absorption coefficients (μ_{en}/ρ), total molecular energy-absorption cross sections ($\sigma_{m,en}$) and average atomic energy-absorption cross sections ($\sigma_{a,en}$) can be then derived. There have been a great number of investigations for determination of mass attenuation coefficient for biomoleculs (A. Tursucu et al., 2013; R. M. Lokhande et al., 2017). On the other hand, mass energy-absorption coefficient is a measure of the average fractional amount of charged particles as a result of these interactions. It has an essential role in determining the absorbed dose in medical field (R. M. Lokhande et al., 2017)

In the present work, mass attenuation coefficients, mass energy-absorption coefficients (μ_{en}/ρ) and average atomic energy-absorption cross sections ($\sigma_{a,en}$) of some C-H-N-O materials based materials in the energy range 0.122-1.330 MeV have been calculated. The energy dependence of μ_m, (μ_{en}/ρ) and ($\sigma_{a,en}$) is shown in tabular form and graphically for n-acetyl-l-tryptophan. These values are compared with theoretical values calculated using XCOM and Win-XCOM program and are found to be in good agreement. (M.J. Berger and J.H. Hubbell, 1987; 1999).

CALCULATION METHODS

Mass Attenuation Coefficient

According to Beer-Lamberts law:

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

Where, I_0 and I are the incident and transmitted photon intensities, respectively, μ (cm^{-1}) is the linear attenuation coefficient of the material and t (cm) is the sample thickness. Rearrangement of Eq. (1) yields the following equation for the linear attenuation coefficient:

$$\mu = \frac{1}{t}\ln\left(\frac{Io}{I}\right) \qquad (2)$$

The mass attenuation coefficients μ/ρ ($cm^2\ g^{-1}$) for the samples were obtained by using the following Eq.

$$\mu_m = \frac{\mu}{\rho}\left(cm^2 gm^{-1}\right) = \frac{1}{\rho t}\ln\left(\frac{Io}{I}\right) \qquad (3)$$

Where, ρ (g/cm^3) is a measured density of the corresponding sample.

Mass Energy-Absorption Coefficient

Mass energy-absorption coefficient is calculated by following Eq.

$$\frac{\mu_{en}}{\rho} = (\frac{\mu_{tr}}{\rho_r})(1-g) \qquad (4)$$

Where, the factor g represents the average fraction of the kinetic energy of secondary charged particles (produced in all types of interactions), i.e. subsequently lost in radiative energy-loss processes as the particles slow to rest in the medium (Manjunathguru and Umesh, 2009).

Molecular Energy-Absorption Cross Section

Molecular energy-absorption cross section is calculated by

$$(\sigma_{m,en}) = \frac{M}{N_A}(\frac{\mu_{en}}{\rho}) \qquad (5)$$

Average Atomic Energy-Absorption Cross Sections

It is given by

$$\sigma_{a,en} = \frac{\mu_{en}/\rho}{N_A \sum W_i / A_i} = \frac{1}{N_A}\sum f_i A_i (\mu_{en}/\rho) = \frac{\sigma_{m,en}}{\sum_i n_i} \qquad (6)$$

where, $f_i = n_i / \sum_i n_i$ is the fractional abundance of the i^{th} element and n_i and $\sum_i n_i$ denote the number of atoms of the i^{th} constituent element and total number of atoms in molecular formula respectively.

Experimental Details

The six radioactive sources used for the present work were procured form Bhabha Atomic Research Centre, Mumbai, India. Gamma rays emitted by these radioactive sources were collimated and detected by the NaI (Tl) scintillation detector. The signals from the detector (2”×2”) NaI (Tl) crystal having energy resolution of 8.2% at 0.662MeV gamma rays from the decay of Cs^{137} after suitable amplification was recorded in EG&G ORTEC 13-bit plug-in-card coupled to a PC/AT. The C-H-N-O materials based materials under investigation were pellet ($0.13 g/cm^2$ of uniform thickness) shaped and confined in a cylindrical plastic container having the same diameter as that of sample pellet. The diameters of the pellets were determined with the help of a traveling microscope. Each sample pellet was weighed in a sensitive digital balance having an accuracy of 0.001mg. The experimental has been discussed in detail by P.P. Pawar and G.K. Bichile, 2013.

C-H-N-O materials based materials	**122 keV**		**356 keV**		**511 keV**		**662 keV**		**1170 keV**		**1275 keV**		**1330 keV**	
	Exp.	**The.**	**Exp.**	**The.**	**Exp.**	**The.**	**Exp.**	**The.**	**Exp.**	**The.**	**Exp.**	**The.**	**Exp.**	**The.**
Crotonic acid	0.157	0.158	0.109	0.109	0.091	0.092	0.079	0.079	0.064	0.064	0.062	0.061	0.059	0.059
Sapinic acid	0.037	0.162	0.026	0.112	0.022	0.096	0.020	0.086	0.015	0.072	0.015	0.062	0.014	0.061
Oleic acid	0.154	0.154	0.111	0.110	0.095	0.095	0.076	0.076	0.067	0.068	0.063	0.063	0.059	0.059

Results and Discussion

μ_m values were measured experimentally and theoretically for C-H-N-O materials based materials studied in the present work at photon energies of current interest and μ_m values for Crotonic acid (C4H6O_2) are plotted in Figure (1). It is clearly seen that the μ_m depends on photon energy and decreases with increasing photon energy.

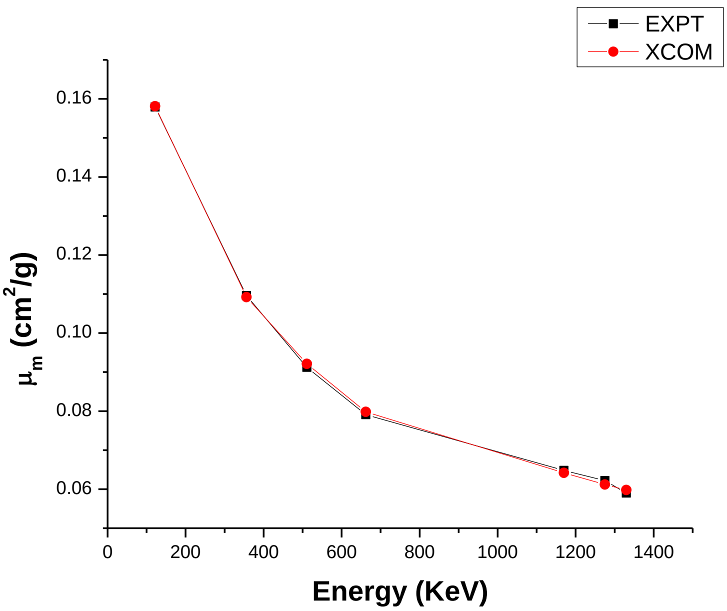

FIGURE 1. Typical plot of μ_m versus energy for Crotonic acid($C_4H_6O_2$)

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Mass energy-absorption coefficients, μ_{en}/ρ and average atomic energy-absorption cross-sections, $\sigma_{a,en}$ were tabulated in Table 2 and Table 3 respectively and are graphically represented for Crotonic acid(C4H6O_2) in Figure (2) and Figure (3) respectively.

TABLE 1 Mass Energy-Absorption Coefficients, μ_{en}/ρ (cm^2/g) of the Investigated C-H-N-O materials based materials.

C-H-N-O materials based materials	122 keV		356 keV		511 keV		662 keV		1170 keV		1275 keV		1330 keV	
	Exp.	The.	Exp.	The.	Exp.	The.	Exp.	The.	Exp.	The.	Exp.	The.	Exp.	The.
Crotonic acid	0.472	0.467	0.339	0.331	0.285	0.285	0.258	0.259	0.193	0.194	0.185	0.185	0.186	0.184
Sapinic acid	0.483	0.47	0.339	0.332	0.289	0.285	0.262	0.259	0.198	0.194	0.192	0.185	0.183	0.184
Oleic acid	0.475	0.47	0.337	0.331	0.265	0.286	0.26	0.259	0.203	0.198	0.169	0.186	0.185	0.184

TABLE 2 Average Atomic Energy-Absorption Cross-Sections, $\sigma_{a,en}$ (barn/atom) of the Investigated C-H-N-O materials based materials.

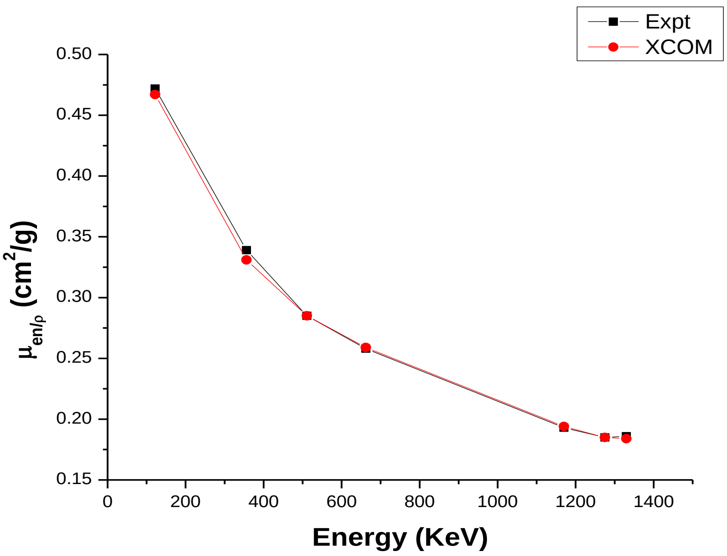

FIGURE 2. Typical plot of μ_{en}/ρ versus energy Crotonic acid ($C_4H_6O_2$)

In the energy range 0.122-1.330 MeV, chemical composition of materials does not affect their attenuation properties. Values of μ_m, μ_{en}/ρ and $\sigma_{a,en}$ are initially high and decrease sharply with increase in incident photon energy. The plots of μ_{en}/ρ and $\sigma_{a,en}$ versus energy show identical behavior to that of μ_m

CONCLUSION

The present experimental investigation has been undertaken to get information on mass attenuation coefficient, μ_m values and related parameters (μ_{en}/ρ and $\sigma_{a,en}$) for the chosen fatty acid samples such as Crotonic acid(˜$C_{13}H_{14}N_2O_3$), Sapinic acid ($C_{16}H_{30}O_2$) and Oleic acid ($C_{18}H_{34}O_2$). In this energy region, Compton scattering is predominant interaction process and values of μ_m and μ_{en}/ρ are dependent of photon energy. μ_{en}/ρ is the most useful factor for determination of radiation exposure when flux of gamma rays is known. It is also useful for determination of radiation dose. By determining the elemental composition of different C-H-N-O materials based materials, new fatty acids substitute phantom materials can be developed where measurements are made under radiation conditions.

REFERENCE

1. A. Tursucu, P. Onder, D. Demir and T. Oznuluer, "Studies on mass attenuation coefficient, effective atomic number and electron density of some amino acids", *International Journal of Physical Sciences*, 2013, Vol. 8(4), pp 147-156.
2. E J. Hall, *Radiation and life Pregamon Press*, 1978, New York p.55.
3. J. H. Hubbell, "Review of photon interaction cross section data in the medical and biological context" *Phys. Med. Biol.*, 1999, 44 R1-22.
4. M.J. Berger, J.H. Hubbell, "XCOM: Photon Cross Section Database," Wb Version 1.2, available at http:// Physics.nist.gov/XCOM. National Institute of standards and Technology, Gaithersburg, MD 20899, USA (1999). Originally published as NBSIR 87-3597 "XCOM: Photon Cross Sections on a Personal Computer" (1987).
5. P.P. Pawar, G.K. Bichile, "Studies on mass attenuation coefficient, effective atomic number and electron density of some amino acids in the energy range 0.122-1.330 MeV" *Radiat. Phys. Chem*, 2013, .92, 22-27.
6. P.P. Pawar, A.P. Tadkalkar and G.K. Bichile, "Total attenuation cross-sections of several proteins at 661.6, 1173, 1332.5 keV", 2012, *Asian journal of chemistry*, Vol. 24, No. 12, 5953-5954.
7. R. M. Lokhande et al, measurement of rediiological data of some amin acids in the energy range 0.122- 1.330 MeV. AIP conference proceding 1728 (1), 020207.