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EFFECT OF GAMMA RAY RADIATIONS ON UNDECYLIC ACID AT ESSENTIAL ENERGY IN MEDICAL APPLICATIONS

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Abstract: The radiological parameter mass attenuation and atomic cross section with biological material is essential in radiation dosimetry, medical therapy and radiobiology. Use of radioactive material such as; isotopes is increasing in the field of medical field specially in; diagnostics, research and development, bio-technology, pharmaceutical, agriculture etc. The attenuation parameters are the basic quantities required for determining the energy deposition and penetration in a given material. Here undecylic acid are play an essential role in human health society. So, this work focus on the absorption of gamma active radiation for fatty acid. The effect of gamma active radiations on absorption in undecylic acid are shown using attenuation parametrs which will be essential photon energy region of interest (500keV- 1500 keV) in many medical and biological applications. By performing transmission experiments using ^{137}Cs, ^{54}Mn, and ^{22}Na gamma active sources with gamma ray spectrometry, The measured experimental data were compared against NIST-Xcom program and It has been found that the variations of observed values are decreasing with increasing photon energies.

Keywords: - Mass Attenuation Coefficients; Total Attenuation Cross Section; Undecylic Acid; Gamma-Active Sources.

I. INTRODUCTION

Investigation of radiation effects on bio-materials molecules find immense applications in the field of medical sector, pharmaceutical, agriculture, radiology etc. The study of gamma photon interactions with bio-material is essential and the data on the transmission of gamma-rays in biological shielding materials assumed great significance by virtue of their plenty of applications in the field of medical sector Kaewkhao et al. (2008). A large number of photon attenuation measurements and analysis have been made for different materials and the attenuation function has been studied as a function of different parameters**.** The attenuation coefficient measurement studies have to give more attention to materials of biologically interest in the energy range 10-1000keV. The atomic cross-section can be expressed as a function of the photon energy.

In order to make use of the fact that scattering and absorption of gamma-radiations are related to the density and effective atomic numbers of the material, knowledge of the mass attenuation coefficients is of quite important. From the mass attenuation coefficient, we can be deriving related parameters, such as the mass energy-absorption coefficient, the total interaction cross-section, molar extension coefficient, effective atomic numbers etc. The mass attenuation coefficient is a measure of the average number of interactions between incident photons and matter that can be occur in a given mass per unit area thickness of the substance encountered. Early calculations of effective atomic numbers were based on parameterization of the photon interaction cross-section by fitting data over limited ranges of photon energy and atomic number Jackson (1981). now a days, using an accurate databases of photon interaction cross-sections, mass attenuation and interpolation programs (Gerward et al.2001,2004 and Berger et al. (1987), it is possible to calculate effective atomic numbers with much improved accuracy and information content over wide ranges of photon energy and elemental composition. In the present work, we used the method of deriving atomic cross section was followed by using the experimental results of mass attenuation coefficients. Experimental results were compared with theoretical values and it has been in good agreement.

A variety of physiological functions inside living systems are performed by complex molecules such as vitamins, enzyms, proteins, fatty acids, amino acids are composed of C,H,N and O based elements. Photons of energy from 1000 keV down to about 10 keV are widely used for medical and biological applications, Hubbell (1999), especially during diagnosis and therapy. A thorough knowledge of the nature of interaction of these biologically important complex molecules such as fatty acids, amino acids is desirable in this energy region. Hence, in recent years, this has many investigators over the years to determine the atomic cross-sections as well as composition dependent quantities such as effective atomic numbers (Z_{eff}), and effective electron densities (N_{eff}) of such complex molecules of biological interest in this energy region by employing different methods [Kirby et al. (2003), Midgley (2004, 2005), Shivaramu et al.(2001,2001), Sandhu et al. (2002),Gowda et al. (2004,2005), Manjunathaguru et al. (2006),Manohara (2007) and El- Kateb et al. (1991)].

Theoretical values for the mass attenuation coefficients can be found in the tabulation by Hubbell and Seltzer (1995). A convenient alternative to manual calculations, using tabulated data, is to generate attenuation data, as needed using a computer. For this purpose Hubbell and Berger (1987) developed XCOM program software for calculating mass attenuation coefficients or photon interaction cross-sections for any materials, for a wide range of photon energies.

There have been a plenty number of experimental as we as theoretical investigations to analysis of radiological parameters for complex biological molecules such as carbohydrates, proteins, fats and oils composed of C,H,N and O based materials in varying proportions Sandhu et al.(2002) have investigated fatty acids in the energy region 81-1330 keV Gowda et al. (2004,2005) have reported total attenuation cross-sections for sugar and amino acids. Also Manjunathguru and Umesh Manjunathguru (2006), Manohara and Hanagodimath (2007), have determined the effective atomic numbers of several bio-molecules. Measurements on the sample containing H,C, and O in the energy range 54-1333 keV have been reported by El-Kateeb and Abdul Hamid (1991). Recently, several related research work are published in this type of research work namely; Kore, P.S., Pawar P.P (2014), S.S. Pawar, P.S. Kore, P.P.Pawar(2019), Kore, P.S., Pawar P.P and T. Palani Selvam (2016), P.S. Kore, P.P. Pawar, M.N. Rode, S.M. Dongarge (2019) were devoted on the investigation of above parameters to determine Absorption coefficient, mass attenuation coefficients, total attenuation cross section and such type of essential radiological parameters for complex biological molecules such as amino acids, enzyms, lipids, carbohydrates, proteins, fats and oils composed of H, C, N and O elements in varying proportions.

In this work, we have measured the mass attenuation coefficients, the atomic cross-sections, for C, H, N and O based undecyclic acids in the energy range 500keV to 1500keV and then compared these experimentally evaluated parameters with theory using Win-XCOM program.

II. Theory

In this section, some theoretical relations are summarized that have been used for the determination of (μ_m) in the present work. When a monochromatic beam of gamma ray photons is incident on a matrial, some photons are emitted due to the dominant interaction processes and therefore, the transmitted beam is attenuated. The extent of attenuation depends on given target. This attenuation of the beam is expressed by the following equation:

$$I = I_o e^{-\mu t} \quad \text{......... (1)}$$

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:

$$\mu = \frac{1}{t}\ln\left(\frac{I_o}{I}\right) \quad \text{.......... (2)}$$

In Eq. (2), the mass attenuation coefficients μ_m ($cm^2\ g^{-1}$) for the samples were obtained from Eq. (3) by using the density of the corresponding samples:

$$\mu_m = \frac{\mu}{\rho}(cm^2 g^{-1}) \quad \text{......... (3)}$$

Where ρ (g/cm^3) is a measured density of the corresponding sample. The values of mass attenuation coefficients were used to determine the total attenuation cross section (σ_{tot}) by the following relation.

$$\sigma_{total} = \mu_m \left({M}/{N_A}\right) \quad \text{............ (4)}$$

Where $M = \sum_i n_i A_i$ is the molecular weight of the compound, N_A is the Avogadro's number, n_i is the total number of atoms in the molecule and A_i is the atomic weight of the i^{th} element in a molecule.

III. Experimental set up and Measurements

The three radioactive sources ^{137}Cs, ^{54}Mn, and ^{22}Na which are widely used in related work were used in the present investigation. Gamma rays of energy 511, 662, 840, 1170, 1275, 1330 emitted by the above cited gamma active sources, were collimated and detected by gamma ray spectrometer. The signals from the detector were amplified and analyzed with 8K multichannel analyzer. The Undecylic acid ($C_{11}H_{22}O_2$) under investigation which took in empty container and It was observed that the attenuation of photons of the empty containers were negligible. The mean of this set of values was taken to be the mass of the sample and the mass per unit area was determined in each case. The sample thickness was selected in order to satisfy the following ideal condition as far as possible Creagh, (1987): $2 \leq \ln (I_0 / I) \leq 4$.

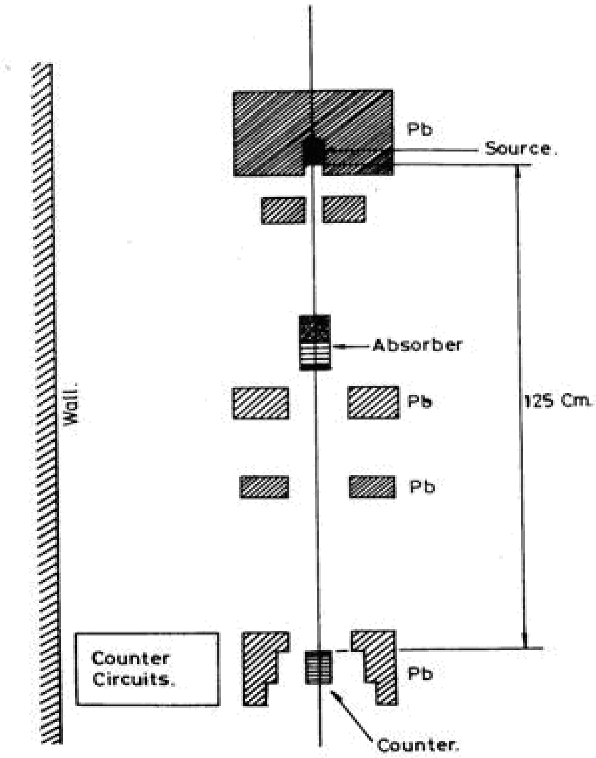

Fig. 1 The schematic view of the experimental set up.

For measurement of incident and transmitted photon energies a narrow beam good geometry set up was used. The schematic view of the experimental set up is displayed in Fig.1. From the measured values of unattenuated photon intensity I_0 (with empty plastic container) and attenuated photon intensity I (with sample), the mass attenuation coefficients (μ/ρ) for all the samples of undecyclic acids were calculated using Eq.(3).The values of mass attenuation coefficients were also obtained using XCOM program at all photon energies of current interest. Apart from multiple scattering and counting statistics, the other possible sources of error due to the small angle scattering contribution, sample impurity, photo built-up effects, dead time of the counting instrument, and pulse pile effect were evaluated and taken care. Hence no small angle scattering corrections were applied to the measured data. The error due to the sample impurities can be high only when large percentage of high Z impurities is present in the sample. Undecyclic acid sample used in the present study were of high purity (99.9 %) and no content of high Z impurities was present hence, sample impurity corrections were not applied to the measured data. The non-uniformity of the sample material introduces a fraction of error of about half the root mean square deviation in mass per unit area. It is also a consequence of the multiple scattering inside the sample. In the multichannel analyzer used in the present study, there was a built-in provision for dead time correction.

Table1. The mean atomic numbers calculated from the chemical formula for Undecylic acids.

Fatty acids	Molar mass (g/mol)	Chemical Formula	Mean atomic number Z
Undecylic acid	186.29	($C_{11}H_{22}O_2$)	2.97

Table 2 Mass attenuation coefficient μ_m (cm^2/g) of Undecylic acid.

Fatty acids	511keV		662keV		840keV		1170keV		1275keV		1330keV	
	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.
Undecylic acid	0.092	0.095	0.076	0.086	0.067	0.077	0.054	0.066	0.055	0.062	0.050	0.062

Table 3 Atomic cross-sections, σ_{tot} (barn/molecule) of Undecylic acid.

Fatty acids	511keV		662keV		840keV		1170keV		1275keV		1330keV	
	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.	Exp.	Theo.
Undecylic acid	27.8045	29.8379	25.8954	26.7769	22.3368	23.9940	19.4863	20.4382	17.9875	19.4488	18.5621	19.2323

IV. RESULTS ANS DISCUSSION

The values of mean atomic number calculated from the chemical formulae of undecyclic acid acids studied in the present work are displayed in Table1. The experimentally measured mass attenuation coefficient μ_m (cm^2/g) for Undecylic acid ($C_{11}H_{22}O_2$) at 511, 662, 840, 1170, 1275, 1330keV photon energies have been tabulated in Table2 and the typical plot of μ_m versus energy E for Undecylic acid ($C_{11}H_{22}O_2$) is displayed in Fig. 2. The Fig. 2 also includes the variation of theoretically determined μ_m values versus energy. It is clearly seen that the mass attenuation coefficient (μ_m) depends on photon energy and decreases with increasing photon energy. As can be seen in Table 2 and the typical plot displayed in Fig. 2, the experimental (μ_m) values agree with theoretical values calculated using the XCOM programme. Measured total atomic cross section (σ_{tot}) values for the presently studied for undecyclic acid have been displayed in Table 3. The typical plots of σ_{tot} versus E are displayed in Figs.(3).

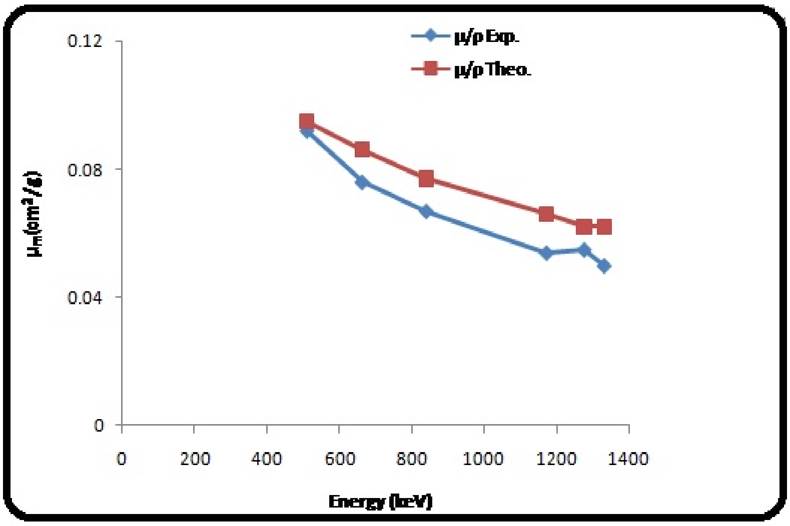

Fig. 2 The typical plot of μ_m versus energy E for Undecylic acid ($C_{11}H_{22}O_2$).

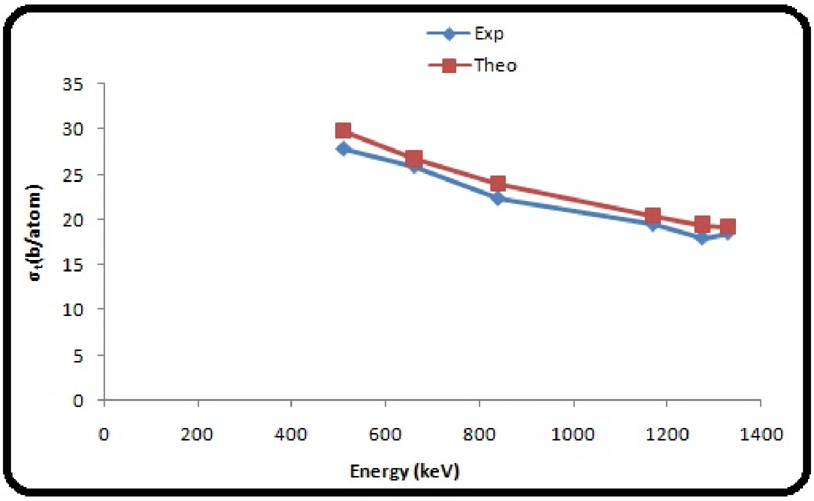

Fig. 3. The typical plots of σ_t versus E for Undecylic acid ($C_{11}H_{22}O_2$)

V. CONCLUSION

1. The present experimental study has been undertaken to get information on mass attenuation coefficient μ_m values and related atomic cross section for undecyclic acid samples. It has been found that the μ_m is useful and sensitive physical quantity to determine the atomic cross section for ..C, H, N and O based biological compounds.
2. The total attenuation cross sections of undecyclic acid with low-and medium Z elements. at photon energies of biomedical importance emitted by the radio isotopes namely C_o^{57},Ba^{133} and ^{60}Co have been measured. In the interaction of photons with matter, μ_m values are dependent on the physical and chemical environments of the samples. The mass attenuation coefficient (μ_m) values were found to decrease with increasing photon energies.
3. The variation of σ_t is identical to μ_m. Results of the study help to understand how μ_m values change with variation of the atomic cross section values in the case of the H, C and O based biological compounds.

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