Measurement of linear and mass attenuation coefficient of β-Naphthalene soluble in Ethanol at gamma ray energies 0.36 MeV

[1*]Ravindra C. Alange

Assistant Professor, Department of Physics,
Shri. Madhavrao Patil Mahavidyalaya, Murum, Omerga, Osmanabad, India.

Abstract: The attenuation coefficient was calculated using the mixture rule for different concentration at 0.36 MeV. Photon absorption parameters such as linear attenuation and mass attenuation coefficient, determined at 0.36 MeV. The measured attenuation coefficient for the β-Naphthalene soluble in Ethanol solution is linearly increased with increase in concentration. The presented data on mass attenuation coefficient and related parameters of β-Naphthalene soluble in Ethanol at gamma ray energy 0.36 MeV, helpful in radiation physics ,dosimetry and technological applications.

Keywords: Mass and linear attenuation coefficients, Gamma-rays**.**

1. INTRODUCTION

The linear and mass attenuation coefficients for organic materials and their solutions for different gamma ray energies play an important role solving the different problems in radiation physics and dosimeters [1]. The mass attenuation coefficient usually depends upon the energy of radiation and the nature of material. The absorption parameter of various materials has been an important part of research in radiation chemistry and physics [2]. Accurate value of photon mass attenuation coefficient are required to provide essential data in diverse field such as nuclear diagnostics and medicine, radiation protection and dosimeters, gamma ray fluorescence studies, radiation physics, shield, security screening and etc.[3-4]. The knowledge of the absorption parameters such as mass attenuation coefficient, linear attenuation coefficient, total atomic cross-section , electronic cross-section, effective atomic number, and electron density play an important role in understanding the physical properties of organic materials [5]. Extensive studies have been carried out to determine mass attenuation coefficients for various organic material and photon energy.. Recently, many workers [6-12] have used the mixture rule in order to provide mass attenuation coefficients for multi-element materials.

Recently Teli et al, [13], have used the mixture rule for multielemental media in order to provide attenuation and energy absorption for materials which are generally in liquid form or soluble in solvent such as water. The observations were compared with values which are derived from applications of mixture rule by using tabulated values for each element (Hubbell, 1982) [14]. The linear attenuation coefficient for some chemical solutions have been studied which shows a linear relationships with concentration [15-16]. Similar method will be used to establish the relationship between concentration of the solution and density, effective atomic number, and electronic density. Roberts in 1945 used condenser type of ionization chamber in the measurements and calculated the absorption of filtered gamma rays from radium (B + C) in aluminum, carbon and lead [17]. Mc Daniel et al. constructed gamma ray spectrometer to measure the energy distribution and absorption of gamma rays emitted in the Li7 (P, γ) reaction and further calculated absorption coefficient at 17 MeV in Lead and Aluminum [18]. Beta β-Naphthalene are used for various type, Antibacterial, Biological dyes. In Antibacterial inflection arises the innovation of the tissues by microorganism. Keeping these points in view, attempts have been made to measure the mass attenuation coefficient, of β-Naphthalene soluble in Ethanol samples of different concentration at the energy 0.360 MeV.

2. EXPERIMENTAL ARRANGEMENT

The experimental arrangement is illustrated in Figure 1. A cylindrical prefix container of internal diameter 2.62 cm was placed blow the source at a distance of 1.2 cm and above the detector at 2.2 cm by using efficient geometrical arrangement. The NaI (Tl) crystal is used as a detector connected to multichannel analyzer. A suitable size stand is made by for the source & absorber (container) is kept along the axis of the detector in the stand. The whole system is enclosed in the lead (Pb) castle.

The gamma rays passed through empty container reaching the detector. The spectrum is obtained for 1800 Sec. using MCA which gives plot of channel number versus counts. We select the interested peak which is smoothed for avoiding the random nature and obtain the peak gross area A0, i.e. (The sum of the spread counts which are coming under the peak.) This is obtained because in MCA the counts get spread over some energy range around the photo peak. This increases the accuracy of measured counts. Further β-Naphthalene and Ethanol solution is kept in the container and gamma rays are passed through it. The interested peak gross area is measured as A1. The solution concentration is varied by adding 1ml of Ethanol to it. The gamma rays are passed through such solutions and interested peak gross area measured as A2, A3, A4, A10. Fig show the spectrum observed for A0 only empty container having gamma energy from 0.36 MeV

The measurement of linear attenuation coefficient of β-Naphthalene soluble in ethanol for different concentrations and estimated from them the attenuation coefficient for β-Naphthalene soluble in ethanol by using the mixture rule developed by Teli (1998) established the validity and utility of the solution technique. This method is simple and avoids the need of preparation of pure crystalline compound for experiment thereby saving time and expenditure. The use of multichannel analyzer has also improved the results as we could replace the counts at the photo peak by the area under it. Further the variation of concentration of solution is made easy by adding alcohol to solution without changing the compound amount in it. This saves the compound quantity and thus further economizes the experiment [19-20].

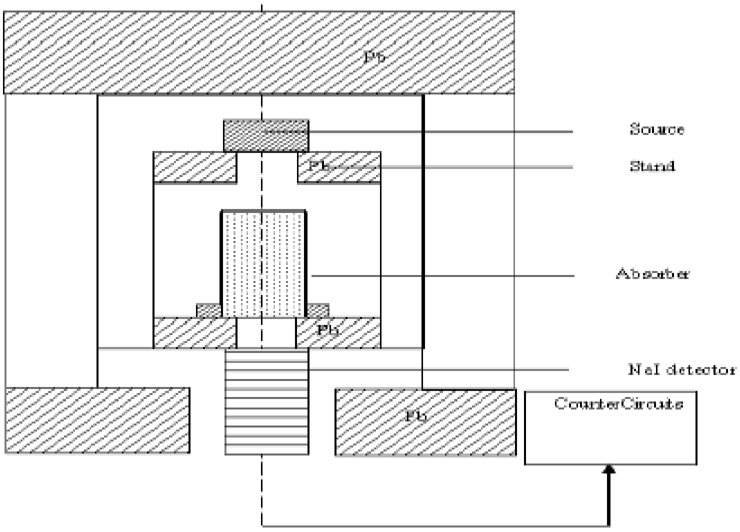

Fig. 1 Experimental set up for measurement of gamma absorption coefficient for solutions.

3. Results and Discussion

According to Hubbell's mixture rule [14], the mass attenuation coefficient of gamma rays in chemical or any other mixtures of compound is assumed to depend upon the sum of the cross section presented by all the atoms in the mixture because the bonds are only of the order of few electron volts; there have no significant effects on the Compton, photo or pair interaction.

Mass attenuation coefficient for solution is given by [19].

$$\left(\frac{\mu}{\rho}\right)_{Sol} = \sum_i W_i \left(\frac{\mu}{\rho}\right)_i \text{---------------- (1)}$$

Where, ρ is the density and which is made up on solution of elements. Wi is the fraction by weight. The effect of shrinkage on the linear attenuation coefficient of a solution is given by Bragg mixture rule which we assume without approximation for alcohol namely,

$$\left(\frac{\mu}{\rho}\right)_{Sol} = \left(\frac{\mu}{\rho}\right)_a W_a + \left(\frac{\mu}{\rho}\right)_c W_c \text{-------- (2)}$$

When the Phenol is dissolved in ethanol then the homogeneous solution is forms. If the solution is homogeneous then one can neglect the density from both sides. If we use this formula for the proposed work in the following way then it will be

$$\rho_{solution} = \mu_{ethenol} W_{etenol} + \mu_{phenol} W_{phenol} \text{-------------- (3)}$$

Table 1 gives the values using equation (3) for various concentration and theoretical values of (β-Naphthalene) and (Ethanol) are calculated by multiplying their densities to (μ/ρ) which is calculated by Hubble mixture rule, which is used to calculate theoretical (μ_{the}) given in the table-1

$$\left(\frac{\mu}{\rho}\right) = \sum_i W_i \left(\frac{\mu}{\rho}\right)_i \text{------------- (4)}$$

3.1 Solution technique for calculation of linear attenuation coefficient of Phenol

Using the data the experimental linear attenuation coefficient of the β-Naphthalene with ethanol solution (μ_{exp}) is obtained from,

$$\left(\mu_{exp}\right) = \frac{1}{h} ln \left(\frac{A_0}{A}\right) \text{----------------- (5)}$$

Where h is the height of the solution.

The mixture rule for aqueous solution is obtained from equation (3). The equation (3) is used to obtain theoretical (μ_{the}) and experimental (μ_{exp}) is obtained by equation (5). μ_{exp} values are given in the table 1 in 6th column and μ_{the} values are given in 7th column and the percent error is obtained by the equation (6) and is given in 8th column of table 1.

$$\% \ error = \frac{\mu_{the} - \mu_{the}}{\mu_{the}} * 100 \text{ ----------- } (6)$$

μ/ρ for alcohol and Phenol is obtained from Hubbell table by multiplying its density, we get theoretical (μ_{the}) value for ethanol alcohol and β-Naphthalene compound then by using eqn.(3) the (μ_{the}) is obtained the results calculated are tabulated in table 1 for β-Naphthalene solution. Eqn (3) is the equation of straight line between (μ_{exp} and μ_{the}) verses concentration in which ethanol volume is fixed. The intercept is the attenuation coefficient for the alcohol and its slop the attenuation coefficient for the β-Naphthalene. From graph the slope is 0.0234 and intercept is 10.365 which is the linear attenuation coefficient for the β-Naphthalene and ethanol alcohol if we multiply them by fraction by weight. We observe from these tables that, the (μ_{exp} are within the acceptable limit showing very good agreement.

Table1. Linear and mass attenuation coefficient of β-Naphthalene soluble in Ethanol at gamma ray energy 0.36 MeV A_o =16.55 (Sec^{-1})

Sr. No.	$C=V_N/V'$	h cm	A (Sec^{-1})	Ln Ao/A	μ expt. Cm^{-1}	μthe. Cm^{-1}	% Error
1.	0.07593	2.01	9.11	0.597013	0.297022	0.298884	0.6232
2.	0.069507	2.19	8.56	0.659286	0.301044	0.293157	-2.69021
3.	0.064086	2.38	8.35	0.684125	0.287447	0.288324	0.303931
4.	0.059449	2.56	8.01	0.725695	0.283475	0.284189	0.251464
5.	0.055439	2.75	7.71	0.763868	0.27777	0.280613	1.01309
6.	0.051935	2.93	7.45	0.798172	0.272414	0.277489	1.828924
7.	0.048847	3.12	7.12	0.843478	0.270346	0.274736	1.598
8.	0.046106	3.3	6.75	0.896844	0.271771	0.272292	0.191425
9.	0.043657	3.49	6.42	0.946968	0.271338	0.270108	-0.45527
10.	0.041454	3.68	6.25	0.973805	0.264621	0.268144	1.313912

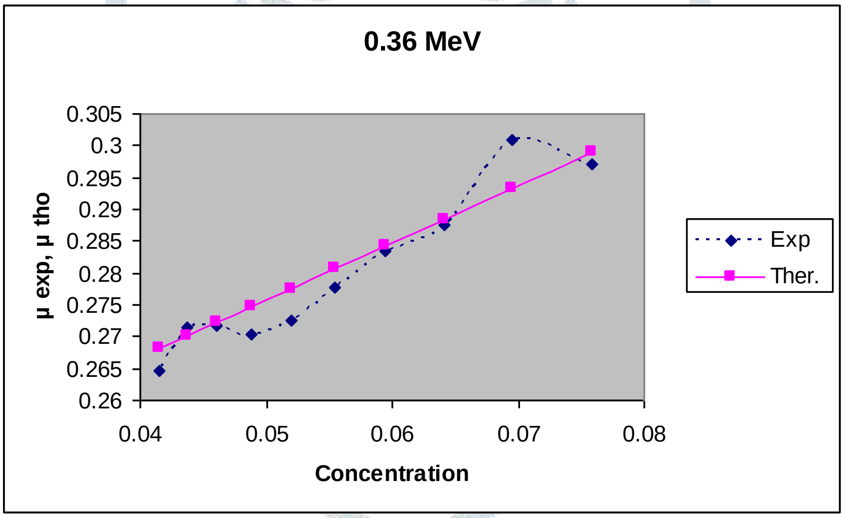

Fig.2. Graph of concentration (C) VS μ_{exp}. & μ_{the} for 0.36 MeV

4. Conclusions

Attenuation coefficient for β-Naphthalene soluble in Ethanol at gamma ray energy 0.36 MeV, calculated by using the mixture rule developed by Teli(1998).The obtained experimental result suggest that attenuation coefficient increased with increase in concentration. The presented data on mass attenuation coefficient and related parameters of β-Naphthalene soluble in Ethanol at gamma ray energy 0.36 MeV .

References

[1]. Al-Buriahi, M. S., Singh, V. P., Arslan, H., Awasarmol, V. V., & Tonguc, B. T, 2020, Gamma-ray attenuation properties of some NLO materials: potential use in dosimetry. Radiation and Environmental Biophysics, 59(1), ., 145-150.

[2]. Hubbell, J. H. (1977). Radiation Research, 70(1), 58-81. Greening, John Raymond. Fundamentals of radiation dosimetry. CRC Press, 1985.

[3]. Bushberg, J. T., & Boone, J. M. (2011). The essential physics of medical imaging. Lippincott Williams & Wilkins.

[4]. Ahmed, S. N. (2007). Physics and engineering of radiation detection. Academic Press.

[5]. Jackson, Daphne F., and David J. Hawkes., Physics Reports 70, no. 3 (1981): 169-233.

[6]. Jackson, D. F., & Hawkes, D. J. (1981). X-ray attenuation coefficients of elements and mixtures. Physics Reports, 70(3), 169-233.

[7]. Hine, G. J. (1952). The effective atomic numbers of materials for various gamma ray processes. Phys Rev, 85, 725.

[8]. Midgley, S. M. (2004). A parameterization scheme for the x-ray linear attenuation coefficient and energy absorption coefficient. Physics in Medicine & Biology, 49(2), 307.

[9]. Kadam, R. H., Alone, S. T., Bichile, G. K., & Jadhav, K. M. (2007). Measurement of atomic number and mass attenuation coefficient in magnesium ferrite. Pramana, 68(5), 869-874.

[10]. Gowda, S., Krishnaveni, S., & Gowda, R. (2005). Studies on effective atomic numbers and electron densities in amino acids and sugars in the energy range 30–1333 keV. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 239(4), 361-369.

[11].10.Rutherford, R. A., Pullan, B. R., & Isherwood, I. (1976). Measurement of effective atomic number and electron density using an EMI scanner. Neuroradiology, 11(1), 15-21.

[12]. Gaikwad, D. K., Pawar, P. P., & Selvam, T. P. (2017). Mass attenuation coefficients and effective atomic numbers of biological compounds for gamma ray interactions. Radiation Physics and Chemistry, 138, 75-80.

[13]. Kore, P. S., Pawar, P. P., & Selvam, T. P. (2016). Evaluation of radiological data of some saturated fatty acids using gamma ray spectrometry. Radiation Physics and Chemistry, 119, 74-79.

[14]. Teli M T Chauehari L M and Malode S S: Appli Radiat Isot (1994 a) 45,987

[15]. Hubbell, J. H. (1982). Photon mass attenuation and energy-absorption coefficients. The International Journal of Applied Radiation and Isotopes, 33(11), 1269-1290.

[16]. Tousi, E. T., Bauk, S., Hashim, R., Jaafar, M. S., Abuarra, A., Aldroobi, K. S. A., & Al-Jarrah, A. M. (2014). Measurement of mass attenuation coefficients of Eremurus–Rhizophora spp. particleboards for X-ray in the 16.63–25.30 keV energy range. Radiation Physics and Chemistry, 103, 119-125.

[17]. Mitkar, S. R., & Dongarge, S. M. (2012). Study the Linear and Mass Attenuation Coefficient of Alcohol Soluble Compound for Gamma Rays at Energy 662 KeV. J. Chem. Pharm. Res, 4(8), 3944-3949.

[18]. Roberts, J. E. (1945). Absorption of radium (B+ C) gamma-rays. Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences, 183(994), 338-355.

[19]. McDaniel, B. D., Von Dardel, G., & Walker, R. L. (1947). The Absorption of 17-Mev Gamma-Rays in Lead and Aluminum. Physical Review, 72(10), 985.

[20]. Teli, M. T., Chaudhari, L. M., & Malode, S. S. (1994). Attenuation coefficients of 123 keV γ-radiation by dilute solutions of sodium chloride. Applied radiation and isotopes, 45(10), 987-990.