Measurement Mass Attenuation Coefficient of Palmitic Acid by Using Sources of Gamma Ray

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Abstract

The purpose of this paper is to determine the mass attenuation coefficient (μ/ρ), of a sample. In this work used (C16H32O2) fatty acid, exposed to gamma rays (γ), emitted from various sources ^{57}Co, ^{133}Ba, ^{22}Na, ^{137}Cs, ^{54}Mn, and ^{s}Co with energies from 0.122 to 1.330 MeV. It exposes the compound to gamma rays and discloses the radiation force that passes through the sample, the rest of the gamma radiation attenuated. A NaI fluorescence detector (Tl) with an accuracy of 8.2% (at 662 kV) was used for the gamma ray detector beam. An advantage of using (μ/ρ) coefficient data can be obtained effective atomic numbers, atomic cross-section and effective electron densities.

Key Words: Mass Attenuation Coefficient, Emitted of Gamma Rays.

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Introduction

There are some parameters as atomic cross-section, density of electron, active number of atomic and other that depend in calculating it directly and mainly on the calculation of the mass attenuation coefficient, and many researchers have indicated when calculating such coefficients that the mass attenuation coefficient which write as (μ/ρ), was relied on in completing the calculations (Hussein Faraj, Yahya Hadi, and Adil TAldalawi 2019). The parameter of attenuation that gives the fraction of the energy consumed or distributed to evaluate the reaction between radiation and matter is one of the activities parameters (Singh et al. 2004).

One should define those criteria for this quantitative evaluation, among them the mass attenuation coefficient of the substance (Laxman 2013). This makes it important to investigate the (μ/ρ) in various materials in the physics research. The (μ/ρ) has been used in evaluating the effective cross-sectional number of atoms and the density electron, usually according to radiation energy and the substance nature.

The (μ/ρ) is the measurement of the potential relation between radiation absorbed and unit mass matter per area. There is a major interest in manufacturing, biological, agriculture and medical application in knowingness of (μ/ρ) of radiation and other related products gamma photons (Pawar et al. 2013b). Data on the (μ/ρ) of Fatty acid by using sources of $Co^{57}, Ba^{133}, Na^{22}, Cs^{137}$ and Co^{60} are $0.122, 0.356, 0.511, 0.662, 1.170, 1.275$ and $1.330\ MeV$ are very helpful. The energy of the incident ray is the basis to control the interaction between incident ray and substance (Kore and Pawar 2014). The absorber attenuation gamma (photons) differs from either alpha or beta radiation in equalization. Although these two corpuscular radiations are distinct, and can thus be avoided completely, only increasingly thicker absorbers will mitigate gamma radiation. (Pawar et al. 2013a).

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The study was performed to gain knowledge about the (μ/ρ) coefficient of mass attenuation by using palmitic acid sample due to most of the research presented recently to calculate the mass effect coefficient, samples of the type of amino acids and fats in addition to sugars have been approved, because they are rather complex compounds consisting mainly of carbon, hydrogen and oxygen molecules (Al-Sharifi et al. 2018) (Gowda, Krishnaveni, and Gowda 2005). Thus, fatty acid was adopted within this work.

Theory

The term gamma-rays is used to include all electromagnetic radiations emitted by radioactive substances. The spectral region which gamma rays occupy ranges from soft x-ray region to very short wavelength of the order of few x-units ($1x^0=10^{-11}$ cm) (Kaplan 1963). The gamma rays are characterized by their frequency υ the energy $h\upsilon$ which may be expressed in ergs, eV or in the unit of m_0c^2 . The gamma rays do not bend in electric and magnetic fields. They travel with the velocity of light and made to diffract and interfere just as x-rays. The gamma rays are very penetrating and being uncharged they produce less ionization per unit length of the path. The ionization produced per unit length of path is only 1 to 10 percent of beta particles (β) of same energy (D. C. Tayal 2009). Gamma rays (γ) when traverse through the matter are stopped only in one or two encounters while alpha (α) and beta particles require several encounters to be stopped. Further, since gamma-radiations are removed in the matter only in first few angstroms of it or they may travel long distance before being encountered, therefore range concept in gamma-rays is very much vague.

It has been experimentally observed that a mono-energetic and homogeneous beam of gamma radiations, when passes through a thin absorber, is attenuated in such a fashion that change in intensity of the beam is proportional to the thickness of the absorber and intensity of incident radiation; mathematically (Hendee, Ritenour, and Hoffmann 2003)

$$\Delta I = -\mu I_0 \Delta x \qquad (1)$$

Where
ΔI = Change in intensity
I_0 = Incident intensity
Δx =thickness of the absorber
μ= proportionality constant and is called absorption coefficient. The integration of eq. (1) yields to exponential absorption,

$$I = I_0 e^{-\mu x} \qquad (2)$$

The eq. (2) determines the intensity of radiation of initial intensity I after traversing the thickness x of the absorber (Al-Sharifi et al. 2018).

The change in intensity of gamma-radiations in passing through the matter is a measure of combined effects of absorption and deflection and this is the reason why absorption is used synonymous with attenuation.

Sometimes it is desirable to express the attenuation of gamma radiations in terms of quantity called the half thickness and is defined as the thickness of the absorber require to reduce the intensity to one half of its incident value. The eq. (2) can be reformulated as (D. C. Tayal 2009)

$$\log_e \frac{I}{I_0} = -\mu x$$
$$\log_e \frac{1}{2} = -\mu x_{1/2}$$
$$\mu = \frac{\log_e 2}{x_{1/2}} = \frac{0{\cdot}693}{x_{1/2}} \qquad (3)$$
$$\frac{\mu}{\rho} = \frac{0{\cdot}693}{x_{1/2}\mathrm{P}}$$

Where ρ the density of matter.

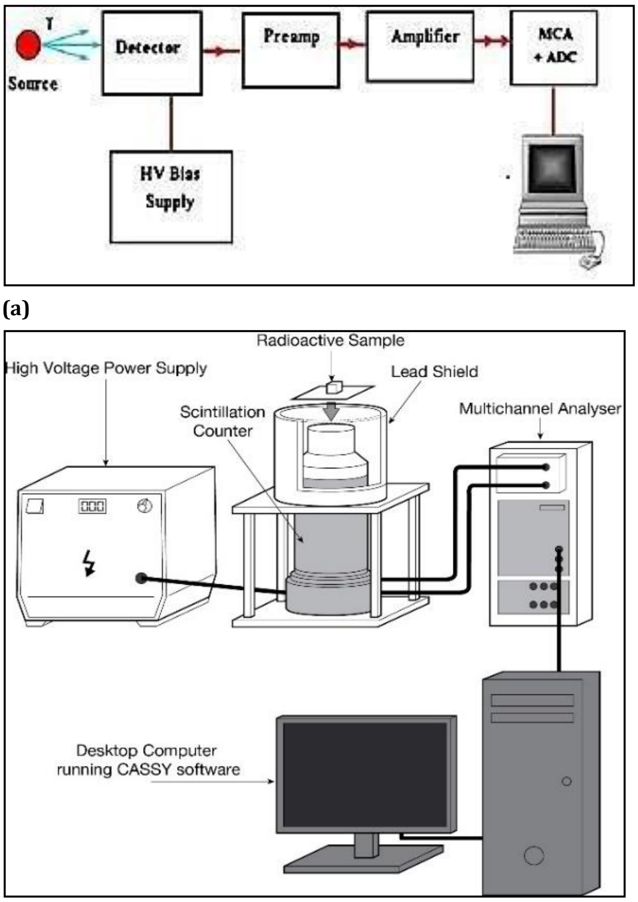
By using the density of the related samples, mass attenuation coefficients for the samples were extracted from the following equation (Kore and Pawar 2014).

$$\mu_m = \frac{\mu}{\rho}(\mathrm{cm}^2\mathrm{gm}^{-1}) = \frac{1}{\rho t}\ln\left(\frac{I_0}{I}\right) \qquad (4)$$

Experimentally the mass attenuation coefficient μ/ρ calculated by chart ln (I_0/I) as a function of the thickness x of the material traversed (Hussein Faraj, Yahya Hadi, and Adil TAldalawi 2019). The graph should be a straight line of slope ($-\mu/\rho$). In our work have been the study the mass attenuation coefficient so has taken the thickness multiplied by the density of a sample which was Palmitic Acid $T^*\rho$ (gm/cm^2).

Experimental and Measurement Operation

Used in the current inquiry γ-rays with energy (0.122, 0.360, 0.511,0.662,1.170,1.275and1.330) MeV which emitted from radioactive sources $Co^{57}, Ba^{133}, Na^{22}, Cs^{137}$ and Co^{60} . The NaI (Tl) detector was collimated and detected which can see in figure 1. The detector signals have been amplified by 8 K multi-channel analyzer. The Palmitic acid sample ($C_{16}H_{32}O_2$), During the experiment, the sample was put in a plastic tube cylindrical. With a traveling microscope the diameters of the samples were determined. Photons of empty containers have been marginal attenuation was detected. The sensitive digital balance of a sample pellet is 0.001 mg precision. Multiple weights were replicated to maintain a stable weight. The mean value of this collection was called the sample mass. The density per unit area was estimated in each case using the pellet diameter and the medium value of the pellet density. To meet the following ideal conditions as far as possible, the sample thickness was chosen 2< ln(I0/I) < 4 (Pawar and Bichile 2013).



(a)

(b)

Fig. 1. (a) Block diagram of a lowlevel background gamma-ray-spectrometer; (b) Scintillation counter as a spectrometer

A narrow beam with strong geometry may be used to calculate events and transmitted energy of photons. The practical (*μ/ρ*) for Palmitic acid sample was obtained from the graph that was placed between the ln(I_0/I) and the mass thickness as shown in following figures (section 4), were (I) was calculated before placing the sample, after that, I_0 was calculated with the presence of the sample and this process was repeated for each radioactive source. The *(μ/ρ)* values using Online XCOM to achieved it (Berger et al. 1987), on all current photon energies expressing theoretical data. Other potential sources of error due to the small-angle dispersion contribution, sample impurity, sample irregularity, photographic effects integrated, the dead time of the measuring instrument, and pulse pile effect were analyzed and taken into consideration in addition to multiple dispersion and counting data. The overall dispersion angle was less than 30 minutes by changing the distance between the sensor and the source (30<d<50) cm. According to Hubbell and Berger (1968), in measured cross sections at intermediate energies the contributions of both incoherent and coherent scattering at those angles are insignificant. Therefore, the measured data were not corrected by small-angle scattering. Only when a significant proportion of high Z impurities are in the sample, will the error due to sample impurities be high. The sample used in the present analysis was of high purity (99,9%) and no high (Z) impurities content was present; the measured data did not obtain sample impurity corrections. The loss of the sample material results in a fraction of an error of approximately half the root means square weight variance per unit area. In the present work, the mass variance per unit area and the error due to sample non-uniformity are below 4% of all energies. By determining the optimal count rate and counting time, the photon built-up effect was kept at low. The built-up photon depends on the atomic number and thickness of the sample as well as the photon energy incident. This is also a function of the multiple dispersion within the sample. A dead time correction clause was used in the multi-channel analyzer used in the present analysis. The pulse stacks of effects have been kept low by choosing the optimal number and duration.

Results

The mass attenuation coefficient (μ/ρ) of Palmitic acid sample (C_{16} H_{32} O_2), have been examined by using gamma rays with different energy sources, 0.122, 0.360, 0.511, 0.662, 0.840 1.170, 1.275 and 1.330 MeV, and the sample density was (ρ = 0.852 g/cm^3).

The results are proven among the following tables and figures. The values of (μ/ρ) thus obtained are considered to be in strong accordance with the theory. In these eight following figures founded the mass attenuation coefficient as a slopes, it should be noted that all the following tables represent the calculation of the mass attenuation coefficient of the different sources and their energies, in addition to that the chart represent the relationship between the mass thickness and ln I_0/I.

Calculate the variation as a comparison of theories and test values as seen in Table 9.

Table 1. Source ^{57}Co for energy 0.122 MeV, I_0=18820

Sr.No.	T cm	T*ρ gm/cm²	I	I_0/I	ln(I_0/I)
1	0.2	0.1704	18327	1.026916	0.0266
2	0.4	0.3408	18017	1.044579	0.0436
3	0.6	0.5112	17226	1.092545	0.0885
4	0.8	0.6816	16927	1.111853	0.1060
5	1	0.852	16303	1.154370	0.1436
6	1.2	1.0224	15949	1.180033	0.1655
7	1.4	1.1928	15648	1.202676	0.1845
8	1.6	1.3632	15057	1.249891	0.2231
9	1.8	1.5336	14795	1.272084	0.2407
10	2	1.704	14570	1.291714	0.2560

Table 2. Source ^{133}Ba for energy 0.356 MeV, I_0=19500

Sr. No.	T cm	T*ρ gm/cm²	I	I_0/I	ln(I_0/I)
1	0.2	0.1704	19088	1.021600	0.0214
2	0.4	0.3408	18929	1.030188	0.0297
3	0.6	0.5112	18454	1.056658	0.0551
4	0.8	0.6816	18082	1.078404	0.0755
5	1	0.852	17824	1.094013	0.0899
6	1.2	1.0224	17465	1.116527	0.1102
7	1.4	1.1928	17326	1.125462	0.1182
8	1.6	1.3632	16835	1.158312	0.1470
9	1.8	1.5336	16528	1.179788	0.1653
10	2	1.704	16203	1.203447	0.1852

Table 3. Source ^{133}Ba for energy 0.511 MeV, I_0=22562.8

Sr. No.	T cm	T*ρ gm/cm²	I	I_0/I	ln(I_0/I)
1	0.2	0.1704	22091	1.021355	0.0211304
2	0.4	0.3408	21681	1.040692	0.0398857
3	0.6	0.5112	21567	1.046162	0.0451285
4	0.8	0.6816	20996	1.074625	0.0719714
5	1	0.852	20637	1.093315	0.0892142
6	1.2	1.0224	20554	1.097744	0.0932571
7	1.4	1.1928	19735	1.143301	0.1339212
8	1.6	1.3632	19648	1.148369	0.1383428
9	1.8	1.5336	19518	1.156023	0.1449856
10	2	1.704	19219	1.174014	0.1604285

Table 4. Source ^{137}Cs for energy 0.662 MeV, I_0=23225

Sr. No.	T cm	T*ρ gm/cm²	I	I_0/I	ln(I_0/I)
1	0.2	0.1704	22901	1.014133	0.014033775
2	0.4	0.3408	22607	1.027334	0.026967551
3	0.6	0.5112	22403	1.036669	0.036013001
4	0.8	0.6816	21931	1.059011	0.057335101
5	1	0.852	21792	1.065739	0.063668877
6	1.2	1.0224	21232	1.093849	0.089702652
7	1.4	1.1928	21008	1.105543	0.100336428
8	1.6	1.3632	20685	1.122805	0.115829802
9	1.8	1.5336	20424	1.137126	0.128503978
10	2	1.704	20265	1.146069	0.136337754

Table 5. Source ^{54}Mn for energy 0.840 MeV, I_0=23231

Sr. No.	T cm	$T^*\rho$ gm/cm^2	I	I_0/I	$\ln(I_0/I)$
1	0.2	0.1704	22908	1.014078	0.013980288
2	0.4	0.3408	22729	1.022101	0.021860576
3	0.6	0.5112	22517	1.031703	0.031210864
4	0.8	0.6816	22073	1.052450	0.051121153
5	1	0.852	21609	1.075055	0.072371441
6	1.2	1.0224	21527	1.079159	0.076181729
7	1.4	1.1928	21277	1.091837	0.087862017
8	1.6	1.3632	20796	1.117073	0.110712305
9	1.8	1.5336	20684	1.123134	0.116122593
10	2	1.704	20565	1.129644	0.121902882

Table 6. Source ^{60}Co for energy 1.170 MeV, I_0=23260

Sr. No.		$T^*\rho$ gm/cm^2	I	I_0/I	$\ln(I_0/I)$
1	0.2	0.1704	23007	1.010995	0.010935454
2	0.4	0.3408	22755	1.022214	0.021970908
3	0.6	0.5112	22419	1.037492	0.036806362
4	0.8	0.6816	22309	1.042625	0.041741816
5	1	0.852	22022	1.056200	0.054677270
6	1.2	1.0224	21739	1.069951	0.067612724
7	1.4	1.1928	21481	1.082798	0.079548179
8	1.6	1.3632	21312	1.091424	0.087483633
9	1.8	1.5336	21080	1.103425	0.098419087
10	2	1.704	20840	1.116116	0.109854541

Table 7. Source 22Na for energy 2.275 MeV, I0=23271

Sr. No	T cm	$T^*\rho$ gm/cm^2	I	I_0/I	$\ln(I_0/I)$
1	0.2	0.1704	23036	1.010216	0.010164383
2	0.4	0.3408	22899	1.016260	0.016128767
3	0.6	0.5112	22484	1.034991	0.034393150
4	0.8	0.6816	22427	1.037647	0.036955331
5	1	0.852	22140	1.051084	0.049821916
6	1.2	1.0224	21781	1.068426	0.066186301
7	1.4	1.1928	21662	1.074280	0.071650683
8	1.6	1.3632	21327	1.091131	0.087215066
9	1.8	1.5336	21162	1.099647	0.094989451
10	2	1.704	21102	1.102791	0.097843833

Table 8. Source ^{60}Co for energy 1.330 MeV, I_0=23413

Sr. No.	T cm	$T^*\rho$ gm/cm^2	I	I_0/I	$\ln(I_0/I)$
1	0.2	0.1704	23151	1.011301	0.011237939
2	0.4	0.3408	22916	1.021708	0.021475877
3	0.6	0.5112	22750	1.029130	0.028713816
4	0.8	0.6816	22501	1.040552	0.039751755
5	1	0.852	22105	1.059174	0.057489694
6	1.2	1.0224	21908	1.068684	0.066427632
7	1.4	1.1928	21805	1.073759	0.071165571
8	1.6	1.3632	21484	1.089810	0.086003501
9	1.8	1.5336	21371	1.095533	0.091241448
10	2	1.704	21154	1.106807	0.101479387

Table 9. Mass attenuation coefficient & values deviation

sample	source	Energy MeV	(μ/ρ) theo.	(μ/ρ) expm	deviation
$C_{16}H_{32}O_2$	Co	0.122	0.1607	0.1556	3%
	Ba	0.356	0.1123	0.1078	4%
	Na	0.511	0.0971	0.0941	3%
	Cs	0.662	0.0867	0.0841	3%
	Mn	0.840	0.0777	0.0762	2%
	Co	1.170	0.0662	0.0642	3%
	Na	1.275	0.0633	0.0614	3%
	CO	1.330	0.0619	0.0601	3%

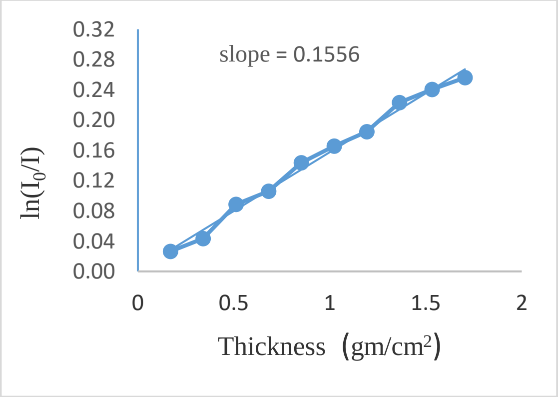


Fig. 2. Chart between thickness and ln I_0/I for energy 0.122 MeV

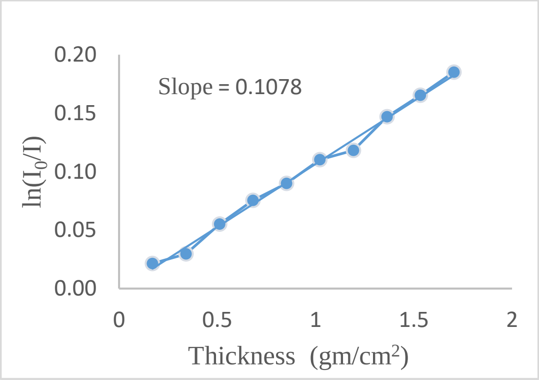


Fig. 3. Chart between thickness and ln I_0/I for energy 0.356 MeV

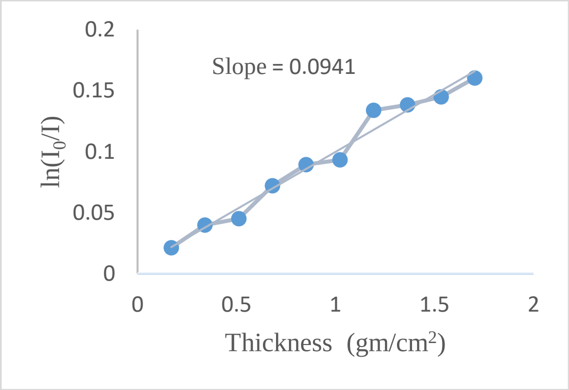


Fig. 4. Chart between thickness and ln I_0/I for energy 0.511 MeV

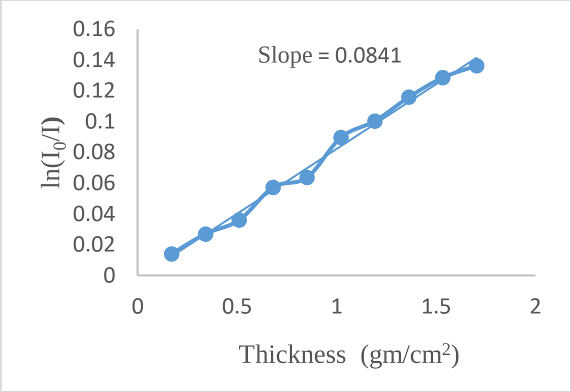


Fig. 5. Chart between thickness and ln I_0/I for energy 0.662 MeV

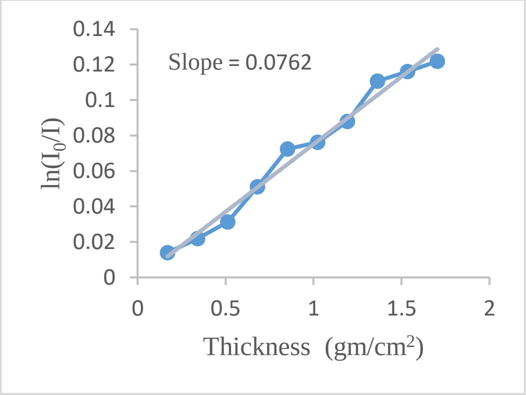


Fig. 6. Chart between thickness and ln I_0/I for energy 0.840 MeV

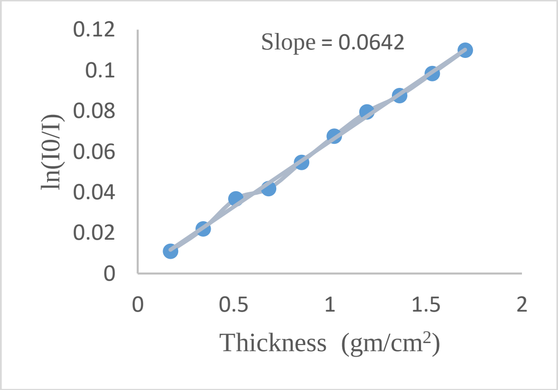


Fig. 7. Chart between thickness and ln I_0/I for energy 1.170 MeV

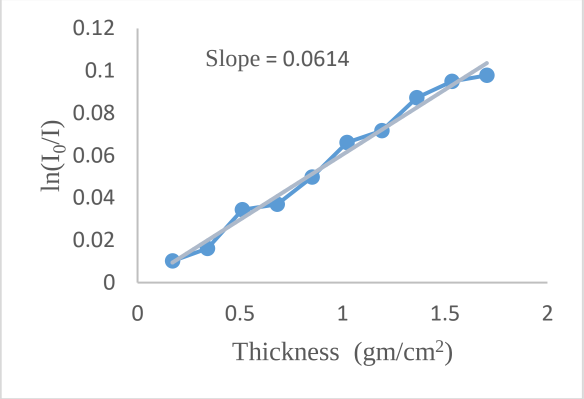


Fig. 8. Chart between thickness and ln I_0/I for energy 2.275 MeV

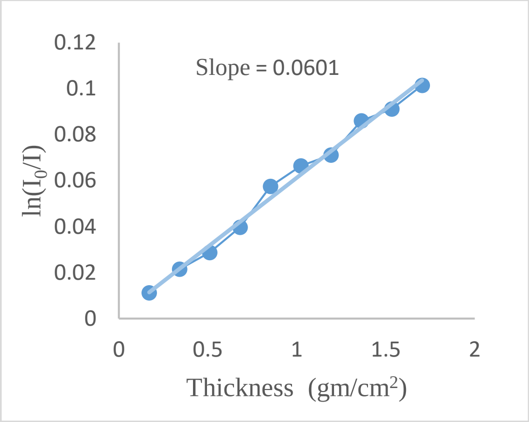


Fig. 9. Chart between thickness and ln I_0/I for energy 1.330 MeV

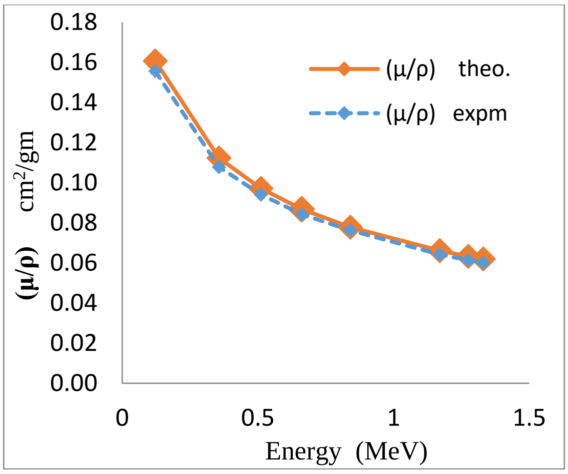


Fig. 10. The chart between μ/ρ and energy at MeV to shows a deviation in theoretical and experiment values

Conclusion

The values of mass attenuation coefficients measured for palmitic acid were studied using Gamma rays (γ), emitted from deferent sources ^{57}Co, ^{133}Ba, ^{22}Na, ^{137}Cs, ^{54}Mn, and ^{60}Co with energies from 0.122 to1.330 MeV. The measured values were found to be in well good agreement with mixture rule. This research method is very useful for systematic study in basic sciences and also in research area. The results valid the gamma attenuation law. The values obtained (μ/ρ) can be used to study the effective atomic numbers, atomic cross-section and effective electron densities. We expect the effective coefficient of the atomic number and effective electron density to decrease in the beginning and is almost constant as a consequence of gamma radiation energy via the attenuation coefficient computed in this article.

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