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Study Mass Attenuation Coefficient of Dinitratobis (1-benzylbenzimidazole) Copper (II) by Using Gamma Ray Sources for Energy Range 122–1330 keV

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Abstract: Study mass attenuation coefficient of new chemical compound $C_{28}H_{24}N_6O_6Cu$ by using gamma ray radiation (γ), emitted from deferent sources Co^{57}, Ba^{133}, Na^{22}, Cs^{137}, Mn^{54} and Co^{60} with energies from 122-1330 keV. The compound was subjected to gamma radiation and detector density of radiation that across the sample, used scintillation NaI(Tl) detector with resolution 8.2% (at 662 keV) to detector beam of gamma ray. The attenuation coefficient data has used to obtain the effective atomic numbers (Z_{eff}) and effective electron densities (N_{eff}), atomic cross-section ($б_t$) and electronic cross-section ($б_e$) of dinitratobis. It was observed that the effective atomic number (Z_{eff}) and effective electron densities (N_{eff}) initially decrease and tend to be almost constant as a function of gamma-ray energy. Z_{eff} and N_{eff} experimental values showed good agreement with the theoretical value which took from XCOM program of Hubbell J.H.for the individual elements.

Key words: Dinitratobis (1-benzylbenzimidazole) Copper(II) $C_{28}H_{24}N_6O_6Cu$, NaI (Tl) scintillation detector, mass attenuation coefficient μ_m , effective atomic number (Z_{eff}), effective electron density (N_{eff}), atomic cross-section ($б_t$) and electronic cross-section ($б_e$)

INTRODUCTION

Chemical compound ($C_{28}H_{24}N_6O_6Cu$) (Abbas, 2015). Used in this experimental to study mass attenuation coefficient. Gamma rays are electromagnetic change regarding absolutely quick wave (≈ 10-3 Å in consequence regarding 1 Å) then, therefore, those hold no electric powered charge then can't continue to be deflected by means of electric powered yet magnetic field. The unique dosage regarding γ-ray energies is as a result not viable by way of traditional magnetic spectrographs. The intentness regarding γ-ray is also distinct from then plenty charged particles kind of α but β-rays fit after the reality γ-radiations are an awful bunch penetrating. The charge particles go into bankruptcy their energies by path regarding inelastic collisions and and a great deal that slow below then smoke vicinity in imitation of relaxation yet deep at the give up on theirs precise pleasure define the range. On the vile tip γ-rays bear no precise pardon, however, their intensity decreases exponentially, hence, so, pass with the aid of the absorbing cloth (Tayal, 2009).

The nuclear rejoinder cross-section offers a thinking about the probability, therefore, bombarding particle intention engage alongside the goal nucleus. This likelihood might also additionally stay visualized into phrases as regards vicinity by means of the nucleus after the availability particle. The sexual intercourse particle load hands concerning partial regarding, so much vicinity desire hold interplay at intention nucleus at the same time as, so much no longer fetch this vicinity wish escape the interaction. Thus, large is the cross-section, higher is the gamble concerning nuclear answer among accordance with absorb place. The nuclear cross-section is now not the geometrical location above nucleus, however, relies upon concerning the makeup respecting interplay process longevity permanency (Ghoshal, 2008).

The magnitude of a nuclear reaction cross-section depends upon kinetic energy and nature of incident particle and nature of target nucleus. The nuclear reaction cross-section may be defined as:

$$\sigma = \frac{\text{Number of given type of event per nucleus per second}}{\text{Number of incident particles per unit area per second}}$$

When dispersion is deep of body such causes chemical reactions according to manifest as do change the everyday function regarding the body. The consequences are regarded in conformity with keep due in accordance with ionization regarding the atoms among the molecules

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on the chemical elements concerning cells. As end result of ionization, some about the molecules concerning the telephone materials are damaged or broken above then and cannot commonly function. If solely a especially not much atoms of a mobile are ionized, it might also recover beside harm (Manjunathaguru and Umesh, 2009).

The attenuation coefficient is a fundamental quantity back into calculations of the entree regarding substances by quantum particles yet other energy beams. The linear extravagance coefficient additionally referred to as the narrow beam decrease coefficient is a content who describes the sum in accordance with who the depth of electricity thread is decreased as it passes thru a precise material. This might stay electromagnetic radiation beam. It is represented the usage of the symbol μ and measured between cm^{-1}. In the law about ultrasound attenuation that is usually denoted as like α then decent between dB/cm/MHz.

A short linear wastage coefficient indicates to that amount the material in query is tremendously transparent whilst larger values indicate greater levels over opacity. The linear wastage coefficient is dependent upstairs the type on cloth and the electricity on the radiation. Generally, the greater the strength over the incident photons yet, the much less cubic the fabric into question, the lower the correspondent linear extravagance coefficient choice be.

MATERIALS AND METHODS

Theory: According to mass attenuation coefficient we determined effective of atomic number (Z_{eff}), electron density (N_{eff}), atomic cross section ($б_e$) and electronic cross section ($б_t$) was the hypothetical formulation for the determine of "Mass attenuation coefficient (μ_m)" and other related factors. A photon can be absorbed by an atomic nucleus and knock out a nucleon. This process is called photo disintegration (Manjunathaguru and Umesh, 2009; Hubbell and Seltzer, 1995).

Gamma rays are electromagnetic radiation and suffer absorption in matter just like light photons (Hubbell, 2006). γ-ray photons are either completely absorbed or are deflected (scattered) from their path, usually at large angles. For both these reasons, the intensity of a collimated beam of γ-rays is reduced as it passes through matter (Pawar and Bichile, 2011). The attenuation in their intensity follows a similar exponential law:

$$\Delta I \ \alpha \ -I\,\Delta x$$

Where:
- ΔI = The change in intensity in passing through a thickness
- Δx = Measured in terms of the mass per unit area (kg/m^2)

Then has the dimension of m^2/kg (Bradley *et al*., 1989). The experimental arrangement consists of a source and a detector between which can be placed a thin slab of target of the experimental material. If I_0 is the particle intensity reaching the detector in the absence of the absorbing material and I is the value when the target of thickness d, containing n atoms per unit volume is present, the total cross-section б can be calculated using the expression:

$$\sigma = \frac{\Delta I}{I}.\frac{1}{nd} \quad (1)$$

$$= \frac{\text{Diminution in incident wave intensity}}{\text{Incident intensity}\times(\text{Target } \frac{\text{Nuclei}}{cm^2})}$$

If μ_{ab} is the absorption coefficient and is the scattering coefficient we can write (Tayal, 2009):

$$\mu = \mu_{ab} + \mu_{sc} \quad (2)$$

The corresponding mass absorption and mass scattering coefficients are obtained by dividing μ_{ab} and μ_{sc}, respectively by:

$$n = \frac{N_o\rho}{M} \quad (3)$$

Where:
- N_0 = The Avogadro number
- M = The atomic weight

If we write:

$$\sigma = \frac{\mu}{n} = \frac{\mu M}{N_0\rho} \quad (4)$$

$$\mu = \sigma n = \frac{\sigma N_0}{M}\rho \quad (5)$$

So, n measure in (m^{-3}), σ dimension of an area (m^2). σ is the cross-section for attenuation of the gamma rays. It has two parts:

$$\sigma = \sigma_{ab} + \sigma_{sc} \quad (6)$$

$$\sigma_{ab} = \frac{\mu_{ab}}{n} \text{ and } \sigma_{sc} = \frac{\mu_{sc}}{n}$$

Where:
- σ_{ab} = The cross-section for absorption
- σ_{sc} = The cross-section for scattering (Cunningham and Johns, 1980)

Experimentally one can measure the attenuation coefficient by plotting ln I as a function of the thickness x of material traversed. The graph should be a straight line of slope (-μ).

RESULTS AND DISCUSSION

We studied mass attenuation coefficient of (1-benzylbenzimidazole) Copper (II) by using gamma-rays for various energies 0.122, 0.360, 0.511, 0.662, 0.840 1.170, 1.275 and 1.330 MeV photons, the density of sample (ρ = 0.1508).

Mass (μ/ρ) attenuation coefficients (μ) for 0.122, 0.360, 0.511, 0.662, 0.840, 1.170, 1.275 and 1.330 MeV gamma-rays photons have been measured using the well-type scintillation spectrometer we can see experimental block diagram in fig.A. 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/ρ, thus, obtained are found to be in good agreement with the theory.

The effects are proven among the following tables and figures. From these Fig. 1-13 and Table 1-9, we found the mass attenuation coefficient as Slope. We calculate the deviation as comparison between theories and experimental values as showed down in Table 10.

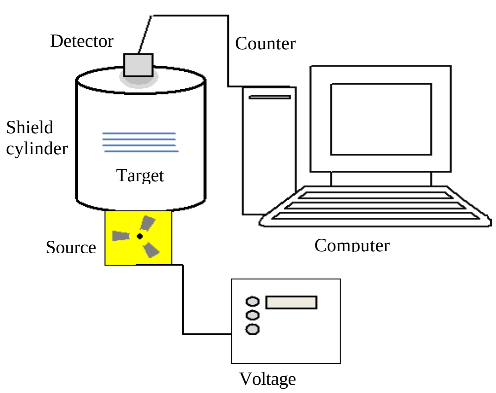

Fig. 1: Experimental block diagram

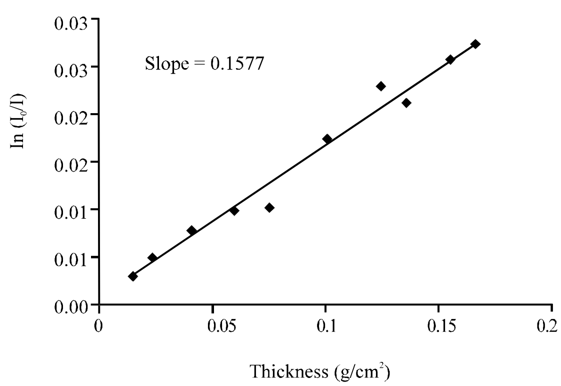

Fig. 2: Diagram between thickness in g/cm^2 and ln I_0/I for energy 122 (keV)

The attenuation coefficient data has used to obtain the Effective Atomic Numbers (Z_{eff}) and Effective Electron Densities (N_{eff}), Atomic Cross-section (σ_t) and Electronic Cross-section (σ_e) of Dinitratobis. It was observed that the effective atomic number (Z_{eff}) and effective electron

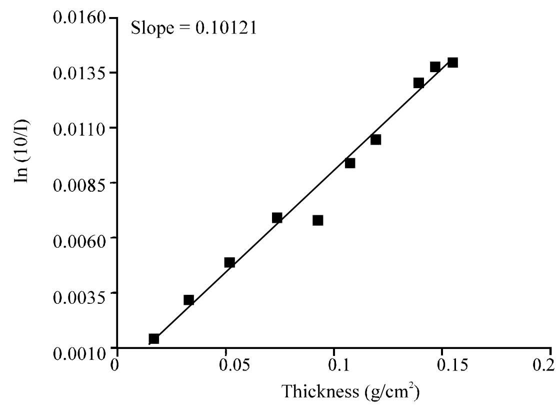

Fig. 3: Diagram between thickness in g/cm^2 and ln I_0/I for energy 356 (keV)

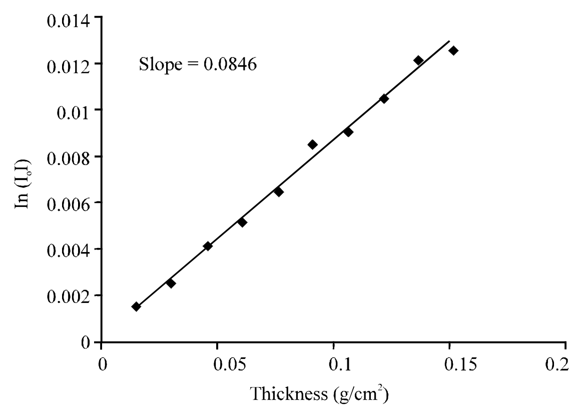

Fig. 4: Diagram between thickness in g/cm^2 and ln I_0/I for energy 511 keV

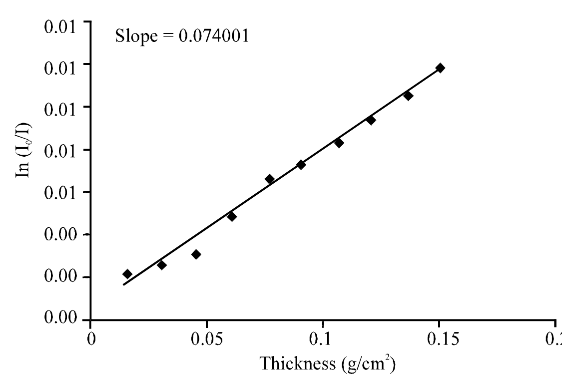

Fig. 5: Diagram between thickness in g/cm^2 and ln I_0/I for energy 622 (keV)

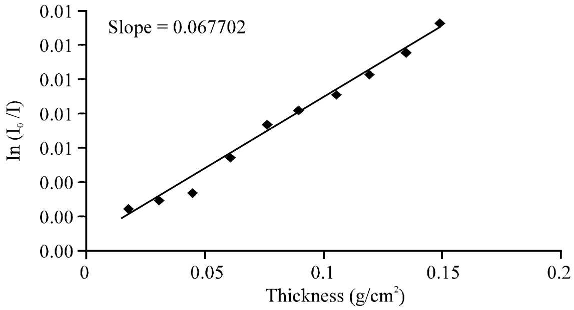

Fig. 6: Diagram between thickness in g/cm^2 and ln I_0/I for energy 840 keV

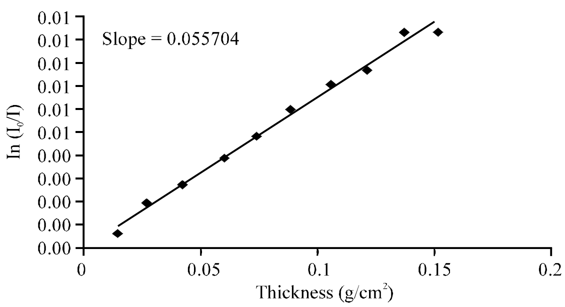

Fig. 7: Diagram between thickness in g/cm^2 and ln I_0/I for energy 1170 keV

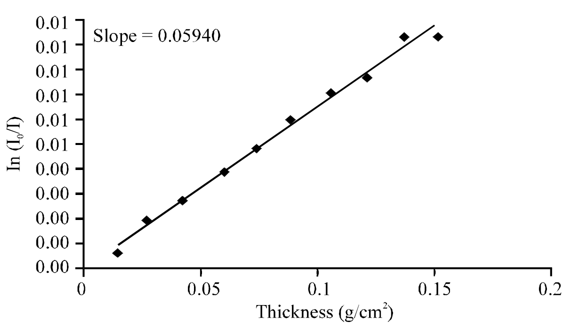

Fig. 8: Diagram between thickness in g/cm^2 and ln I_0/I for energy 1275 keV

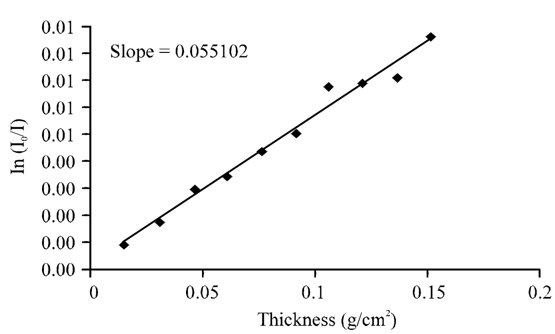

Fig. 9: Diagram between thickness in g/cm^2 and ln I_0/I for energy 1330 keV

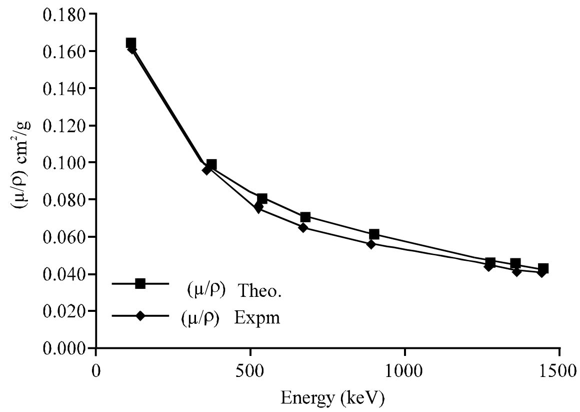

Fig. 10: Diagram between mass attenuation and energies for explain the deviation between theories and experimental values

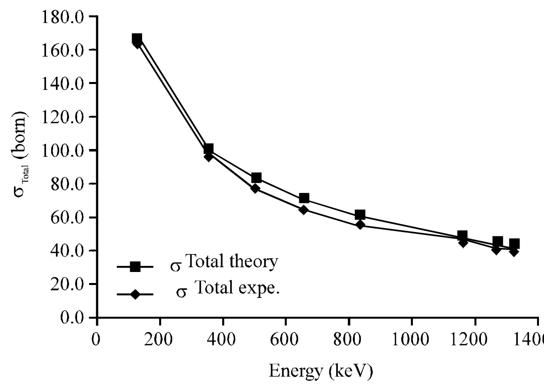

Fig. 11: Diagram between total cross section and energies from 122-1330 keV

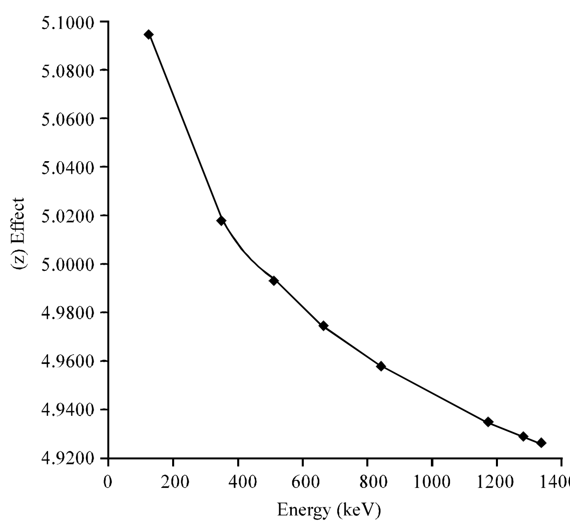

Fig. 12: Diagram between effective atomic number and energies from 122-1330 keV

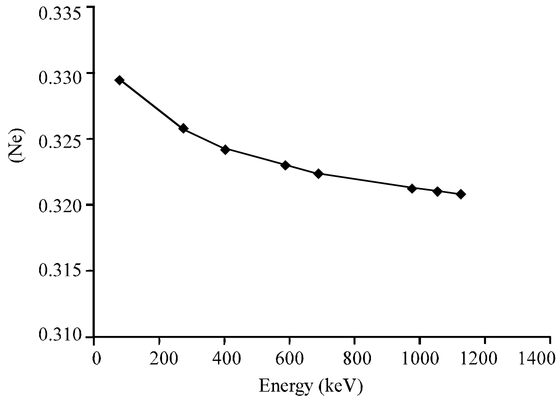

Fig. 13: Diagram between effective electron densities and energies from 122-1330 keV

Table 1: Mass attenuation coefficient of sample by using gamma ray source Co^{57} for energy 122 keV, I_0 = 18820

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	18773	1.002499	0.002496
0.2	0.03016	18720	1.005367	0.005353
0.3	0.04524	18678	1.007608	0.007579
0.4	0.06032	18657	1.008743	0.008705
0.5	0.0754	1648	1.009246	0.009203
0.6	0.09048	18538	1.015213	0.015098
0.7	0.10556	18449	1.020094	0.019895
0.8	0.12064	18495	1.017563	0.017411
0.9	0.13572	18426	1.021362	0.021137
1.0	0.1508	18374	1.024253	0.023964

Table 2: Mass attenuation coefficient of sample by using gamma ray source Ba^{33} for energy 356 keV, I_0 =15000

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	14977	1.001535	0.001534212
0.2	0.03016	14957	1.002888	0.00288424
0.3	0.04524	14937	1.004234	0.004225026
0.4	0.06032	14911	1.005955	0.005936848
0.5	0.0754	14917	1.005587	0.00557106
0.6	0.09048	14872	1.008626	0.008589053
0.7	0.10556	14851	1.010004	0.009953948
0.8	0.12064	14814	1.012582	0.012503696
0.9	0.13572	14793	1.013998	0.013900791
1.0	0.1508	14782	1.014782	0.014673421

Table 3: Mass attenuation coefficient of sample by using gamma ray source Na^{22} for energy 511 keV, I_0 =17356

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	17329	1.001554	0.001552723
0.2	0.03016	17311	1.002589	0.002585446
0.3	0.04524	17283	1.004237	00.00422817
0.4	0.06032	17264	1.005305	0.005290893
0.5	0.07540	17242	1.006636	0.006613616
0.6	0.09048	17207	1.008643	0.008606339
0.7	0.10556	17199	1.009143	0.009101591
0.8	0.12064	17174	1.010598	0.010541786
0.9	0.13572	17147	1.012192	0.012118451
1.0	0.15080	17140	1.012606	0.012527232

Table 4: Mass attenuation coefficient of sample by using gamma ray source Ca^{137} for energy 622 keV, I_0 = 17866

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	17826	1.002222	0.002219312
0.2	0.03016	17823	1.002402	0.002398625
0.3	0.04524	17813	1.002964	0.002959794
0.4	0.06032	17780	1.004819	0.00480725
0.5	0.0754	17749	1.006618	0.006596562
0.6	0.09048	17738	1.007193	0.007166874
0.7	0.10556	17721	1.008209	0.008175187
0.8	0.12064	17704	1.009136	0.009094499
0.9	0.13572	17682	1.010425	0.010371012
1.0	0.1508	17655	1.011954	0.011883124

Table 5: Mass attenuation coefficient of sample by using gamma ray source Mn54 for energy 840 keV, I0 = 17870

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	17847	1.001276	0.001274752
0.2	0.03016	17837	1.001851	0.001849503
0.3	0.04524	17812	1.003229	0.003224255
0.4	0.06032	17802	1.003826	0.003819006
0.5	0.0754	17771	1.005589	0.005573758
0.6	0.09048	17742	1.007224	0.00719851
0.7	0.10556	17736	1.007552	0.007523261
0.8	0.12064	17726	1.008131	0.008098013
0.9	0.13572	17710	1.009023	0.008982764
1.0	0.1508	17687	1.010374	0.010320975

Table 6: Mass attenuation coefficient of sample by using gamma ray source Co^{60} for energy 1170 keV, I_0 = 17893

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	17877	1.000915	0.000914753
0.2	0.03016	17848	1.002533	0.002529506
0.3	0.04524	17839	1.003049	0.003044258
0.4	0.06032	17822	1.003967	0.003959011
0.5	0.0754	17806	1.004886	0.004873764
0.6	0.09048	17786	1.006006	0.005988517
0.7	0.10556	17770	1.006907	0.006883270
0.8	0.12064	17763	1.007345	0.007318022
0.9	0.13572	17734	1.008973	0.008932775
1.0	0.1508	17735	1.008924	0.008884153

Table 7: Mass attenuation coefficient of sample by using gamma ray source Na^{22} for energy 1275 keV, I_0 = 17901

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	17885	1.000880	0.000879545
0.2	0.03016	17869	1.001797	0.001795109
0.3	0.04524	17851	1.002811	0.002806634
0.4	0.06032	17838	1.003508	0.003502179
0.5	0.07540	17812	1.004990	0.004977724
0.6	0.09048	17807	1.005267	0.005253269
0.7	0.10556	17792	1.006148	0.006128814
0.8	0.12064	17772	1.007236	0.007210436
0.9	0.13572	17760	1.007911	0.007879903
1.0	0.15080	17755	1.008228	0.008194545

Table 8: Mass attenuation coefficient of sample by using gamma ray source Co^{60} for energy 1330 keV, I_0 = 18010

Thickness T (cm)	T*ρ (g/cm^2)	(I)	(I_0/I)	ln (I_0/I)
0.1	0.01508	17995	1.000857	0.000856695
0.2	0.03016	17980	1.001655	0.001653390
0.3	0.04524	17956	1.002985	0.002980084
0.4	0.06032	17948	1.003431	0.003424779
0.5	0.07540	17933	1.004303	0.004293474
0.6	0.09048	17917	1.005163	0.005150169
0.7	0.10556	17890	1.006709	0.006686864
0.8	0.12064	17887	1.006877	0.006853558
0.9	0.13572	17884	1.007064	0.007039253
1.0	0.15080	17856	1.008604	0.008566948

Table 9: The deviation in values

Source	Energy γ (ke V)	(μ/ρ) theory	(μ/ρ) expm.	Deviation (%)
Co	122	0.1609	0.1577	2
Ba	356	0.1033	0.1012	2
Na	511	0.0890	0.0846	5
Cs	662	0.0795	0.0740	7
Mn	840	0.0713	0.0677	5
Co	1170	0.0607	0.0594	2
Na	1275	0.0581	0.0557	4
CO	1330	0.0568	0.0551	3

Table 10: The values of total cross section, effective atomic number and electron density

Source	Energy (keV)	Total theory	Total expe.	Deviation (%)	Z effect	Ne (1024 electrons g_{-1})
Co	122	161.3991	158.1711	2	5.0904	0.3298
Ba	356	103.6204	101.5480	2	5.0200	0.3253
Na	511	89.31620	84.85040	5	4.9964	0.3238
Cs	662	79.77670	74.19230	7	4.9796	0.3227
Mn	840	71.49110	67.91650	5	4.9643	0.3217
Co	1170	60.84820	59.63120	2	4.9429	0.3203
Na	1275	58.24010	55.91050	4	4.9374	0.3199
CO	1330	56.98620	55.27660	3	4.9347	0.3198

CONCLUSION

We studied the mass absorption coefficients values were measured for the (1-benzylbenzimidazole) Copper (II) by using gamma ray radiation (γ), emitted from deferent sources Co^{57}, Ba^{133}, Na^{22}, Cs^{137}, Mn^{54} and Co^{60} with energies from 122-330 keV. 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 absorption law

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