*Available online at* www.scholarsresearchlibrary.com

**Scholars Research Library**

**Archives of Physics Research, 2012, 3 (1):60-69**
*(http://scholarsresearchlibrary.com/archive.html)*

**ISSN : 0976-0970**
**CODEN (USA): APRRC7**

# Gamma Ray Photon Interaction Studies of Cu in the Energy Range 10keV to 1500keV

**Pravina P. Pawar**

*Department of Physics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra State, India*

---

**ABSTRACT**

*Measurements of mass (μ/ρ) and linear (μ) attenuation coefficients of Copper in the energy range 10keV to 1500keV have been carried out under narrow-collimated-beam method with HP (Ge) as a photon detector. The values of mass (μ/ρ) and linear (μ) attenuation coefficients thus obtained are found to be in good agreement with the values computed theoretically by J.H.Hubbell and S.M. Seltzer [Tables of X-Ray Mass Attenuation coefficients (1995)].*

**Keywords:** of mass (μ/ρ) and linear (μ) attenuation coefficients, HP (Ge) photon detector.

---

## INTRODUCTION

A scientific study of interaction of radiation with matter demands a proper characterization and assessment of penetration and diffusion of rays in the external medium. The attenuation coefficient is an important parameter, which is widely used in industry, agriculture, science, and technology, etc.The study of mass attenuation coefficient of various materials has been an important part of research in Radiation Chemistry and Physics.

With wide spread utilization of radiation and radioisotopes in medicine ,industry and basic sciences, the problem of radiation protection has become important aspect while handling radiation sources and radiation generating equipments. Selection of materials for radiation shielding and protection needs accurate assessment of interaction parameters. These parameters are of immense importance for photons being highly penetrating radiation as compared to particulate radiations.

Accurate values of photon interaction parameters like mass and linear attenuation coefficients in several materials are needed in solving various problems in radiation physics and other related areas. In the last few decades there has been an increasing interest in accurate measurements of attenuation coefficients of elements or compounds for X-rays and low-energy gamma-rays. This is mainly due to the fact that careful measurements of attenuation coefficients allow important information about the composition of materials or tissues, or at least allow discrimination between materials which have a very similar composition [1].

Although a number of experimental measurements are reported in the literature [2], the work therein actually carried out is limited to a few energy points and materials. Further, the experimental techniques used by different workers are not identical and hence it is difficult to intercompare the experimental results. A survey of other relevant measurements [3-13] reported shows that in many of these measurements the experimental results for the same elements at the same energies are somewhat inconsistent. Appreciable discrepancies between the experimental and theoretical values were observed in some of these measurements. It was therefore decided to carry out accurate measurements of photon attenuation data covering the 10-1500 keV energy range in Nickel and then determines from the attenuation data the interaction parameters like mass and linear attenuation coefficients.

In the earlier work, the photons were detected by organic scintillators and total absorption – proportional counters. The accuracy of the final results was limited by the poor efficiency of either of these detectors. A good photon detector with high-energy resolution characteristics as used in the present measurements is an essential requirement for higher accuracy. Solid-state detectors have the high-energy-resolution characteristics necessary for such measurements to be performed accurately. The present paper reports photon interaction parameters like mass ($\mu/\rho$) and linear attenuation coefficients ($\mu$) of Nickel in the energy range 10 keV to 1500 keV through photon transmission measurements perform under narrow-beam counting geometry with HP (Ge) as a photon detector.

## MATERIALS AND METHODS

The experimental setup used and the procedure followed were the same as described earlier [14].Transmission ratio $I_0/I$ for various thicknesses (gm/cm$^2$) of Cu foils at 279, 284, 355, 362, 637, 662, 834, 1170 and 1330keV as shown in Table1.

Where

$I_0$ = 3943 is the number of particles of radiation counted without absorber, and
I is the number of particles of radiation counted with absorber.

## Observation Tables

**Table1. $I_0/I$ for various thickness (gm/cm$^2$) and energies of Copper foils.**

| Thickness gm/cm$^2$ | $I_0/I$ 279 keV | 284 keV | 355 keV | 362 keV | 637 keV | 662 keV | 834 keV | 1170 keV | 1330 keV |
|---|---|---|---|---|---|---|---|---|---|
| 0.3596 | 1.08087 | 1.06625 | 0.99870 | 0.9862 | 0.8562 | 0.8516 | 0.8357 | 0.8039 | 0.7686 |
| 0.7192 | 1.08562 | 1.07089 | 1.00280 | 0.9902 | 0.8592 | 0.8546 | 0.8386 | 0.8065 | 0.7710 |
| 1.0788 | 1.13828 | 1.12208 | 1.04755 | 1.0338 | 0.8919 | 0.8869 | 0.8696 | 0.8352 | 0.7972 |
| 1.4384 | 1.16968 | 1.15259 | 1.07409 | 1.0597 | 0.9110 | 0.9058 | 0.8980 | 0.8520 | 0.8209 |
| 1.7980 | 1.20801 | 1.18980 | 1.10634 | 1.0910 | 0.9341 | 0.9286 | 0.9098 | 0.8722 | 0.8308 |
| 2.1576 | 1.21923 | 1.20067 | 1.11573 | 1.1002 | 0.9408 | 0.9352 | 0.9161 | 0.8780 | 0.8361 |
| 2.5172 | 1.30003 | 1.27895 | 1.18302 | 1.1655 | 0.9882 | 0.9821 | 0.9610 | 0.9191 | 0.8733 |
| 2.8768 | 1.35638 | 1.33344 | 1.22950 | 1.2106 | 1.0204 | 1.0139 | 0.9915 | 0.9469 | 0.8984 |
| 3.2364 | 1.44063 | 1.41478 | 1.29832 | 1.2773 | 1.0674 | 1.0602 | 1.0357 | 0.9872 | 0.9346 |
| 3.5960 | 1.44432 | 1.41835 | 1.30132 | 1.2802 | 1.0694 | 1.0622 | 1.0376 | 0.9890 | 0.9361 |

## RESULTS AND DISCUSSION

From Table 1 the graphs of the thickness vs.$I_0/I$ are plotted for the Copper foils at photon energies 279, 284, 355, 362, 637, 662, 834, 1170 and 1330keV respectively, as shown in Figures 1-9. Linear attenuation coefficient μ (cm$^{-1}$) and mass attenuation coefficient μ/ρ (cm$^2$/g) of Copper absorber at Photon energies from 10 to 1500keV are given in Table 2.

The linear and mass attenuation coefficients were calculated for Copper foils at various thicknesses by using gamma transmission measurements. It was observed that the experimental values of number of particles of radiation counted without absorber ($I_0$) per number of particles of radiation counted with absorber (I) were linearly increased with increasing thickness. Also it is observed by table 2 that as energy increases the value of linear and mass attenuation coefficients goes on decreasing.

The comparison of their measurements with the theoretical values [15] is done by calculating the Percentage deviation as:

$$\% \text{ deviation} = \frac{(\mu/\rho)_{theo} - (\mu/\rho)_{exp}}{(\mu/\rho)_{theo}} \times 100$$

These are also presented in the table 2 and the author found the deviation mostly below 1.5 % indicating thereby excellent agreement of the author's measurements with theory. Figure 1-9 shows plot of the thickness vs.$I_0/I$ for the Copper foils at photon energies 279, 284, 355, 362, 637, 662, 834, 1170 and 1330keV respectively. Using this graph, slope can be calculated and these slope is nothing but the ($\mu/\rho$) mass attenuation coefficient of element at that particular energy. And then the linear attenuation coefficient is obtained by multiplying the mass attenuation coefficient of the element by its density.

**Table2. Linear attenuation coefficient μ ($cm^{-1}$) and mass attenuation coefficient μ/ρ ($cm^2/g$) of Nickel absorber at Photon energies 279, 284, 355, 362, 637, 662, 834, 1170 and 1330 keV.**

| Sr.No. | Energy keV | μ ($cm^{-1}$) | μ/ρ ($cm^2/g$) |
|---|---|---|---|
| 1 | 279 | 1.092 a | 0.122 a |
| | | 1.074 b | 0.120 b |
| | | -1.675 c | -1.666 c |
| 2 | 284 | 1.056 a | 0.118 a |
| | | 1.056 b | 0.118 b |
| | | 0.000 c | 0.000 c |
| 3 | 355 | 0.904 a | 0.101 a |
| | | 0.904 b | 0.101 b |
| | | 0.000 c | 0.000 c |
| 4 | 362 | 0.877 a | 0.098 a |
| | | 0.877 b | 0.098 b |
| | | 0.000 c | 0.000 c |
| 5 | 637 | 0.635 a | 0.071 a |
| | | 0.627 b | 0.070 b |
| | | -1.276 c | -1.429 c |
| 6 | 662 | 0.627 a | 0.070 a |
| | | 0.618 b | 0.069 b |
| | | -1.456 c | -1.449 c |
| 7 | 834 | 0.600 a | 0.067 a |
| | | 0.600 b | 0.067 b |
| | | 0.000 c | 0.000 c |
| 8 | 1170 | 0.555 a | 0.062 a |
| | | 0.546 b | 0.061 b |
| | | -1.648 c | -1.639 c |
| 9 | 1330 | 0.501 a | 0.056 a |
| | | 0.492 b | 0.055 b |
| | | -1.829 c | -1.818 c |

*a (experimental)*
*b (Hubbell and Seltzer) values.*
*c (Percentage deviation)*

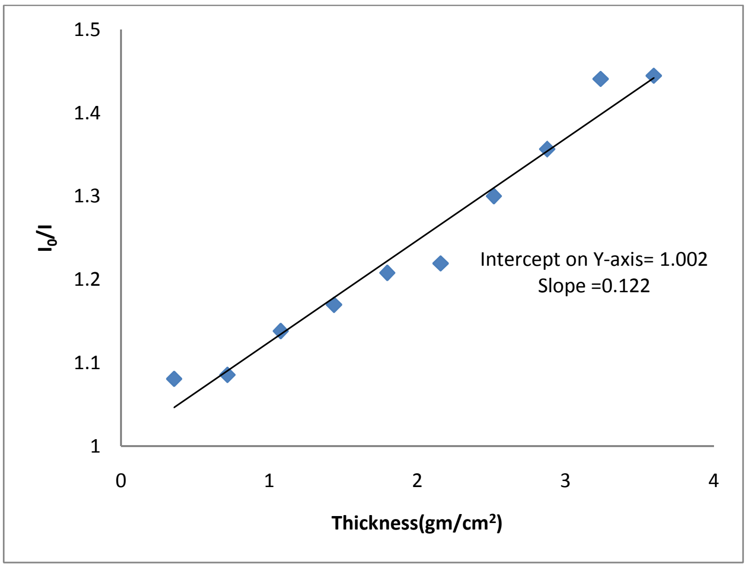


**Figure 1. Thickness vs.$I_0$/I for the Copper foil at 279 keV.**

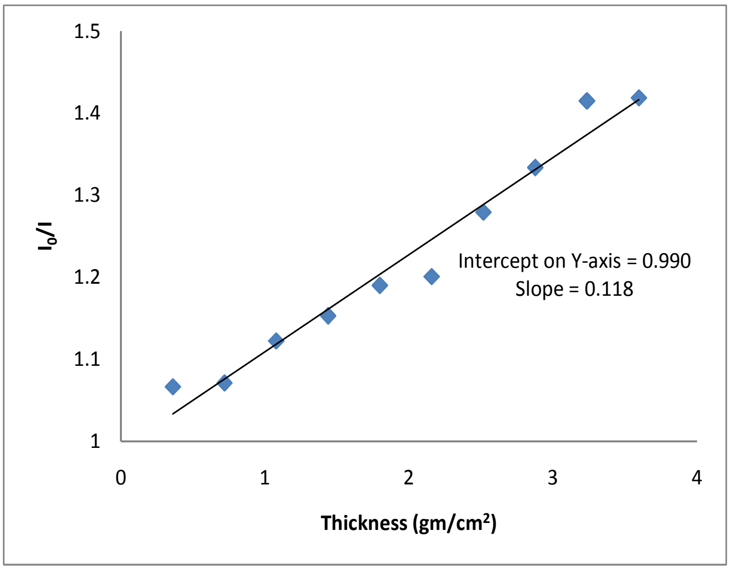


**Figure 2. Thickness vs.$I_0$/I for the Copper foil at 284 keV.**

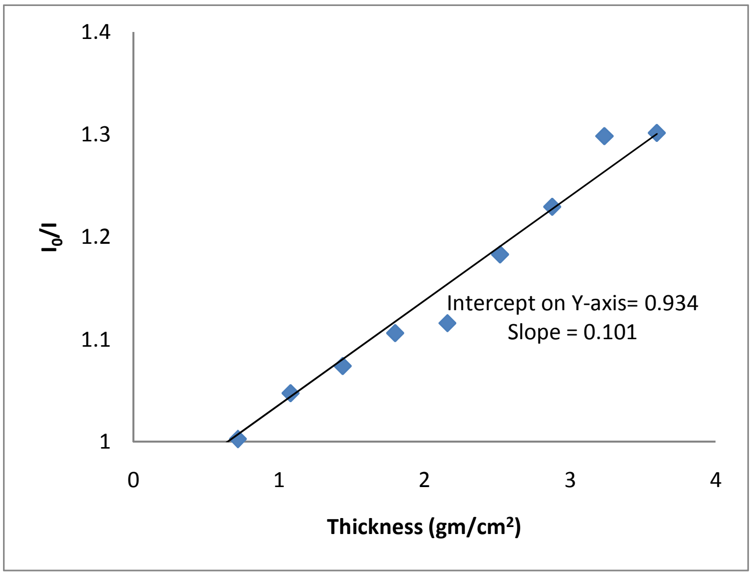


**Figure 3. Thickness vs.$I_0$/I for the Copper foil at 355 keV.**

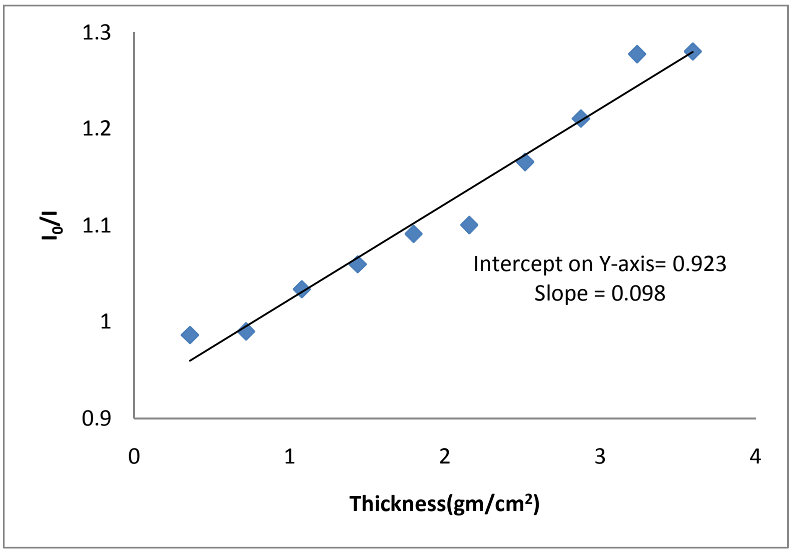


**Figure 4. Thickness vs.$I_0$/I for the Copper foil at 362 keV.**

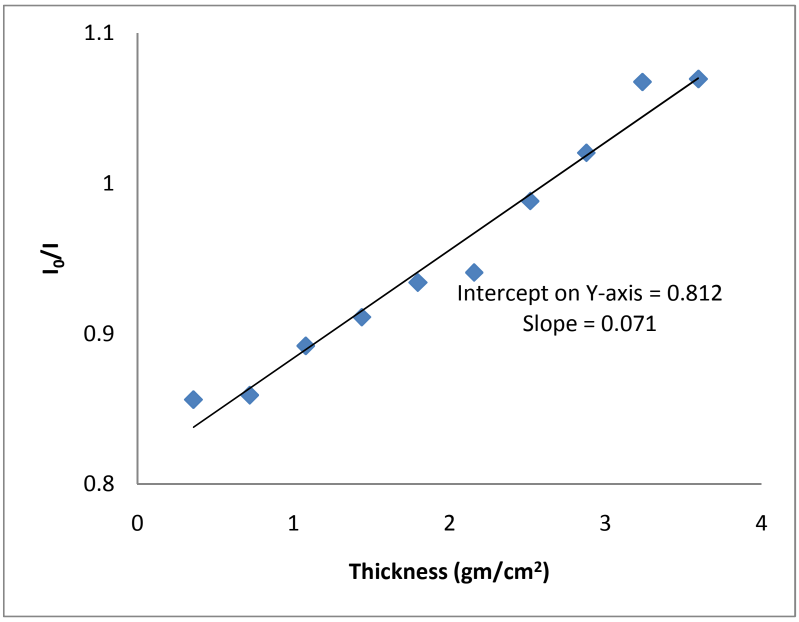


**Figure 5. Thickness vs.$I_0$/I for the Copper foil at 637 keV.**

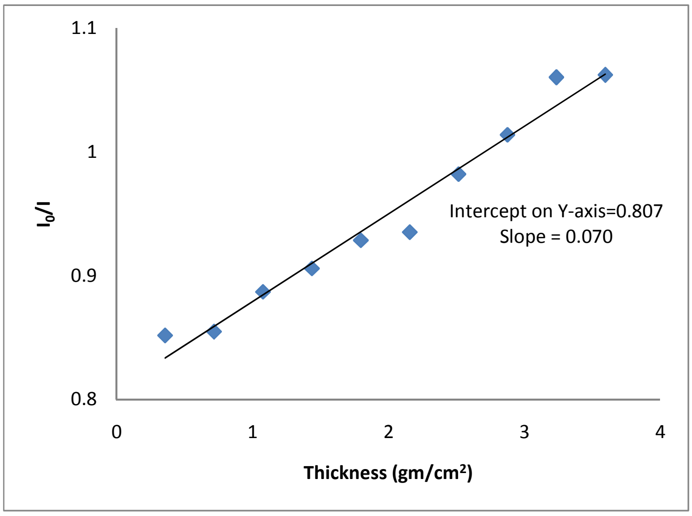


**Figure 6. Thickness vs.$I_0$/I for the Copper foil at 662 keV.**

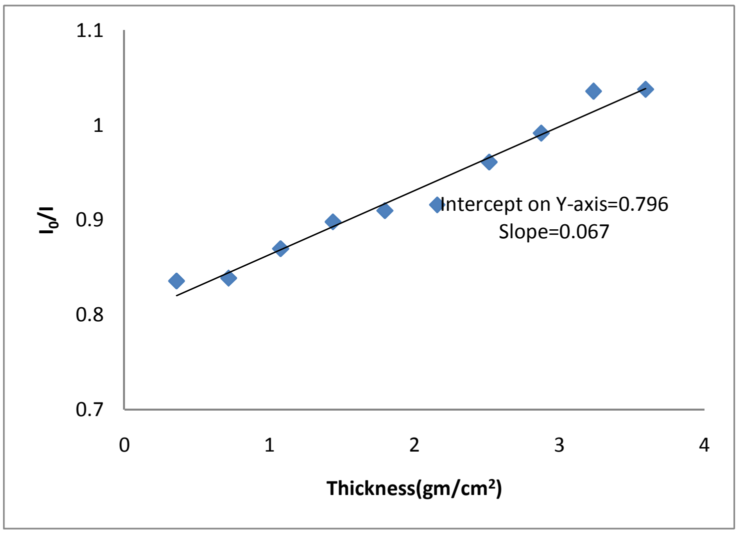


**Figure 7. Thickness vs.$I_0$/I for the Copper foil at 834 keV**.

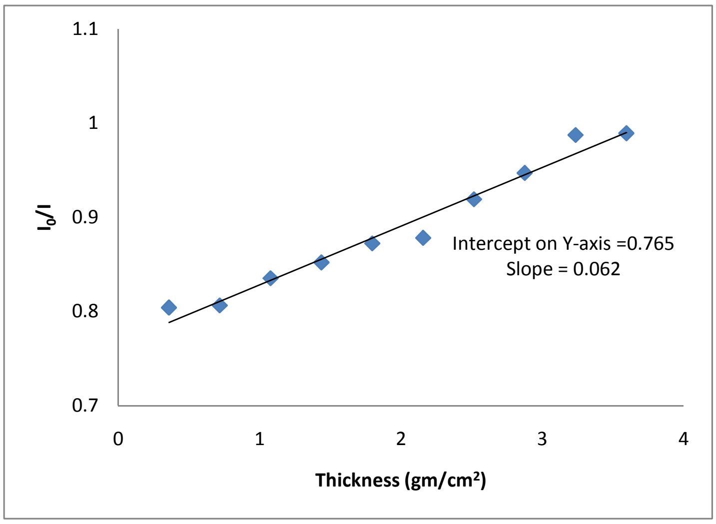


**Figure 8. Thickness vs.$I_0$/I for the Copper foil at 1170 keV.**

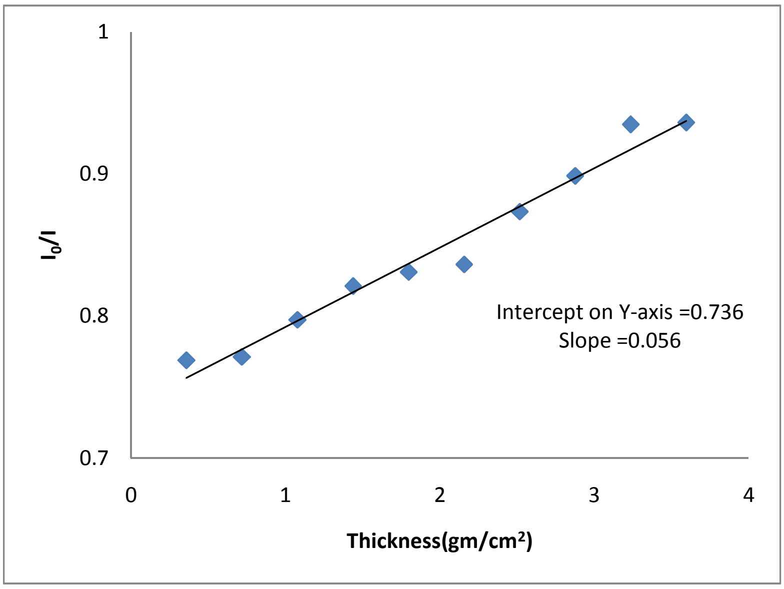


**Figure 9. Thickness vs.$I_0$/I for the Copper foil at 1330 keV.**

## CONCLUSION

The theoretical values of mass attenuation coefficient for element are available from [15] and the author carried out the work of their experimental measurement with excellent accuracy. The agreement of the author so measured values with theory confirms the theoretical considerations of the contribution of various processes such as photoelectric effect, the Compton scattering and the pair production. The measured mass and linear attenuation coefficients of element are useful for dosimetry and radiation shielding purpose.

From the results of the present study, it is observed that the errors quoted are due to mainly counting statistics, since the sample impurity corrections are negligible. The agreement seems to be good within experimental error. The mass attenuation coefficient $\mu/\rho$ of Nickel foils of various thicknesses have been studied by using gamma radiation in the energy range 10 keV to 1500 keV. The results have been presented in a graphical form from Figure 1-9.The increasing linear nature of graphs of number of particles of radiation counted without absorber ($I_0$) per number of particles of radiation counted with absorber (I) vs. the thickness of absorber are fitted by the least square method. The slope of these graphs gives the value of the mass attenuation coefficients. Then the linear attenuation coefficient ($\mu$) is obtained by multiplying the mass attenuation coefficient of the element by its density. The results are in good agreement [16-17].

**Acknowledgment**
The author Pravina P.Pawar is thankful to Dr. Govind K.Bichile for his fruitful discussion.

## REFERENCES

[1] E C McCullough Med.Phys.1975,2 307; Z.H.Cho, C.M.Tsai and G.wilson *Phys.Med.Biol*.20 879 **(1975)**

[2] K Parthasaradhi and H H Hansen *Phys Rev.* A, 10 563 **(1974)**
[3] S A Colgate *Phys.Rev*.87 592-01 **(1952)**
[4] Wyard S.J. *Phys.Rev*.87 165L **(1952)**
[5] P R Howland and W E Kreger *Phys.Rev*.95 407-10 **(1954)**
[6] S Shimizu, T Hanai and S Okamoto *Phys.Rev*.85 290-94 **(1952)**
[7] V Lakshminarayana and Jnanananda *J.Sci.Ind.Res*.B,20 1 **(1961)**
[8] R Quivy *J. Phys*. (Paris), 27 94-96 **(1966)**
[9] R C Murty *Proc.R.Soc.Lond*.84 1032-34. **(1964)**
[10] R P Knerr and H Z Vonach *Angew Phys*,22 507 **(1967)**
[11] M Wiedenbeck *Phys.Rev*. 126 1009 **(1962)**
[12] E H McCrary, Plassmann, J M Puckett,A L Conner and Zimmermann *Phys.Rev*.153 307-12 **(1967)**
[13] J L Perkin .and A C Douglas. *Proc.Phys.Soc.Lond*.92 618 **(1967)**
[14] P P Pawar and G K Bichile *J.Chem.Pharm. Res*.3 (6) 693-706 **(2011)**
[15] J H Hubbell and S M Seltzer Tables of X-Ray Mass Attenuation coefficients and Mass Energy-Absorption Coefficients **(1995)**
[16] P P Pawar *J. Chem. Pharm. Res,* 3(4) 899-903 **(2011)**
[17] P P Pawar and G K Bichile *J.Chem.Pharm.Res.* 3(5) 267-273 (**2011**)