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Gamma Ray Photon Interaction Studies of Zn in the Energy Range 360-1330keV photons.

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ABSTRACT

The linear attenuation coefficient (μ), mass attenuation coefficient (μ/ρ) were calculated for Zn element. The values of gamma ray mass attenuation coefficient were obtained using a NaI (Tl) detector using scientillation counter with radioactive gamma ray sources having energy 0.36,0.511,0.662,1.17,1.28 and 1.33 keV. The experimentally obtained values of μ andμ/ρ thus obtained are found to be in good agreement with the theory. Mass attenuation coefficient and linear attenuation coefficient of gamma rays photons of energy for 360- 1330 KeV in zinc have been determined experimentally through photon –transmission measurement performed under narrow collimated beam counting geometry with scintillation spectrometer as a photon detector. The Mass attenuation coefficient and linear attenuation coefficient values reported in this work are found to be in good agreement with the values computed theoretically. Mass attenuation coefficient and linear attenuation coefficient represent a subject of considerable interest and importance, since it is required in solving various problems in a radiation physic and radiation dosimetry and of interest for industrial, biological, agriculture and medial studies.

Keywords: Mass attenuation coefficients, linear attenuation coefficients, gamma rays, Zinc (Zn)

INTRODUCTION

Gamma-ray interaction process with matter have been used for determining mass attenuation and photon absorption coefficient for various materials [1] the absorption of gamma rays in solid and crystalline material has been the subject of numerous investigation [2]. Measurement of mass attenuation coefficient and energy absorption coefficient for gamma rays using different experimental technique [3] extended these techniques to the materials in the liquid form.

To study the effect of multi energetic gamma ray irradiation on absorption coefficients of increasing atomic number metallic thin foils. Experimental technique used above for measuring the linear and mass attenuation coefficient of metallic thin foils as a function of increasing gamma ray energies and increasing atomic number of foils. The gamma rays absorption coefficient smoothly decreases when the atomic number of sample increases for fixed gamma ray energy. the present experimental result will be compared with the theoretical result in the form of electromagnetic waves or energy emitted from a source is generally referred to as radiation comes from many sources such as nuclear fuel and medical procedures.

photon attenuation coefficients is an important parameter for characterizing the penetration and attenuation properties of x-ray and gamma rays in materials. Accurate data on photon attenuation coefficients are required in a verity of applications in nuclear science, technology and medicine [1]. Mass attenuation coefficients and linear attenuation coefficients are two quantities widely used in the study of interaction of x-rays with matter. The photoelectric effect, Compton scattering and pair production processes are the predominant interactions between the photons and atoms apart from other types over a wide range of energies by irradiating the material with gamma rays ionization of the material takes place and stored energy of the material increases [2]. Accurate values of photo electric cross section from photon radiation in several materials are needed in solving various problems in radiation physics and radiation dosimetry It is important to note that much of the data is related with theoretical work and only few experimental results are available for comparison. It is necessary to ensure that the theoretically predicated values do indeed agree with experimental results [3]. Extensive studies have been carried out for the determination gamma ray attenuation coefficients for various elements and photon energy [4-5, 7-10].

Interaction of radiation with matter:
Nuclear radiations (α, β, γ-rays) have been used for a long time and serious accidents leading to confirmed and suspected deaths of persons arising from direct and indirect effects of radiations have occurred. In different applications of radiations it is observed that, over-exposure is harmful and under-exposure is ineffective. Gamma rays and ultraviolet radiations, for instance, produce electrons through the well-known mechanism of photoelectric, Compton and pair production.

The gamma rays are highly penetrating and can therefore, reach easily in to the internal organs of the body. Therapy of deep-sited tumors is, therefore amenable to gamma rays. Gamma rays have different penetration depths in different materials. Lead is the most efficient absorber of gamma rays. Gamma ray shielding is usually described in terms of a parameter known as the half value layer (HVL) of the absorber. HVL is the absorber thickness that reduces the original gamma ray intensity I_0 to half, the transmitted intensity. I_t of the gamma ray beam from a material containing (n), HVL is given by [2].

Theory: The mass absorption coefficient is used alternatively with linear attenuation coefficient in calculation it is defined as,

$I = I_0\rho - \mu t$

$I = I_0\rho - \mu/\rho\ (\rho t)$ ---- (1)

as $$\mu = \frac{1}{t}\ln\left(\frac{I_0}{I}\right) \quad \text{-----} \quad (2)$$

and $$\mu/\rho = \frac{1}{\rho t}\ln\left(\frac{I_0}{I}\right) \quad \text{-----} \quad (3)$$

Where I and I_0 are intensities of gamma radiation of energy E transferred through the container respectively with and without absorber of thickness t then the linear (μ) and mass (μ/ρ) attenuation coefficient are given from the above experimental law.

MATERIALS AND METHODS

For the present study a good resolution NaI (Tl) detector is used for measurements. The present experimental arrangement can be identified as being of narrow beam attenuation geometry which avoids the scattered and the secondary radiations reaching from the detector. The gamma ray spectrometer will be calibrated using standard multi energy gamma sources. All the samples of elemental solids are thin uniform circular shaped of diameter 3cm for each irradiated samples material and for a given gamma ray energy we measure the number of gamma photons detected when we place the sample to be irradiated in the path of gamma rays, for different atomic number foils.

Table 1: Linear attenuation coefficient μ (cm^{-1}) and mass attenuation coefficient μ/ρ (cm^2/gm) of Zn absorber at photon energies 360, 511, 662, 1170, 1280, 1330 KeV.

Sr. No.	Energy KeV	μ(cm^{-1})	μ/ρ(gm/cm2)	% deviation
1	360	0.75	0.10	0.43
2	511	0.60	0.08	0.78
3	662	0.54	0.07	0.99
4	1170	0.36	0.05	1.06
5	1280	0.34	0.04	1.21
6	1330	0.38	0.05	0.85

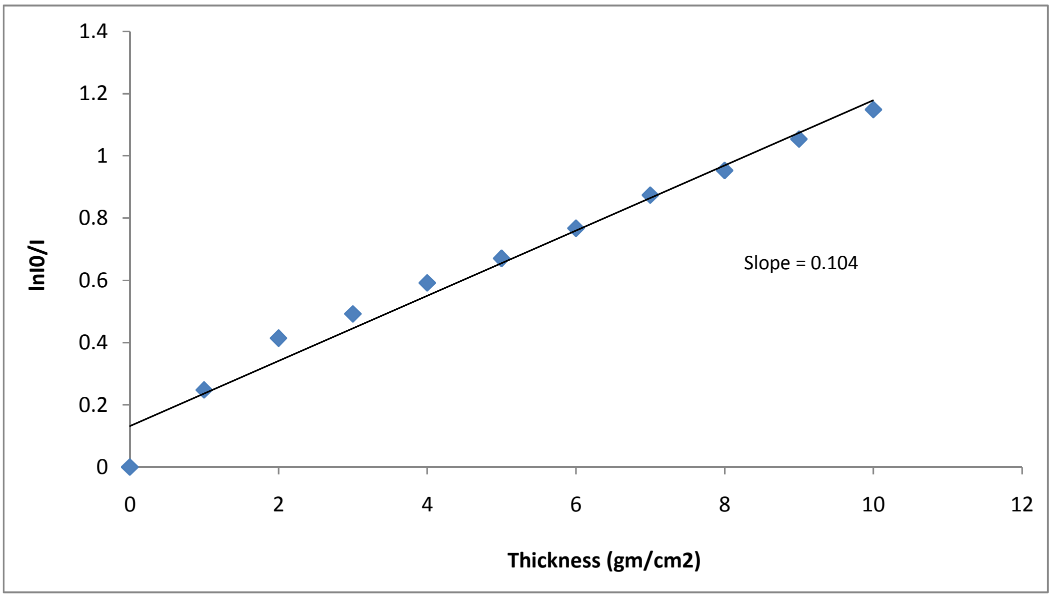

Fig.1 Thickness in gm/cm2 vs.ln I_0/I for zinc at 0.360 MeV.

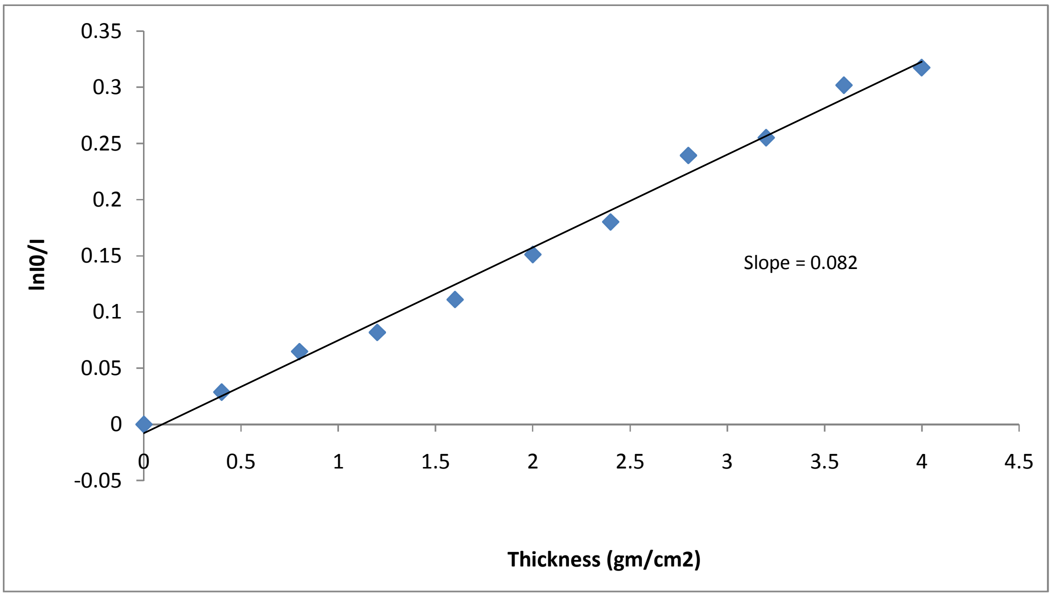

Fig.2 Thickness in gm/cm2 vs.ln I_0/I for zinc at 0.511 MeV.

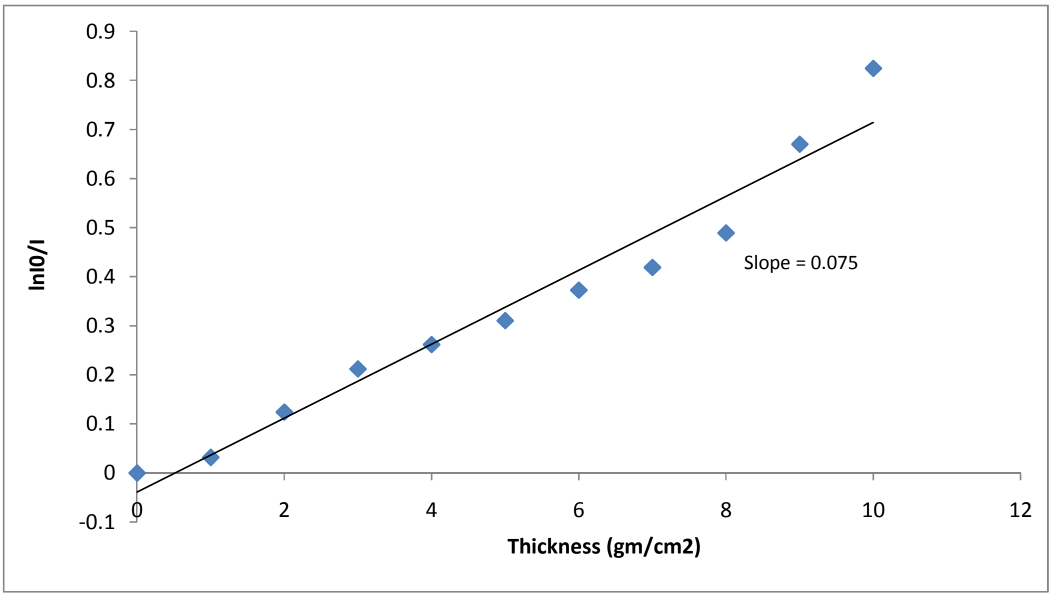

Fig.3 Thickness in gm/cm2 vs.ln I_0/I for zinc at 0.662 MeV.

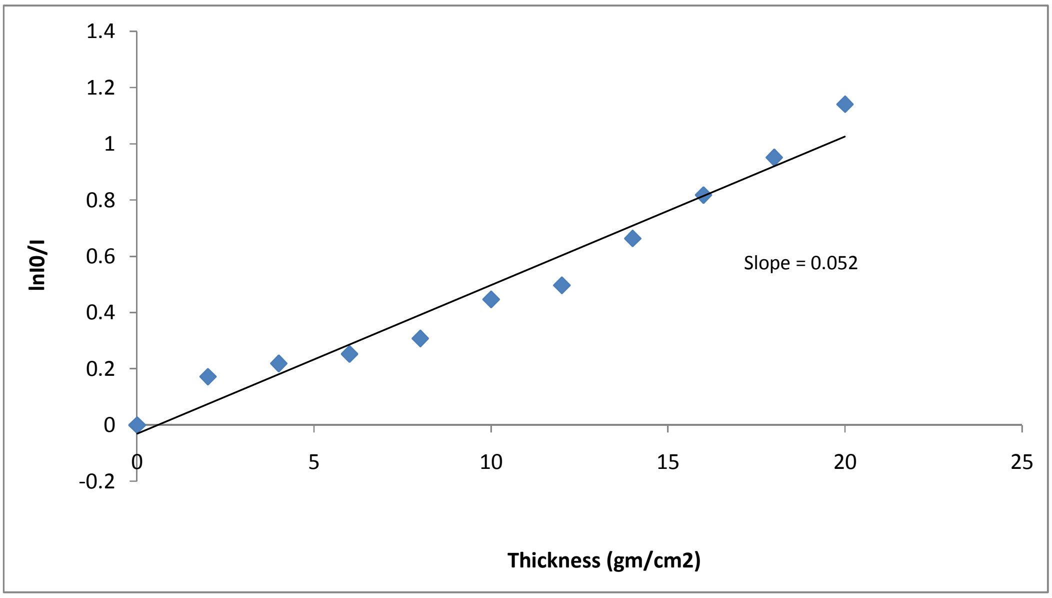

Fig.4Thickness in gm/cm2 vs.ln I_0/I for zinc at 1.170 MeV.

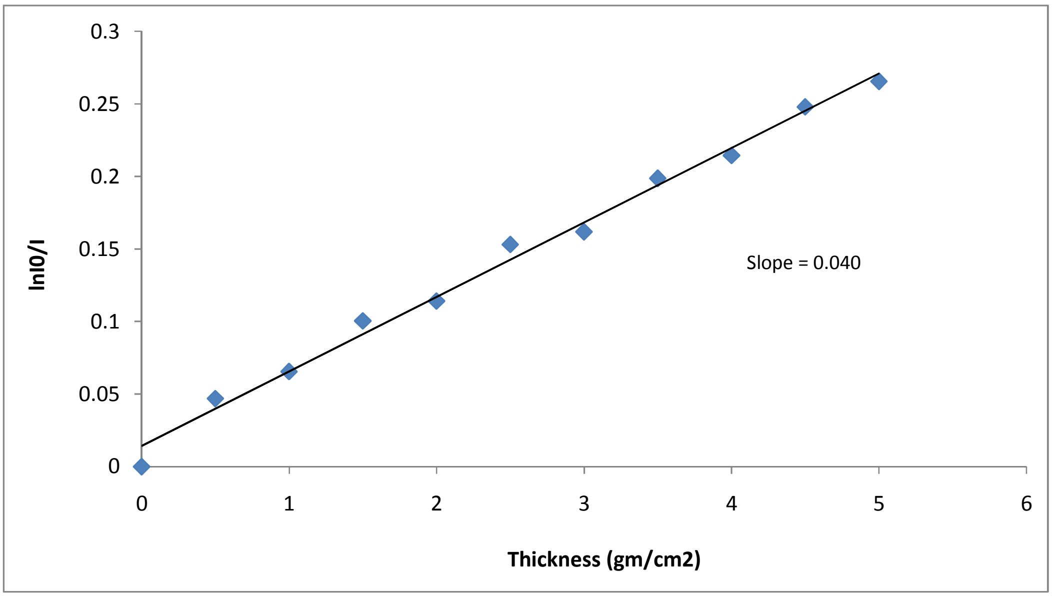

Fig.5Thickness in gm/cm2 vs.ln I_0/I for zinc at 1.1280 MeV

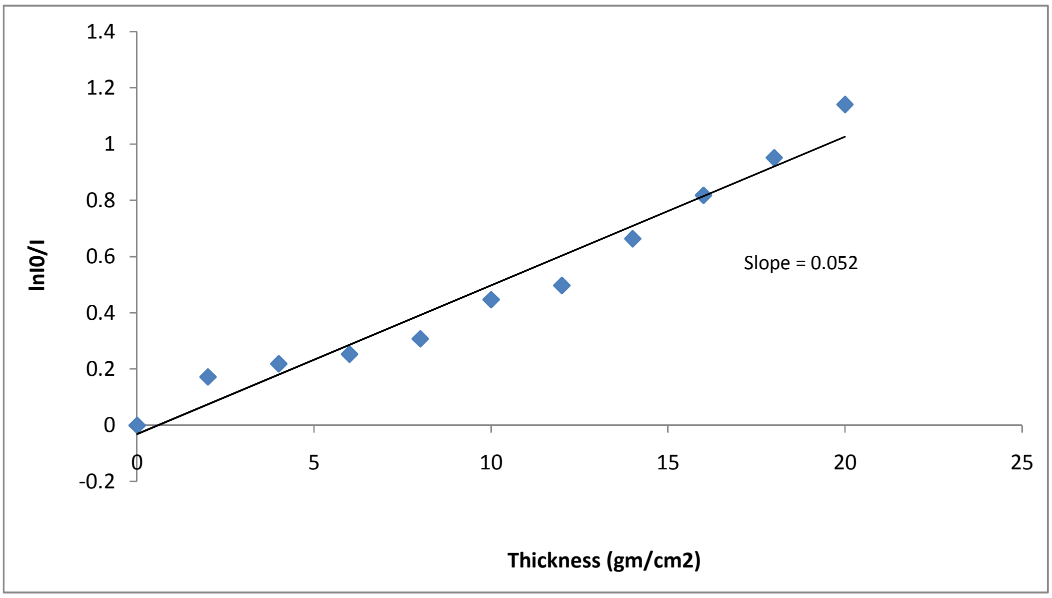

Fig.6Thickness in gm/cm2 vs.ln I_0/I for zinc at 1.330 MeV.

RESULTS AND DISCUSSION

Mass attenuation coefficient of elemental solids (Zn) absorber for multi gamma ray energies (Ba^{133},Na^{22}, Cs^{137}, Co^{60},) has been studied.

Various parameters such as linear attenuation coefficient (μ), mass attenuation coefficient (μ/ρ), photo-electric cross-section, total photon interaction cross section (σ_{tot}) have been obtained for elemental solids.

The comparison of their measurement with the theoretical values [6] is done by calculating the percentage deviation as,

$$\text{Percentage deviation} = \frac{\frac{\mu}{\rho}\,(\text{theor}) - \frac{\mu}{\rho}\,(\text{expt})}{\frac{\mu}{\rho}\,(\text{Theor})} \times 100$$

These are also presented in the Table 1 and the author found that the deviation mostly below 2% indicating these by excellent agreement of the authors measurements with theory. The linear attenuation coefficient is obtained by multiplying the mass attenuation coefficient of the element by its density. Fig. 1 to 6 shows plot of ln I_0/I v/s thickness (t) for Zn at 360, 511, 662, 1170, 1280 and 1330 keV using this graphs, slope can be calculated and this slope is nothing but the (μ/ρ) mass attenuation coefficient of element at that particular energy.

APPLICATIONS

The measured mass and linear attenuation coefficients of zinc are useful in medical field. The data is useful in radiation dosimetry and other fields.

CONCLUSION

The theoretical values of mass attenuation coefficient for element are available from [6] and the author so measured values with theory confirms the theoretical considerations of the contributions of various process such as photo electric effect, Compton scattering and the pair production. The measured mass and linear attenuation coefficient of elements are useful for dosimetry and radiation shielding purpose.

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