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Mass Attenuation Coefficients of Cr, Ni, Cu, and Ag elements (24 $\leq$ z $\leq$ 47) by Using Gamma Energy at 279.30 keV

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ABSTRACT
Mass attenuation coefficient for γ-ray photons of energy 0.279MeV in Cr, Ni, Cu, and Ag have been determined experimentally through photon-transmission measurements performed under narrow-beam counting geometry with HP (Ge) as a photon detector. The mass attenuation coefficient values reported in this work are found to be in good agreement with the values computed theoretically.

Keywords: Mass attenuation coefficient, HP (Ge) photon detector, Narrow-beam counting geometry.

INTRODUCTION

Mass attenuation and energy absorption coefficients are widely used in the study of interaction of γ-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 γ-rays, ionization of the material takes place and the stored energy of the material increases [1]. Extensive studies have been carried out to determine γ-ray attenuation coefficients for various elements and photon energy [2-4].

Accurate values of photoelectric cross sections for 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 based on theoretical work and only few experimental results are available for comparison. Such comparison is necessary to ensure that the theoretically predicted values do indeed agree with experimental results [5].Although a number of experimental measurements are reported in the literature [6-7], 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. It is, therefore, necessary to carry out accurate measurements of photon attenuation data. Therefore, in the present work accurate photon transmission measurements have been carried out under a narrow beam counting geometry employing high resolution HP (Ge) as a photon detector. The attenuation data has been used to obtain the photoelectric cross sections. Photoelectric cross sections are determined either by counting the photoelectrons emitted during photoelectric absorption or by detecting those photons which have not undergone any interaction within the material [8-9]. In the earlier work, the photoelectrons 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. In view of these facts, it was considered worthwhile to carry out accurate and systematic measurement of total photon cross sections, which form the basic input data for the calculation of photoelectric cross sections. Hence, in the present investigation, systematic measurements on the total photon cross sections at the energy point 279.30keV, using a high resolution photon detector is made and results are employed to extract photoelectric cross sections.

EXPERIMENTAL SECTION

In the present work the photoelectric-cross-section values for 279.30 keV photons are determined in four elemental solids of atomic numbers ranging from 24 to 47 through photon-transmission measurements. The monoenergetic photon radiation required for these measurements was derived from ^{203}Hg radionuclide .The source was procured as a sealed source from BARC, Trombay, Mumbai. The photon transmission measurements were done under a narrow beam counting geometry employing high resolution HP Ge solid state detector. The HPGe detector utilized in the present work is of 30.3 cc active volume and was obtained from EG2G, ORTEC USA. The detector was operated at liquid nitrogen temperature and had a good stability of the order of 0.01 % over the entire range of photon energy. The energy resolution of the detector at 279.30 keV from ^{203}Hg was about 3.3% with full width at half maxima (FWHM) being 180 eV.

The experimental set up used in the present work as shown in figure1. The experimental system consists mainly of two aluminum collimators of about 12 cm long, having internal and external diameters of 10 and 60 mm, respectively. These collimators were internally lined with 4 mm-thick perspex so as to provide a scatter-free collimated photon beam 2mm in diameter. With the present experimental system, it was established from the photon spectrum that the energy of transmitted photons did not change appreciably due to scatter or fluorescent radiation from the collimators. A provision was made midway between the collimators to introduce absorbers which were in the form of thin foils. The entire system was arranged vertically over the HP (Ge) detector, ensuring that the central axis of the collimators coincided with the central axis of the detector.

Radioactive source of ^{203}Hg had thin beryllium windows for the exit of photon radiations. The source was kept in a lead container which was provided with an aperture for the exit of photons. The source container assembly was then kept over the collimator so as to allow a narrow, well-collimated photon beam from the collimator incident normally on the absorbers. The source and the detector were well aligned with the collimators. The incident energy of photon radiations from the source was known accurately from the photon spectrum. The chosen absorbers include thin and uniform foils of high purity of chromium, nickel, copper, and silver. These foils were weighed accurately using a digital balance, and from their measured area the thickness proportional to the areal density in g cm^{-2} was determined. The absorbers had varying thicknesses of a few mg cm^{-2}and higher thicknesses were obtained by stacking the foils together.

The presently used absorbers are uniform sheets of Cr, Ni, Cu, and Ag. These sheets/foils were weight accurately and from their measured area, the thickness (t) in gm/cm^2 was determined in each case. The absorbers had varying thicknesses of a few mg/cm^2. The higher values of thickness were obtained by stacking required number of foils together. The absorbers used were of nuclear grade of specified purity of the order of 99.95%. No further attempts were made to ascertain the purity of these absorbers.

The schematic experimental set-up is as shown in Figure 1.

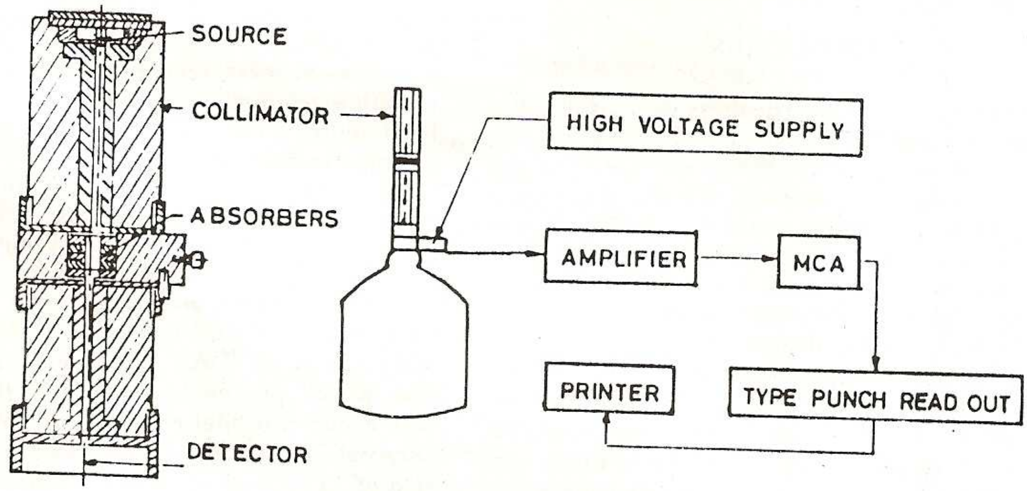

Figure. 1 Block diagram of photon counting system.

Counts recorded for various thicknesses (gm/cm^2) at 0.279 MeV as shown in Table1.

Number of particles of radiation counted without absorber (I_0) = 3943.

Table1. Counts per 100 second for Chromium foil

Sr.No	Thickness gm/cm^2	Trial I	Trial II	Trial III	Mean (I)	I_0/I
1	0.05	4052	4036	3994	4027	0.97906
2	0.1	4002	4057	4117	4058	0.97150
3	0.15	4043	4033	4019	4031	0.97800
4	0.2	3980	3866	3913	3919	1.00595
5	0.25	3963	3998	3967	3976	0.99170
6	0.3	3964	3920	3834	3906	1.00947
7	0.35	3742	3900	3811	3817	1.03283
8	0.4	3818	3833	3810	3820	1.03210

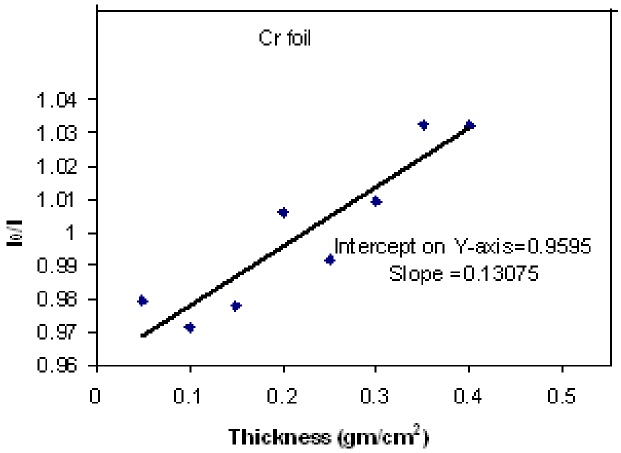

Figure 2.The thickness vs.I_0/I for the Chromium foil

Table2. Counts per 100 second for Nickel foil

Sr.No	Thickness gm/cm^2	Trial I	Trial II	Trial III	Mean (I)	I_0/I
1	0.05	3933	4013	3898	3948	0.99873
2	0.10	3993	3961	3759	3904	1.00998
3	0.15	3833	3769	3909	3837	1.02762
4	0.20	3821	3933	3867	3873	1.01807
5	0.25	3939	3882	3911	3910	1.00843
6	0.30	3803	3758	3658	3739	1.05456
7	0.35	3709	3674	3674	3685	1.07001
8	0.40	3694	3707	3686	3695	1.06711
9	0.45	3690	3636	3671	3665	1.07585
10	0.50	3730	3634	3648	3670	1.07438

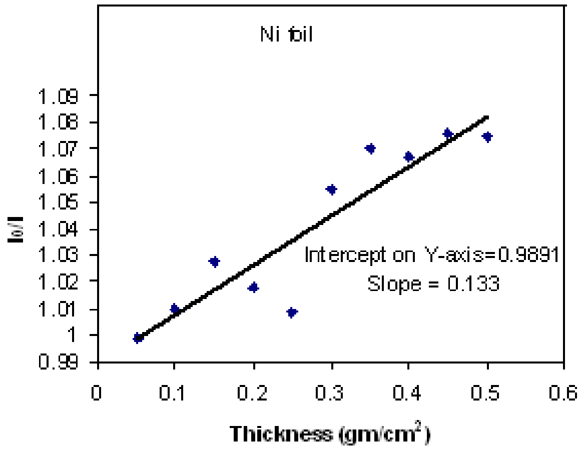

Figure 3.The thickness vs.I_0/I for the Nickel foil

Table3. Counts per 100 second for Copper foil

Sr.No	Thickness Gm/cm2	Trial I	Trial II	Trial III	Mean (I)	I_0/I
1	0.3596	3906	3813	3976	3898	1.01154
2	0.7192	3803	4009	3836	3882	1.01554
3	1.0788	3780	3777	3586	3714	1.06165
4	1.4384	3615	3623	3626	3621	1.08892
5	1.7980	3575	3581	3387	3514	1.12208
6	2.1576	3550	3515	3388	3484	1.13174
7	2.5172	3367	3261	3221	3283	1.20103
8	2.8768	3234	3226	3013	3157	1.24897
9	3.2364	3033	3014	2914	2987	1.32005
10	3.5960	3062	2899	-	2980	1.32315

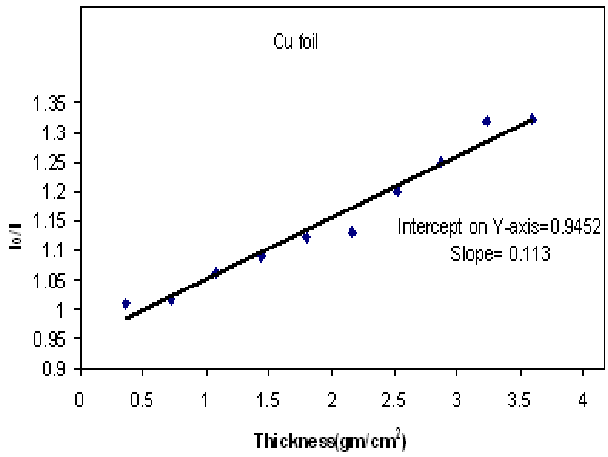

Figure 4.The thickness vs.I_0/I for the Copper foil

Table 4. Counts per 100 second for Silver foil

Sr.No	Thickness gm/cm^2	Trial I	Trial II	Trial III	Mean (I)	I_0/I
1	0.05	3975	4015	4005	3998	0.98624
2	0.1	3996	4036	-	4016	0.98182
3	0.15	3982	4005	4002	3996	0.98673
4	0.2	4025	3917	3997	3979	0.99095
5	0.25	4078	3956	3913	3982	0.99020
6	0.3	4002	3930	3954	3962	0.99520
7	0.4	3827	3827	-	3827	1.03031

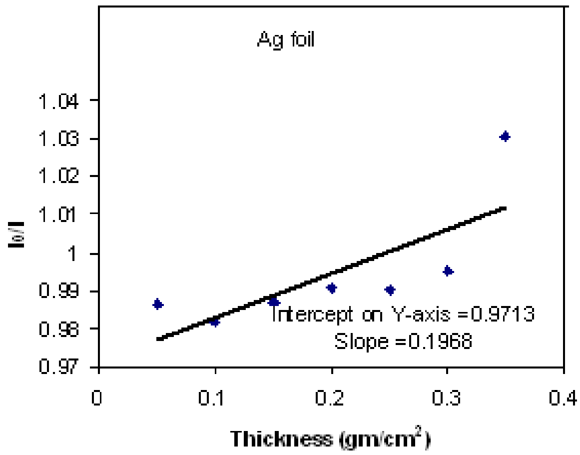

Figure 5.The thickness vs.I_0/I for the Silver foil

RESULT AND DISCUSSION

The linear and mass attenuation coefficients were calculated for various elements ($24 \leq z \leq 47$) 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 that as density increases mass attenuation coefficients values also increases.

CONCLUSION

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 coefficients μ/ρ of various elements ($24 \leq z \leq 47$) have been studied by using gamma radiation at energy 279.30 keV.The results have been presented in a graphical form from Figure 2-6.

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 linear attenuation coefficient μ can be calculated by using density of that element. The results are in good agreement [10-11].

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REFERENCES

[1] F S Terra Mod.Phys. Lett. B8 28 **1997,** 1781.
[2] C M Davison; R D Evans Phys Rev. 81 **1951,** 404.
[3] A L Conner; H F Atwater E H Plassm, Ann *Phys Rev* A1 **1970,** 539.
[4] B Goswami and N Chaudhari, *Phys Rev* A7 **1973,** 1912.
[5] U Turgut; O Simsek; E Buyukkasap, *Pramana* 69 **2007,** 2199.
[6] J H Scofield *Lawrence Livermore Laboratory Report No.***1973,** *UCRL* 51326, (unpublished).
[7] K Parthasaradhi; H H Hansen Phys Rev. A 10 **1974,** 563.
[8] V R K Murthy; K.S Rao; K Parthasaradhi; S.R. Rao; V Lakshminarayanan, *J.Phys. B* 10 **1977,** 3189.
[9] P R Sasi; V L Narayana; K Parthasaradhi; K L Narasimhan; S B Reddy; K V Ramaniah, *Nucl Instrum Methods A* 256 **1987,** 373.
[10] J H Hubbell ;S. M. *Seltzer NISTIR* **1995,** 5632 .
[11] P P Pawar, *J.Chem.Pharm.Res.*,3(4): **2011**,899-903.