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RESEARCH ARTICLE OPEN ACCESS

Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}$ $(Cu_xZn_{0.8-x})$ Fe_2O_4 with five different combinations of Cu and Zn

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ABSTRACT: The total photon cross sections were measured using gamma ray spectrometry based on NaI(Tl) scintillation detector at various energies with good collimated geometrical setup, in the gamma ray spectrometer with multichannel analyser experiment. In the present study the synthesized Nano material such as Magnesium doped with Cu and Zn invarious percentages were chosen. To prepare sample, we have chosen citrate gel auto combustion method. Because, by using citrate gel auto combustion method we can synthesize bulk amount of material for sample preparation. The cross sections for synthesized Nano material were extracted at five photon energies 30.85 KeV, 42 KeV, 59.54 KeV, 512 KeV, 661.6KeV. The results are compared with theoretical values by using XCOM programme.

Keywords: Total photon, Mg synthesized Nano, citrate-gel auto combustion, scintillation.

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I. INTRODUCTION:

In the recent days the study of photon cross sections of metals have tremendous uses in the area of industrial, medical, aeronautical and so on. So that, the study of total photon cross section has taken important role in research area. So far the literatures have shown so many studies on various metals and metal oxides, even though some studies are missing. Were, in the article we have reported the values of Total photon cross sections of synthesized Nano material at different energies, i.e., 30.85 KeV, 42 KeV, 59.54 KeV, 512 KeV, 661.6 KeV.

To prepare sample we have adopted the citrate-gel auto combustion method. The synthesized sample which was Magnesium doped with Cu and Zn in different percentages. The general formula for synthesized Nano material is $\mathbf{Mg_{0.2}(Cu_xZn_{0.8-x})Fe_2O_4}$. After successfully synthesized material samples by using Citrate-gel auto combustion method we have taken to carry out total photon cross section experiment by using different energy gamma ray sources and NaI(Tl) Scintillation Detector. The block diagram of experiment was shown below.

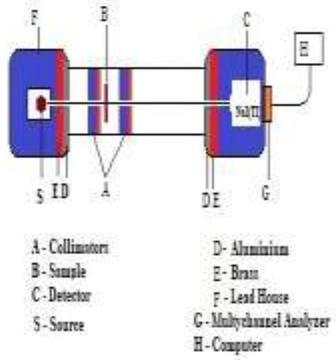


Figure.1: Block diagram of good geometrical experimental setup.

In this study we used the different radioactive isotopes as sours of gamma ray. They are listed in the table.(a) below along with their energies and their half life time.

Sl.No:	Radioisotope	Energy of the Photons selected in KeV[a]		Half-life Time
		X-Rays	γ-Rays	
1	^{241}**Am**	--	59.54	433 Years
2	^{133}**Ba**	30.85	81	10.7 Years
3	$^{(142+154)}$**Eu**	42	--	16.0 Years
4	^{141}**Ce**	--	145.4	32.5 Days
5	^{137}**Cs**	32.1	661.6	30.17 Years
6	^{60}**Co**	1173	1332	5.27 Years
7	^{22}**Na**	511	1270	2.6 Years

[a]C.M. Ledere and V.S. Shily. Tables of Isotopes Wiley New Yark

Table.(a): Radio Isotopes and photon energies used in the present work.

These Gamma ray radioactive sources are Europium (152+154Eu), Barium (133Ba) Cerium(^{141}Ce), Sodium(^{22}Na), Cobalt(^{60}Co) and Cesium (^{137}Cs) which was obtained from BRIT, Bhabha Atomic Research Centre, Trombay Mumbai, India. And from the isotope division Americium Laboratories, Americium, Buckinghamshire, England, U.K we bought Americium (241Am) of strength 30mCi. For X-energies the sources were prepared by drop deposition and evaporation of a liquid source of high specific activity,. In the method a small cylindrical grove drilled in Perspex container. The source is covered on the top with a thin Mylar foil to avoid contamination.

II. ANALYSIS OF EXPERIMENTAL DATA:

To analyse the obtained data, were used the standard formulas and Compared with theoretical values of XCOM programme.

$I_0 = I\ \mathbf{exp}(-\mu_{\mathbf{m}} t)$ …….. **(1)**

Where, I_0 andI are the un-attenuated and attenuated photon intensities respectably.

Sample thickness is $\mathbf{t(g/cm^2)}$.

The mixture rule will give the total mass attenuation coefficient $\boldsymbol{\mu_m}$.

$\boldsymbol{\mu_m} = \Sigma_i \mathbf{W_i}(\mu_m)_{\mathbf{i}}$ **……… (2)**

W_i – is the weight fraction, μ_m –is the mass attenuation coefficient of ithelement.

For a material composed of multi element the fraction by weight is given by,

$\mathbf{w_i} = {}^{n_i}\!/_{\sum_i \mathbf{n_i A_i}}$ **..……. (3)**

A_i – is the atomic weight of the i^{ith} element and $n_i$is the number of formula units.

The total atomic cross-section ($\boldsymbol{\sigma_t}$) for material can be obtained from the measured values of $\boldsymbol{\mu_m}$ using the following relation,

$\boldsymbol{\sigma_t} = {}^{\mu_m \mathbf{N}}\!/_{\mathbf{N_A}}$ **…………(4)**

Where $\mathbf{N} = \sum_i \mathbf{n_i A_i}$ atomic mass of materials, $\mathbf{N_A}$is the Avagadro's number.

The total electronic cross-section (σ_e) for the element is expressed by the following equation

$$\sigma_e = \frac{1}{N_A}\sum \frac{f_i N_i}{Z_i}(\mu_m)_i = \frac{\sigma_i}{Z_{eff}} \qquad (5)$$

Where f_i denotes the fractional abundance of the element I with respect to the number of atoms such that f1+f2+f3+f4+….fi =1 Z_i is the atomic number of ith element

The total atomic cross-section (σ_t) and total electronic cross-section (σ_e) are related to the effective atomic number (Z_{eff}) of the material through the following relation

$$Z_{eff} = \frac{\sigma_t}{\sigma_e} \qquad (6)$$

Finally, the average distance between two successive interactions, called the photon mean free path (λ), is given by

$$\lambda = \frac{\int_0^\infty x\ \exp(-\mu x)dz}{\int_0^\infty \exp(-\mu x)dx} = \frac{1}{\mu} \qquad (7)$$

Where (μ_l) is the linear attenuation coefficient and x is the absorber thickness.

The statistical errors are limited to 1 percentage by collecting a sufficient number of counts under the photo peak for the selecting of interest. The introduced overall errors on the total photon mass attenuation coefficients are thus around two percentages.

III. RESULTS AND DISCUSSION:

The synthesized nano material which is Magnesium doped with Cu and Zn mixtures are$\mathbf{Mg_{0.2}(Cu_{0.0}Zn_{0.8})Fe_2O_4}$, $\mathbf{Mg_{0.2}(Cu_{0.2}Zn_{0.6})Fe_2O_4}$, $\mathbf{Mg_{0.2}(Cu_{0.4}Zn_{0.4})Fe_2O_4}$, $\mathbf{Mg_{0.2}(Cu_{0.6}Zn_{0.2})Fe_2O_4}$, $\mathbf{Mg_{0.2}(Cu_{0.8}Zn_{0.0})Fe_2O_4}$. These samples are synthesized by using well developed citrate gel auto combustion method, because, it is an easy process to synthesize bulk amount of sample material and cheap in cost.

Where, the total photon cross sections are extracted at five energies. The experimental values which are obtained from scintillation NaI(TI) detector and compared with theoretical values from XCOM, they are good agreed with each other. The graphs were drawn between energies of theoretical

values from XCOM versus the obtained values of present experiment.
Here we report the data with help of graphs are:

Table.3.1: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.0}Zn_{0.8})Fe_2O_4$ general formula is $Mg_{0.2}(Cu_xZn_{0.8-x})Fe_2O_4$

S.No	Energy in KeV	Total Photon Cross Sections in (gm/cm^2) X 10^2	
		Theoretical Values from XCOM	Practical Values
1	30.85	663.9	652.4
2	42	268.8	254.7
3	59.54	948.5	932.7
4	512	0.1639	0.1576
5	661.6	0.08648	0.07989

Graph.3.1: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.0}Zn_{0.8})Fe_2O_4$

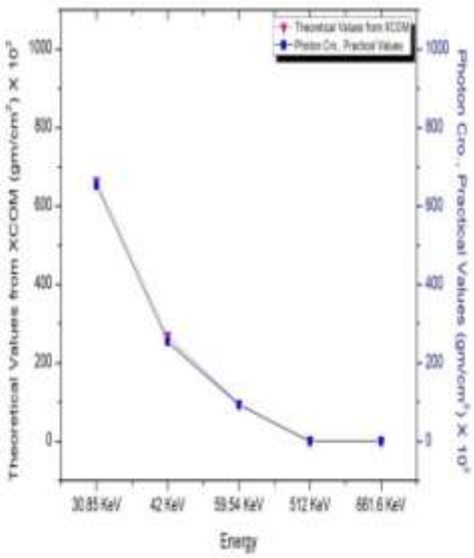


Table: 3.2. Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.2}Zn_{0.6})Fe_2O_4$ general formula is $Mg_{0.2}(Cu_xZn_{0.8-x})Fe_2O_4$

S.No	Energy in KeV	Total Photon Cross Sections in (gm/cm^2) X 10^2	
		Theoretical Values from XCOM	Practical Values
1	30.85	653.4	642.7
2	42	264.3	252.7
3	59.54	93.21	92.89
4	512	0.1606	0.1547
5	661.6	0.08472	0.08393

Graph.3.2: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.2}Zn_{0.6})Fe_2O_4$

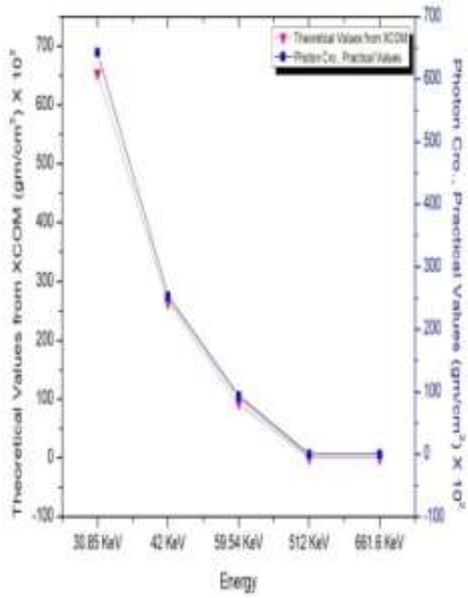


Table: 3.3: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.4}Zn_{0.4})Fe_2O_4$ general formula is $Mg_{0.2}(Cu_xZn_{0.8-x})Fe_2O_4$

S.No	Energy in KeV	Total Photon Cross Sections in (gm/cm^2) X 10^2	
		Theoretical Values from XCOM	Practical Values
1	30.85	642.9	637.6
2	42	259.9	248.7
3	59.54	91.56	90.97
4	512	0.1572	0.1497
5	661.6	0.08296	0.08176

Graph.3.3: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.4}Zn_{0.4})Fe_2O_4$

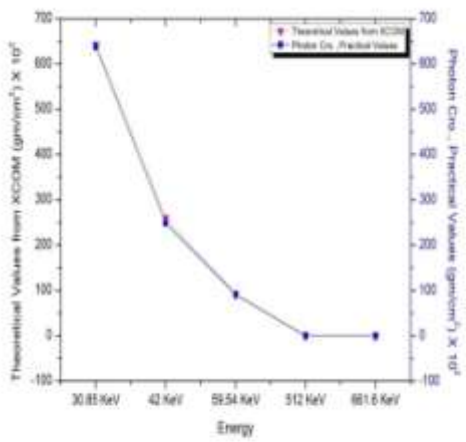


Table: 3.4: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.6}Zn_{0.2})Fe_2O_4$ general formula is $Mg_{0.2}(Cu_xZn_{0.8-x})Fe_2O_4$

S.No	Energy in KeV	Total Photon Cross Sections in (gm/cm^2) X 10^2	
		Theoretical Values from XCOM	Practical Values
1	30.85	632.5	621.7
2	42	255.5	254.7
3	59.54	89.92	89.42
4	512	0.1539	0.1461
5	661.6	0.08120	0.08101

Graph.3.c Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.6}Zn_{0.2})Fe_2O_4$

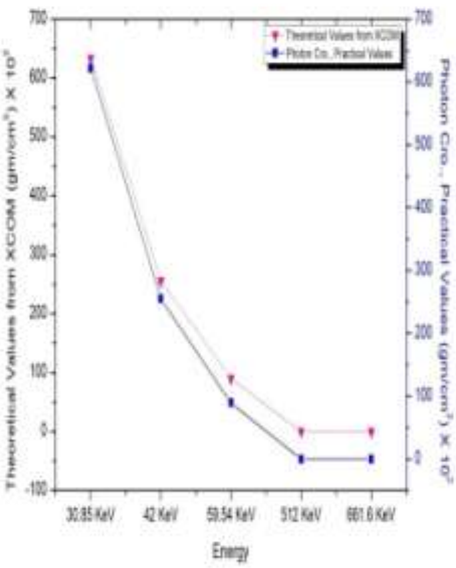
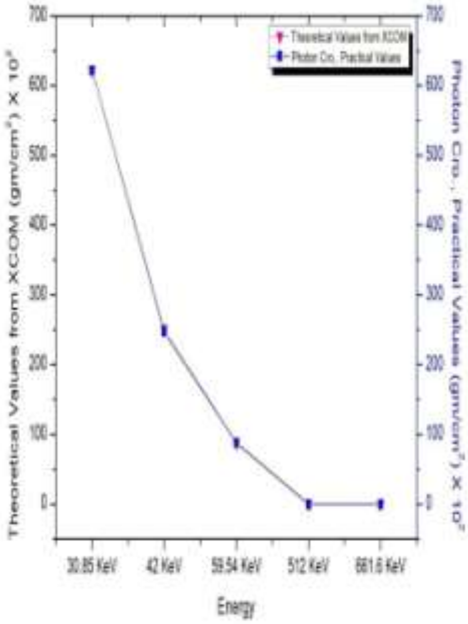


Table: 3.5: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.8}Zn_{0.0})Fe_2O_4$ general formula is $Mg_{0.2}(Cu_xZn_{0.8-x})Fe_2O_4$

S.No	Energy in KeV	Total Photon Cross Sections in (gm/cm^2) X 10^2	
		Theoretical Values from XCOM	Practical Values
1	30.85	622.0	621.7
2	42	251.0	246.8
3	59.54	88.27	87.97
4	512	0.1506	0.1479
5	661.6	0.07945	0.07826

Graph.3.5: Total Photon Cross Sections of synthesized Nano Material $Mg_{0.2}(Cu_{0.8}Zn_{0.0})Fe_2O_4$



IV. CONCLUSION:

We see the increase in the gamma ray energy shows that the decrease of photon energy in all the graphs. For more number of synthesized nano materials we may obtain the same property. But some of the rare earth elements may not agree at Z_{eff} value.

Mass attenuation coefficients of chosen combination samples for the total photon interaction processes is high initially and decreases rapidly with increase in gamma photon energy up to 661.6 KeV. Mass attenuation coefficients increases slightly with increase in photon energy. Mass attenuation coefficient is helpful for detail study in shielding of materials. The results of the present investigation are shown graphically in all five combinations. Mass attenuation coefficient (μm) for the total photon interaction processes is initially high and decreases sharply with increase in incident photon energy up to 100 Kev. Above 100 Kev the rate of decrease of μm (total) with incident photon energy is less and above 661.6KeV μ (total) increases slightly with further increase in incident photon energy.

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