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Effect of sample thickness on the measured mass attenuation coefficients of perspex and bakelite

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Abstract : Mass attenuation coefficients μ (cm^2/gm) of perspex and bakelite for photons have been measured for different absorber thicknesses for the medium energy gamma rays from three radioactive isotopes, ^{133}Ba, ^{137}Cs, and ^{60}Co. It is seen that μ (cm^2/gm) remains constant up to 1 mean free path and after that it increases with the further increase in absorber thickness

Keywords : Mass attenuation coefficient, thickness, perspex and bakelite

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With the increasing applications of radiations in many fields such as industry, medicine, agriculture and research etc., several scientists are trying to study, in depth, various gamma ray interactions in composite materials. Accurate values of attenuation coefficients in several materials for photon radiations are needed in solving various problems in radiation physics and radiation dosimetry. A large number of photon attenuation measurements, calculations and complications in elements have been made available by several authors [1-3]. The effect of different parameters such as geometry and absorber thickness etc. on the attenuation coefficients is also accurately known for pure elements. Gopal and Sanjeevaiah [4] studying attenuation coefficients of C, Al, Cu, Sn and Pb have reported the increase in mass attenuation coefficient, μ (cm^2/gm) with increase in absorber thickness after 1 mean free path.

This type of work for composite materials is seen very limited, especially the studies concerning the accuracy of mass attenuation coefficient of composite materials affected by geometry and thickness etc. are quite scarce.

Keeping above points in view, an attempt has been made to investigate the effect of absorber thickness on the measured mass attenuation coefficients of perspex and bakelite for different source energies. The chosen materials, obtained from a scientific store, are made up of C, H, and O in proper ratio, as perspex (H: 8.05%; C: 59.99%; O: 31.96%) and bakelite (H: 5.55%; C: 78.24%; O: 16.21).

The total mass attenuation coefficients of these materials were determined by performing transmission experiments with a set up of narrow beam geometry. Radioactive sources of strength 5–20 mCi obtained from BARC Bombay (India) were used in the present work which were housed in a lead container after checking any type of impurity. NaI(Tl) detector (4.5 cm thickness and 5.1 cm diameter) with KL 9656 photomultiplier tube has been used along with amplifier and ND62 multichannel analyzer. The experiments were conducted in an air conditioner room to avoid the possibility of shifting of photopeaks. The photopeaks of gamma ray energies were recorded with and without placing absorber between source and detector for the present materials. The transmission experiments were repeated for the chosen energies (302+356, 662 and 1173+1332 keV). For each of the sample thickness mass attenuation coefficients, μ (cm^2/gm) were determined and corresponding μx values were calculated. The background counts were obtained by placing a lead piece 15 cm in length in the sample position, which were subtracted from the gross data counts.

The errors in the present studies are mainly due to the counting statistics, non uniformity of absorber, the impurity contents and the Compton scattering photon reaching the detector. In performing the experiments a large number of counts were recorded to make the statistical error < < 1%. The fractional error due to non uniformity of the materials was estimated to be $(\Delta t)^2/2$ where Δt is the relative fractional variation of the thickness, which is found to be less than 0.5%. As the chosen materials are of high purity, the error due to the presence of impurities is negligible. In a good geometrical set up the solid angle was adjusted in such a way so that the Compton scattered contribution of photons can be neglected.

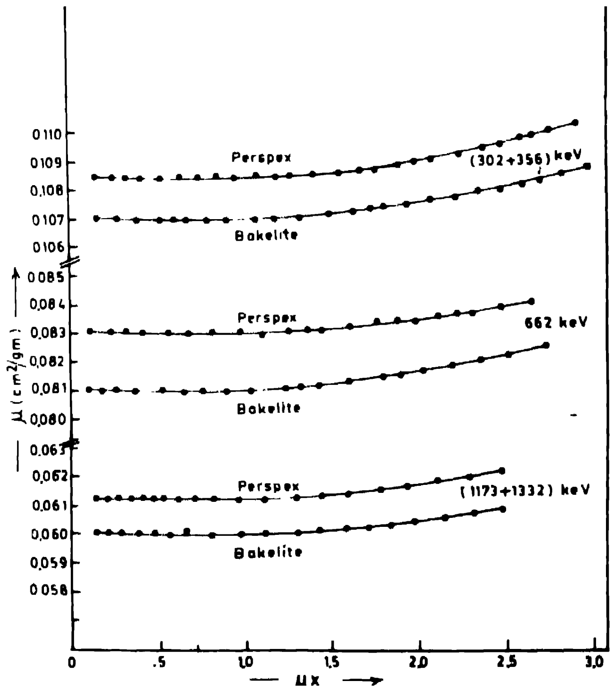

Figure 1. Plot of mass attenuation coefficient *vs* μx (abscissa) of perspex and bakelite for different photon energies

The measured values of mass attenuation coefficients μ (cm^2/gm) of perspex and bakelite are shown in Figure 1 against the absorber thickness. From these results, it is seen that for these chosen materials μ remains constant for $\mu x < 1$. This may be because of the fact that the number of multiple scattered photons reaching the detector becomes negligible and the collimated narrow beam geometry condition is preserved. Further when $\mu x > 1$, the mass attenuation coefficients of these materials increases with the increase in sample thickness. Although this increase is small it is outside the limits of errors. It may be due to the reason that the number of multiple scattered photons reaching the detector increases as the sample thickness increases. These results of composite materials are in line with the findings of Gopal and Sanjeevaiah [4] who have also reported the similar variation in μ (cm^2/gm) with sample thickness for pure elements (C, Al, Cu, Sn and Pb).

Table 1. Mass attenuation coefficients (cm^2/gm) of perspex and bakelite

Photon Energy	perspex		bakelite	
(keV)	μ_{exp}	μ_{th}	μ_{exp}	μ_{th}
(302+356)	0 1084	0 1090	0 1070	0.1065
662	0 0832	0 0831	0 0810	0.0810
(1173+1332)	0 0613	0 0614	0 0602	0.0590

From these findings, it is reported that adopting the measuring sequence of Conner *et al* [1] and considering $\mu x < 1$, the accurate values of mass attenuation coefficients of perspex and bakelite can be determined. Under such conditions the measured values of μ of these materials are listed in Table 1 which are in good agreement with the theoretically computed μ values with the help of a recent and state-of-the-art computer programme of Berger and Hubbell [5] on PC (AT).

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