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Research Article

COHERENT AND INCOHERENT SCATTERING CROSS SECTIONS OF SOME SUGARS AT ANGLES BELOW 10^0 FOR ^{241}Am GAMMA RAYS

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ABSTRACT
In this paper, we report the total (Coherent +Incoherent) scattering cross sections of some Sugars such as Lactose, Maltose, Fructose and Sucrose measured at angles less than 10^0 for ^{241}Am (59.54keV) gamma rays. These cross sections have been measured by a method similar to the one reported earlier by one of the authors (Puttaswamy et al., 1984, Marigowda et al., 1986). The experimental cross sections so obtained are compared with the data interpolated from theoretical compilations of Hubbell et al., (1975) based on non-relativistic Hartree–Fock model (NRHF) for the samples of interest. In the low momentum transfer region studied, it is observed that the non-relativistic theoretical total scattering cross sections computed using HF form factor and scattering function tabulated by Hubbell et al., (1975) (NRHF) are quite adequate in explaining the measured total scattering cross sections.

Key Words: *Coherent Scattering, Incoherent Scattering, Low Momentum Transfer, Non-relativistic Hartree- Fock Model*

INTRODUCTION
Scattering of gamma rays at small scattering angles by materials involves low momentum transfer to the struck electron. In the incident energy region above 50keV up to say 1000keV, for scattering angles less than 10^0, it is difficult to separate out the coherent scattering from the main peak particularly due to the severe limitations imposed as a result of the finite resolution of the detector. Hence, several methods have been reported in literature to remedy this problem. It may be observed that the shadow cone method, although widely used for this purpose, suffers from a number of drawbacks. The limitations of the other methods used at small angles have also been pointed out in literature (Chitwattanagorn et al (1980), Hauser and Mussgnug (1966), Ramanathan et al (1979), Taylor et al (1981)). So there is a need for measuring the scattering cross sections at forward angles using a different experimental method involving minimum corrections.

Such a method for measuring the scattering cross sections of gamma rays at small angles, which uses a simple geometrical set up similar to that of the experimental set up employed for the measurement of total attenuation cross sections was described earlier (Puttaswamy K S et al (1984)). Recently this method was used to determine the total scattering cross sections of some alloys by us (Vinay Kumar et al (2011)). This method is simple and involves only the measurement of the scattered intensity superposed as a small addition to the direct transmitted beam. It makes use of a NaI(Tl) detector, to determine experimentally the total (coherent + Incoherent) scattering cross sections of the samples. In the present work, we have reported the measured total scattering cross sections of the sugars measured at angles 4^0-10^0 at 59.54keV by this method.

MATERIALS AND METHODS
The schematic diagram of the experimental set up used is as shown in figure 1. It consists of a radioactive source which is placed at the centre of a lead collimator C and having a collimating hole with a diameter slightly larger than the diameter of the source. The photon beam which emerged from the collimator C was further shaped to a very fine beam using lead collimators C_1,C_2 and C_3 having very narrow collimator holes (C_2 and C_3 had diameter less than 4 mm through the hole).

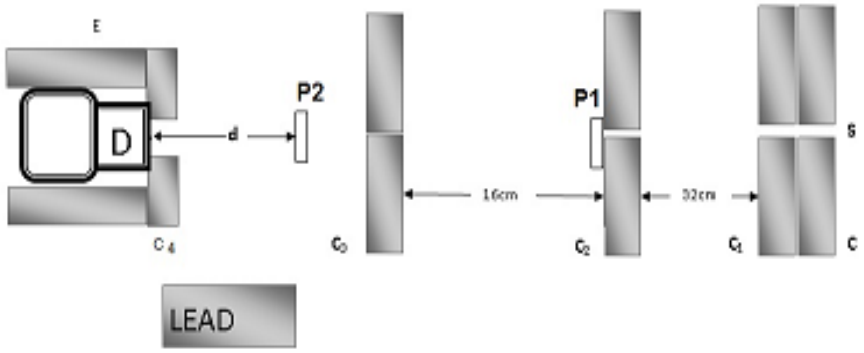

Figure 1: The experimental set-up (not to scale). S is the source, D is the NaI(Tl) detector, C,C_1,C_2,C_3 and $C_4$are lead collimators, E is the lead shielding around the detectors,P1 and P2 are the scatterer positions.

In the total attenuation cross section measurements usually extreme care is taken to prevent the scattered photons from reaching the detector by selecting a very small angle of acceptance (less than few minutes), whereas in the present studies the scattered photons at small angles were allowed to reach the detector by increasing the angle of acceptance of the detector by varying the distance d between the target in P2 position and the detector (Figure 1). The spectrum therefore contained both the transmitted photons and the photons scattered within the angle of acceptance of the detector. In order to obtain the contribution of the scattered photons, the usual attenuation coefficient measurement set up was slightly modified and the cross sections were determined from the intensities I_1 and I_2 measured at the two scatterer positions P1and P2 (Figure 1) by using the equation

$$\sigma = \frac{A}{0.60225}\left(\frac{\ln \frac{I_2}{I_1}}{\rho t}\right) barn/mole$$

The ^{241}Am source was procured on a loan basis from the Department of Physics, Mangalore University. Sugars of uniform thickness were used as scatterers. Their maximum thickness (mass per unit area) was chosen to be about one mean free path in order to minimize the multiple scattering **(**Gopal S and Sanjeevaiah (1973), Marigowda *et al.*, (1986)). The detection system used in the present studies consisted of a scintillation head, high voltage unit, low voltage supply, linear amplifier and a multichannel analyzer. The scintillation head of the type SH 644, supplied by Electronics Corporation of India Limited (ECIL), Hyderabad, India which is built into a complete unit comprising of a scintillator, Photomultiplier and Pre-amplifier was used. The scintillator used was a thallium activated (2"X 2") sodium iodide [NaI(Tl)] crystal. The resolution of the detection system used was about 8% for the gamma rays of interest. The detector signal was further amplified by a linear amplifier and the spectrum was analyzed in a personal computer based 8K multichannel analyzer. The entire experiment was carried out in an air-conditioned room wherein the mains' voltage was stabilized.

RESULTS AND DISCUSSION

The total scattering cross sections obtained at the angles $4^0 - 10^0$ are shown in Table 1. The experimental errors were to the extent of 3%-4%. The measured total scattering cross sections of the some sugars were found to be in agreement with the non-relativistic theoretical total scattering cross sections tabulated by Hubbell et al., (1975). Which were computed using the form factor and scattering functions based on the non-relativistic Hartree-Fock model within the range of experimental errors.

Conclusions

Thus in this work, the coherent and incoherent scattering cross sections of some sugars have been measured in the angular range 4^0-10^0 at 59.54keV. To the knowledge of the authors, these data are the first of their kind at this energy and angular range.

Table: 1.Measured and calculated total scattering cross section of 59.54keV gamma rays for some sugars (barn/mole). (Experimental errors are to the extent of 3% to 4%)

S. No.	Sugars	d in cm	□ in deg	Total scattering cross section $\Delta\sigma_{sca}$ (coh+incoh) (in b/atom)	
				present	NRHF
1	Lactose	29.88	4	0.041	0.042
		19.88	6	0.123	0.124
		14.87	8	0.381	0.383
		11.85	10	0.752	0.753
2	Maltose	29.88	4	0.042	0.042
		19.88	6	0.124	0.124
		14.87	8	0.384	0.383
		11.85	10	0.754	0.753
3	Fructose	29.88	4	0.042	0.042
		19.88	6	0.123	0.124
		14.87	8	0.385	0.383
		11.85	10	0.755	0.753
4	Sucrose	29.88	4	0.041	0.042
		19.88	6	0.126	0.125
		14.87	8	0.383	0.382
		11.85	10	0.751	0.750

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