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A. Cannata, A. Esposito and M. Pelliccioni:

MEASUREMENTS OF THE X-RAY MASS ATTENUATION COEFFICIENTS FOR SOME MIXTURES IN THE ENERGY RANGE 5-12 keV.

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ABSTRACT.

Measurements have been made of mass attenuation coefficients for some dosimetry-related materials using low energy photons in the range 5-12 keV. The results are compared with theoretical calculations.

1. - INTRODUCTION.

Many theoretical treatments of X-ray dosimetry require an accurate knowledge of the probabilities of various interactions with matter. For this purpose the available data of mass attenuation coefficients and mass energy absorption coefficients are normally used. Several compilations have been done for photon energies above 10 keV. Under this energy, data are rarer, particularly the experimental ones, as the scarsity of sources. Recently synchrotron radiation produced in storage rings has began to be used as a source of soft X-rays. In fact it represents a practically uniquely calibrated source in this energy region. The synchrotron radiation beam can be monochromatized using silicon crystals monochromators. In the Adone storage ring at the Frascati National Laboratories there is one of these facilities. Its characteristics have been described in a previous note together with the results of measurements of mass attenuation coefficients for some thermoluminescent materials in the energy range between 5 and 12 keV(1). Here are shown the results of measurements of the mass attenuation coefficients for some mixtures often used in dosimetry.

2. - EXPERIMENTAL RESULTS.

A narrow monoenergetic photon beam of intensity I_o is attenuated to an intensity I in passing through a layer of material with mass-per-unit area x according to the law:

$$I = I_o e^{-\mu/\varrho x} \qquad (1)$$

in which μ/ϱ is the mass attenuation coefficient and ϱ the density of the material investigated.

Equation (1) can be rewritten as:

$$\mu/\varrho = \frac{1}{x} \ln \frac{I_o}{I} \qquad (2)$$

from which the value of μ/ϱ can be obtained measuring I_o and I.

The experimental layout and the other details of the experimental technique have been illustrated in the previous mentioned note(1). Here, only some points are recalled. The values of I_o and I have been measured by an ionization chamber. The monochromatized X-ray beam used has an energy definition better than 10^{-3}. But, for each photon energy E, the beam includes higher harmonics of the fundamental wavelength which are also diffracted by the monochromator. The relative contribution of the second harmonic is about 5 % at 5 keV, 1 % at 6 keV and can be disregarded for photon energies above 6 keV. The 3E component is negligible above 4 keV.

TABLE I - Composition of the material investigated.

Material	Formula	Density (g/cm^3)
Bakelite	$C_{43}H_{38}O_7$	1.28
Perspex	$(C_5H_8O_2)_n$	1.18
Polyethylene	$(C_2H_4)_n$	0.92
Teflon	$(CF_2)_n$	2.17

The composition of the material investigaed is presented in Table I.

The results of the measurements together with the results of the calculations are shown in Table II.

The highest uncertainties in the values of μ/ϱ in Table II for photon energy of 5 keV are due to the influence of the second harmonic.

As can be seen experimental results give reasonable agreement with those predicted with calculations. Some differences are probably due to the dissimilarity of the composition of the materials used in the measurements with respect to those of the calculations.

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TABLE II - Experimental mass attenuation coefficients (cm^2/g) for some mixtures and comparison with calculations.

Energy (keV)	Bakelite			Perspex			Polyethylene				Teflon	
	This work (cm^2/g)	Hu77[2] (cm^2/g)	ICRU70[3] (cm^2/g)	This work (cm^2/g)	ICRU70[3] (cm^2/g)	Hu82[4] (cm^2/g)	This work (cm^2/g)	HU77[2] (cm^2/g)	ICRU70[3] (cm^2/g)	Hu82[4] (cm^2/g)	This work (cm^2/g)	Hu82[4] (cm^2/g)
5		22.24	22.5	28.84 ± 2.08	26.2	26.18	16.10 ± 0.98	15.85	16.4	15.85	56.76 ± 4.18	52.82
6			12.8		14.9	15.07			9.22	9.11		30.70
7	9.00 ± 0.44			9.71 ± 0.21			5.86 ± 0.16				19.6 ± 1.0	
8	5.93 ± 0.33	5.36	5.31	6.42 ± 0.15	6.24	6.33	4.17 ± 0.14	3.84	3.82	3.84	13.2 ± 0.7	12.97
9	4.18 ± 0.29			4.61 ± 0.13			3.05 ± 0.14				9.3 ± 0.5	
10	2.95 ± 0.30	2.78	2.73	3.61 ± 0.15	3.22	3.27	2.51 ± 0.17	2.02	1.98	2.02	6.8 ± 0.5	6.65
11	2.17 ± 0.12						2.08 ± 0.07				5.0 ± 0.3	
12	1.81 ± 0.15			2.20 ± 0.07			1.81 ± 0.09				3.9 ± 0.2	
15		0.93	0.91		1.05	1.08		0.72	0.71	0.73		2.04

REFERENCES.

(1) - C. Bacci, A. Cannata, A. Esposito, C. Furetta and M. Pelliccioni, Measurements of the X-ray mass attenuation coefficients for some TL dosemeters in the energy range 5-12 keV, Frascati report LNF-81/52 (1981).

(2) - J. H. Hubbell, Photon mass attenuation and mass energy absorption coefficients for H, C, N, O, Ar and seven mixtures from 0.1 keV to 20 MeV, Radiation Research 70, 58 (1977).

(3) - International Commission on Radiation Units and Measurements, Radiation Dosimetry: X-rays generated at potentials of 5 to 150 kV., ICRU report 17 (1970).

(4) - J. H. Hubbell, Photon mass attenuation and energy absorption coefficients from 1 keV to 20 MeV., Submitted to Intern. Jnl. of Appl. Radiation and Isotopes.