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ENERGY RESPONSE OF SOME THERMOLUMINESCENT DOSEMETERS TO 4 - 12 keV X-RAYS

C.BACCI(") , A.CANNATA(+), A.ESPOSITO(+), C.FURETTA(°), M.PELLICCIONI(+).

(") Istituto di Fisica G.Marconi, Università di Roma. Italia.

(+) Laboratori Nazionali di Frascati dell'INFN. Italia.

(°) 1^ Cattedra di Fisica Medica, Servizio di Fisica Sanitaria, Facoltà di Medicina e Chirurgia, Università di Roma. Italia.

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ABSTRACT: A monochromatic X-ray beam has been utilized to investigate the energy response of some thermoluminescent phosphors in the range from 4 to 12 keV. The results show no significant energy dependence in this range.

1. INTRODUCTION

In view of wide spread interest in the use of thermoluminescent dosemeters (TLD) we would like to call attention to the energy dependence of the response of some phosphors, commercially available, to very low energy photons. In order to select the most suitable detector for dose measurements, the energy dependence must be known.

Untly recently, TL investigation by photons below 12 keV has not been comprehensively attempted. Data has been reported by Bassi et al. (1), Reddy and Mehta (2), as calculated energy dependence, and by Law (3) as experimental data from 11 to 26 keV. We think that our data may be useful to many people working in TLD dosimetry field.

2. EXPERIMENTAL SET-UP

TLDs irradiations were made usin the synchrotron radiation facility recently available from 1.5 GeV Adone storage ring at the Frascati National Laboratories. The X-ray beam emerging tangentially from Adone is monochromatized using a single Si crystal monochromator. It is possible, in this way, to obtain a soft X-ray beam in the energy range from 1.5 keV to 12 keV, with an energy resolution better than 10^{-3} per cent. The experimental set-up is shown in fig.1. The X-ray beam coming from Adone moves across X-ray channel and, after the monochromator, goes through the collimator C, where TLDs in polyethylene bags

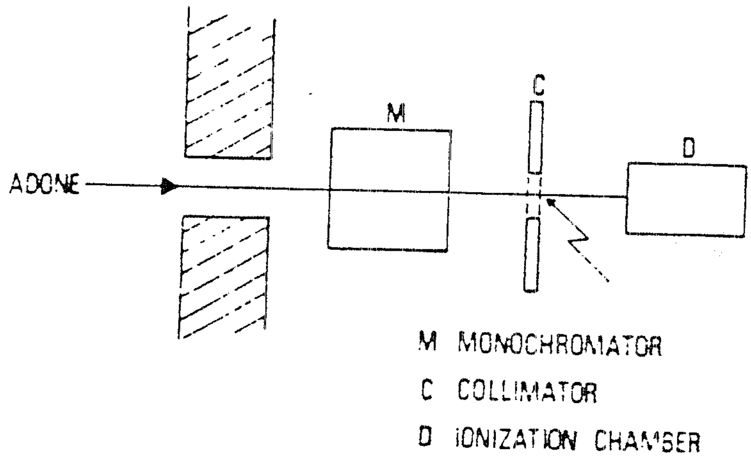

Fig.1. Experimental set-up.

are placed. Then the beam enters into a ionization chamber. This chamber measures the intensity I_0 of the beam through the polyethylene only. The same chamber measures the intensity I_1 when the beam moves across phosphors in polyethylene bag.

The absorbed dose was determined by equation:

$$D = \frac{2.61 \times 10^4}{f \times f_{att}} \times \frac{I_o - I_1}{m} \Delta t$$

where

D = absorbed dose (Gy),

m = mass of the detectors (g),

f_{att} = attenuation factor of kapton window between absorber and ionization chamber,

f = ionization chamber efficiency,

I_o = ionization chamber current without TLDs (μA),

I_1 = ionization chamber current with TLDs (μA),

Δt = exposure time (sec).

The TL response is given at first as TL/D: this provided a measure of the sensitivity of phosphors to low energy X rays; after that, the TL/D response for each energy were normalized to the TL/D response at 12 keV.

Because the Adone stored electron current varied during experiment, it has been necessary to normalize I_0 and I_1 to 1 mA stored current. This has been possible because the X-ray flux is proportional to the electron current in Adone.

3. EXPERIMENTAL RESULTS

The TLDs used in this investigation, supplied by Harshaw Chem. Co., in ribbon form, are listed in table 1.

Table 1 - TLDs used

TLD-700	LiF:Mg,Ti	1/8x1/8x0.015 inch
TLD-700	LiF:Mg,Ti	1/8x1/8x0.035 inch
TLD-400	CaF_2:Mn	"
TLD-800	$Li_2B_4O_7$:Mn	"
TLD-900	$CaSO_4$:Dy	"

The chips were irradiated to the soft X ray energies ranging from 4 to 12 keV, with 1 keV steps. All exposures were made with the chips in polyethylene bags centered in the X-ray beam, which was perpendicular to the surface of the ir radiated chips. Because of their different sentivities, the phosphors were exposed at different doses. Before irradiations the chips were annealed according to manufacturer's specifications and early works (4,5,6). To avoid the possibility of any reader drift over the experimental period, all dosemeters were read during a single session. No fading correction was used . The thermoluminescence from the phosphors was measured in a Harshaw TLD reader, model 2000, with a linear heating rate of 10 °C/sec.

The chips were weighed to estabilish their mass in order to calculate the received absorbed dose.

The sensitivities of the tested phosphors at the different energies are shown in fig.2a,b,c,d,e. The very different sensitivity denote that the absorbed energy depends on the Z of phosphors, of course.

The response of borate is considerably lower than the other phosphors: this fact is also due to the optical unit in the reader, which is not particularly suitable for detecting the

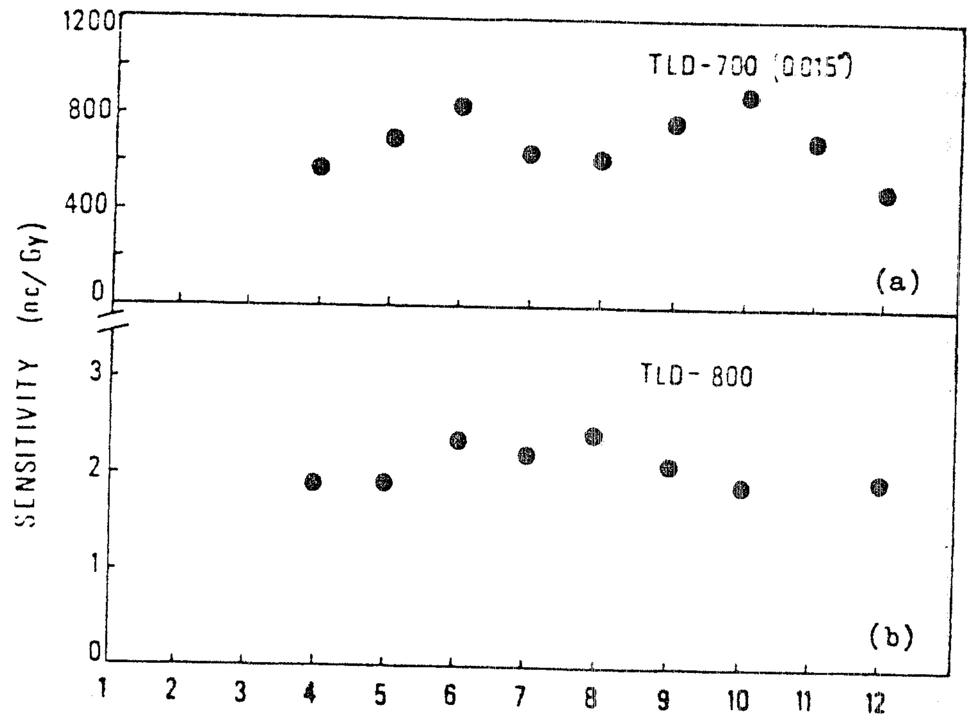

Fig.2a,b. TLDs sensitivities. E (keV)

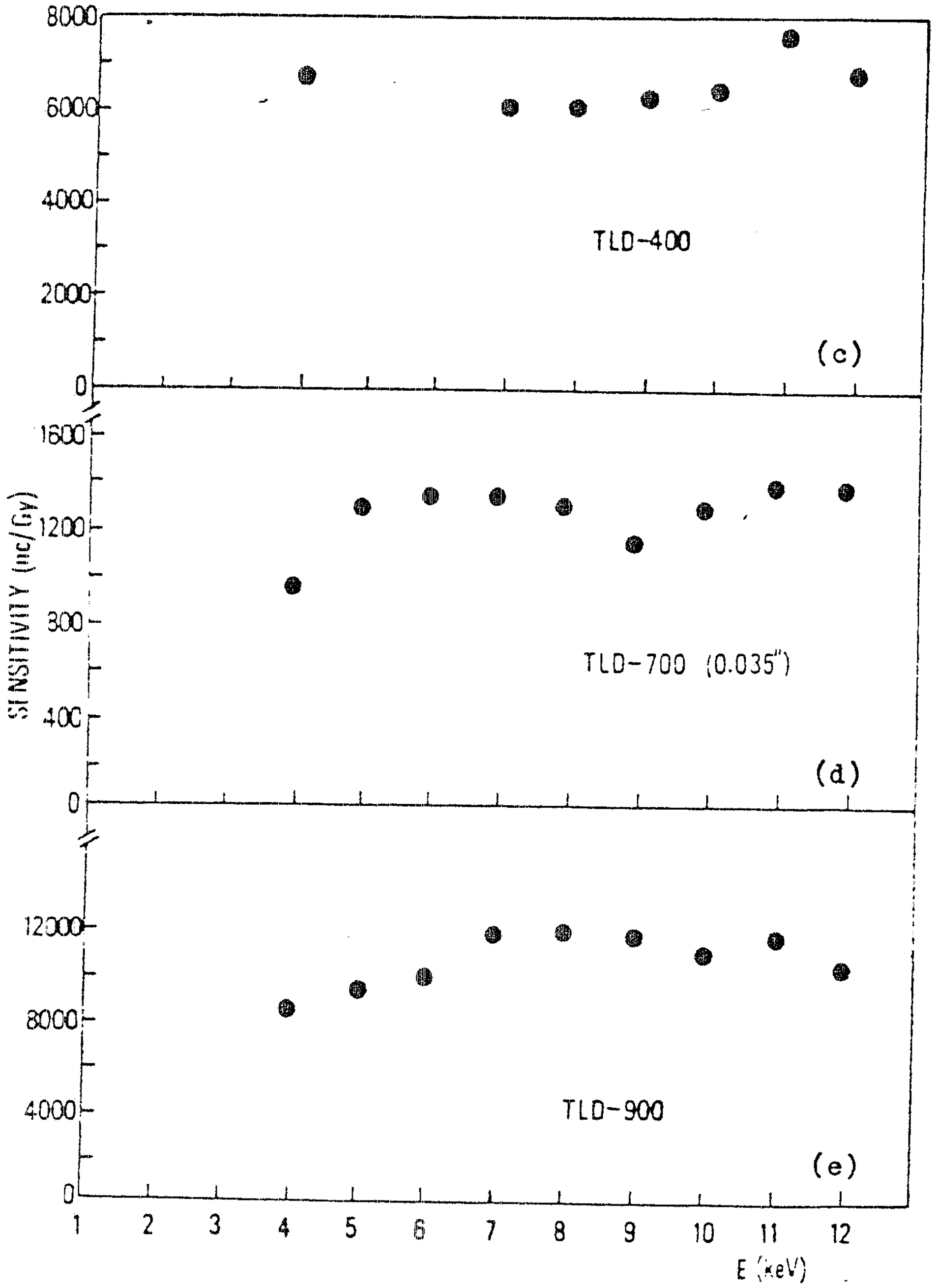

Fig.2c,d,e. TLDs sensitivities.

orange-yellow emitted by $Li_2B_4O_7$:Mn. Fig.3 shows the relative response to $(TL)_{12\ keV}$.

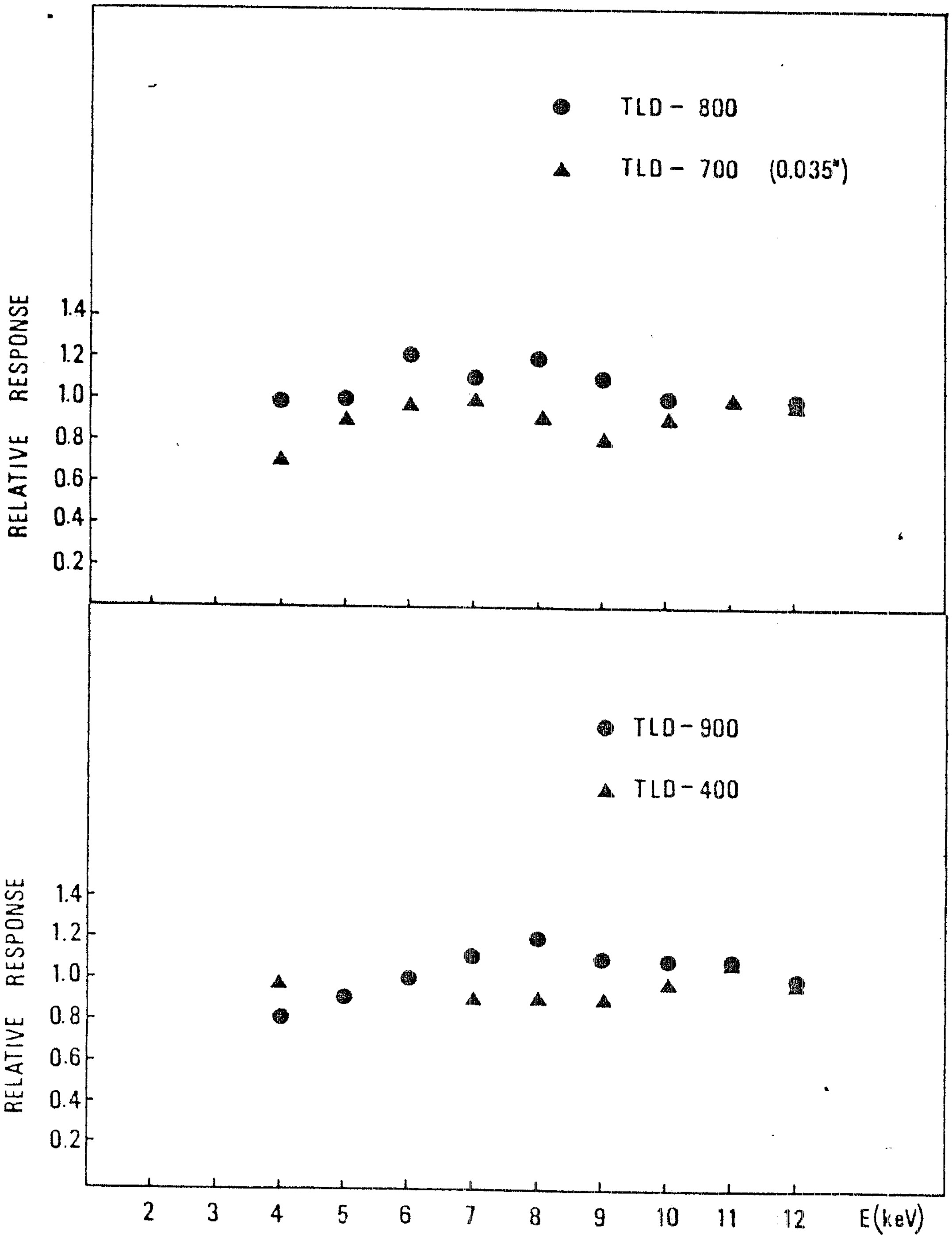

Fig.3. Relative response to $(TL)_{12\ keV} = 1$.

From figures 3 we can note that the relative responses are roughly constant, on the energy range used, for all TLD types.

4. CONCLUSIONS

From the results shown in fig.s 3, it is possible to deduce that there is no evident problem of energy dependence in the TLDs response to X-rays ranging from 4 to 12 keV. This could allow the use of any type of tested phosphors for dosimetry of very soft X-ray beams. On the other hand a selection is necessary according to the absorbed dose levels. In particular, from fig.s 2, TLD-800, a tissue-equivalent material, can be used in low sensitivity cases; whereas calcium sulphate is useful when high sensitivity is required.

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