GRAPHITE MIXED $CASO_4$:Dy PELLETS FOR LOW ENERGY X - RAY DETECTION

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ABSTRACT

Sintered pellets of $CaSO_4$:Dy + Teflon with a thickness between 0.2 and 0.8 mm and with a graphite content from 0 to 20 % were investigated for application for low energy photon dosimetry. The effective X - ray energies used were: 14.3, 21.2, 31.2, 37.3, 64.4, 74.5 and 92.3 keV. The studied parameters were the relative sensitivities, lower detection limits and energy responses. Pellets 0.8mm thick and with a 5% graphite content showed the best results, when aiming at the lowest relative TL response for X-rays with an effective energy of 31.2 keV.

1. INTRODUCTION

The $CaSO_4$:Dy is one of the most popular thermoluminescent dosimetric material due to its high sensitivity, low cost and its uncomplicated production procedure [1-3]. A disadvantage is that it presents a high energy TL response for photons due to its high atomic number. With the addition of graphite in the production process of the pellets [4,5], the measurable TL from the detectors will be emitted only from the surface layer and, it is possible to reduce the energy dependence of the TL response to beta radiation, although this will reduce the inherent sensitivity [4]. The presence of graphite in the dosemeter has no effect on the TL characteristics of the phosphor, and it is

possible to keep the same mechanical strength for detectors with graphite as for those without graphite.

During the last ten years, pellets of $CaSO_4$:Dy+Teflon with different thicknesses (0.2; 0.4; 0.6 and 0.8 mm) have been produced and studied by the Dosimetric Materials Production Laboratory of IPEN for beta radiation detection [6,7]. Data on sensitivity and energy dependence of the TL response of $CaSO_4$:Dy + Teflon pellets as a function of graphite content in the pellet have been reported previously [8].

The objective of this work is to study the TL response of $CaSO_4$:Dy + Teflon pellets with different thicknesses and different graphite contents in the Teflon mass, aiming it using them for dosimetry in low energy photon fields.

2. MATERIALS AND METHODS

Sintered TLD pellets of different thicknesses were obtained from homogeneous mixtures of $CaSO_4$:Dy (35% by weight), Teflon powder and graphite (0; 0.5; 1; 3; 5; 10 and 20% by weight). Pellets with a diameter of 6 mm and a thickness between 0.2 and 0.8 mm, were prepared from these mixtures by cold pressing and the sintering in a microwave furnace CEM - MAS 7000.

The TL response was determined using the Harshaw TL reader model 4000. Each reported value corresponds to the average of five measurements.

The gamma irradiations were carried out using a ^{60}Co (1 GBq) source . The X - ray irradiations were carried out using two systems: a therapy equipment Westinghouse, model Duocondex with effective energies between 31,2 and 92,5 keV (table 1) and a Rigaku Denki X - ray generator with effective energies between 14.3 and 21.1 keV (table 2). The samples were always irradiated sealed in Hostaphan foil, 15μm thick, and under electronic equilibrium conditions.

All $CaSO_4$:Dy + Teflon pellets with different thicknesses and graphite contents were submitted to 0.01 Gy of ^{60}Co gamma radiation and X-rays with effective energies of 14.3; 21.2; 31.2; 37.3; 64.4; 74.5 and 92.3 keV .

3. RESULTS

The decrease of the TL sensitivity with the increase of the graphite content was the same for all thicknesses for the graphite contents studied. Detectors with 10 – 20%, with high graphite contents, are not attractive as those with 5% because of their lower sensitivity and high lower detection limit, although they show a response with lower energy dependence. The typical total reduction in the TL response of a pellet with 5% of graphite compared to one without graphite, for ^{60}Co radiation, was estimated to be 90%, in agreement with previous results [8] .

The Figure 1 shows the TL response to 31,2 keV energy point (maximum energy dependence TL response) as a function of pellet thickness for different graphite contents. It shows that thin detectors doesn't presents flat response in low energy photon fields and that it is obtained for thickness larger than 0.6 mm (40mg).

The lower detection limit, defined as three times the standard deviation of the zero dose reading of the detectors expressed in terms of dose units, was calculated for each type of dosemeter. In the case of pellets of 0.8mm with 5% graphite this value is 3.0 μGy for 31.2 keV X - rays.

The best of energy dependence TL results, relative to ^{60}Co, can be seen in the Figure 2 for 0.8 and 0.6mm thick pellets and graphite contents of 0, 3 and 5 %.

4. CONCLUSION

The best TL results aiming at the lowest relative TL response for X-rays with an effective energy of 31.2 keV were that ones obtained with 0.8 mm thick pellets with 5% of graphite content, that reduces the relative energy dependence TL response for 31.2 keV by a factor of about 1.73 (from 13 to 7.5).

If the reduced energy dependence to beta rays with average energy between 100 and 800 keV of the graphite mixed $CaSO_4$:Dy Teflon pellets produced at IPEN [8] is considered, it appears attractive for beta as well as mixed beta-gamma dose measurements and makes them useful in personnel monitoring.

5. Acknowledgements

The authors acknowledge the partial financial support of Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Fundação de Apoio à Pesquisa do Estado de São Paulo (FAPESP).

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FIGURE CAPTIONS

Figure 1: Relative TL response as a function of pellet thickness and graphite content to 31.2 keV photon field.

Figure 2: Photon energy relative TL response curve of graphite mixed and pure TL dosimeters with 0.6 and 0.8 mm thick (40 and 50 mg respectively).

TABLE CAPTIONS

Table 1 Experimental conditions for irradiation by X-rays with Westinghouse, model Duocondex X - Rays generator.

Table 2 Experimental conditions for irradiation by X-rays with Rigaku Denki X - Rays generator.

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Voltage kV	Current mA	Added Filtration	H VL	$E_{eff.}$ keV	Absorbed Dose Gy
60	15	--	2.45 mmAl	31.2	0.01
80	15	--	3.6 mmAl	37.2	0.01
120	15	0.5mmCu	0.55 mmCu	64.4	0.01
160	15	0.5mmCu	0.78 mmCu	74.5	0.01
200	15	1.0mmCu	1.33 mmCu	92.3	0.01

Table 2 Experimental conditions for irradiation by X-rays with Rigaku Denki X - Rays generator.

Voltage kV	Current mA	Added Filtration	H V L	$E_{eff.}$ keV	Absorbed Dose Gy
25	30	0.44mmAl	0.24mmAl	14.3	0.01
50	25	1.02mmAl	0.89mmAl	21.1	0.01

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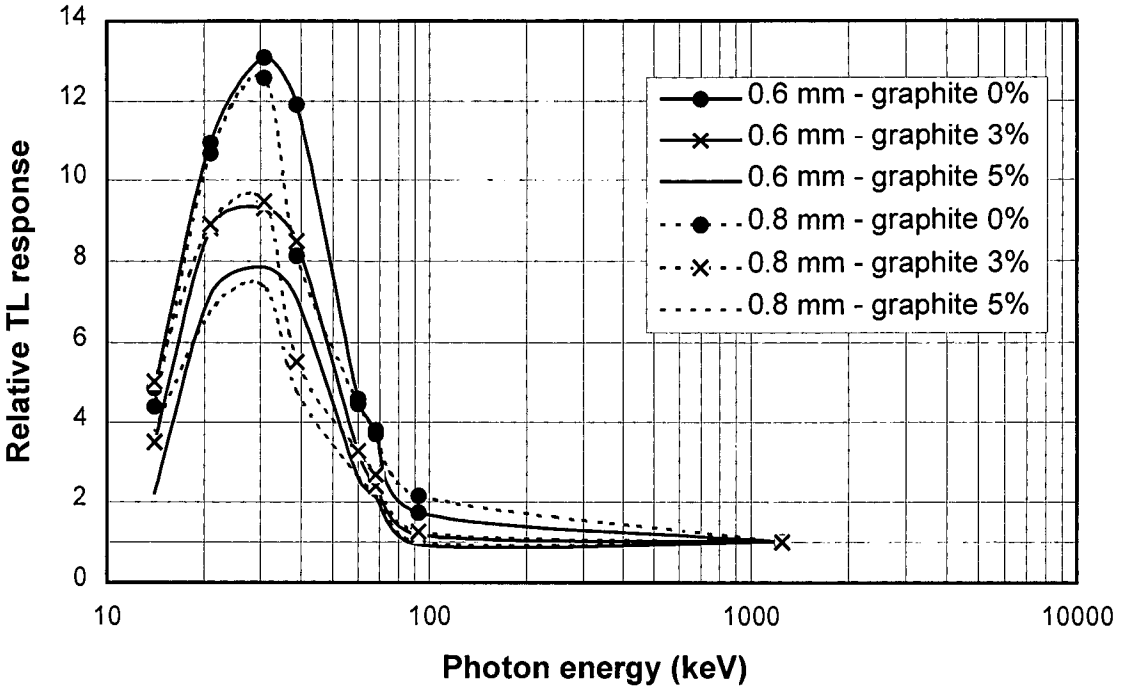
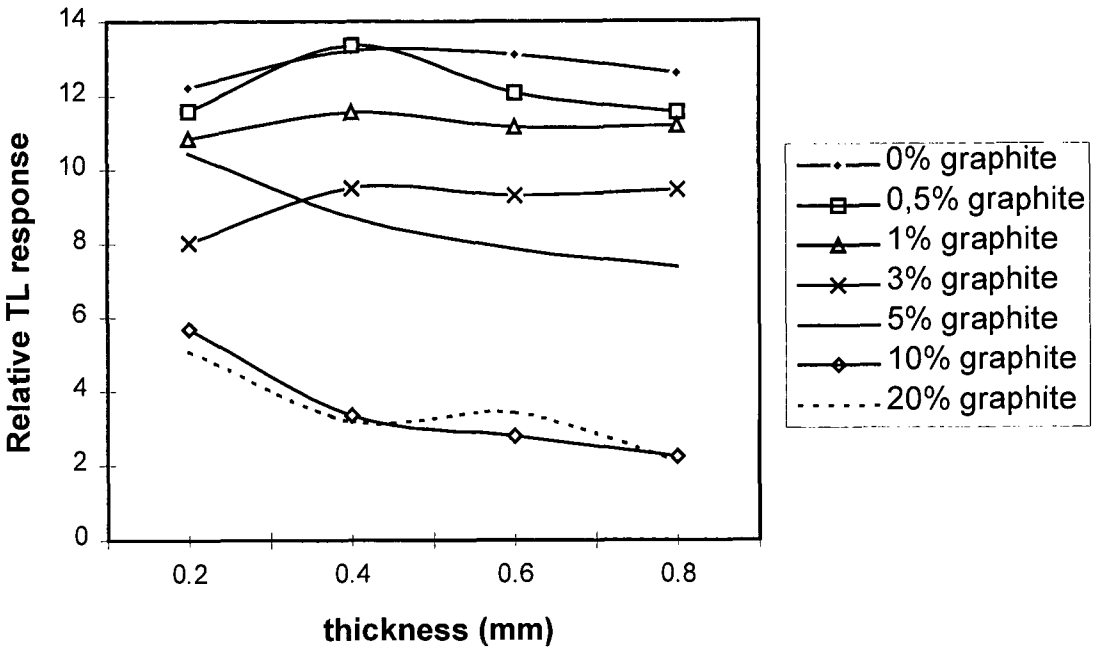


Figure 2: Photon energy relative TL response curve of graphite mixed and pure TL dosimeters with 0.6 and 0.8 mm thick (40 and 50 mg respectively).



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