GRAPHITE MIXED $CaSO_4$:Dy TL DOSEMETERS FOR BETA RADIATION DOSIMETRY

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ABSTRACT

Sintered pellets of $CaSO_4$:Dy of different thickness with graphite contents from 0 to 10% were investigated for application for beta dosimetry.

INTRODUCTION

During the last few years many attempts have been made to develop detector devices for assessment of radiation doses from low energy beta rays to the unprotected skin [1-3]. The Dosimetric Materials Production Laboratory of IPEN developed thin pellets of $CaSO_4$:Dy (0.20 mm thick) for beta radiation detection [4]. This type of dosemeter shows good sensitivity but high energy dependence for beta mean energies below 100 keV. In this work it was investigated the TL characteristics of the sintered $CaSO_4$:Dy dosemeters with graphite contents from 1 to 10% for application for personnel dosimetry.

EXPERIMENTAL MEASUREMENTS

TLD pellets were obtained from a homogeneous mixture of $CaSO_4$:Dy (0.1% mol) phosphor (35% by weight), Teflon powder and graphite (0; 0.5; 1; 2; 5 and 10% by weight). Pellets of this mixture, with a diameter of 6.0 mm and thickness between 0.20 mm and 0.80 mm were first cold pressed and then sintered.

The TL response of these pellets were determined using the Harshaw TL Reader model 2000 (AB). Prior to irradiation, the samples were subjected to an annealing at 300°C for 3 h. They were irradiated under the same conditions. Each reported value corresponds to the average of five measurements.

The beta irradiations were carried out using the beta Secondary Standard System of the Calibration Laboratory of IPEN, with ^{90}Sr - ^{90}Y (74 MBq), ^{204}Tl (18.5 MBq) and ^{147}Pm (0.5 GBq) sources (manufactured by Buchler & Co., Germany). The detectors were always placed on a 12 mm thick phantom (Lucite) and covered with a 15 μm thick (2.1 $mg.cm^{-2}$) polyethylene terephtalate (Hostaphan) foil during the irradiation.

The gamma irradiations were carried out using a ^{60}Co source (1.0 GBq). The samples were always irradiated sealed in Hostaphan foil 15 μm thick and under electronic equilibrium conditions.

RESULTS

The CaSO :Dy Teflon pellets with different graphite contents were exposed to 2.58 x 10^{-5} $C.kg^{-1}$ (100mR) of ^{60}Co gamma radiation. The decrease of the TL sensitivity with increasing graphite content is observed. Pellets with thickness of 0.20 mm showed the highest TL response when exposed to 10 mGy of ^{204}Tl radiation.

The individual reproducibility of the dosemeters was investigated for each dosemeter type by calculating the standard deviation from ten sucessive dose measurements. The average reproducibility obtained for ten pellets irradiated with 10 mGy (^{90}Sr - ^{90}Y) under identical conditions was 3% (1σ) for all type of dosemeters.

The dose threshold defined as three times the standard deviation of the zero dose reading of the dosemeters expressed in terms of dose units, was calculated for each type of dosemeter. From Table 1 it can be seen that the dose threshold for dosemeters 0.20 mm thick with graphite content of 10% is approximately 23.0 μGy for gamma radiation of ^{60}Co, which is an acceptable level for application for personnel dosimetry.

The TL response of all type of $CaSO_4$:Dy dosemeters was measured for ^{90}Sr - ^{90}Y, ^{204}Tl, and ^{147}Pm beta sources normalized to ^{60}Co radiation. The energy dependence for 0.20 mm thick pellets is shown in Table 2. It can be seen that the beta ray response of $CaSO_4$:Dy dosemeters with a graphite content of 10% gives an optimal response curve when compared with the response curve of pellets without graphite.

After a storage period of one month at room temperature, the results from the stored dosemeters were compared with dosemeters annealed, immediately irradiated, stored for 24 h and then read out: only 3% fading was found in the TL response.

CONCLUSIONS

The graphite mixed $CaSO_4$:Dy Teflon pellets produced at IPEN appear attractive for beta as well as mixed beta-gamma dose measurements. The reduced energy dependence to beta rays with average energy between 100 and 800 keV makes them useful in personnel monitoring.

REFERENCES

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Table 1 - Effect of graphite content on background TL and dose threshold (0.20 mm thick).

Graphite Content	Minimum Measurable Absorbed Dose			
	^{60}Co	^{90}Sr-^{90}Y	^{204}Tl	^{147}Pm
%	μGy	μGy	μGy	μGy
0	1.30	1.50	2.70	7.00
0.5	2.90	2.60	4.30	14.00
1	3.60	3.70	5.80	17.00
2	7.60	7.00	8.90	24.00
3	12.00	15.00	20.00	53.00
5	20.00	20.00	33.00	60.00
10	23.00	30.00	36.00	113.00

Table 2 - Energy dependence of 0.20 mm thick pellets with 0% and 10% graphite content.

Source	Mean energy	Relative TL response	
	MeV	0% graphite	10% graphite
^{90}Sr-^{90}Y	0.80	1	1
^{204}Tl	0.24	0.50	0.90
^{147}Pm	0.06	0.20	0.40