Preliminary Study of the $CaSO_4$:Dy Behavior to Application in Beta Radiation OSL Dosimetry

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Abstract. The use of the optically stimulated luminescence (OSL) technique in radiation dosimetry has been conditioned to the availability of suitable material. This paper aims to evaluated the behavior of $CaSO_4$:Dy dosimeters irradiated using a ^{90}Sr/^{90}Y beta source. The dosimeters were heat-treated at 300°C for 3 hours. The beta irradiation and the OSL signal were obtained using a TL/OSL Risø reader. The evaluated parameters were reproducibility, dose-response curve and signal OSL decay as function of reading time of $CaSO_4$:Dy dosimeters in 0.1 to 10 Gy dose range.

1 Introduction

The use of optically stimulated luminescence (OSL) as dosimetric technique was introduced in 1956 by Antonov-Romanovskii and since then has been widely studied and applied in various areas of dosimetry [1]. Its application extends from medical physics to methods of dating. The optically stimulated dosimeters have not been much exploited in medicine yet, but Yukihara and McKeever (2008) mention that research involving OSL technique is increasing gradually in recent years. Properties as high sensitivity and the all-optical nature of the process are the two properties most exploited in medical dosimetry application [2].

OSL is a luminescent signal emitted by a semiconductor or an insulator (previously irradiated) when exposed to light. The intensity of OSL signal is a function of radiation dose absorbed by the material, so the luminescence response can be used as a basis for a method of dosimetry. The process is similar to the thermoluminescence,

but differs in the stimulation: instead of thermal stimulation, in OSL defects in the detector are stimulated by optical means [3].
The $CaSO_4$:Dy dosimeters are largely employed in radiation protection to personal dosimetry and recent studies show their application in thermoluminescent dosimetry in radiotherapy for dose measurements of photons and electrons beams [4,5]. This paper aimed to evaluated the behavior of $CaSO_4$:Dy dosimeters irradiated in $^{90}Sr/^{90}Y$ beta source using OSL technique. The dose-response curve, the heat decay of OSL signal and the reproducibility of the dosimeters were analyzed.

2 Materials and Methods

2.1 Materials and Equipments

- ✓ 25 $CaSO_4$:Dy dosimeters;
- ✓ ^{60}Co gamma source (656.4MBq);
- ✓ $^{90}Sr/^{90}Y$ beta source (1.48 GBq - 0.1Gy/s);
- ✓ Furnace VULCAN model 3-550 PD;
- ✓ TL/OSL Risø reader model TL/OSL-DA-20;
- ✓ Blue Led NICHIA - NSPB-500AS (470 nm);
- ✓ Hoya U-340 filter.

2.2 Methods

Before irradiation the dosimeters were heat-treated 300ºC/3h using a furnace VULCAN model 3-550 PD. Twenty five dosimeters of $CaSO_4$:Dy were irradiated in air under electronic equilibrium conditions with a ^{60}Co gamma source to be selected according to their sensitivity. After the TL readings the individual and average TL responses of the dosimeters were obtained; they were separated into 5 groups of 5 detectors according to their sensitivity. The selected dosimeters were irradiated with a $^{90}Sr/^{90}Y$ beta source with doses ranging from 0.1 up to 10 Gy using a TL/OSL Risø reader, Fig.1.
To OSL signal readings the $CaSO_4$;Dy dosimeters were stimulated with Blue Led NICHIA - NSPB-500AS (470 nm) For this measurement was used the Hoya U-340 filter. The dose-response curve was obtained to 0.1, 0.5, 2.0, 5 and 10 Gy and the thermal decay curve of OSL signal was got to 0.0, 0.10, 0.14, 0.17, 0.25, 0.34, 0.50, 1.0, 3.0 and 5.0 hours after the beta irradiation.

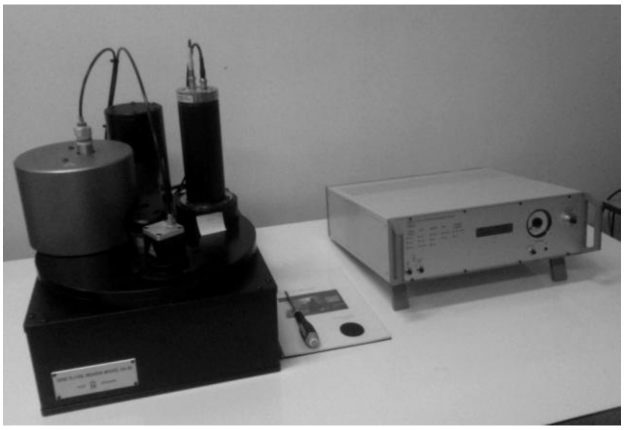

Fig. 1. TL/OSL reader Risø model TL/OSL-DA-20

Each value is the average of five measurements of dosimeters of the same sensitivity group and the error bars represent the standard deviation of the mean (1σ).The reproducibility was calculated with the respective equation:

$$\text{Reproducibility}\,(\%) = \frac{\sigma}{\sqrt{\mathrm{n}} \cdot \overline{R}} \cdot 100\,,$$

where: σ is the standard deviation, n is the number of dosimeters and $\overline{R}$ is the mean of the OSL response of the dosimeters of each group.

3 Results

In the Figure 2 is show the OSL dose-response curve of $CaSO_4$:Dy dosimeters to beta radiation to the following doses: 0.1, 0.5, 1.0, 5.0 and 10 Gy. The OSL response curves for different doses of beta radiation according to the time of reading after irradiation are showed at Figure 3. The Figure 4 shows the thermal decay curve of the OSL signal of the $CaSO_4$:Dy dosimeters for the maximum reading time after the irradiation (5 hours).

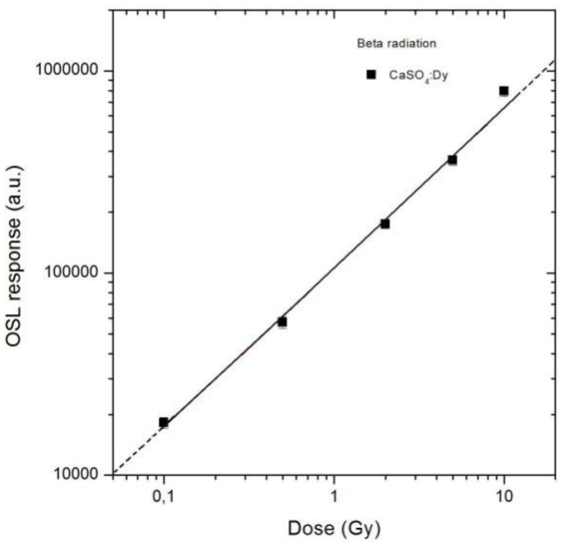

Fig. 2. OSL dose-response curve of $CaSO_4$:Dy dosimeters.

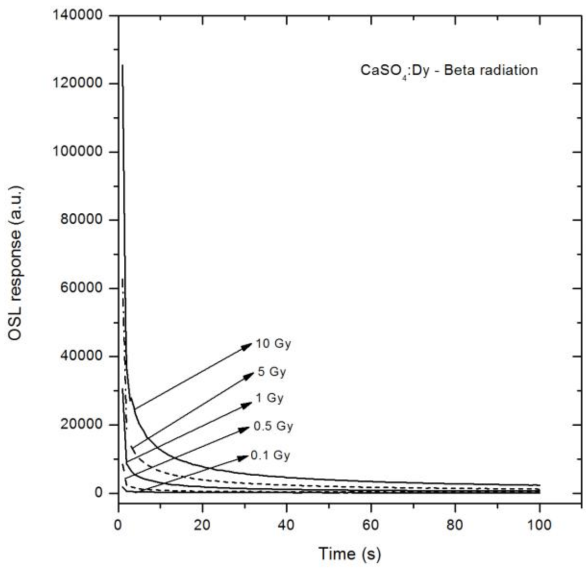

Fig. 3. OSL response to different doses.

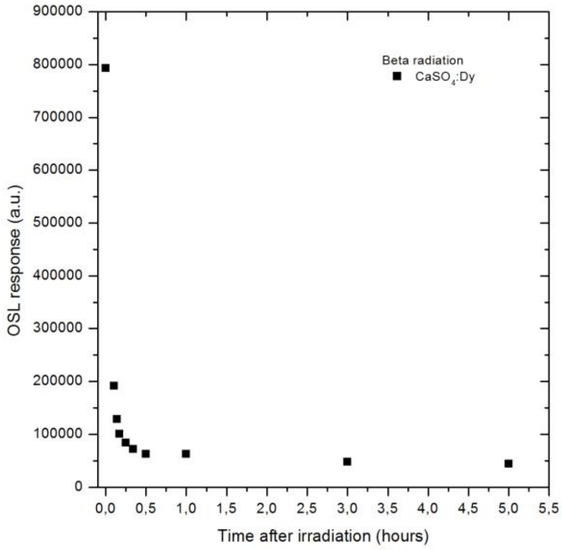

Fig. 4 OSL Thermal decay curve of the $CaSO_4$:Dy dosimeters

The Table 1 presents the reproducibility of $CaSO_4$:Dy dosimeters irradiated in beta radiation source with doses ranging from 0.1 to 10 Gy.

Table 1. Reproducibility of $CaSO_4$:Dy dosimeters to $^{90}Sr/^{90}Y$ beta radiation.

	Dose (Gy)	**Reproducibility (%)**
$CaSO_4$:Dy $^{90}Sr/^{90}Y$ beta radiation	0.1	$\pm$ 3,01
	0.5	$\pm$ 2,85
	1.0	$\pm$ 2,95
	5.0	$\pm$ 2,77
	10	$\pm$ 2,67

4 Discussion and Conclusions

The OSL dose-response curve of $CaSO_4$:Dy dosimeter to $^{90}Sr/^{90}Y$ beta radiation presented linear behavior in the dose range from 0.1 to 10 Gy.

In Figure 4 it can be seen that the thermal decay of the OSL signal occurs approximately in the first 30 minutes (0.5 hour) after irradiation. After this time the OSL signal remains practically constant until the maximum reading time (5 hours) of this work.
The intensity of OSL response immediately after irradiation is 16 times greater than the intensity of the OSL response 5 hours after irradiation. This loss of OSL signal with the reading time can be related to factors such as the treatment process, the reading process and type of dosimetric material [6]. The reproducibility of the signal OSL ranged from 2.67% to 3.01%, which was found in accordance with values reported in the literature (up to 5%).
It should be remembered that this is a preliminary study but with the results already obtained about the dose-response curve, reproducibility and decay heat of the OSL signal, it can be concluded that the $CaSO_4$:Dy dosimeter may be used for beta radiation dosimetry with readings immediately after irradiation.

References

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