Performance of commercial Al_2O_3:C detectors in standard X-ray beams using the OSL technique

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Abstract: In this work, OSL commercial detectors were tested in standard X radiation beams, radioprotection level, to verify the possibility of their use in personal dosimetry. for this kind of radiation. The reproducibility, the dose-response curve and the energy dependence of the OSL detector were determinate. The reproducibility and the dose-response curve showed an acceptable behavior for the potential use in individual monitoring of the OSL commercial detector, however these detectors presented a high dependence of its OSL response on X-ray energy, that has to be taken into consideration.

Key words: optically stimulated luminescence, individual dosimetry, X-rays.

1. INTRODUCTION

Dose limits are extremely important as part of the evaluations in occupational exposure to ionizing radiations [1]. The OSL technique, originally applied to archaeological and geological dating, medical and environmental dosimetry [2], has been applied to individual dosimetry in recent years and became a very successful dosimetric technique, in particular using Al_2O_3:C as detector [3]. This material has become the main OSL material for individual radiation detection [4]. Commercial detectors of Al_2O_3:C have been developed and tested; however, most of the tests have been performed with gamma beams. Akselrod et al. [4] and Pinto et al. [5] reported about the Al_2O_3:C commercial detector characterization for beta radiation. However, medical personal staff may be exposed to other kinds of radiation, e. g. X-rays. Yukihara et al. [6] have tested Al_2O_3:C in X-rays dosimetry for medical applications, in computed tomography beams.

The OSL technique has several advantages over the thermoluminescence (TL) technique: the readout method is optical, requiring no heating of the samples; the measurement is less destructive and potentially more sensitive than TL; and the response may be evaluated several times on the same sample [7, 8,9]. Moreover, the OSL technique presents faster readouts and maximum efficiency.

In order to apply the OSL phenomenon as an individual dosimetry technique, it is necessary to certify its operation to guarantee correct measurements with minimum variations. The assurance of the adequate performance of the detectors is obtained by the results of characterization tests, within a quality control program, with evaluation of the reproducibility, the dose response curve and the energy dependence of its response. In Brazil, the evaluation criteria of the performance of the measurement systems of measures utilized in personal monitoring are established by the Brazilian Commission of Nuclear Energy (CASMIE) [10].

The objective of this work was to test the performance of OSL commercial detectors in standard X radiation qualities, radioprotection level.

2. METHODOLOGY

The irradiations of the OSL detectors with X-rays were performed using a Pantak/Seifert system, GmbH & Co., Germany. Table 1 shows the characteristics of the standard X radiation qualities, radioprotection level.

Table 1 – Characteristics of the standard X radiation qualities, radioprotection level

Radiation quality	Tube potential (kV)	Current (mA)	Half-value layer (mmCu)	Filtration (mm)	Air kerma rate (µGy/min)
N-60	60	20	0.25	0.6Cu+4.0Al	471.0
N-80	80	20	0.61	2.0Cu+4.0Al	191.0
N-100	100	20	1.14	5.0Cu+4.0Al	92.6
N-150	150	20	2.40	2.5Sn+4.0Al	742.0

The measurements were obtained using OSL InLight Dot detectors of Al_2O_3: C (Fig. 1), a Landauer microStar reader and associated software. Each radiation detector is composed by a layer of Al_2O_3:C sandwiched between two layers of polyester with a total thickness of 0.3 mm and diameter of 0.7 mm [11].

All operational tests, described elwhere [12], were performed before the measures in the present work.

Figure 1 - Landauer InLight Dot detectors of Al_2O_3: C

For the irradiations, each Al_2O_3:C InLight Dot detector was positioned on a cardboard phantom.

The measurements were always taken immediately after the irradiations. The detectors were optically treated at 26 x 10^3 lux for 24 hours prior to each reutilization. A Delta OHM radiometer, model D09721, LUX LP 9021PHOT sensor, was utilized to determine its light levels [13].

3. RESULTS

3.1. Reproducibility

Ten detectors were exposed to the N-80 standard X radiation quality, and the reproducibility of their OSL response was obtained taking ten measurements of each OSL dosimeter, irradiated with 6.0 mGy of absorbed dose. The result obtained was 4.3%; it is within the acceptable limits for individual monitoring. CASMIE [10] recommends 7.5% as the maximum value.

3.2. Dose-response curve

The Al_2O_3: C detectors were irradiated with the N-80 standard X radiation quality in the dose range of 0.2 mGy to 2 mGy. Ten detectors were utilized for each absorbed dose. The dose-response curve (Fig.2) presented a linear response for low doses, which are more probable to occur in individual monitoring.

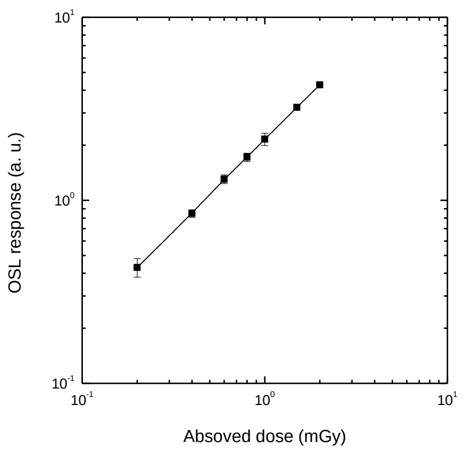

Figure 2 - Dose-response curve of Landauer InLight Dot detectors exposed to the N-80 standard X radiation quality

3.3. Energy dependence

The OSL detectors were exposed to a dose of 3 mGy of each X radiation quality beam (Fig.3). This material presents a high dependence of its OSL response on the X-ray energy. Further studies will be undertaken in order to choose filters to minimize the energy dependence of the detectors.

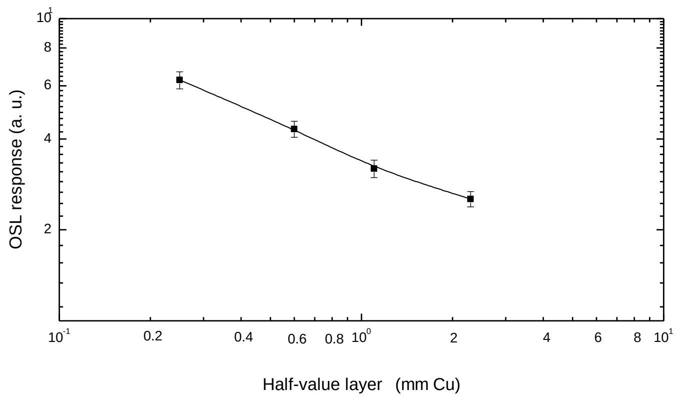

Figure 3 – Energy dependence curve of Landauer InLight Dot detectors exposed to the N-80 standard X radiation quality beams

4. CONCLUSION

The reproducibility and the dose-response curve showed an acceptable behavior for the OSL commercial detectors potential use in individual monitoring. However, the use of these detectors for individual monitoring of workers exposed to X-rays is conditional to the results of further studies that will be developed, in order to control the energy dependence.

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