CHARACTERIZATION OF Al_2O_3 SINTERED PELLETS FOR DOSIMETRIC APPLICATIONS IN RADIOTHERAPY

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ABSTRACT

Al_2O_3 sintered pellets were tested in relation to their thermoluminescent properties, in order to investigate the possibility of their use for dosimetry in the radiotherapy cases of ^{60}Co radiation. The material presents a glow peak at about $280^{o}C$, a linear dose response between 0.1 and 100 Gy, suitable reproducibility and lower detection limit. The thermoluminescent response can easily be corrected for the fading, when necessary.

1 - INTRODUCTION

The thermoluminescent (TL) properties of aluminium oxide (Al_2O_3) in different forms (pure and doped) with respect to radiation detection have been investigated by several authors over the past years[1,2,3]. Summers[4] presented a review of the thermoluinescence glow curves in single crystal samples of Al_2O_3 (alpha phase) over the temperature range 10 to 700 K due to excitation with ultraviolet light, X rays or gamma rays. This kind of material is recommended to be used for accidental and high-dose dosimetry[5]. Osvay and Golder[3] observed that it presents a linear dose response and low cost, and it is easy to handle.

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This study involves the performance testing of calcined alumina powder (alpha phase), in order to verify if it can be used for the radiotherapy dosimetry performed with doses up to 3.0 Gy of ^{60}Co radiation.

2 - MATERIALS AND METHODS

Calcined alumina powder (alpha phase) produced by Alcoa was used to obtain sintered pellets of Al_2O_3 (8 mm diameter and 1 mm thickness). They were first cold pressed and then sintered at 1650^{O}C during one hour to obtain the required properties for this study. These pellets were produced at the Ceramic Materials Department of IPEN.

In order to determine the TL characteristics of the samples, they were irradiated under equilibrium conditions, that is, the samples were placed between 3 mm thick Lucite plates. All the Al_2O_3 samples were irradiated using a Telecobalt unit (Keleket Barnes Flexaray, model IS, 7.46 TBq). Prior to each irradiation, the samples were subjected to a thermal treatment at 400^{O}C for one hour. The readout of the samples was made on a Harshaw Nuclear Systems Model 3000 TL Analyser, with a linear heating rate of 5^{O}C/s. The reading cycle was performed within 50 s, with a constant flux of N_2 of 4.0 L/min. The maximum temperature of 300^{O}C was reached in each readout cycle. The output data were recorded in a X-Y register with two channels.

3 - RESULTS

a. Glow Curve

Figure 1 shows the glow curve for a Al_2O_3 pellet irradiated with 1.0 Gy. The main glow peak appears at about $280^{o}C$.

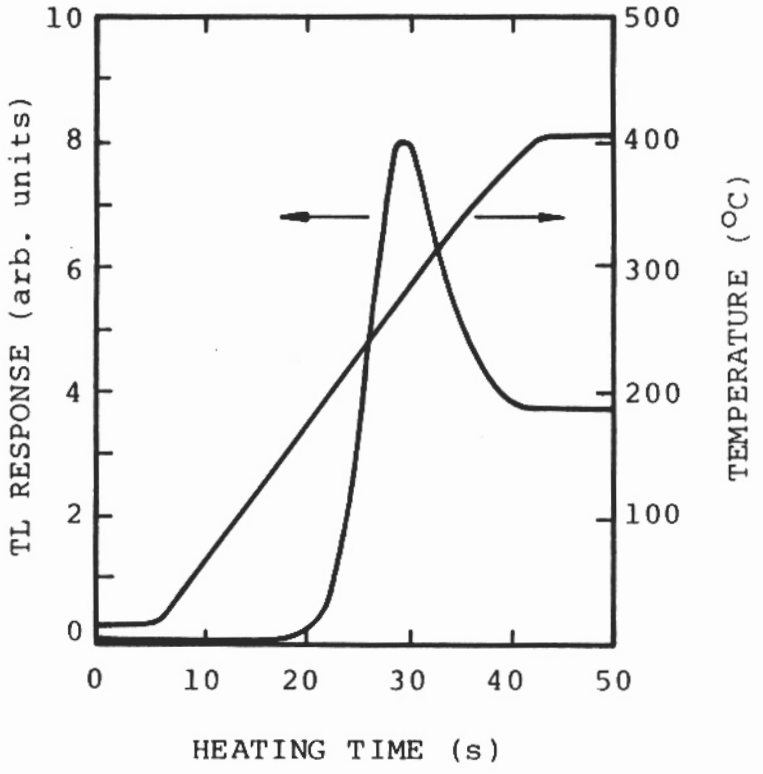

Fig.1 : TL glow curve of Al_2O_3 pellet irradiated with 1.0 Gy (^{60}Co).

b. Reproducibility

The reproducibility of the TL response of the Al_2O_3 pellets was obtained using 10 pellets, each measured 10 times after repeated standard annealing and irradiation. The spread of the TL response of each pellet, after 10 readout cycles was less than 4.3%. They

were irradiated with an absorbed dose of 1.0 Gy and then they were stored for 23 hours before being evaluated, in order to remove an instable $77^{O}C$ TL peak from the glow curve.

c. Radiation Dose Response

The TL response of the Al_2O_3 pellets as a function of absorbed dose of ^{60}Co gamma radiation was measured and a linear dose response was obtained in the interval between 0.05 and 100 Gy and is shown in Figure 2.

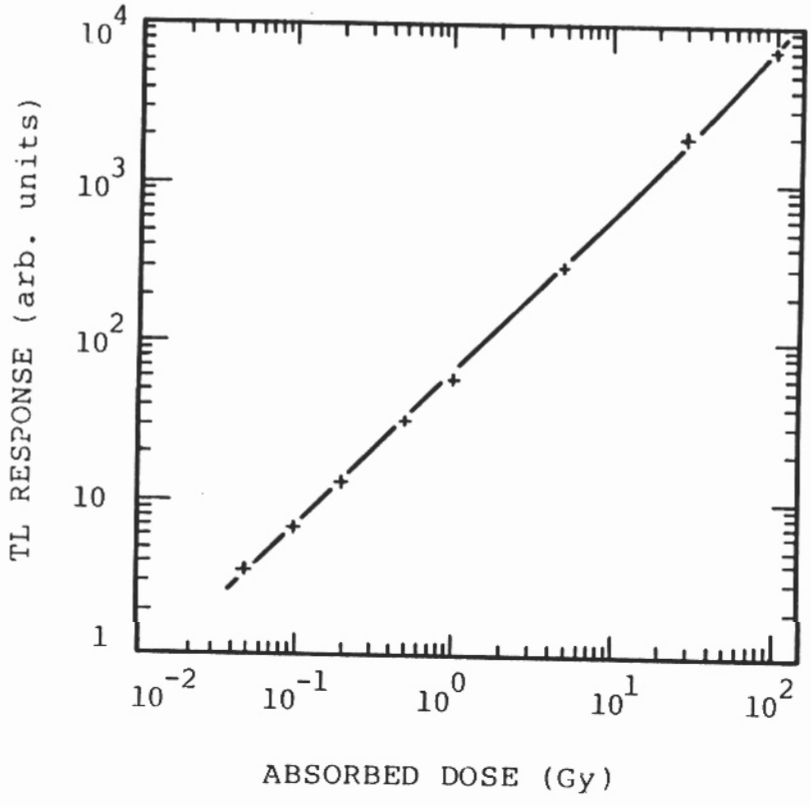

Fig.2 : TL response of Al_2O_3 pellets as a function of absorbed dose (^{60}Co).

d. Lower Limit of Detection

The lowest detectable value was determined studying the variability of the signal obtained by the reading of non irradiated pellets. It was taken as being equal to three standard deviations from the mean zero dose reading of the pellets. The lowest detectable value was 0.01 Gy.

e. Fading

The Al_2O_3 pellets were subjected to an absorbed dose of 1.0 Gy of the ^{60}Co source, and then the fading at ambient temperature was studied up to 90 days. It showed initially a rapid decrease (25% after one day), reaching a relative stability after three days.

4 - CONCLUSION

The Al_2O_3 (alpha phase) pellets present dosimetric properties. The results indicate the feasibility of their use for radiotherapy dosimetry in the case of ^{60}Co radiation.

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