ASSESSMENT OF $CaSO_4$:Dy THERMOLUMINESCENT DETECTORS RESPONSE FOR DIFFERENT PHANTOM MATERIALS AND PHOTON ENERGIES.

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Abstract: This work proposes the use of $CaSO_4$:Dy sintered discs as an alternative to LiF commercial dosimeters in the radiation therapy dosimetry of photon beams, studying the photon energy dependence response with energies ranging from 41keV to 6MeV using an water filled phantom (30 x 30 x 15 cm^3), a PMMA and a solid water phantom. $CaSO_4$:Dy was chosen because is one of the most useful and sensitive thermoluminescent dosimeter material for radiation dosimetry, and in the form of sintered discs are very suitable for applications requiring a large number of measurements.

Key words: thermoluminescence, dosimetry, TLD detectors, radiation therapy, TLD response.

1. INTRODUCTION

During the first 50 years since the beginning of radiotherapy, the technological progress was relatively slow and mainly based on X ray tubes, but in the last decade radiotherapy has been the object of a technological revolution because of the new techniques developed such as Three Dimensional-Conformal Radiation Therapy and Intensity Modulated Radiation Therapy (IMRT). The clinical use of these techniques requires a complete knowledge of the imaging of the volumes to be treated and also the dosimetry of the clinical electron and photons beams that are used in those cases. Thermoluminescence (TL) or thermally stimulated luminescence has been actively developed in the past years due to its reliability, sensitivity and commercial availability and is currently in use with LiF: Mg, Ti (TLD-100) commercial dosimeters in the dosimetric quality assurance of the output of therapy machines, which must be verified routinely [1, 2].

2. OBJECTIVES

This paper summarises the obtained results of the use of $CaSO_4$:Dy sintered discs as an alternative to LiF commercial dosimeters in the radiation therapy dosimetry of photon beams, studying the photon energy dependence response with energies ranging from 41keV to 6MeV. The obtained results show the feasibility of use for the dosimetry of clinical photon beams.

3. MATERIALS AND METHODS

$CaSO_4$:Dy single crystals produced by the Dosimetric Materials Laboratory at IPEN were used to produce thin sintered pellets of $CaSO_4$:Dy pressed in a matrix of polytetrafluorethilene (PTFE) (6.0mm in diameter and 0.8mm in thickness), which is known to be highly sensitive to photons to be used as a TLD dosimeter [3]. The dosimeters were irradiated with ^{60}Co gamma radiation and X rays chosen from the International Standards Organization's (ISO) Narrow Series [4], using the irradiation facility from Radiation Metrology Department of IPEN. The radiation quality chosen was RQR-10, which yields an effective energy of 41keV. The thermoluminescent dosimeters were also irradiated with photons from a clinical linear accelerator at *Hospital Israelita Albert Einstein* in São Paulo, Brasil, with different energies ranging from 2 to 6 MeV. Four detectors were used for each dose using an water filled phantom (30 x 30 x 15 cm^3), a PMMA and a solid water phantom (plates of 30 x 30 cm^2). The TL measurements were performed using a Harshaw 5500 Automatic TLD reader in a nitrogen atmosphere, with a linear heating rate of 10°C.s^{-1}. The reading cycle was performed within 23s. The maximum temperature of 250°C was reached in each readout cycle. Results on reproducibility, radiation dose response and energy dependence are presented.

4. Results

4.1. Glow curve

Figure 1 shows the glow curve for a $CaSO_4$:Dy pellet irradiated with 1 mGy (Co^{60}). The main glow peak appears at about 220°C.

4.2. Reproducibility

The dose response reproducibility of the $CaSO_4$:Dy TLD detectors were obtained measuring them 10 times after repeated and standard annealing (300°C/1h) and irradiation procedures (5mGy). The standard deviation after ten readout cycles was lower than 3.5% for $CaSO_4$:Dy detectors. The pellets were irradiated and then they were stored for 24 hours before being evaluated, to remove an unstable

110°C TL peak from the glow curve that is shown in figure 1.

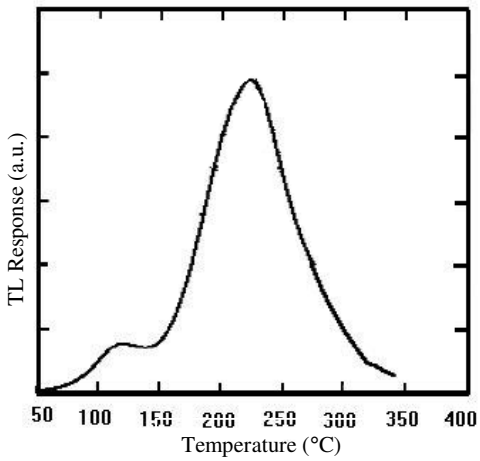

Fig. 1 – Glow curve of $CaSO_4$:Dy Teflon TLD disc after irradiation to 1 mGy of Co^{60}.

4.2. Calibration curves

The TLD response of $CaSO_4$:Dy detectors as a function of the absorbed dose was obtained placing the detectors in the photon beams of a clinical linear accelerator (LINAC), in the dose range of 0.1 to 5Gy, depth of maximum dose using the water filled ISO phantom, a PMMA and a solid water phantom. Figure 2 shows the setup for the samples irradiation using the clinical linear accelerator for the solid water phantom.

Fig. 2 – Setup for the samples irradiation.

The TL response of $CaSO_4$:Dy sintered discs as a function of absorbed dose for the energy of 41keV was obtained in the interval between 0.5 and 2Gy for water filled and PMMA phantoms respectively. Figure 3 shows the obtained results. The dose response calibration curves for TLD dosimeters for solid water and PMMA phantoms were also obtained, and the data for the energy of 2MeV are shown in figure 4. Similar results were obtained for the other phantoms and other energies. A linear dose response was obtained in this interval for all the tested phantoms.

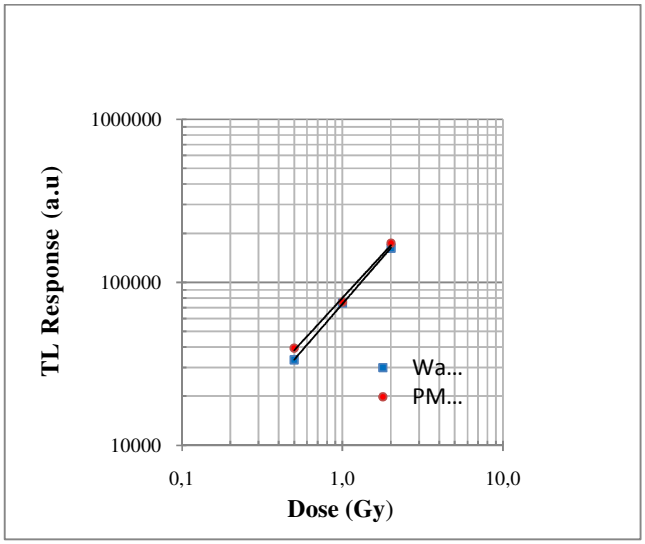

Fig. 3 – Calibration curve with PMMA and water filled phantom for the energy of 41keV X-rays.

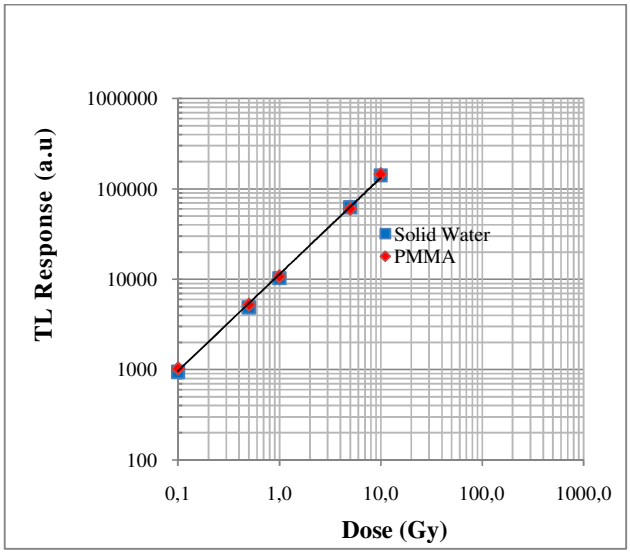

Fig. 4 - Calibration curve with the PMMA and solid water phantom for the energy of 2MeV.

4.3. Energy dependence

The performance of the $CaSO_4$:Dy detectors was studied in relation to its energy dependence for different photon beam energies and the values were normalized to ^{60}Co. The TL response was measured from samples exposed to 1,0Gy in X radiation beams of 41keV, and photon beams of 2 and 6MeV in front of the phantom. The maximum energy dependence was reached for 41keV of effective energy, as expected, since in this energy range dominates photoelectric effect. The uncertainties were always inferior to 5.0%. Figure 5 shows the energy response of the $CaSO_4$:Dy

sintered discs for the water filled and PMMA phantoms. Similar results were obtained for the solid water phantom.

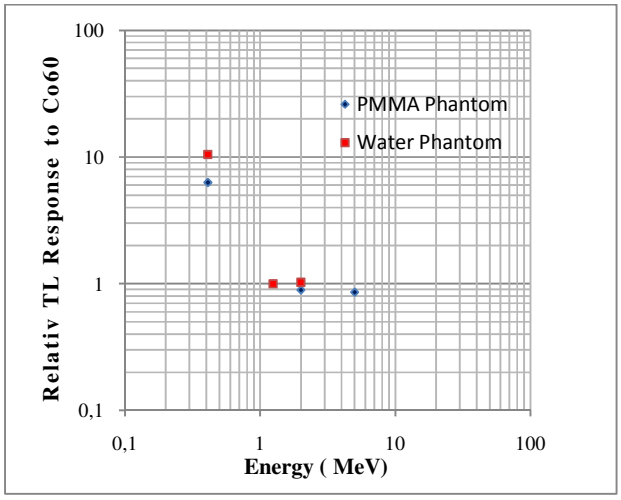

Fig. 5 – Energy response of $CaSO_4$:Dy sintered discs, normalized to Co^{60}.

5. CONCLUSION

The results obtained with $CaSO_4$:Dy TL detectors used in this work demonstrate the possibility of their use for the dosimetry of clinical photon beams. Results on reproducibility, radiation dose response and energy dependence indicate the suitability of their use for dosimetry of clinical photon beams.

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