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DOSE-RESPONSE OF SEMI-SPHERICAL $CaSO_4$:Tm THERMOLUMINESCENT PELLETS

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Introduction: Thermoluminescent dosimeters (TLD) have been widely employed in different applications, such as medicine and radiation protection. Thermoluminescent pellets of calcium sulfate doped with dysprosium ($CaSO_4$:Dy) pressed with Teflon® have been broadly used for different purposes in Brazil. However, there are studies using different doping materials, such as Thulium, and showing good results of sensitivity, homogeneity and reproducibility [1]. The geometry of the pellets is also an important component in dose assessment, and it is well known that pellets with cylindrical shape have high angular dependence. This work shows preliminary dosimetric evaluations of semi-spherical shaped thermoluminescent pellets of $CaSO_4$:Tm for use in personal dosimetry. The dose-response curve, repetitivity and group homogeneity were studied.

Material and method: The Yamashita method was used to produce the $CaSO_4$:Tm phosphor. A mixture of powder $CaSO_4$:Tm and Teflon® (2:1 proportion in mass) was pressed in a hydraulic press (3 ton) to produce 60 thermoluminescent pellets. The pellets are shaped in a semi-spherical format with 0.9 mm maximum height and 5 mm diameter. After pressing the pellets, any extra powder around the pellets was removed with the aid of sandpaper. This resulted in pellets with slightly different masses. The mean mass of the group of pellets was 30.6 ± 1,8 mg.

The thermal treatment employed was 1 hour at 400°C before irradiation and no thermal treatment was employed before readings. A Thermo QS 3500 reader was used to acquire the TL signal from 50ºC up to 400ºC at 10ºC/sec.

In order to find the initial radiation dose in which the pellets' response became stable, consecutive doses of 2 mGy were given using a ^{137}Cs source (dose rate of 1.37 μGy/s). The dose-response curve was obtained for doses ranging from 0.5 to 50 mGy.

Results: A dose of 16 mGy was found necessary to stabilize the thermoluminescent signal of the dosimetric pellets. The variation coefficient representing the reproducibility of the individual pellets was found to be between 0.84% and 4.26%, and 59.8% for the group.

The dose-response curve is given in Figure 1. A good linearity ($r^2 = 0.998$) was found, showing a sensitivity of 99.46 ± 1.61 nC/mGy. The lower detection dose limit was found to be 7.80 ± 1.82 mGy. The relative response of the pellets of $CaSO_4$:Tm and commercial $CaSO_4$:Dy irradiated with 2 mGy in the same conditions was found to be 1.05, showing the improved thermoluminescent response of the studied pellets.

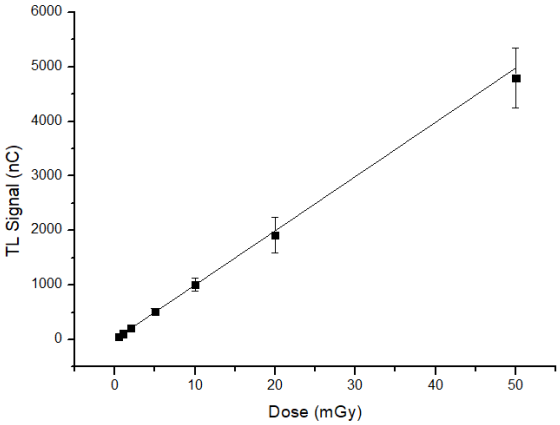

Figure 1: Dose-response curve for the dosimetric pellets of $CaSO_4$:Tm.

Conclusions: The semi-spherical shape pellets of $CaSO_4$:Tm has proven to be easy to handle despite their shape and have shown adequate response in low doses. Even though the variation coefficient for the group is high, this may be caused by the manual production of the pellets. Overall, the pellets showed promising results to be used in personal dosimeters.

References:

1. Forner, L. A.; Viccari, C. and Nicolucci, P. (2020) *Dosimetric properties of thermoluminescent pellets of $CaSO_4$ dopped with rare earths at low doses*. Rad. Phys. Chem. v. 171, 108704.