PRELIMINARY RESULTS ON SINTERED $CaSO_4$ PELLETS FOR X RADIATION DOSIMETRY USING THE TSEE TECHNIQUE

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INTRODUCTION

The increasing use of radioactive sources in medicine, industry and research has led to a growth in the number of persons exposed to some kind of ionizing radiation, therefore the importance of an accurate dosimetry. Thermally Stimulated Exoelectron Emission (TSEE), consisting of low energy electrons that are emitted from surfaces of many insulating solids at temperatures below those at which thermionic emission occurs, is a technique that can be used to measure weakly penetrating radiations, such as alpha and beta particles and low energy X-rays. The principles of exoelectron emission are very similar to those of thermoluminescence. Due to an exposure to ionizing radiation, electron traps in the energy band gap of an insulator are occupied. During the heating, the trapped electrons are released and are emitted from the surface of the crystal, if their energy exceeds the electron affinity (1,2,3). The emitted electrons are called exoelectrons and the curve of this emission as a function of temperature is called TSEE glow curve (1,3). Exoelectron dosimetry differs from thermoluminescent dosimetry in that particles (electrons) rather than photons provide the indication of dose. Due to the short range of exoelectrons, the sensitive layer of the dosemeter is thin enough that emission can be considered as a surface phenomenon (2). Usually, exoelectrons are measured with detectors counters, such as windowless Geiger-Müllers, ionization chambers or proportional counters (4). Sometimes, exoelectrons emission studies have to be performed in high vacuum conditions; in this case an electron multiplier is employed. Normally, this equipment is used preferentially for experimental research than for practical dosimetric purposes. In all devices, the samples are linearly heated up to a certain temperature. In this work the properties of pure $CaSO_4$ sintered pellets and others with 10% of graphite were investigated, using the TSEE technique, in order to verify their usefulness for dosimetric purposes.

MATERIALS AND METHODS

Powdered $CaSO_4$ crystals and chemically pure graphite powder were used to produce sintered pellets of pure $CaSO_4$ and others with 10% of graphite (6mm diameter and 0.8mm thickness). The $CaSO_4$ sintered pellets were tested in X radiation beams of a Rigaku-Denki generator, Model Geigerflex with a Philips tube Model PW/2184/00 (Tungsten target and Beryllium window - 60 kV). Prior to each irradiation, the samples were thermally treated at 300 °C for 15 min. The readout of the samples was made in a 2π windowless proportional counter with hemispherical volume and with P-10 gas flow (10% Methane + 90% Argon). The diameter of the gold anode wire is 50 μm and the operating high voltage is 2.0 kV. The samples are inserted into the counter and are fixed on a heater plate (Monel) ; they are linearly heated at a rate of 5.0 °C/s. The temperature control for linear heating is carried out by a temperature programmer (TP-2000, Theall Engineering Company), that provides rates between 0.1 and 5.0 °C/s, from room temperature up to about 400 °C. The glow curves were recorded in a multichannel scaler (EG&G - Ortec ACE-MCS SN 363 plug-in card).

RESULTS

Figure 1 shows the TSEE glow curve for a $CaSO_4$ sintered pellet irradiated with 10 Gy of X radiation (0.91 mmAl of HVL, 50 kV). The main glow peak appears at about 120 °C. Although the glow curve obtained with $CaSO_4$ + 10% of graphite is not shown, it is similar to that obtained with pure $CaSO_4$. The reproducibility of the TSEE response of the $CaSO_4$ sintered pellets was obtained measuring them 10 times after repeated standard annealing and irradiation procedure. The standard deviation after ten readout cycles was lower than 5.0% for pure $CaSO_4$ and 11.0% for $CaSO_4$ + 10% of graphite sintered pellets.

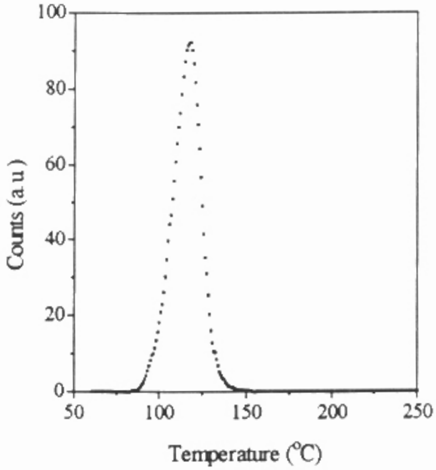

Figure 1. Typical TSEE glow curve for a pure $CaSO_4$ sintered pellet (10Gy).

The TSEE response of both kinds of materials as a function of the absorbed dose of X radiation was measured and the results are shown in Fig.2. The standard deviation of these measurements was always less than 10%. Although the observed sublinear TSEE behavior, the response increment in function of the absorbed dose show that these materials may be used for X radiation dosimetry in the range of 50 mGy up to 100 Gy.

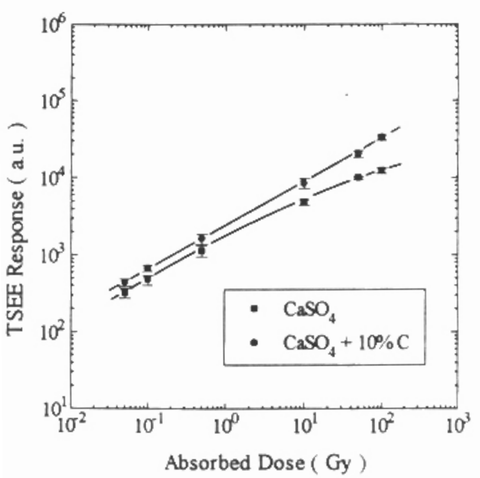

Figure 2 . The TSEE response for $CaSO_4$ sintered pellets.

The lowest detectable value was determined studying the variation 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 0.5 mGy. The performance of the $CaSO_4$ and $CaSO_4$ + 10% of graphite sintered pellets was studied in relation to its energy dependence for X-rays. The

TSEE response was measured from samples exposed to 10 Gy in X radiation beams of 25, 30, 40,45 and 50 kV in air. The maximum energy dependence was reached for 19 keV of effective energy, as shown in Fig.3

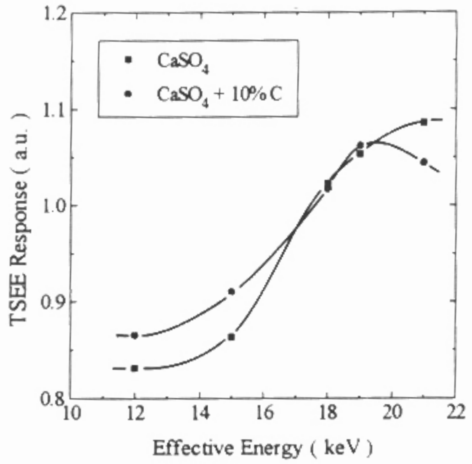

Figure 3. Energy dependence of $CaSO_4$ sintered pelllets.

CONCLUSION

The preliminary results on some dosimetric characteristics as reproducibility, glow curves ,calibration curves and energy dependence of the calcium sulphate sintered pellets studied in this work indicate that these materials may be useful for X radiation dosimetry between 0.5 mGy and 100 Gy.

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