CALCIUM SULPHATE FOR GAMMA RADIATION DETECTION USING THE TSEE TECHNIQUE

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ABSTRACT

Thermally stimulated exoelectron emission (TSEE) is a technique that can be used to measure weakly penetrating radiations such as alpha and beta particles and low energy X radiation, due to the shallow surface region within which exoelectrons originate. In this work, the experiments were carried out with a proportional counter developed at IPEN with P-10 gas flow. The properties of pure $CaSO_4$ sintered pellets and others with 10% of graphite were investigated, in order to verify their usefulness as dosemeters. The $CaSO_4$ sintered pellets were tested in gamma radiation of ^{60}Co and results on exoemission glow curves, response reproducibility and calibration curves of the samples are presented.

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 [1], is a technique that can be used to measure weakly penetrating radiations, such as alpha and beta particles and low energy X-rays [2,3].

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. The emitted electrons are called exoelectrons and the curve of this emission as a function of temperature is called TSEE glow curve [2,4].

Exoelectron dosimetry differs from thermoluminescence 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 sufficiently thin enough that emission can be considered as a surface phenomenon[5].

Usually, the exoelectrons are measured with detectors counters, such as windowless Geiger-Müllers, ionization chambers or proportional counters [1,6,7]. 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. These pellets were produced at the Dosimetric Materials Production Laboratory of IPEN.

In order to determine the TSEE characteristics of the samples, they were irradiated under equilibrium conditions, that is, the samples were placed between 3mm thick Polymethyl Methacrylate (Lucite) plates. The $CaSO_4$ sintered pellets were tested in gamma radiation of a Telecobalt Unit (Keleket Barnes Flexaray, Model IS, 7.46 TBq). Prior to each irradiation, the samples were thermally treated at 300 °C for 15 min.

The readout of the samples was made in a 2p windowless proportional counter with hemispherical volume and with P-10 gas flow (10% Methane + 90% Argon). The diameter of the gold wire is 50 mm 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/s. The glow curves were recorded in a multichannel analyser 7450 EG&G - Ortec.

RESULTS

Figure 1 shows the TSEE glow curve for a $CaSO_4$ *sintered pellet* irradiated with 10 Gy (^{60}Co). 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 using 10 pellets, each measured 10 times after repeated standard annealing and irradiation procedure. The mean standard deviation after ten readout cycles was 3.0% for pure $CaSO_4$ and 2.5% for $CaSO_4$ + 10% C of graphite sintered pellets respectively.

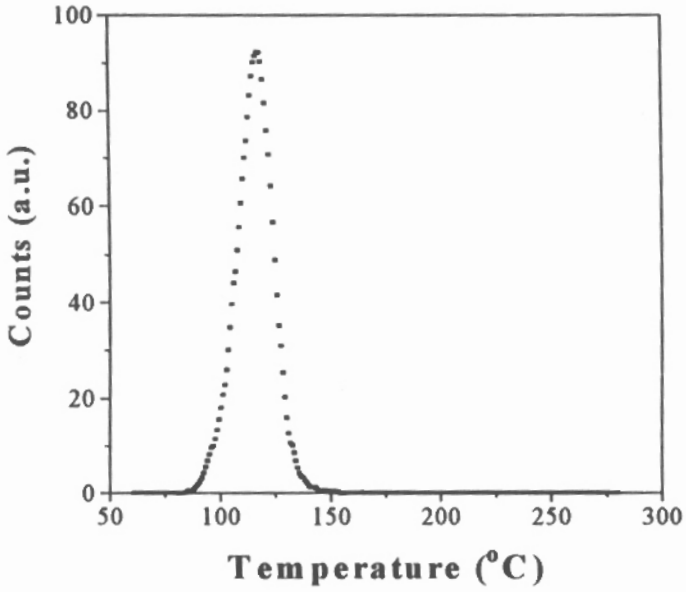

Fig.1. TSEE glow curve for pure $CaSO_4$ sintered pellet.

The TSEE response of both kinds of materials a function of the absorbed dose of ^{60}Co gamma radiation was measured and the results are shown in Fig.2. The mean 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 gamma radiation dosimetry in the range of 1mGy up to 1 kGy.

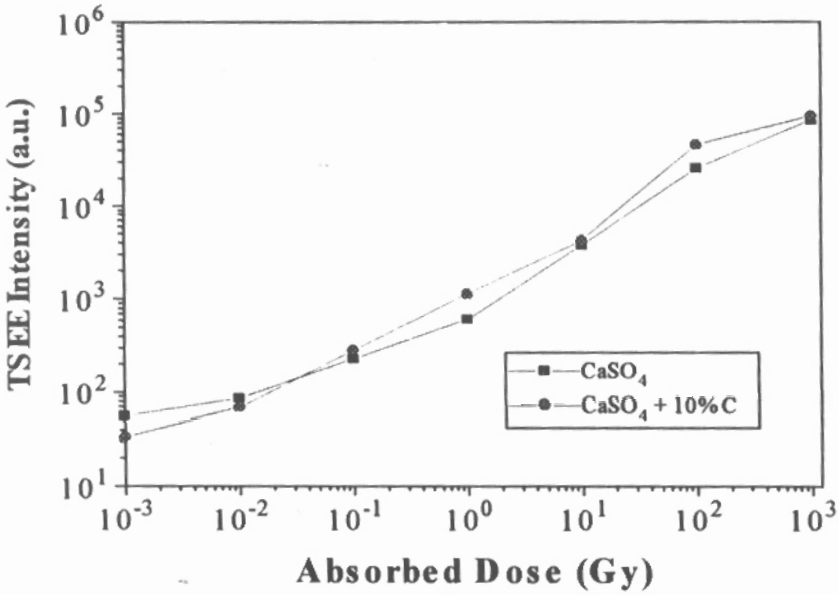

Fig.2. The TSEE response for pure $CaSO_4$ sintered pellet and with 10% of graphite.

CONCLUSION

The preliminary results on some dosimetric characteristics as reproducibility, glow curves and calibration curves of the calcium sulphate sintered pellets studied in this work indicate that these materials may be useful for gamma radiation dosimetry between 1 mGy and 1 kGy.

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