FAST NEUTRON DOSIMETRY USING $CaSO_4$:Dy TERMOLUMINESCENT DOSIMETERS

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INTRODUCTION

Sulphur as a threshold detector is widely used in fast neutron dosimetry to measure the activity beta of ^{32}P arising from $^{32}S(n,p)^{32}P$ reaction[1,2]. However, conventional pellet-activation techniques require sensitive radiation detectors for the measurement of induced activity in sulphur pellets[3]. Thermoluminescent dosimeters could combine in a single device the functions of an activation-pellet and a detector of radiation emited by itself. The use of activation of $CaSO_4$:Dy for detection of fast neutrons has been suggested by some autors[4] However, quantitative measurements have not been reported so far.

In this paper we describe the use of $CaSO_4$:Dy phosphor powder in fast neutron dose measurements using the activation of sulphur from the reaction $^{32}S(n,p)^{32}P$.

The thermoluminescence induced during the irradiation and also the thermoluminescence due to decay of the short-lived activation products, is erased annealing the dosimeters, after a post-irradiation time of 3 d.

MATERIAL AND METHODS

Samples of 30 $\pm$ 0.5 mg of $CaSO_4$:Dy powder prepared at the Instituto Nacional de Investigaciones Nucleares (ININ) of Mexico were used[5]. These dosimeters were irradiated in a mixed field of epicadmium neutrons and gamma rays in the tangencial west-2 beamport of the Triga Mark III Reactor at the Nuclear Center of Mexico. The dose range used was 10^{-2}-10^{2} Gy with an associated gamma dose in the range 10-10^{3} Gy. The fast neutron and gamma ray doses with which the $CaSO_4$:Dy was irradiated were measured with sulphur pellets[2] and $Li_2B_4O_7$:Mn phosphor[6] powder.

After post-irradiation time of 3d, the dosimeters were treated to 800°C of temperature during 1 h in order to erase all thermoluminescence produced during irradiation and also thermoluminescence induced by the decay of all the short-lived activation products.

After this treatment the dosimeters were stored in plastic capsules of 2 mm thickness at room temperature (21°C) in the darkness to allow the self-irradiation of

$CaSO_4$:Dy from ^{32}P beta particles.

The self-induced Thermoluminescence was measured at different intervals of post-irradiation time; these measures give an estimation of the fast neutron dose to which the dosimeters were exposed.

The thermoluminescent readings were plotted as a function of the post irradiation time of 30 d as a function of fast neutron dose in gray.

RESULTS

The figure 1 shows the build-up of thermoluminescent response of $CaSO_4$:Dy powder as a function of the post-irradiation time. Each point on the plot was obtained by taking averages of ten readings. After a post-irradiation time of 30 d, the signal of the accumulated thermoluminescence produced by 2.2 x 1011 n/cm^2 was equal to 3 x 10^{-3} Gy of ^{60}Co equivalent gray.

The minimum detectable gamma dose with this phosphor is 3 x 10^{-6} Gy of ^{60}Co gamma rays(5), and this dose corresponds to a fast neutron dose of 9 x 10^{-4} Gy.

The figure 2 shows the calibration curve for fast neutron dose in gray as a function of accumulated thermoluminescence during a post-irradiation time of 30 d. This calibration plot corresponds to a straight line on full log paper which is a typical calibration plot for thermoluminescent dosimeters.

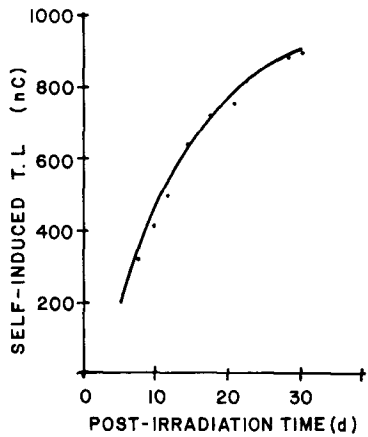

Fig. 1 Self-induced thermoluminescence in $CaSO_4$:Dy powder as a function of the post-irradiation time using 2.2 x 10^{-11} n/cm^2.

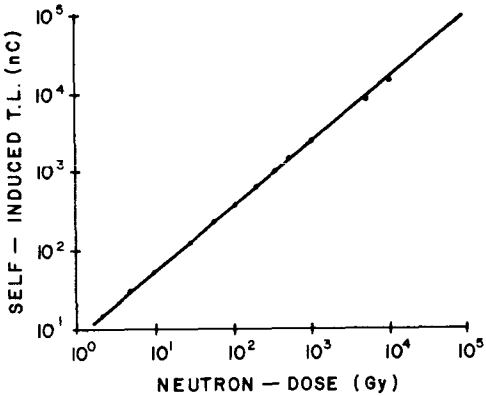

Fig.2.- $CaSO_4$:Dy powder calibration plot which was obtained after a post-irradiation time of 30 d. for epicadmium neutrons.

CONCLUSIONS

Three conclusions may be drawn from this work:

1.- Sulphur activation in $CaSO_4$:Dy thermoluminescent dosimeters is a useful method in fast neutron dosimetry.

2.- A calibration curve for fast neutron dose as a function of accumulated thermoluminescence during a post-irradiation time of 30 d, was obtained as a straight line in a full log paper in the dose range from 2 to 10^4 Gy.

3.- The minimum fast neutron dose measurable with $CaSO_4$: Dy powder as 9×10^{-4} Gy for measurements made after a post-irradiation time of 30 d.

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