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DOSIMETRY IN A PILOT PLANT FOR BULK DISINFESTATION OF GRAIN BY ELECTRON IRRADIATION. I.-LITHIUM FLUORIDE IN POWDERED FORM *

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ABSTRACT

Experimental work using powdered lithium fluoride to determine dose, in the bulk treatment of grain with electrons, is described, as well as an analysis of LiF stability and its response to irradiation.

INTRODUCTION

Disinfestation of maize by ^{60}Co gamma irradiations has been extensively studied[(1)] as a joint project between the Instituto de Física, UNAM and Programa de Tecnología, INEN.

To evaluate the applicability of the process using electron irradiation, a pilot plant was built for the radiation disinfestation of grain. A description of the pilot plant appears in another work[(2)].

A diagram of this plant is shown in figure 1.

The plant is capable of treating several tons of bulk product per day, using a Van de Graaff electrostatic accelerator (model AN, High Voltage Engineering Corp. Mass. U.S.A.).

One of the technical problems that must be solved is to determine the accelerator's physical parameters in order to administer the appropriate dose to the grain. For this purpose, small capsules containing lithium fluoride powder (LiF, Baker Reagent 2381) were moved with the

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bulk of grain through the electron beam. This form of LiF was used because of its low cost. This method provided similar irradiation conditions to the grain and the capsules containing the dosimeter, since, the capsules were similar in size to individual grain particles. The thermoluminescence reading (TL) of the calibrated lithium fluoride powder gave a determinations of the radiation dose.

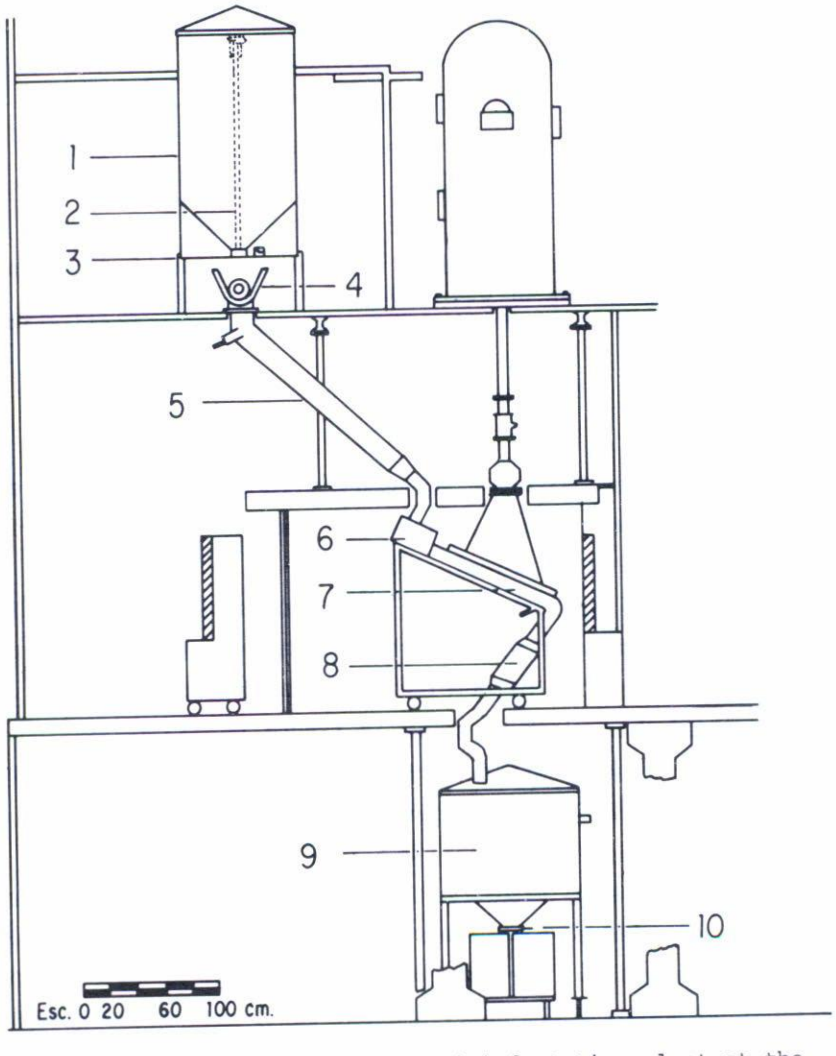

Fig. 1. Side view diagram of the grain disinfestation plant at the Instituo de Física, UNAM. Number 1 indicates the grain container; 2, the tube which regulates the grain flow; 3, a valve; 4 a screw conveyor; 5, the tube through which the grain falls; 6, a box with a regulation valve; 7, the irradiation channel; 8, the tube which sends the irradiated grain to 9, the container and 10, the exit valve.

Materials and methods

The lithium fluoride used in this experiment is a chemical reagent grade from J.T. Baker Co. (catalog numer 2381) and is intended mainly for analytical work, not for TLD (thermoluminescence dosimetry).

After irradiation in small gelatine capsule, .01±.0005g of each samples was taken to determine the area under the TLD glow curve, which could be related to absorbed dose by its calibration response. The TLD reading was recorded with a Harshaw, model 2000 TL analyzer. We used only new LiF powder for all gamma and electron irradiations, without any annealing procedure before or after each irradiation.

For the calibration, the glow curve for LiF irradiated with ^{60}Co gamma radiation was obtained, and the TL peak temperatures were found. We also studied the time variation of the TL reading, determining the half life (time required to get half of the initial TL reading) for each peak, by using conventional methods.

The calibration of TL reading against dose(3) was made using ^{60}Co gamma radiation from a Gammacell 200 (Atomic Energy of Canada Ltd.), property of Centro de Estudios Nucleares, UNAM.

The dose for LiF was determined against standard doses in water using Fricke (ferrous sulfate) solution as the primary dosimeter.

Afterwards the LiF capsules were irradiated with 1.0 MeV electrons as described before and the glow curve was found. We then analyzed the TL reading against the accelerator's beam current, which was collected at a metallic plate fixed to the channel where the bulk was irradiated.

All the experiments were carried at room temperature ($\sim$20°C).

RESULTS

Figure 2 shows the glow curve from LiF irradiated with gamma radiation (solid curve). There are two glow peaks, one at 120°C and the other at 225°C. The shapes were obtained under conditions indicated in the figure. When we studied the decay intensities of each, it was found that the first had a half life of 4.65 hours and the second 191.8 hours.

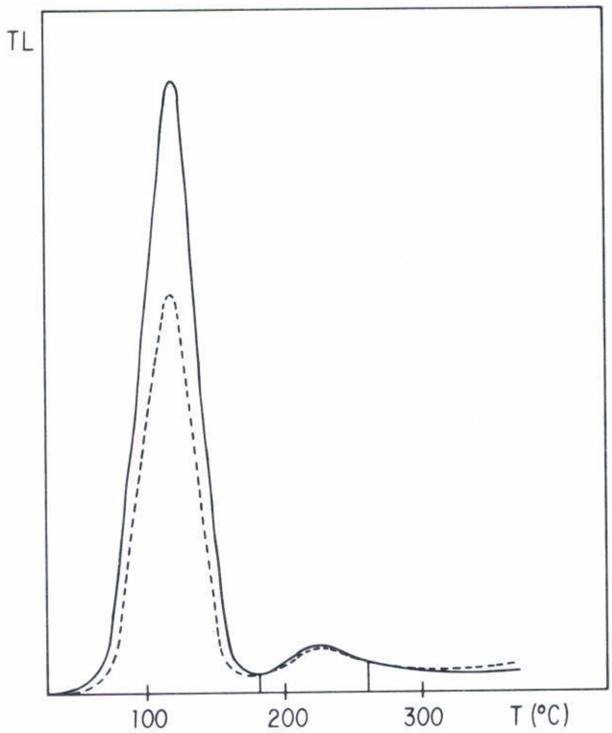

Fig. 2. Glow curves of Baker's 2381 LiF irradiated at equivalent dose with ^{60}Co gamma rays (solid line) and 1.0 MeV electrons (broken line). All irradiations were made with new powder without annealing and using same dose rates. Reading conditions were the same for all the glow curves obtained. The time between the end of irradiation and reading was 10 ± .5 min for both gamma and electron irradiations. The TL reading was measured in arbitrary units. All the glow curves were obtained in a Harshaw model 2000 TL analyzer. The conditions of the analizaer were as follow: temperature rate 5°C sec^{-1} ; maximum temperature 400°C; high voltage 560 volts.

Figure 2 also shows the glow curve of LiF irradiated with 1.0 MeV electrons (broken line). When we compare this curve with that of the gamma irradiation, we notice that the TL reading depends on the type of radiation used. It appears the energy in electron volts required to produce trapping centers in the LiF lattice is greater for 1.0 MeV electrons than for gamma rays, but this needs further investigation. It can also be seen from the figure that the high-temperature glow peak is the same for gamma and 1.0 MeV electron radiation.

In figure 3 we present a graph of the TL reading for the second peak versus gamma-ray dose. A linear dependence of TL reading with dose is observed in the range from 10 to 40 krad. Above 50 krad we obtained the usual supralinearity region (which is not presented in the graph). 10 krad is the lower detection limit, which in general depends on the LiF powder quality. Fitting our data by least squares we found:

$$D = 2.4154\ I - .112\ \text{(krad)}$$

where I = TL reading expressed in nC.

with an uncertainty of about 10%.

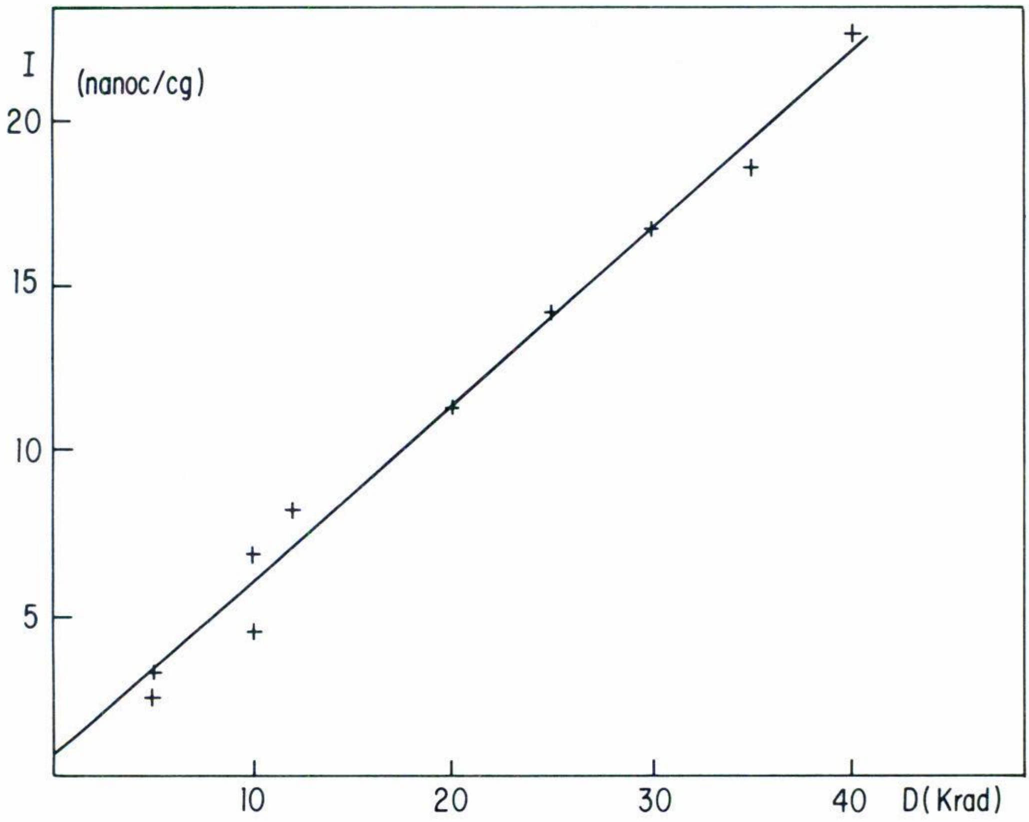

Fig. 3. Graph of the TL reading of .01 g samples as a function of dose for Baker's 2381 LiF irradiated with ^{60}Co gamma rays. I was measured in nC (nanocoulomb) and D in krads.

Finally, figure 4 shows a graph of the TL reading versus electron beam current from the Van de Graaff accelerator. Here we see a linear dependence of TL reading with beam current, between 30 and 80 μA. By the same arguments mentioned for figure 3, this graph cannot be extrapolated with good statistics below 25 μA.

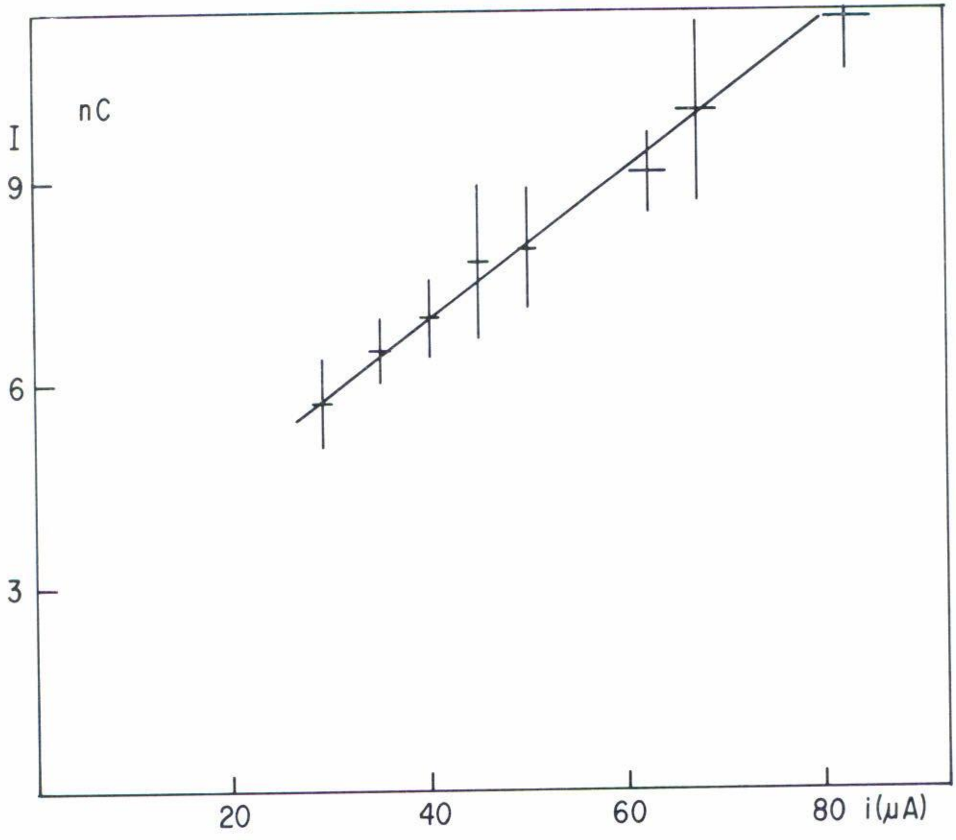

Fig. 4. Graph of the TL reading of .01 g samples versus beam current from the Van de Graaff accelerator. I was measured in nC and i in μA.

CONCLUSIONS

Baker 2381 LiF powder has few applications in dosimetry because of the poor stability of its low temperature glow peak and the relatively low resolution of the second one. Nevertheless it can be used in the range mentioned above with about 10% uncertainty, with the advantage of cheaper cost and ready accessibility, as compared with other commercial LiF dosimeters.

As can be seen from figure 2 we did not observe any qualitative difference between the shapes of the glow curves of gamma and electron irradiation, only a larger area for the ^{60}Co irradiation. Thus, the TL reading of the dosimeter does not depend on the type of radiation, when the high temperature glow peak is used. The TL reading is a linear function of dose in both cases.

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