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GLASS DETECTORS FOR DOSE DETERMINATION IN A FLOWER IRRADIATION PROCESS

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Abstract — A routine dosimetric system was developed using commercial glass samples. Using the optical absorption technique, the dosimetric characteristics of Brazilian glass samples, batch uniformity, response reproducibility, re-use, absorbed dose response, detection range, response stability, were studied. As an application, the dosimetric system was tested in a flower irradiation process. All the obtained results show the usefulness of the proposed system for high dose dosimetry.

INTRODUCTION

The ability to monitor radiation processes in a convenient and reliable manner is very important to the growth of the radiation processing industry. At present, there is a considerable number of radiation plants worldwide for sterilisation of medical devices, curing of coatings on different surfaces, cross-linking of polymers, treatment of food and flowers, etc. In all these fields it is vital to measure and control the radiation doses. Many types of glass dosemeters have been used, needing for their evaluation different and sometimes sophisticated techniques[1–6].

In this work a routine dosimetric system, with Brazilian commercial glass samples, was used. The feasibility of using these radiation detectors was tested in a radiation process involving flower irradiation. The objective was to evaluate the material sensitivity to ^{60}Co radiation.

MATERIALS AND METHODS

Commercial glass samples, with dimensions of $100 \times 100 \times 2$ mm^3, were used as radiation detectors. A neutron activation analysis of the material showed 70.3% of SiO_2, 15.1% of Na, 4.1% of Mg, 0.77% of Al_2O_3, 0.35% of K_2O, 0.13% of Ca, 0.10% of Fe and about 10% of other components.

A thermal treatment of 300°C for 15 min was enough for re-use of the glass samples.

A simple densitometer (M.R.A., Brazil, transmission 400–550 nm), specially designed for 2 mm thick glass samples, was used for the optical density measurements.

The irradiations were performed in air, using a panoramic ^{60}Co gamma radiation source, Yoshizawa Kiko Co., of IPEN. The dosimetry of the source was obtained using the Fricke method[7]. Electronic equilibrium was achieved at the glass samples by using Lucite plates (3.0 mm) on both sides, and taking into account the composition and thickness of the material, during the irradiations.

RESULTS

Re-use and reproducibility

Initially the detectors were subjected ten times to a reproducible irradiation procedure (1 kGy, ^{60}Co), thermal treatment (300°C for 15 min) and optical density measurements. No appreciable decrease in the response was observed. The samples are therefore considered reusable. The reproducibility was good, with the standard deviation of the measurements lower than 2%. The batch uniformity was also studied, with the coefficient of variation lower than 2%.

Thermal fading

The thermal fading at room temperature was observed taking daily measurements (over 40 days) of glass samples after an irradiation (10 kGy) with ^{60}Co. Initially the glass response presents a rapid decay (about 25% in the first 24 h after irradiation), but then it becomes linear and slow. This fading effect is undesirable, but it is not a great problem even in routine work, because the dose evaluations are usually made after a specific time interval. A correction factor may be applied, when necessary.

Dose–response curve

Initially the calibration curve for the glass samples was obtained by keeping the source dose rate constant at 1.09 kGy.h^{-1} and exposing the detectors for different irradiation time periods. Linearity could not be observed, because of the different thermal fading of each glass measurement. To use this kind of calibration curve, it would be necessary to determine correction factors depending on each irradiation situation (time intervals).

This fact could be avoided by keeping constant the irradiation time (2.5 h) for the calibration curve, because the response decay would be the same for the doses between 0.2 and 7.5 kGy. In this work the irradiation

time interval of 2.5 h was chosen for practical reasons. The optical density measurements were always taken 20 min after the irradiations.

Figure 1 shows the calibration curve. Linearity can be observed between 100 Gy and 1.0 kGy, and a tendency to saturation after 7.5 kGy. The standard deviation of the measurements was always lower than 2.4%.

Flower irradiation

Three groups of flowers were exposed to ^{60}Co radiation with absorbed doses of 200, 400 and 600 Gy, following procedures already established by Kikuchi *et al*[8]. Eight glass samples were irradiated together with each flower group. The absorbed doses were determined using the calibration curve of Figure 1.

Table 1 summarises the results for the dose determination using the glass samples. As can be seen, the best results were obtained for the determination of the absorbed doses of 400 and 600 Gy. The very low per cent variation of 0.3% between the determined and the nominal doses in the case of 600 Gy may be attributed to the irradiation time of 2 h 32 min, which is similar to that used to obtain the calibration curve (2.5 h), even if there was an interruption time of 19 min during the process. Even if fading is not taken into account, the highest deviation in the ratio of the determined and nominal doses was only 7.7% for 200 Gy, and it is certainly related to the fact that the irradiation time (51 min) was much lower than the 2.5 h used for the calibration curve. If necessary, better results can be achieved if fading is taken into account.

Even if the detectors are applied in conditions other than those of the calibration curve, the results show that they are sensitive to ^{60}Co radiation and may be useful for dosimetric purposes.

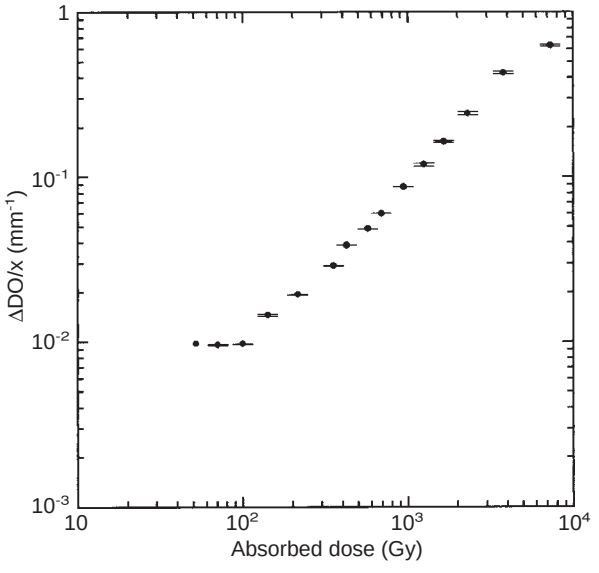

Figure 1. Calibration curve of commercial glass samples irradiated with ^{60}Co. Measurements of optical density/sample thickness, x, in relation to absorbed dose, using a densitometer.

CONCLUSIONS

The proposed method of use of commercial glass samples for high dose dosimetry is simple, cheap and does not require any sophisticated evaluation equipment, but only a densitometer. The glass samples may be used as Yes/No radiation detectors by changes of their colour due to irradiation, allowing immediate confirmation of irradiation. Even with thermal fading, this dosimetric system may be useful, as shown in the flower irradiation process described here.

This work presents the main ideas for a dosimetric system procedure using glass samples; the users have to adapt it to their own experimental conditions.

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Table 1. Flower irradiation test using glass radiation detectors. Measurements taken with a densitometer.

Nominal absorbed dose (Gy)	200.0 ± 2.8	400.0 ± 5.6	600.0 ± 8.4
Determined absorbed dose (Gy)	215.4 ± 3.9	396.9 ± 6.7	602 ± 11
Irradiation time (min)	51	102	152
Interruption time during irradiation (min)	0	10	19
Time interval between end of irradiation and measurement (min)	25	60	25
$\frac{\text{Determined dose}}{\text{Nominal dose}}$	1.077 ± 0.024	0.992 ± 0.022	1.003 ± 0.023

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