DOSIMETRY CHARACTERISTICS OF GLASSES FOR GAMMA HIGH DOSES

Valéria A. C. Quezada and Linda V. E. Caldas

Instituto de Pesquisas Energéticas e Nucleares
Comissão Nacional de Energia Nuclear
CP 1109 - CEP 05422-970
São Paulo - Brasil

INTRODUCTION

The vitreous materials present non-comum characteristics; they also own special and useful technological properties, because of their atypical nature. Although a glass doesn't present the elevated crystal order, it is not destituted of a structure.

Ionizing radiation induces in glasses absorption bands that depend on the material constitution and on the irradiation conditions. The colour change is due to the mechanism of oxidation and reduction of their elements and to the colour centers formation (1). Several high dose dosimetry methods have been developed, because of the increasing radiation use in industrial processes, as the sterilization of medical and food products(2).

In the present work the possibility of use of commercial glasses in gamma dosimetry was studied between 18Gy and 7.5kGy, through optical density measurements, using a densitometer and a spectrophotometer.

MATERIALS AND METHODS

Commercial glass samples, with dimensions of 11.50 x 50.00 mm and thicknesses between 2.00 and 2.07mm, were initially analysed (neutron activation method) and they showed several components as SiO_2 (71%), Al_2O_3 (0.90%), Fe(0.13%), Mg (4%), Na (15%), K_2O (0.40%) and Ca (0.13%).

Reutilization of the material was achieved by thermal treatments at 300° C during 15 minutes. All irradiations were made in air, using a panoramic ^{60}Co source Yoshizawa Kiko Co. Ltd. (10.8 Tbq).

Optical absorption spectra were obtained (air as reference) between 300 and 700nm, always 20 minutes after the irradiations, using the spectrophotometer Femto, model 482, Brazil, simple beam. A special densitometer was provided by MRA, Brazil, in order to allow measurements up to high doses using glass samples, with transmission between 400 and 550 nm.

RESULTS

In Figure 1 the optical absorption spectra of the studied glasses are shown. The glass samples are transparent in the visible region, before the exposition to ^{60}Co radiation, presenting an optical absorption band at about 310nm. After irradiation they become light brown coloured and a main large band at 420nm is shown; its intensity increases with the absorbed dose.

In order to test the batch uniformity and the response repeatability, the samples were 10 times irradiated with 1 kGy (^{60}Co). The batch uniformity presented variation coefficients of 1.8 and 3.5%, and the response repeatability, of 1.8 and 3.6%, for measurements taken at respectively the densitometer and at the spectrophotometer.

The thermal fading at room temperature can be seen in Figure 2 for both cases of densitometer and spectrophotometer. A steady initial decay (25% in 24 hours) and a subsequent slow decay can be observed. Only after 18 days the samples showed a constant response.

Figure 3 presents the calibration curves of the glass samples irradiated between 18 Gy and 7.5 kGy. A linear behaviour can be observed from 30 Gy to 7.5 kGy, for the spectrophotometer measurements. In the case of the results obtained with the densitometer, the linear region resulted from 0.1 to 1.5 kGy, with a subsequent supralinear behaviour up to 7.5 kGy and a tendency to saturation.

The low dose limits were determined for these glass samples as 19 and 100 Gy using as measuring instruments respectively the spectrophotometer and the densitometer. These same results can be obtained from Figure 3.

9th International Congress on Radiation Protection, Vienna, Austria, April 14-19, 1996.
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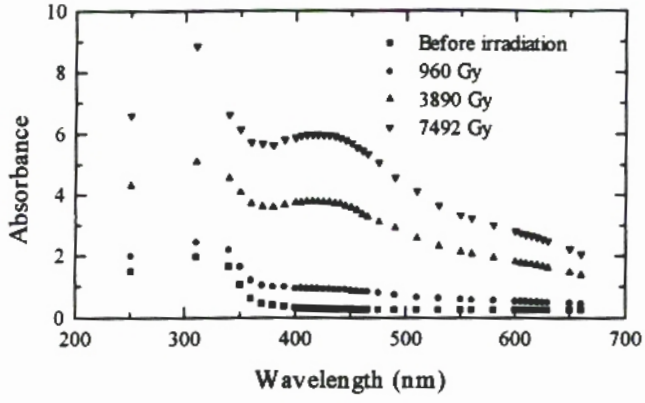

Figure 1 - Absorption spectra of the glasses before and after irradiation.

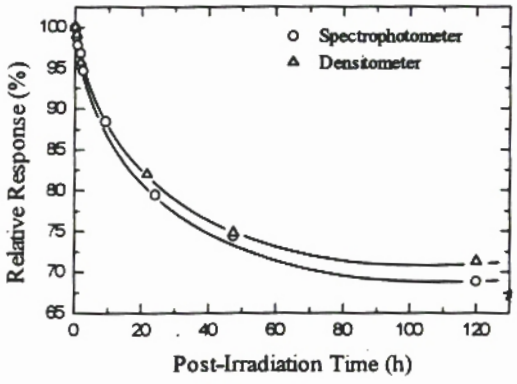

Figure 2 - Thermal fading at room temperature of the glasses irradiated with ^{60}Co.

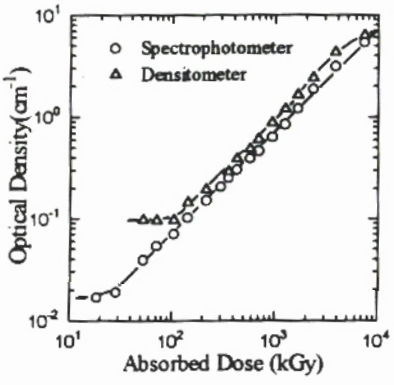

Figure 3 - Calibration curves of the glasses irradiated with ^{60}Co (2.3 kGy)

CONCLUSIONS

The commercial glass samples studied in this work present adequate dosimetric characteristics as batch uniformity, response repeatability, reutilization and linear behaviour in determined dose intervals, which make them suitable detectors for routine high dose dosimetry in the range of 18 Gy to 7.5 kGy. However, these glasses present an undesirable thermal fading effect, which does not constitute a great problem even in routine work, because the dose evaluations are normally made after a certain time interval. A correction factor has to be applied to the results.

The main advantages of these radiation detectors for gamma high doses are the very low cost and the measuring simplicity. The glasses can also be used as Yes/No detectors, because of their colour change with the absorbed dose.

ACKNOWLEDGEMENTS

The authors acknowledge the partial financial support of Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

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