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Commercial plate window glass tested as routine dosimeter at a gamma irradiation facility

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Abstract

Commercial plate window glass samples were tested as routine high dose dosimeters at a ^{60}Co gamma irradiator facility. These samples were studied in terms of their dosimetric characteristics: response repeatability, fading and calibration curves from 5 to 30 kGy in typical irradiation procedures. The specific absorbance technique was used for the measurements. All results show the feasibility of using plate window glass as a routine high-dose dosimetry system and as yes/no irradiation indicators for a ^{60}Co gamma irradiation facility. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Dosimeter; Glass; High doses

1. Introduction

Radiation processing with gamma radiation has been in commercial use for nearly four decades for different applications. A reliable dosimetry is fundamental for quality assurance of the processes and irradiation products. Almost all dosimetric systems for high doses present some limitable disadvantages for their use. Desirable is a dosimeter that fulfill the traditional requirements of precision, dose-rate independence and post-irradiation stability (McLaughlin et al., 1989).

A dosimetric system for industry needs to be easy to use, fast to measure and cheap. Many dosimeters are used daily at industrial plants; therefore, dosimeter preparation and measurement time must be simple and quick. The dosimeter cost should not play an important role in the radiation processing final price.

Transparent commercial glass has been showing good results as dosimeter (Khan and Ali, 1995) in electron beams (Caldas and de Souza, 1991), for ^{60}Co sources (Quezada and Caldas, 1999; Mansy et al., 1998) in industrial irradiators (Zheng et al., 1988, 1997; Rodrigues Jr., 2000) and in synchrotron radiation (Asano et al., 1996). In this work commercial glass samples were tested as high-dose dosimeters in a gamma irradiation facility. When glass is submitted to high doses, it becomes dark colored, and its optical density is increased proportionally to the absorbed dose; it can be easily measured by a photocolorymeter or a spectrophotometer. Glass is cheap but not stable after irradiation, presenting a very quick initial fading, so the information is not permanent. However, when the glass optical density is measured at the same time interval after irradiation, it maintains proportionality to dose. Calibration curves can be obtained for different time intervals after irradiation, and the application of transparent commercial glass as dosimeter becomes possible.

2. Materials and methods

Sets of three glass samples and two red perspex type 4034 dosimeters were irradiated with several doses at a statical position and inside the tote boxes of a ^{60}Co

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gamma irradiation facility to study the transparent commercial glass optical density response to radiation.

The red perspex dosimeters were used to measure the dose received by the glass samples. Red perspex dosimeters have been largely used around the world in irradiators and electron accelerators (Al-Sheikhly et al., 1991; Whittaker and Watts, 1999).

The transparent commercial glass samples were of the same size as that of the red perspex dosimeters, and they all came from the same glass plate with a thickness of 3.258 ± 0.006 mm. Therefore, their optical density could be measured by the same photocolorymeter used for red perspex. The absorption of glass samples and red perspex dosimeters was measured at 640 nm wavelength by a Tecnow 7000 photocolorymeter, Brazil. Fig. 1 shows the optical absorption spectra of glass samples irradiated with 10 and 20 kGy, measured by a spectrophotometer Micronal, model B442, Brazil.

The irradiations were made at a gamma irradiation facility JS 7500, tote box type, from MDS Nordion, of EMBRARAD, with a nominal activity of 54.7 PBq (1.48 MCi) March 1999. The material was put inside the tote boxes, which were conveyed into the irradiation chamber, where they passed around the source. At the closest position, the dose rate was about 50 kGy/h, and at the most distant position it was about 5 kGy/h. The statical position is 1.5 m far from the source. The dose rate at this position depends on the density of the material inside the tote boxes which are passing in front of the source; the minimum dose rate is about 3 kGy/h, and the maximum is 5 kGy/h.

The ambient temperature was always kept lower than 25°C through air-conditioning.

3. Results

Fig. 2 shows the response fading of glass samples and red perspex dosimeters, up to 27 days. The detectors were irradiated with 6.5 kGy at the statical position. All detector sets showed the same fading behavior: the red perspex dosimeters almost do not change (2%) their absorption value whereas the glass samples present a quick initial fading; after about 12 days the glass response fading is similar to that of red perspex dosimeters. All glass samples lost the same specific absorbance value during the same time interval. This fact suggests the use of calibration curves obtained for different time intervals after irradiation.

The detector sets were irradiated with doses from 5 to 30 kGy at the statical irradiation position and inside tote boxes, where the irradiation conditions were not the same for all doses. Some parameters as dose rate, irradiation interruptions and material density inside the tote boxes were not the same during all irradiations. Calibration curves were obtained taking measurements for 1, 2 h and 1 day after irradiation: Figs. 3 and 4. The standard deviation of all measurements was always lower than 1%.

In spite of the variations in the absorbed dose rate and of several irradiation interruptions, the calibration curves of Figs. 3 and 4 show specific absorbance values

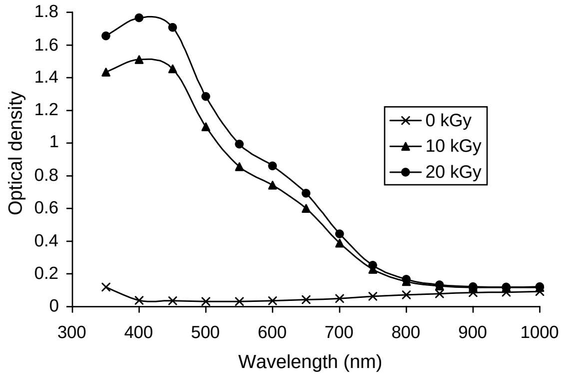

Fig. 1. Optical density spectra of the glass samples for 0, 10 and 20 kGy measured 1 h after irradiation.

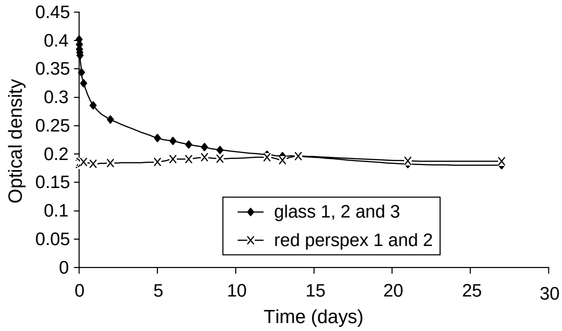

Fig. 2. Fading of glass samples and red perspex dosimeters response of a detector set irradiated with 6.5 kGy at the statical position (^{60}Co).

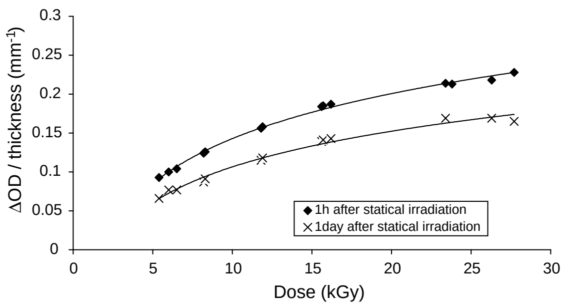

Fig. 3. Glass samples calibration curves for 1 h and 1 day after statical irradiation; ΔOD = specific absorbance by glass sample thickness (mm^{-1}).

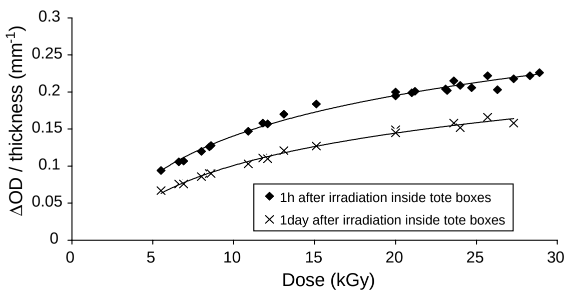

Fig. 4. Glass samples calibration curves for 1 h and 1 day after irradiation inside tote boxes; ΔOD = specific absorbance by glass sample thickness (mm^{-1}).

increasing with the absorbed dose, resulting in calibration curves of adequate behavior for dosimetric purposes.

Repeating the procedure of irradiation and measurement of glass detectors several times, the response repeatability was studied. Maximum variations of 6.3% and 5.5% were obtained, respectively, for statical and inside tote boxes irradiation; these values are compatible for a gamma irradiation facility routine work.

Keeping glass samples protected against direct sunlight and heat, after 1.5 year it was still possible to differentiate very well the irradiated glasses from those not irradiated. This fact shows the usefulness of glasses as yes/no dischargable irradiation indicators, with enormous cost advantages in relation to traditional detectors. In this case fading requires no attention. Glass samples may even be reutilized, through a very simple heat treatment of 300°C during 15 min (Caldas and de Souza, 1991; Quezada and Caldas, 1999). This procedure leads to a very low cost and reliable irradiation indicator system.

4. Conclusion

The possibility of using commercial window glass as routine dosimeters in a gamma irradiation facility has a lot of advantages. This kind of glass is very cheap, it does not need any special preparation, and it is commercially available at window glass stores. The quick initial fading is its main disadvantage, but it can be solved by using calibration curves for the most adequate time intervals after irradiation.

Another very good use for window glass is as yes/no dischargable irradiation indicators.

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