

Thermoluminescence Dosimetry for High Dose Using Commercial Bottle Glasses

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Commercial bottle glasses were analyzed by the thermoluminescent method as routine high dose dosimeters for radiation processing, due to their easy handling and their low cost. The dose-response curve is linear between 0.1 KGy and 75 KGy. The maxim standard deviations for TL signal were approximately 5.5%. the fading rates of the glass response at room and low temperatures as well as at room light has been also investigated. All tested glasses showed their usefulness as high-dose dosimeters.

Keywords: thermoluminescence, common bottle glass, radiation dosimetry

The dose from the ionizing radiation is the energy transferred to matter by ionizing radiation per unit mass of the irradiated material. The SI unit for exposure dose is joule per kilogram and it is called Gray (Gy). Any radiation – induced effect, which is reproducible and quantified, can be used as a dosimetric system.

Radiation processing requires high – gamma dose of the order of kilogray depending on the type of the material.

The most successful industrial applications of radiation are the modifications in the properties of polymers, including [1-6]:

- crosslinking of polymeric materials to enhance their physical properties like thermal stability and tensile strength e.g. crosslinking of polyethylene in cable and wire insulations, the production of heat shrinkable tubes, crosskicking of foam, the radiation vulcanization of natural rubber latex;

- polymerization of coatings, inks and formation of wood plastic composites;

- grafting of different types of monomers on to polymer molecules to form new materials with special properties;
- degradation of polytetrafluoroethylene (Teflon) by irradiation to produce dry lubricants.

Dosimetry is a vital part of the radiation processing industry. Commercial glasses have been investigated in this area by several authors using different techniques, such as: thermoluminescence [7-14], spectrophotometry [15, 16], optical densitometry [17].

The purpose of this work is to point out the thermoluminescence (TL) dosimetric features of common bottle glasses and to recommend their use in radiation technology for high dose measurements.

Experimental part

The glass samples (clear and green types) were powdered up to ~ 0.15 mm grain diameter. Gamma irradiation of the samples encapsulated in plastic ampoules was performed at room temperature with source of ¹³⁷Cs (GAMMATOR M-38-2) at a dose rate of 0.4 KGy·h⁻¹.

For the thermoluminescence measurements (performed with LTM Fimel apparatus), glass samples of 4 mg were used. The thermoluminescence glow curves of the samples were obtained on a large temperature range between room temperature and 450°C. The linear heating

rate was set at 5°C/ s and all measurements were taken at ambient atmosphere. The RTL measurements were carried out soon after the end of the exposures, excepting the fading investigation.

Results and discussion

Figure 1 shows the thermoluminescent glow curves of the clear bottle-glass sample taken after their irradiation with 56 KGy. One can see a broad peak, which represents a superposition of two individual TL peaks located at 165°C and 207°C.

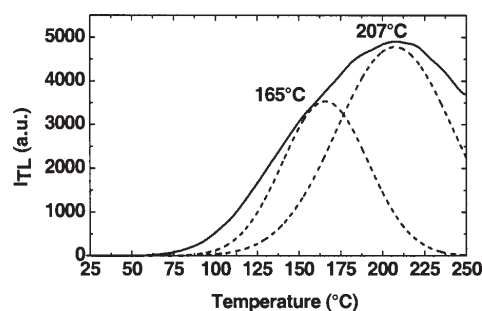


Fig. 1. TL glow peaks of the clear bottle glass sample after irradiation with 56 KGy of ¹³⁷Cs gamma rays

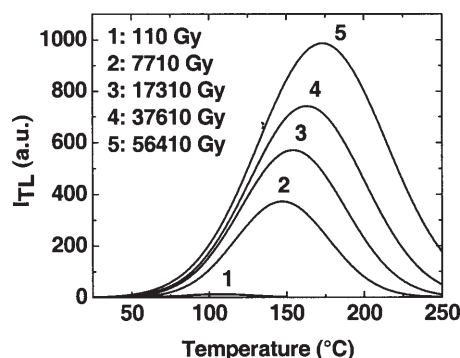


Fig. 2. The shift in the position of first glow peak after irradiation of glass

The structure of the glow curve is dose – dependent as can be observed from figure 2. The temperatures of the peaks are displaced to higher values with the increasing of received dose. This behavior may be explained by the change in the defect concentration of the glass during irradiation.

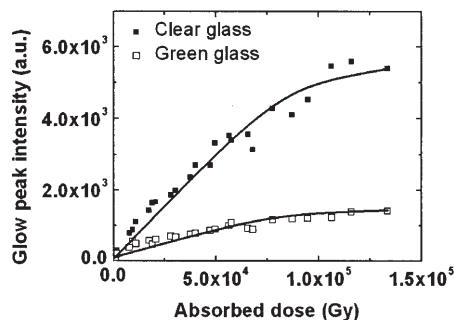


Fig. 3. Dose – response curves of the bottle – glass samples

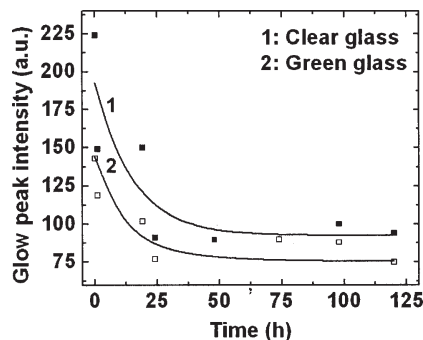


Fig. 4. Fading at room temperature of different bottle glasses

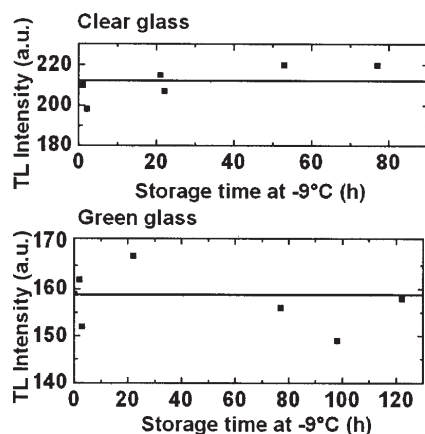


Fig. 5. Fading at low temperature (-9°C) of different bottle glasses

The dose response of the TL intensity to γ - radiation dose is shown in figure 3 for clear and green samples. The samples have responded linearly in the range between 0.1 KGy and 75 KGy. It should be noticed that on this dose range there is no indication of response saturation.

It can be seen that TL response presents a suitable behavior for high dose dosimetry for all types of bottle glasses. On the other hand, these glasses are not highly TL sensitive on low dose range and they emit faint signals at lower radiation dose.

The room temperature stability of stored thermoluminescent signal following irradiation is dependent on the storage temperature. This effect called fading was studied by performing daily measurements up to 120 hours (fig. 4). This figure shows that the glass initially has a fast fading rate and after about 24 h the fading rate was dramatically reduced remaining at a constant value.

No fading was recorded by storage of the irradiated samples at -9°C (fig. 5)

The glass samples show also fading under room light exposure as can be seen in figure 6. This suggests that TL centers are predisposed to photoluminescence induced by visible light [14].

Two types of bottle glass samples were subjected five times to the same procedure of irradiation (1.3 KGy) in

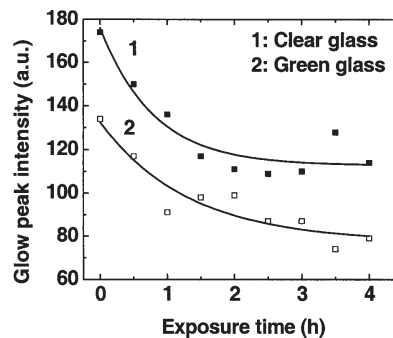


Fig. 6. TL fading under room light exposure

Table 1
REPRODUCIBILITY OF TL RESPONSE OF BOTTLE GLASS SAMPLES

Sample	Standard deviation (%)
clear	5.12
green	5.68

order to study the response reproducibility. The obtained maximum standard deviations were approximately 5.5%. The results are listed in table 1.

The results confirm the utility of bottle-glass for its application in high dose technological measurements.

Conclusions

The results obtained in this work show that bottle glass TL dosimeters are proper for different high-dose levels in radiation chemistry industrial applications.

The commercial bottle glass shows linear dose response up to at least 75 KGy.

The advantages of these materials are their reduced size, very low cost and easy handling.

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