LOW PRE- AND POST-IRRADIATION FADING OF LIF:Mg,Ti DOSIMETERS AS A FUNCTION OF TIME DURING THE MILD AND HOT SEASON IN ISRAEL

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High pre- and post-irradiation fading prevents the attainment of high accuracy in dosimetry measurements, especially in routine dosimetry when the exact duration and time of expossure are not known. The phenomenon of pre-irradiation or post- irradiation fading has been studied extensively, both experimentally and theoretically for LiF:Mg,Ti dosemeters, but the data reported in the literature vary considerably (1). Many factors affect this phenomenon, including the major influence of inclusion or exclusion of the different peaks of the glow curve in the TL signal. It was reported (2,3) that little fading occurred when the lower peaks of the glow curve, the rapidly fading peaks 2 and 3, or peak 2 alone, were excluded from the integrated glow curve.

Doremus and Higgins(4) applied a low preheat temperature, which probably did not eliminate the rapidly fading peak 2. They recorded a high fading for both pre- and post-irradiation by photons.The Dosimetry Center at Soreq Nuclear Research Center, Israel, supplies dosimetry services to 650 facilities throughout the country. Dosemeters can be in the field for periods ranging from 5 to 27 weeks, and are subject to both pre- exposure and post-exposure fading.

An attempt was made at the Soreq Dosimetery Centre to reduce the fading following or preceding gamma radiation by employing a high post-irradiation preheat temperature of 150°. Five TLD-100 dosemeters and five TLD-700/600 dosemeters, chosen at random from the entire dosemeter population, which consists of three TLD-100 batches and two TLD-700/600 ones, manufactured during the years 1992-1994, were exposed for each measurement. Each dosemeter consists of chips of the same thickness, 0.38 mm. The TTP (time-temperature profile) parameters of the hot gas heating technique includes 5 sec of 150°C preheat and a heating rate of $25°C.s^{-1}$ up to a max temp of 300°C. Dosemeters were exposed to 4.6 mSv from ^{137}Cs photons, at the Soreq branch of the Israel Secondary Standards Dosimetry Laboratory.

Measurements were performed for pre-irradiation fading from 1 week to 13 weeks of the three materials. Post-irradiation fading of TLD-600 and TLD-700 was measured from 1 week to 3 months after irradiation. Since TLD-100 is the main type of dosemeter issued in our dosimetry center (>90% of all), more extensive study was devoted to it and post- irradiation measurements for this kind of dosemeters were extended up to 27 weeks. Emphasis was given to measurements corresponding to the halfway point of the different periods, as in routine dosimetry one usually assumes that the exposure occurred halfway through the issue period.

The comparison study of the TLD-100 dosemeters was carried out with a common lower preheat of 100°C[(4)] from 1 day to 12 weeks following gamma-irradiation during the autumn season. Figure1 presents the post-irradiation fading measurements of TLD-100 dosemeters exposed to gamma radiation with 150°C 5 sec preheat. The loss of TL signal due to one month of storage following gamma radiation was approximately 7%, whereas for longer periods the fading was slightly higher: 11% and 12% for 3 months and 6 months, respectively.

Measurements taken during the hotter and more humid seasons (spring- summer) showed a slightly higher fading than that occurring during autumn-spring.

The post-irradiation fading measurements of both TLD-700 and TLD-600 (Fig. 2) showed a slightly higher fading than that of TLD-100. A one-month storage following exposure to photons resulted in a ~10% loss in the TL signal for both TLD-700 and TLD-600, whereas a 3-month storage period caused a ~14% loss. Measurements taken during the hot spring-summer season as compared to those taken during the mild winter-spring season showed a higher fading loss, as was found for TLD-100.

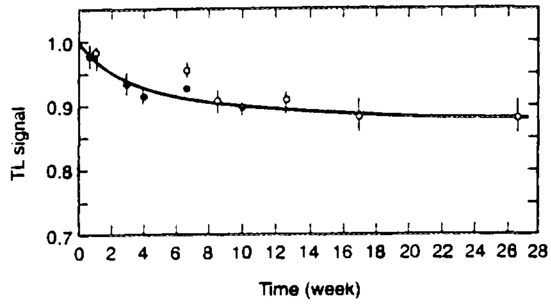


Figure 1. Post-irradiation fading of TLD-100 as a function of time after irradiation during the autumn-winter-spring (O) and spring-summer seasons (●), for post-irradiation preheat of 150°C for 5s

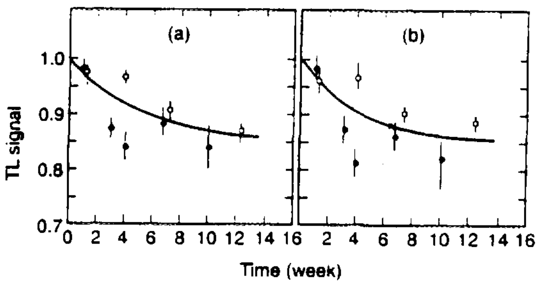


Figure 2. Post-irradiation fading of (a) TLD-700 and (b) TLD-600 as a function of time after irradiation during the winter- (O) and spring-summer (●) seasons, employing a post irradiation pre-heat of 150°C for 5s.

The pre-irradiation fading measurements of TLD-100 and TLD-700/600 (Figs.3 and 4, respectively) were very similar to the post- irradiation ones. The pre-irradiation fading of TLD-700/600 was greater than that of TLD-100, as observed also for post-irradiation measurements.

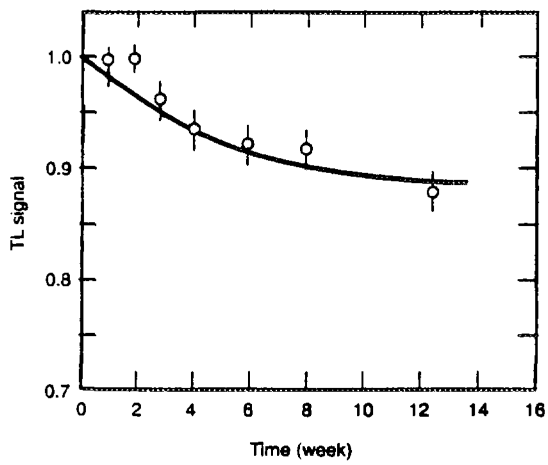
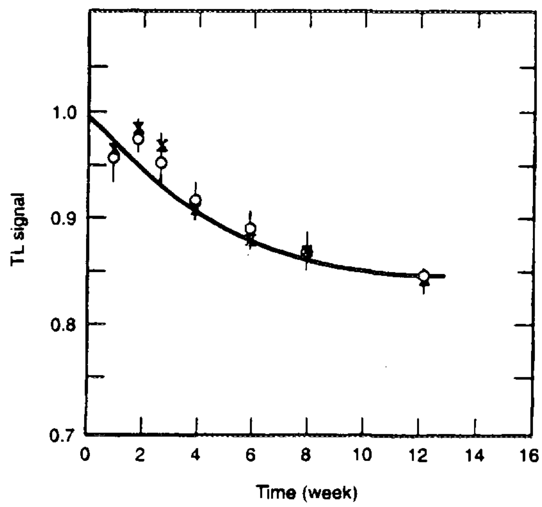


Figure 3. Pre-irradiation fading of TLD-100 during the spring-summer season as a function of time prior to to irradiation, employing a post-irradiation pre-heat of 150°C for 5s.



Figur4. Pre-irradiation fading of (O) TLD-700 and (X) TLD-600 during the spring-summer season as a function of time prior to irradiation, employing a post-irradiation pre-heat of 150°C for 5s.

Measurments of the combined fading of pre- and post-irradiation measured directly and calculated as the sum of pre-and post-fading measured separately (3.4 weeks pre- and 4.6 weeks post-irradiation, and 5.0 weeks pre- and 3.0 weeks post-irradiation),show a combined loss of the TL signal for TLD-100 dosemeters of approximately 12%; the figure was slightly higher for TLD-700 and TLD-600: ~15%.

The range of the combined fading of the one-month-cycle TLD-100 dosemeters measured separately for pre-irradiation and for post- irradiation was also 11-12%, since neither pre-irradiation nor post- irradiation fading dominates. This conclusion led to a high accuracy of the fading correction for the one-month-cycle TLD-100: 12±1% regardless of when the actual exposure to gamma radiation occurred during the issue period. The fading correction factor for the one-month-cycle TLD-700/600 was 15±2%.

The range of a combined pre- and post-irradiation fading for the lately returned monthly dosemeters and the bi-monthly ones returned on time (4 months in the field), was greater: 16±2% for TLD-100 and 20±3% for TLD-700/600. The late-returned TLD-100 dosemeters of the longer issue cycle (8 months in the field) suffered a greater reduction of the TL signal, 20±2%.

The results of a comparative study, employing a low preheat of 100°C for 5 sec. instead of the high preheat of 150°C is presents in Fig 5. As can be seen from the figure, the losses of the TL signal due to one-month and 3 months storage following gamma radiation were 19% and 22%, respectively. These post- irradiation fading results were much higher than those obtained when the 150°C preheat procedure was employed: 7% and 11%, for the same storage periods, respectively (see Fig.1).

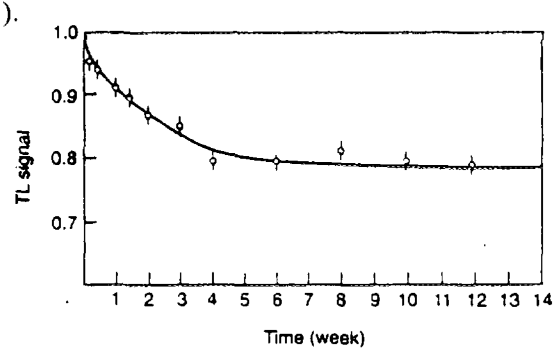


Figure 5. Post-irradiation fading of TLD-100 as a function of time after irradiation during the autumn season employing a post-irradiation pre-heat of 100°C for 5s (a comparative study).

Our post-irradiation fading results for TLD-700 are in good agreement with the results (at a heating rate of 25°C.s^{-1}) reported by Moscovitch et al. (5), in which the sum of peaks 3, 4 and 5 was evaluated by means of computerized glow curve deconvolution. After one month of storage they calculated ~8% fading whereas 3 months' storage caused a reduction of 12% (5). When the total integral was considered, much higher fading was reported: ~20% fading following storage of 30 days (5). Our comparative study showes a similar loss of signal after one-month storage: ~19%.

The post-irradiation fading results for TLD-100 are in agreement with the data reported by Ben-Shachar and Horowitz (3) for unannealed TLD-100 dosemeters exposed to gamma radiation. Employing computerized glow curve deconvolution, they found an ~11% loss of signal after one month of storage when they integrated peaks 3-5, and ~25% of fading when the whole glow curve was integrated.

The photon fading reported by Doremus and Higgins (4) for TLD-700 measured with a similar 8800 system (2 sec 100°C preheat, a heating rate of 30°C.s^{-1}) was much higher than the fading found in our work employing 150°C preheat: approximately 22% loss after one month of post-irradiation storage and slightly greater loss for longer durations.

On the other hand, our comparative results, measured with 5 sec of 100°C preheat, are in very good agreement with their reported post-irradiation measurements. From the comparative study and from Doremus and Higgins (4) results it seems reasonable to assume that employing preheating at 150°C for 5 sec. reduce the thermoluminescence fading. The low fading can be attributed probably to the elimination of the short-lived ($t_{1/2}$=19 h, (6)) peak 2 while the partial removal of peak 3 may also contribute to achieve the reduction of the fading phenomena. The loss of sensitivity in our routine system due to the exclusion of peak 2 (and may be part of peak 3) is insignificant.The high reproducibility of our results shows that our system fulfills the needed requirement of heating control.

References

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