SOME DOSIMETRIC CHARACTERISTICS OF THE RESIDUAL DOSE AND THE PTTL FOR LiF:Ti,Mg

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ABSTRACT

LiF:Ti,Mg TLD cards (G-1 and G-7) were irradiated in the range of 0.15 - 7.5 Gy and the residual dose and the PTTL were measured, in order to reassess the initial dose. We obtained a constant fraction of the initial dose (0.13% and 2.73% respectively) in the dose range 0.15 - 5.0 Gy for both the residual dose and the PTTL.

We evaluated the minimum exposure that can be reassessed, as well, when using both methods. We found that the minimum detectable exposure is ~13 mGy measured by the PTTL and ~360 mGy measured by the residual dose.

INTRODUCTION

The thermoluminescent dosimeter has become increasingly important in all aspects of personnal and environmental monitoring. The main limiting factor that has prevented even a wider use is the loosing of the information accumulated in the crystal during the readout process.

LiF:Ti,Mg , proposed by Cameron (1), has beeen extensively used in dosimetry and it is a good compromise between the various desired characteristics. It is not as sensitive as certain other materials, but allows doses of 0.1 mGy to be measured with high performance equipment. The absence of thermal and optical fading (when different annealings are used) and almost tissue equivalence makes it the most useful TL material in radioprotection (2). There are two ways of reassessing high doses: by measuring the residual dose (second reading) or by the photo-transferred thermoluminescence (PTTL). The PTTL is the thermoluminescence after u.v. light exposure in a phosphor (3) which has been earlier exposed to ionizing radiation, then annealed and readout, leaving some TL as residual (RTL). The LiF:Ti,Mg has deep traps that can be significantly populated by high doses of ionizing radiation. Because normal readout procedures (heating to about 300°C) usually do not depopulate these traps, a second u.v. irradiation followed by the conventional readout can produce a response which is proportional to the original high dose. These "memory effects" in the TL materials can be employed for the re-estimation of doses and have been reported in several works (4,5,6).

The aim of the present work was to measure the residual dose and the PTTL for high doses (to 7.5 Gy) and to detemine the accuracy and the minimum detectable level of the initial dose which can be determined by the two methods.

EXPERIMENTAL MEASUREMENTS

The measurements of the residual doses and the PTTL were performed with the standard LiF:Ti,Mg Harshaw manufactured G-1 or G-7 TLD cards. No annealing was performed. The cards were evaluated in an automatic Harshaw 2271 reader after being irradiated by a $^{90}Sr/^{90}Y$ source built in the system. The u.v. irradiation was performed by a 15 mw u.v. lamp (254 nm) at a distance of about 10 cm.

The TLD cards were irradiated to different doses between 0.15 and 7.5 Gy. The phosphors were evaluated immediately after the irradiation and a second reading was performed to measure the residual dose. After the second reading, the cards were irradiated by the u.v. lamp for 15 minutes and then read again (to measure the PTTL). The average results of the residual dose and the PTTL, obtained from the irradiation of 2 cards (four chips) for each dose, are presented in table 1.

Table 1: The average results of the residual doses and PTTL for exposures of 0.15 - 7.5 Gy.

Exposure (Gy)	Residual dose (mGy)	% of exposure	PTTL (mGy)	% of exposure
0.15	0.20±0.10	0.13	4.8± 0.5	3.20
0.30	0.35±0.06	0.12	7.5± 0.8	2.50
0.45	0.43±0.06	0.10	9.5± 1.0	2.11
0.60	0.75±0.07	0.13	12.1± 1.7	2.02
0.75	1.17±0.17	0.16	19.7± 1.7	2.63
1.00	1.24±0.27	0.12	31.6±10.3	3.16
1.85	2.38±0.56	0.13	55.3±12.2	2.99
3.00	3.67±0.85	0.12	77.9± 8.4	2.60
4.24	4.90±1.60	0.12	139.3± 8.5	3.29
5.66	10.16±2.18	0.18	156.2±27.0	2.76
6.60	14.77±0.66	0.22	258.1±61.8	3.91
7.50	17.67±4.07	0.24	318.5±23.2	4.25

The minimum measurable dose (MMD) of the initial dose when using the PTTL and the residual dose methods were determined by plotting the relative standard deviation of the PTTL (figure 1) and residual dose (figure 2) vs. the exposure and fitting to them the expresion given by Zarand and Polgar (7,8). The MMD is defined as the dose value where the relative standard deviation is 20%. The values obtained are about 13 mGy for the PTTL and about 360 mGy for the residual dose.

CONCLUSIONS

From the results presented in table 1 and in the figures, the followings can be concluded:

A. For the dose range 0.15 to about 5.0 Gy, the value of the residual dose is a constant fraction of the first reading - 0.13 ± 0.03%. There seems to be an increase of the residual dose for doses above 5.0 Gy, probably due to the supralinearity effect (3).

B. The values of the PTTL in the dose range 0.15 to about 5.0 Gy are a constant fraction of the first reading too (2.73 ± 0.44%), and the value of the PTTL seems also to increase for higher doses.

C. The PTTL is higher than the residual dose by more than an order of magnitude and its accuracy is better than that of the residual dose.

D. When employing the PTTL method, the MMD of the initial dose is about 13 mGy and for the residual dose method the MMD of the initial dose is about 0.36 Gy .

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FIG 1 : THE RELATIVE STANDARD DEVIATION
OF THE RESIDUAL DOSE vs THE EXPOSURE

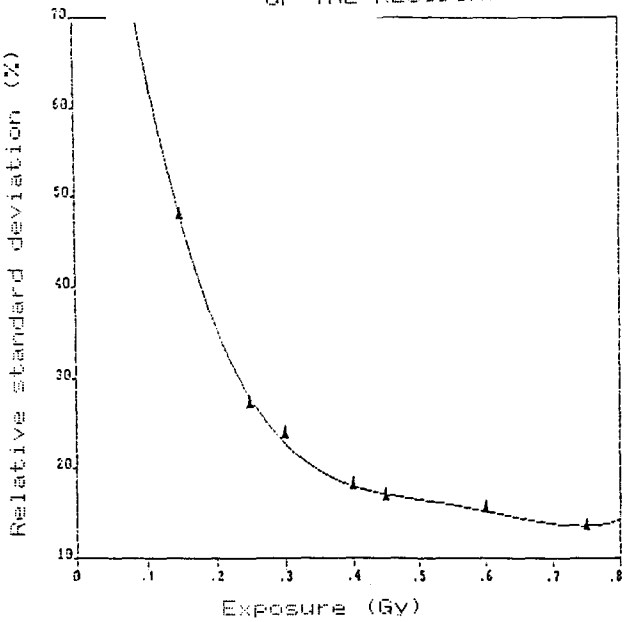

FIG 2 : THE RELATIVE STANDARD DEVIATION
OF THE PTTL vs THE EXPOSURE