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EFFECT OF MATHEMATICAL EVALUATION METHODS OF THERMOLUMINESCENCE GLOW CURVES ON THE MEASURED DOSE

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Three types of glow curve evaluation programs applied on four types of TL dosimeters were tested utilizing microcomputer controlled TL analyser IJS MR-200. The dependence of reproducibility and individual sensitivity of the dosimeters on the mathematical evaluation programs are discussed.

Introduction

The integration of the glow curve between two temperature values is the most common way of glow curve evaluation in commercial TL readers. The absorbed dose is linear with the area under the main dosimetry peak(s) which is proportional to the light sum released during the read-out process. This way of evaluation may not be always the most precise method of dose determination.

Several evaluation methods of the measured glow curve are possible using the new microcomputer controlled TL reader (IJS MR-200, "Jožef Stefan" Institute, Ljubljana, Yugoslavia),so the optimum glow curve evaluation program may be selected for any TL dosimeter. The standard deviation of the determined TL responses is accepted as a criterion for the selection of the adequate evaluation program.

Equipment and methods

Microcomputer controlled IJS MR-200 thermoluminescent reader (analyser) is designed for laboratory use with TL dosimeters as well as for routine dose readings in the range from environmental to accidental doses [1]. The main features of the analyser are: time-linear sampling, digitalisation, storing and subsequent displaying on the monitor time scale of the glow and temperature curve of the TL material; digital stabilization, control and diagnosis of the analog unit; ability of storing 7 different 8-parametric heating programs; ability of storing 15 evaluation programs defined by 2 or 4 parameters and 3 different algorithms (altogether 5 types of evaluations). Analyser has possibilities of file forming on cassette or flopy disc, and possibility of additional programming in BASIC.

CaF_2:Mn ("Jožef Stefan" Institute, Ljubljana), $CaSO_4$:Dy and MgB_4O_7:Dy ("Boris Kidrič" Institute, Vinča, Beograd) and LiF:Mg,Ti (Institute for

Nuclear Physic, Krakow) dosimeters were used. The preheating, readout and annealing times and temperatures were used according to the manufacturer's instructions [2,3,4,5] and our own experience [6,7].

The following evaluation programs were used:

(A) Glow curve peak height measurement;

(B) Integration of glow curve area. The limit of the integration was not fixed with temperature. The start and endpoints of the adjustable integration were determined by given percentage of glow peak height before and after maximum of glow curve.

(C) Integration of glow curve area between two fixed temperature values, which approximately corresponds to the integration limits in program B.

Results and discussion

The standard deviations of the TL responses of CaF_2:Mn dosimeters are shown in Table I. The dosimeters were irradiated and after the readout the obtained glow curve was evaluated using 7 different evaluation programs. The first group of 50 CaF_2:Mn TLDs was used without any selection. After the evaluation of these 50 TLDs, 39 dosimeters were selected. The criterion for selection was that the standard deviation obtained by the evaluation programs A and B_3 was lower than 10%. The standard deviations of these selected dosimeters are also shown in Table I.

Table I

Effect of various evaluations of the measured glow curve on the spread of the TL response of CaF_2:Mn TLDs

TLD	Dose (mGy)	Standard deviations (%) of TL responses using different evaluation programs						
		A	B_1	C_1	B_2	C_2	B_3	C_3
			L40%-R60%		L30%-R95%		L80%-R95%	
50	0.5	6.7	9.5	10.8	9.6	14.1	10.2	10.6
39		5.0	6.2	6.4	6.1	10.3	6.1	7.2
50	1.0	5.1	5.2	7.7	6.1	11.4	7.8	8.4
39		5.1	4.9	5.8	4.4	8.8	5.2	6.5

L means the percentage of the maximum height on the left side of the glow curve when the integration starts

R means the percentage of the maximum height on the right side of the glow curve when the integration stops

Glow curve area integration with adjustable limits (type B) gives better results (lower standard deviation) than classical glow curve area integration between two fixed temperature values (C type). The differences

among the evaluation programs are not so significant with the selected group of dosimeters. Program A gives the best results. It is reasonable because the IJS MR-200 analyser is microcomputer controlled and the reproducibility of the heating cycle is very good.

CaF_2:Mn, $CaSO_4$:Dy, MgB_4O_7:Dy and LiF:Mg,Ti groups of TLDs were irradiated five times with the dose of 0.4 mGy in a plexiglass badge (to improve the electron equilibrium). Each group contained 7 dosimeters. The results are shown in Table II and III.

The mean value of standard deviation of the TL response and each program measured with 7 dosimeters was calculated after each irradiation for each TLD type. The mean values of these standard deviations characterize the uniformity of individual sensitivity of TLDs (Table II). LiF and CaF_2 TLDs show excellent uniformity, about 4%. The values are significantly influenced by the evaluation method. When method C results with higher spread of TL response compared to method B, it is reasonable because method C does not correct the possible shift of the glow curve while method B does.

Table II

Effect of various evaluations of the measured glow curve on the uniformity of individual sensitivity of TL dosimeter (Dose of irradiation = 0.4 mGy)

TLD	Mean value of standard deviation (%) using different evaluation programs					
	A	B_1	C_1	B_2	C_2	C
		L50%-R50%		L15%-R96%		
CaF_2:Mn	3.6	7.4	5.8	9.8	15.1	4.2
$CaSO_4$:Dy	7.8	8.9	8.8	9.4	9.3	9.4
MgB_4O_7:Dy	16.5	18.3	18.8	18.0	16.4	17.7
LiF:Mg,Ti	4.6	5.8	10.0	5.0	15.2	4.3

C means the integration of the whole area under the glow curve

The reproducibility of TL dosimetry for each TLD group is shown in Table III as the standard deviation of the mean value of the TL responses for five irradiations. The best reproducibility was obtained with MgB_4O_7 dosimeters if the glow curve height was measured (program A). The computer controlled evaluation methods do not influence significantly the reproducibility values, which predominantly depend on the type of the dosimeter and on the stability of reader. The reproducibility results obtained here are acceptable, in view of the fact that the time between irradiation and readout was not always the same (i.e. the quick fading was not correct [6]),

and the annealing procedure was not strongly controlled. These results show the good stability of the TL reader.

Table III

Effect of the method of evaluation of the glow curve on reproducibility
(Dose of irradiation = 0.4 mGy)

TLD	Standard deviation (%) of the mean values of TL responses using evaluation program					
	A	B_1 L50%-R50%	C_1	B_2 L15%-R96%	C_2	C
CaF_2:Mn	10.5	11.5	10.6	13.8	9.0	9.8
$CaSO_4$:Dy	13.0	11.8	11.9	11.3	11.7	12.2
MgB_4O_7:Dy	6.9	8.1	7.9	8.1	9.0	11.2
LiF:Mg,Ti	9.9	11.0	8.3	9.6	7.5	10.1

Results of this study indicate that with the choice of an appropriate program of computer control of the TL evaluation the precision of measurement can be improved.

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