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Study on Thermal Treatment Options for TLD-100 Thermoluminescent Dosimeters

A. Sanchez[1], V.P. Campos[2], G.Sabundjian[3] and F.D.G.Rocha[4]

[1] *andreasdpz@hotmail.com, Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN) Av. Professor Lineu Prestes, 2242 CEP 05508-000 - São Paulo, SP, Brazil*

[2] *vpcampos@ipen.br, Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN) Av. Professor Lineu Prestes, 2242 CEP 05508-000 - São Paulo, SP, Brazil*

[3] *gdjian@ipen.br, Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN) Av. Professor Lineu Prestes, 2242 CEP 05508-000 - São Paulo, SP, Brazil*

felicia@marinha.mil.br; Centro Tecnológico da Marinha em São Paulo, Av. Professor Lineu Prestes, 2468 CEP: 055808-000 – São Paulo, SP, Brazil

1. Introduction

The thermal treatment of lithium fluoride thermoluminescent dosimeters LiF:Mg,Ti (TLD-100) [1, 2], both in the research field and in the daily operations of facilities handling dosimeters, has long followed a fixed methodology using ovens and muffle furnaces that is highly efficient and proven to be effective, although time-consuming. The time required for the treatment is approximately 3 hours, not including the manipulation of the pellets. However, it is possible to reduce this time to about 1 to 2 hours by employing the thermal treatment of the TLD reader along with data acquisition. Therefore, this work focuses on quality assurance research in the thermal treatment carried out by the reader in comparison to conventional thermal treatment, aiming for a significant time savings throughout the entire process.

2. Methodology

Most works referring to the thermal treatment of TLD-100 follow a standardized methodology using ovens and muffle furnaces for the dosimeters' preparation stage [3, 4].

Thermal treatment is a crucial component of the characterization and use of TLDs. Its primary objective is to restore the dosimeter to its initial conditions before its first exposure to radiation, eliminating any residual signals. Additionally, it aims to adjust the dosimeter's sensitivity by heating the crystal, releasing stored signals from so-called "electronic traps" [4, 5]. This process takes approximately 3 hours, excluding the time spent manipulating the pellets, which depends on the laboratory's structure. Furthermore, the time spent on data acquisition after irradiation can exceed 1 hour for a quantity of 50 units using the HARSHAW model 5500 reader.

Despite this traditional treatment approach, it is also possible to perform it using the TLD reader itself. This can be achieved through the annealing option, which extends the TLDs' heating time after data acquisition, effectively clearing any residual exposure signals, similar to conditions in an oven [6]. This method saves valuable time, as the data acquisition and annealing steps, for the HARSHAW model 5500 equipment, take approximately 1.5 minutes per pellet, depending on the time used for the last step, which can be a maximum of 20 seconds. Moreover, the HARSHAW model 5500 features a disc where up to 50 TLDs can be positioned for automatic reading, significantly reducing the time spent on this stage to approximately 75 minutes.

Therefore, the aim of this study is to perform thermal treatment in both forms and compare the results obtained for known doses on these dosimeters to ensure there is no signal loss in readings with the treatment conducted by the HARSHAW model 5500. This study does not focus on dosimeter characterization.

A total of 120 TLDs of the TLD-100 type with dimensions of 3.2x3.2x0.89 mm were selected for the experiment. Sixty were treated in a muffle furnace for 1 hour at 400°C and then in an oven for 2 hours at 100°C. The remaining 60 were treated in the reader after data acquisition, using the annealing option at 280°C for 20 seconds.

All pellets were irradiated with a dose of 2 mSv in the Cs-137 Panoramic irradiator model DS20 – Hopewell Designs of the Serviço de Gestão de Metrologia das Radiações (SEGMR) at IPEN/CNEN and were read (evaluated) after 1 hour, allowing sufficient time for the low-energy peaks to stabilize.

After the decay time, the dosimeters were read (evaluated) with a heating rate of 15º C/s, and the acquired data in nC were used to determine the calibration factor Fc according to Eq. 1.

$$Fc = \frac{Dose(mSv)}{Reading(nC)} \tag{1}$$

The Fc is the coefficient determined for each type of thermal treatment.

This process was conducted four times for each type of treatment. In the first stage, calibration factors (Fc) were determined for both conventional treatment and treatment in the reader using the data acquired from the initial irradiation. In the subsequent stages, the previously obtained calibration factors were utilized to verify if the dose calculations for the three subsequent irradiations were within the expected range.

The final stage of the study will involve treating the TLDs and irradiating them with various values of different doses to confirm whether the Fc accurately reflects the dose to which the dosimeters were exposed. After this stage, the data obtained for TLDs treated conventionally and those treated in the reader will be compared and evaluated to determine if there is any loss of information through the proposed treatment.

3. Results and Discussion

The average calibration factors and standard deviations for the treatments obtained in the initial stage of the study were as follows:

- Conventional Treatment: $\overline{F_c} = 0.233 \pm 0.024$ mSv/nC

- Reader Treatment: $\overline{F_c} = 0.157 \pm 0.014$ mSv/nC

The mean doses obtained for both treatments using their respective calibration factors are presented in Table I.

Table I: Average doses obtained using the calibration factors.

Conventional Treatment (Dose, mSv)			Reader Treatment (Dose, mSv)		
1st Reading	2nd Reading	3rd Reading	1st Reading	2nd Reading	3rd Reading
2.13±0.26	2.05±0.26	2.08±0.31	2.09±0.17	2.01±0.18	1.95±0.17

Initially, the mean doses presented in Table I exhibit a very similar behavior between the two treatments, with a slightly smaller standard deviation for the treatment performed in the reader. In both cases, the calculated dose was very close to the exposure dose of 2 mSv, with the conventional treatment showing a maximum discrepancy of 6.65%, and the reader treatment exhibiting a 4.5% difference.
The next stage of the ongoing work involves irradiation with different doses for both treatments and the verification of the coherence of the obtained data.

4. Conclusions

The initial results presented indicate that the doses obtained are very close between the conventional thermal treatment and the thermal treatment using the TLD reader.
Irradiations with different doses may help determine the reliability of these results and whether the thermal treatment performed with the HARSHAW model 5500 reader can replace conventional treatment with real-time savings for TLD handling.

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