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Kinetic parameter study on ALOX-520 TLD Glow Curves performed by different methods using a 195-GC dataset

A. L. T. Silva[1], D. S. Calheiro[2],
L. C. Meira-Belo[3]

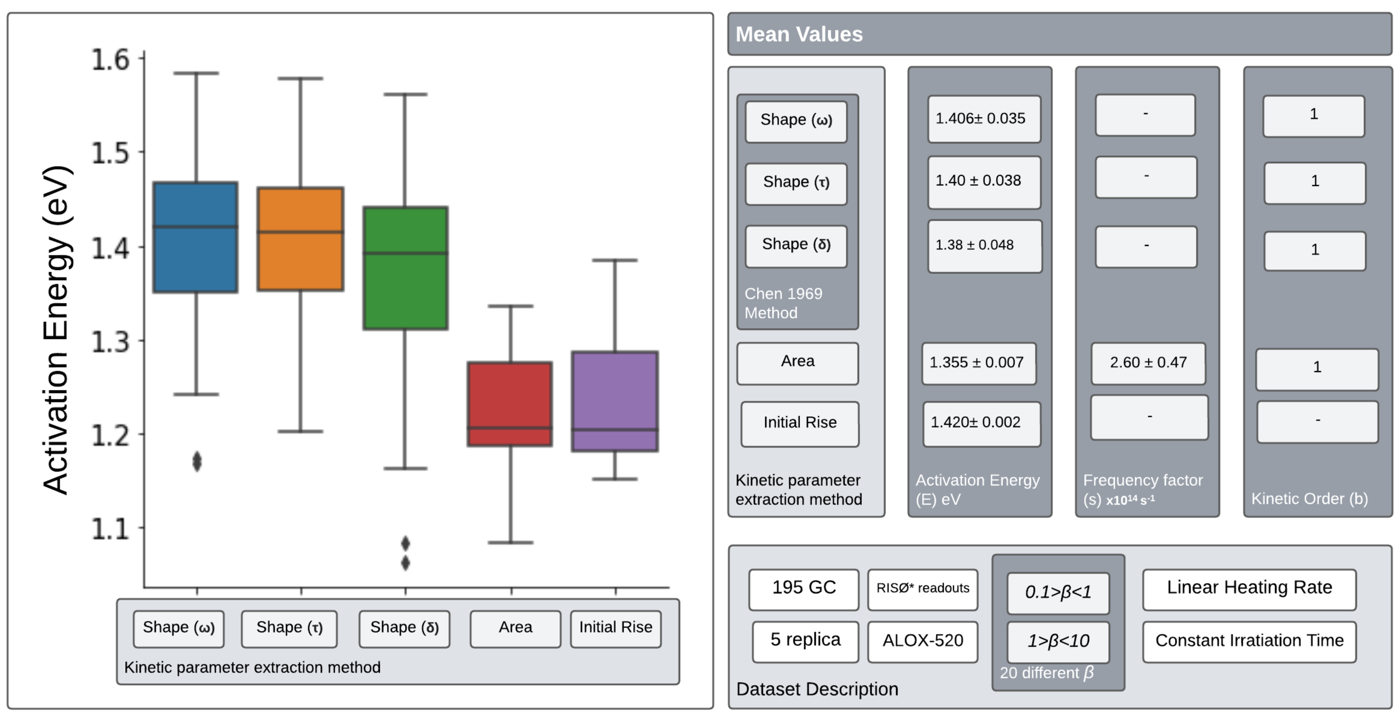
[1] *andre.tavares@cdtn.br, Centro de Desenvolvimento da Tecnologia Nuclear, Brazil*

[2] *danie.calheiro@cdtn.br, Centro de Desenvolvimento da Tecnologia Nuclear, Brazil*

[2] *lcmb@cdtn.br, Centro de Desenvolvimento da Tecnologia Nuclear, Brazil*

1. Introduction

Thermoluminescent dosimeters (TLDs) are reliable tools in both personal and environmental dosimetry, TLDs provide detailed dose assessments crucial for radiation protection and monitoring [1]. Glow Curves (GC) are the measurements of the intensity of light released by the stored energy from irradiated materials measured over a linear or isothermal heat rate; the GC integrals can be used to estimate radiation dose. The theoretical model of Thermoluminescence relies on kinetic parameters (KP), which refer to the characteristics that define the behavior of charge carriers (like electrons and holes) within materials when they are exposed to heat or light and emit photons. These KP include the activation energy (E - the energy required to release trapped charge carriers), the frequency factor (s - a pre-exponential factor related to the probability of charge carrier release), and the order of kinetics (b - describing how the rate of luminescence changes with concentration of trapped carriers) [2]. The techniques to extract KPs from GCs range from area, peak shape analysis, and various heating rate methods to more sophisticated curve fitting approaches. Each method has its specific applications and limitations, highlighting the complexity of accurately characterizing luminescence properties [1]. The objective of this study is to develop a set of functions in Python that automate the extraction the KP from the ceramic TLD detector ALOX-520 [3] GCs and analyze statistic parameter outputs using a 195 GC dataset.



• *RISØ TL/OSL Reader Model DA-20

Figure 1: Statistical Description of calculated Activation Energy (E), frequency factor (s) and kinetic order (b) using peak shape, area, and initial rise KP extraction methods.

2. Methodology

The experiment involved irradiating five ALOX-520 samples using a 90Sr/90Y beta radiation source followed by a TL reading in a RISØ TL/OSL DA-20 Reader. The procedure was repeated to generate 195 GCs, varying the heating rates across 19 settings, with each cycle comprising a 2-second irradiation followed by a readout sequence. A Python Object containing 17 functions to manipulate GC data and extract KP using different methods was developed, and the code implementation was called Lumia.

3. Results and Discussion

The Activation energy (E) obtained via the shape methods display a higher error as well as a high variability (Figure 1 – Boxplot) when compared to the Area and Initial Rise Methods, the additional error can be explained due to the small resolution of the measurements (number of points = 1 channel per temperature) given that the error is half of the size of the temperature channel [4]. The ALOX-520 Ceramic detector has a mean activation energy of de 1.32 eV, varying between 1.24 to 1.50 eV depending on the used

4. Conclusions

The ALOX-520 GC has a mean activation energy of de 1.32 eV, and mean value of frequency factor around 2.6 x10^{14} s-1 from a dataset of 195 GCs. For the future work, use the developed set of functions to extract KPs from other detectors (i.e. TLD-100, TLD-500) and expand the capabilities for working with curve fits and multipeak analysis to generate an automated data processing pipeline to investigate GCs in depth.

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