



Analyzing gamma irradiated Spectrolite in relation to the photo-transfer TL and OSL effects

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1. Introduction

There are materials that have the property of emitting light when they are irradiated with a certain radiation source and subsequently suffering an optical or thermal stimulus; this luminescence characteristic is studied by means of the thermoluminescence (TL) and optically stimulated luminescence (OSL) phenomena. These materials can still present a photo-transfer effect on their luminescence signal, with displacement of the electrons from deeper traps to the shallower traps after illumination; this condition can be observed with the photo-transfer TL (PTTL) and photo-transfer OSL (PTOSL) processes [1-3]. The purpose of this work was to verify the presence of the PTTL and PTOSL responses on the Spectrolite signal, a natural material from silicate family (tectosilicates) and original from Finland, after exposure to gamma radiation (^{60}Co) and illumination by to light-emitting diodes (LEDs) with wavelengths in the UV region, for application in gamma radiation dosimetry.

2. Methodology

In this work, pellets of the powdered material of Spectrolite mixed to Teflon (dimensions of 6.0 mm of diameter and 0.2 mm of thickness) [4], in a proportion [2 (Spectrolite):1 (Teflon)] were studied in relation to their TL/PTTL and OSL/PTOSL responses. In order to verify the presence of the PTTL and PTOSL signals, the experimental procedures occurred in three steps: 1) irradiation and measurement of TL and OSL responses; 2) irradiation, post-irradiation thermal treatment (PITT) and measurement of TL and OSL signals; and 3) irradiation, PITT, illumination with LEDs and measurement of PTTL and PTOSL signals. In all steps, the samples were irradiated to an absorbed dose of 1 kGy with a ^{60}Co source from Gamma-Cell system, model 220, Atomic Energy of Canada (absorbed dose rate of 347.29 Gy/h at July/23). The thermal treatment procedures of PITT of the second and third steps were performed with 200°C/15 min, and for the illumination of the third step, the samples were exposed to a LED with wavelength of 265nm/15 min. In all measurements, the signal was evaluated using the TL/OSL reader system Risø, model TL/OSL-DA-20, and thereafter, the samples were thermally treated with 400°C/1 h for reutilization. For the TL/PTTL signal, the readings were carried out with maximum temperature of 400°C and heating rate of 10°C/s. The OSL/PTOSL measurements were taken under the following conditions: light of blue LEDs as stimulus for signal emission, LED power of 90% and stimulation time of 100 s.

3. Results and Discussion

For the first step, the TL response was obtained after irradiation with 1 kGy and evaluation of the signal. The result revealed a glow curve with the emission dosimetric peak at about 200°C, with peak maximum intensity in about 63×10^3 counts (integral medium value of 6.8×10^6 counts, with relative standard deviation of 3.8%) (Fig. 1a). In the second step, the PITT of 200°C/15 min emptied practically all shallow traps, leaving only a low intensity TL signal in a peak at 350°C, and showing a peak maximum intensity in about 12×10^3 counts (the integral medium value was 6.9×10^5 counts, and the relative standard deviation was 6.9% (Fig. 1b). The last step of the TL group measurements was to verify the existence of PTTL signal after lighting; in this case, it was possible to observe a peak at the beginning of growth at 200°C (integral medium value of 7.5×10^5 counts and relative standard deviation of 4.3%), which suggests a photo-transfer effect, with electrons migrating from the deep traps to the shallow ones, after exposing the samples to light (Fig. 1c).

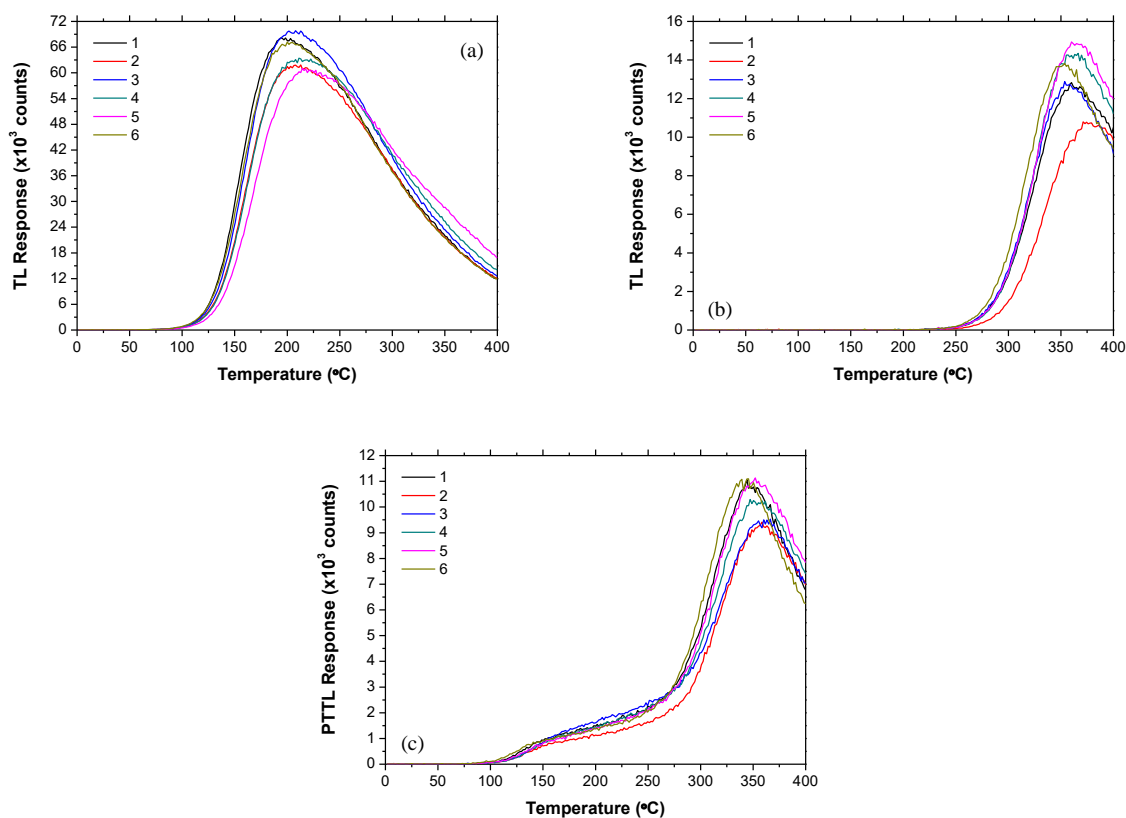


Figure 1: Response measurements of six Spectrolite samples: (a) TL signal after irradiation (1 kGy, ^{60}Co); (b) TL after irradiation (1 kGy, ^{60}Co) and post-irradiation thermal treatment (PITT, 200°C/15 min); and (c) PTTL after irradiation (1 kGy, ^{60}Co), PITT (200°C/15 min) and illumination with LEDs (265 nm/15 min).

Regarding the OSL measurement in step 1, the beginning of the decay occurred at about 2.5×10^4 counts (average value corresponding to the integral under the decay curve of 3.7×10^5 counts, with standard deviation of 6.5%) (Fig. 2a). During the analysis of the OSL signal after PITT (step 2), the curve started to decay at a medium value of 3.3×10^3 counts (while the average value of the integral was of 1.2×10^5 counts and the standard deviation was 3.8%) (Fig. 2b). In relation to the third step, of PTOSL measurement, the signal represented by the decay curve emerged in about 2.0×10^3 counts (average integral average value of 8.4×10^4 and standard deviation of 6.5%), still below the previous result (OSL response after PITT) (Fig. 2c). This fact shows that there was no photo-transfer effect for the PTOSL measurement.

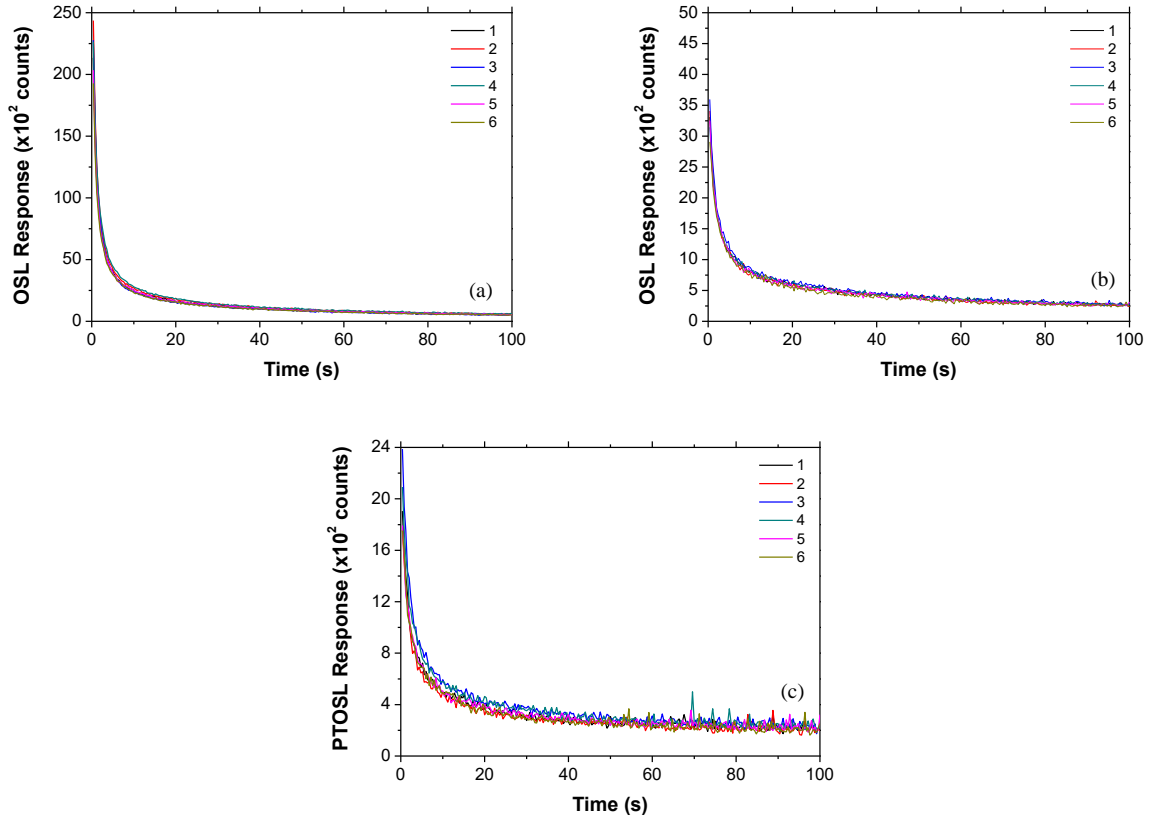


Figure 2: Response measurements of six Spectrolite samples: (a) OSL signal after irradiation (1 kGy, ^{60}Co); (b) OSL after irradiation (1 kGy, ^{60}Co) and post-irradiation thermal treatment (PITT, 200°C/15 min); and (c) PTOSL after irradiation (1 kGy, ^{60}Co), PITT (200°C/15 min) and illumination with LEDs (265 nm/15 min).

4. Conclusions

The data obtained in this work allow observing the presence of photo-transfer effect in the PTTL response, but not in the PTOSL response. These results open a possibility for a continuation of the study with these samples in order to analyze the dosimetric characteristics from their photo-transfer luminescence, including other studies of the PTTL and PTOSL signals, as the response in function of the wavelength and illumination time. Therefore, for application of this material for gamma radiation dosimetry, using these techniques demonstrated here, more studies are needed.

Acknowledgements

The authors would like to thank the Brazilian agencies Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP (Process numbers 2022/13430-2 and 2018/05982-0) and Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq (Process numbers 165609/2020-6, 426513/2018-5, 305142/2021-6 and INCT/INAIS 406303/2022-3), for financial support which made possible the development of this work.

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