# Investigation of aged dental zirconia reinforced lithium silicate for personal dosimetry applications

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# Introduction

- Dangerous radiation events (nuclear accidents or waste, accidents in radiation therapy,  technical or scientific personnel) creates the need to determine the absorbed dose, which led to the Retrospective Accidental Dosimetry.
- Thermoluminescence (TL) stands as one of its most valuable techniques.
- Present work studies the differences that may occur after ageing of a glass-ceramic material (dental material), zirconia reinforced lithium silicate (ZLS), to examine if it can be proved as a potential personal accidental dosimeter.

**Preparation:** Thermal cycling replicates the oral environment by artificially accelerating *in-vitro* ageing: 7300 cycles of repeated baths (5 °C to 37 °C to 55 °C to 37 °C) correspond to 1 year of in-vivo.

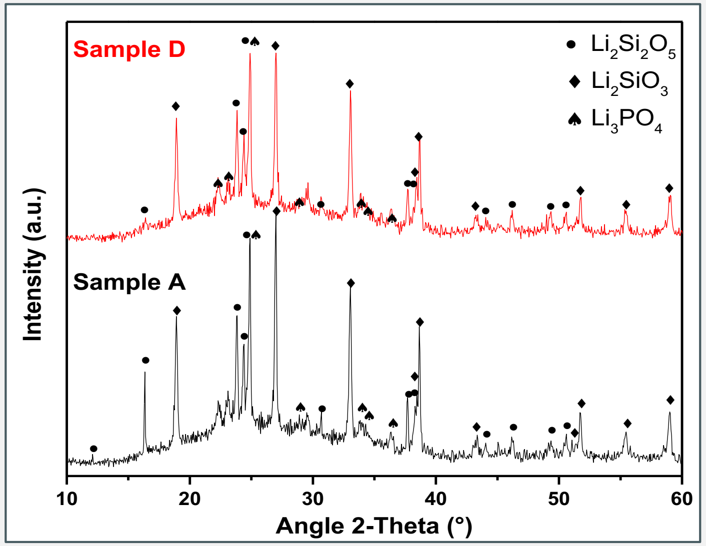
- Sample A: Zero ageing
- Sample B: 7300 TC cycles
- Sample C: 14600 TC cycles
- Sample D: 21900 TC cycles

# Surface Characterization:

All the specimens underwent X-ray diffraction analysis **(XRD)** & Fourier transform infrared spectroscopy **(FTIR).**

The measurements were utilized with a two-cycle Rigaku Ultima+ diffractometer -operating at 40 kV/30 mA-, and a CARY 670 spectrometer -operating in MIR in reflectance mode.

Figure 1: XRD patterns of Sample A and Sample D, as representative. The artificial ageing causes the superficial decrease of the $Li_2Si_2O_5$ phase.
In comparison with Sfampa et al. (2020), the in-vitro aged samples present similar results as with the unpolished ones.



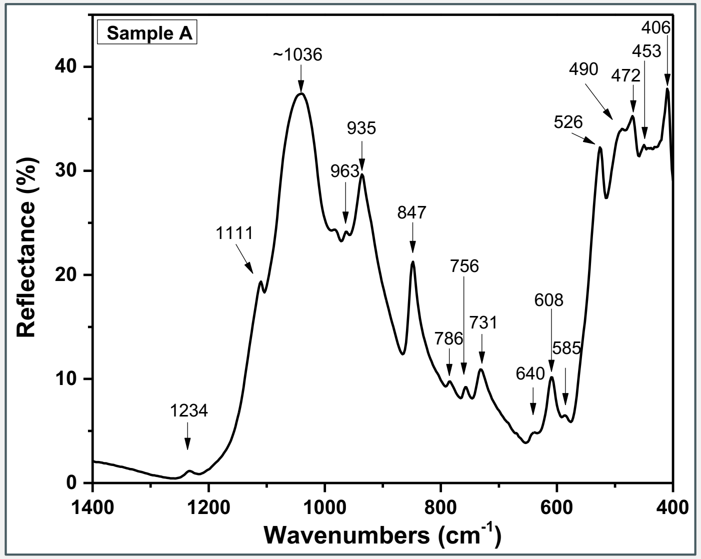




Figure 2: FTIR spectrum of the Sample A, as representative.
$Li_2Si_2O_5$: 1234, 1111, 935, 786, 640, 472 $cm^{-1}$
$Li_2SiO_3$: 935, 847, 731, 608, 526 $cm^{-1}$
$Li_3PO_4$: 1090, 1050, 610, 585, 535, 515, 490, 453, 406 $cm^{-1}$

# Thermoluminescence Measurements:

- TL measurements were carried out using a Risö TL/OSL reader (model DA-15), equipped with a $^{90}Sr/^{90}Y$ beta particle source, delivering a nominal dose rate of 0.0521 Gy/s. A 9635QA photomultiplier tube is used for light detection.
- All measurements were performed in a nitrogen atmosphere with a low constant heating rate of 2 K/s, to avoid significant temperature lag.
- Each data point reported is the average of two measurements carried out on two different aliquots/disks. The applied protocol was according to the following steps:
  - Zeroing of any signal of the sample by heating up to 773 K
  - Irradiating the sample with $D_i$ ($D_i$=1, 8, 32, 128 Gy)
  - Recording TL signal up to 773 K.

The glow curves were analyzed through a deconvolution method of analysis, using the GOK model. Microsoft Excel along with the Solver add-on feature was utilized for the deconvolution.

# Results

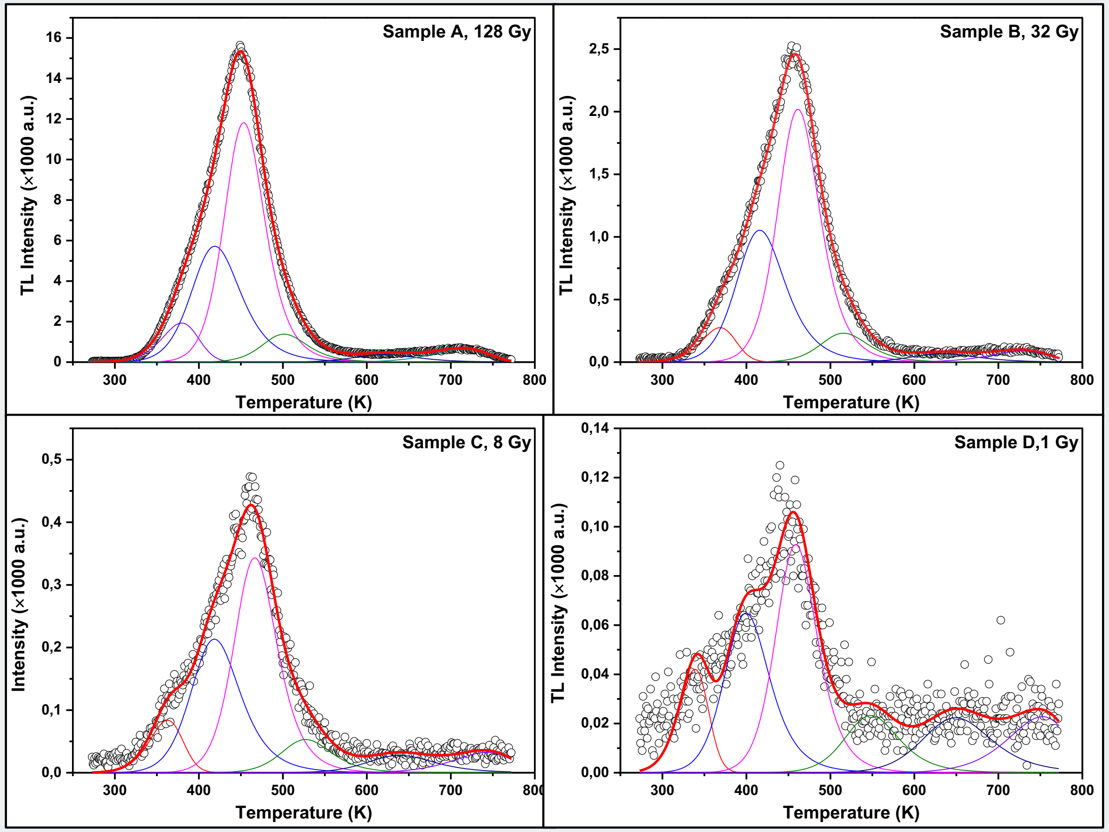



**Figure 3: Glow curve-fitting analysis using the GOK model, under different irradiation doses. Six peaks were used in total and the evaluated energy for the most prominent of them - located at 455 K- is (1.01 ± 0.01) eV.**

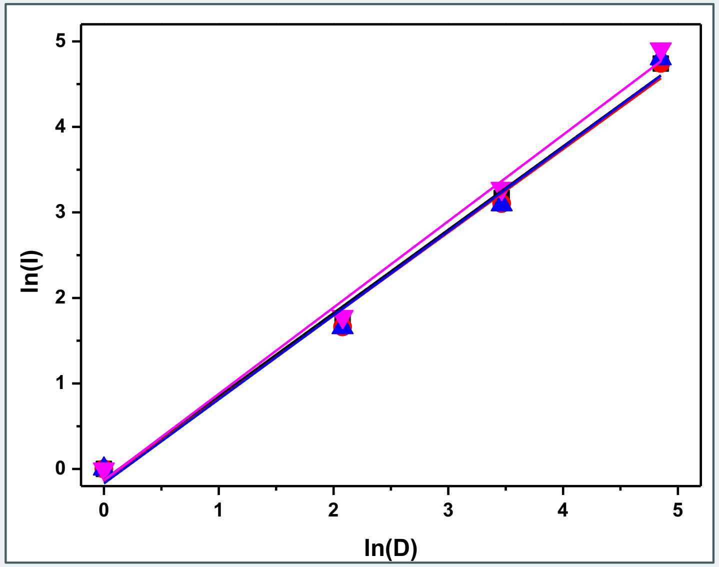



**Figure 4: Dose Response of Samples A, B, C and D, for the dominant peak. Each data point is the average value of two different aliquots, with errors less than 2%. All samples present similar response to the different doses and linear dependence over dose. The results show that the slope is almost equal to 1 for all samples.**

# CONCLUSIONS

- There is a **linear dependence over dose** and the specimens show **no change after different ageing times**. The linear response to the doses is the **most important property** for a potential dosimeter.
- According to the TL results of all of the samples, the artificial ageing does not affect the **dosimetric properties** of ZLS. Therefore, ZLS **can be used** for accidental personal dosimetry applications.
- The **structural differences** –caused by artificial ageing- don't seem to affect the thermoluminescence properties of the material.

References:
[1] Sfampa, I.K., Malletzidou, L., Pandoleon, P., et al. Study of dental zirconia reinforced lithium silicate for its use as a personal accidental dosimeter. *Appl. Radiat. Isot.* 2020, *157*, 109024.
[2] Kitis, G., Gomez-Ros, J.M., Tuyn, J.W.N. Thermoluminescence glow-curve deconvolution functions for first, second and general orders of kinetics. *J. Phys. D. Appl. Phys.* 1998, *31*, 2636-2641.