KINETIC ANALYSIS OF THE GLOW CURVE OF α-Al_2O_3

Yulissa Espitia[1], Rafael Cogollo P.[1], Omar D. Gutiérrez[2]*

[1]Grupo de Materiales y Física Aplicada, Departamento de Física, Universidad de Córdoba, Montería-Colombia.
[2]Grupo de Química Básica, Aplicada y Ambiente, Facultad de Ciencias Exactas y Aplicadas, Instituto Tecnológico Metropolitano, Medellín-Colombia
**e-mail: rafaelcogollo@correo.unicordoba.edu.co ; rafaelcogollop@gmail.com*

6th Asia-Pacific Conference on Luminescence and Electron Spin Resonance Dating
26-28 September 2022, Ankara, Türkiye, Online

Abstract

In this work, the kinetic parameters of the glow curve of pure alumina (α-Al_2O_3) samples irradiated at 10 Gy is reported. The pellets were irradiated using a 6 MeV linear accelerator (LINAC), in air at room temperature, located at the Instituto Médico de Alta Tecnología (IMAT) in Monteria city. The TL reading of the samples was performed on a Bicron® TLD 4500 system. The Peak shape (PS) method and Curve fitting with asymmetric logistic functions were used to carry out a detailed kinetic analysis. Analysis of the TL shows four glow peaks at 162.5, 265.9, 338.7 and 407.7 °C with activation energies of 1.14, 1.26, 2.01 and 1.22 eV respectively, being the recombination processes the main deactivation path. Dosimetric properties such as dose response are also reported.

2. Materials and methods

Commercial boehmite alumina powder (99.995 % purity) was used to prepare pure sintered alumina pellets with 30 mg mass, 5 mm diameter and 1 mm thickness. The pellets were initially compacted at two tons of pressure and then sintered at 1000°C for 3 hours in air at a heating rate of 1°C/minute. Irradiations were performed in air at room temperature at 10 Gy, using a linear accelerator.

The reading of the samples was performed in a TLD 4500, using the heating plate of the equipment. During the reading process, a preheating temperature of 50 °C was used, from which data acquisition was performed at a rate of 5 °C/s until a maximum temperature of 360 °C was reached, followed by heating to 250 °C. All readings were taken in a flow of high purity N_2.

3. Results

3.1 Glow curve features

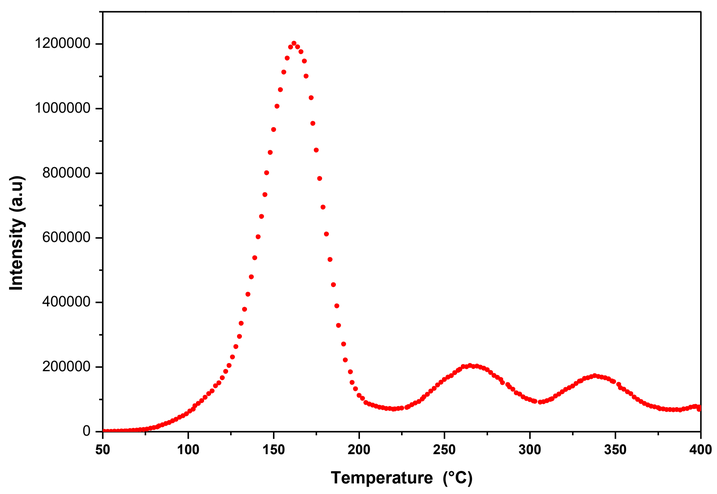

Fig. 1. Glow curve of sintered alumina pellets irradiated at a dose of 10 Gy.

3.2 Dependence of peak position on dose for the main peak glow curve

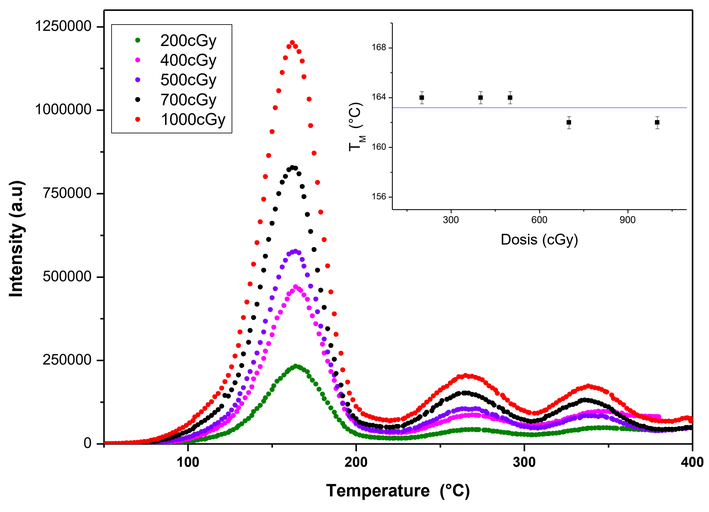

Fig. 2. Glow curves of alumina samples recorded at 5°C/s after irradiation at different doses. The inset shows the change in the position of the main peak with irradiation dose.

3.3 Deconvolution with asymmetric logistic functions

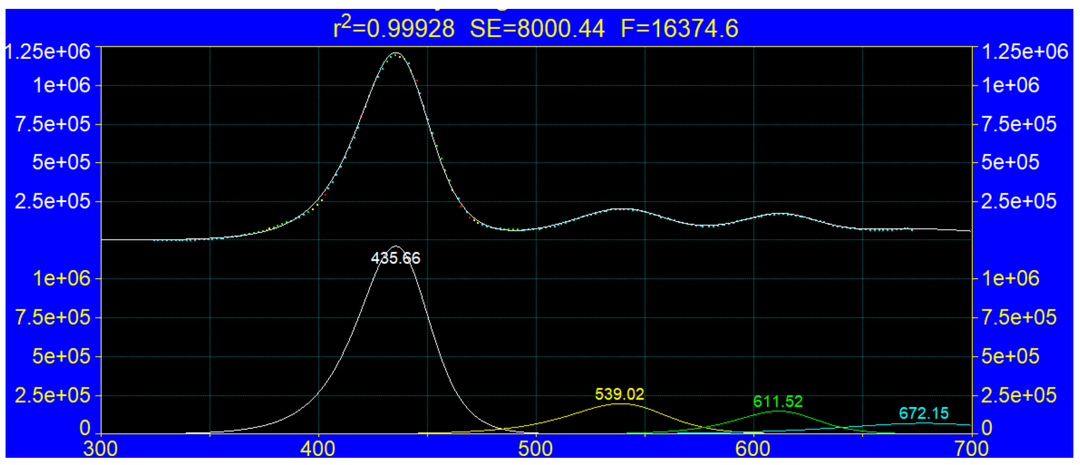

Fig. 3. Curve fitting results for the whole glow curve of alumina sample irradiated at 10 Gy dose.

Table 1. Curve fitting results for the whole glow curve of alumina sample irradiated at 10 Gy dose.

Methods	Peak	b	E (eV)	S (s^{-1})	Remarks
Peak shape method (PS)	1	-	1.13 ± 0.02	-	μ = 0.46 ± 0.03
	2	-	1.25 ± 0.03	-	μ = 0.46 ± 0.03
	3	-	2.01 ± 0.01	-	μ = 0.47 ± 0.03
	4	-	1.22 ± 0.03	-	μ = 0,46 ± 0.03
Curve fitting with asymmetric logistic function	1	1.27±0.01	1.14 ± 0.01	1.00E+12	FOM = 2.20 %
	2	1.25±0.01	1.26 ± 0.01	3.15E+10	
	3	1.32±0.01	2.01 ± 0.01	2.12E+15	
	4	1.27±0.01	1.22 ± 0.01	3.54E+07	

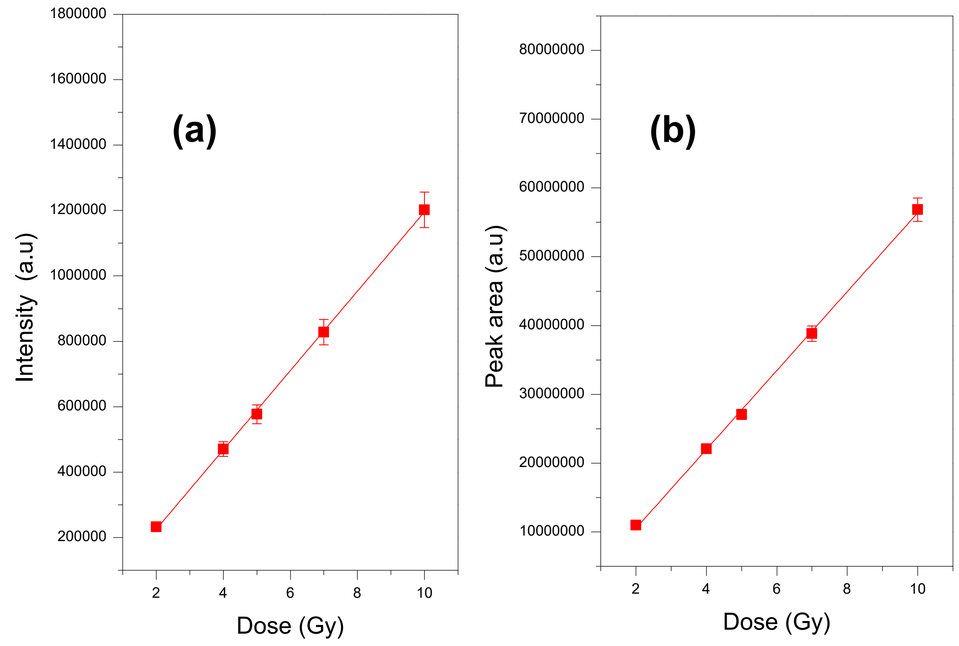

Fig. 4 Linear response of the material with doses from 2 to 10 Gy. The squares represent the experimental data while the line represents the linear fit.

4. Conclusions

- The glow curves of the alumina samples exhibit four experimental peaks around 162.5 °C, 265.9 °C, 338.7 °C and 407.7 °C. The first peak, referred to as the main peak, exhibits high intensity compared to the high temperature peaks, which tells us that there is a larger number of charge carriers trapped in this trap.
- For the four TL peaks, recombination processes are the main deactivation path.
- The fit with the asymmetric logistic functions and the peak shape method presented consistent results
- The response of the material with dose is linear in the range used (≤10 Gy).

References

- Bos A.J.J (2001). High sensitivity thermoluminescence dosimetry. Nucl. Instr. Meth Phy, Res. No 184,1 p,3-28. 0168-9002
- Kalita J. & Chithambo M. (2017). The influence of dose on the kinetic parameters and dosimetric features of the main thermoluminescence glow peak in Al2O3:C,mg. Beam interactions with materials and atoms.
- Pagonis V., Kittis G. & Furetta C. (2006). Numerical and practical exercises in thermoluminescence. Springer.
- Rojas J., Cogollo R. Gil M., Usma J., Gutiérrez O. & Soto A. (2019). Cerium and manganese doped alumina matrices: Preparation, characterization and kinetic analysis of their glow curves. Journal of Luminescence.