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GLOW CURVE KINETICS OF SELF-MADE $CaSO_4$:Dy + PTFE THERMOLUMINESCENT DOSIMETERS

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ABSTRACT

In this paper we present results of various experiments performed to obtain the kinetics parameters for $CaSO_4$:Dy TL dosimeters which were fabricated by the Instituto Nacional de Investigaciones Nucleares (ININ). Kinetics parameters were evaluated by two methods: the glow curve shape method and the isothermal decay method. The average activation energy value determined by the glow curve shape method was 0.68. The isothermal decay method shows the activation energy having the value 0.67. The kinetics order was 2.01 and 2.03, respectively. These results are in good agreement among them.

INTRODUCTION

Thermoluminescent dosimeters (TLDs) based on $CaSO_4$:Dy are extensively used for personal monitoring due to their favorable dosimetric properties. A widely used method for the preparation of $CaSO_4$:Dy phosphor is the crystallization of active powder from sulfuric acid solution in an open system [1, 2].

The method which has now been adopted in our laboratory to produce $CaSO_4$:Dy phosphor is by means of the reaction of calcium nitrate and sulfuric acid as starting materials in a sealed system [3]. Thermoluminescent phosphor produced by this method is mixed with polytetrafluoroethylene (PTFE) to make pellets which will be used as TLDs at the Instituto Nacional de Investigaciones Nucleares

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(ININ) of Mexico.

In order to study the microscopic properties, the analysis of the glow curve kinetics of the self-made $CaSO_4$:Dy + PTFE Thermoluminescent dosimeters is thus performed. The purpose of this paper is to determine the kinetics parameters using the glow curve shape method and the initial rise method. The results are then compared with those obtained by other authors.

DETERMINATION OF TL PARAMETERS

1. Glow curve shape methods

Halperin and Braner [4] gave a method for calculating the activation energy by using the maximum intensity temperature, Tm, and the low temperature half width, $\tau = T_m - T_1$, (see Fig. 1). Another method which uses the falloff of half of the peak, $\delta = T_2 - T_m$, was proposed by Lushchik [5]. Chen [5] modified these two methods and also gave another method in which the total width, $\omega = T_2 - T_1$ is used. The three methods are summed up as:

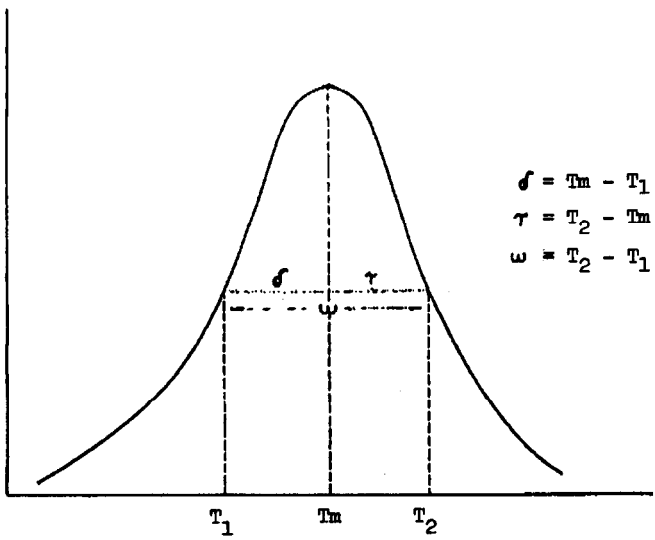

Fig. 1 - Glow curve shape parameters used in glow curve shape methods to determine activation energy and frequency factor.

$$E\alpha = C\alpha(kT_m^2/\alpha - b\alpha(2kT_m) \quad (1)$$

where α stands for δ, τ or ω. The values of $C\alpha$ and $b\alpha$ for the three methods are given by

$$C\tau = 1.51 + 3.0(\mu g - 0.42); \quad b\tau = 1.58 + 4.2(\mu g - 0.42) \quad (1.1)$$

$$C\delta = 0.976 + 7.3(\mu g - 0.42); \quad b\delta = 0 \quad (1.2)$$

$$C\omega = 2.52 + 10.2(\mu g - 0.42); \quad b\omega = 1 \quad (1.3)$$

where $\mu g = \delta/\omega$ is the symmetry factor and k is Boltzmann's constant.

2. Isothermal decay method

The analysis consists in measuring the phosphorescence decay at a given temperature maintaining the sample isothermally at this temperature. Townsend [7] proposed a method for the first order kinetics based on the slope of the linear plot between ln(I) and t at various temperatures. Indeed, the occurrence of exponential decay is rather rare. Thus, Chen [8] proposed an extension of the isothermal decay method to the case of general order kinetics. In this event the plot of $I_0^{(1-1/b)}$ vs t becomes a straight line. This enables the order of the kinetics to be determined by trying various values for b. The proper value is the one which yields a straight line. So, the plot between I_0/I^{b-1} vs t at two given temperatures T_1 and T_2 will yield straight lines of slopes

$m_1 = (b-1)\, s \exp(-E/kT_1)$ i.e.

$$T_1 \ln (m_1/(b-1)s) = E/k \quad (2)$$

Once b has been determined, E and s values can be obtained.

EXPERIMENTAL

Materials used in this study were pellets of $CaSO_4$:Dy + PTFE fabricated at ININ. All the dosimeters used were annealed during one hour at 673 K before use. The radiation source used was a Viokrad ^{60}Co unit (4236 GBq) and the dosimeters irradiated at a

dose of 100 mGy. The measurements were made in a commercial Harshaw 2080 at a linear heating rate of 8.7 K.s^{-1}. Each of the data in this research represents an average of five measurements.

RESULTS

The order of the kinetics determined by Chen's method was 2.01 ± 0.01 and the best value of b to yield a straight line of the plot $(I_o)^{1-1/b}$ vs t was 2.03 ± 0.04. Then we consider that the glow peak under study follows a second order kinetics.

Glow curve shape parameters (τ, δ, ω, μg) were determined for each glow curve and substituted in Eq. 1. Fittings were made using the least squares method considering an uncertainty of ± 0. for E values.

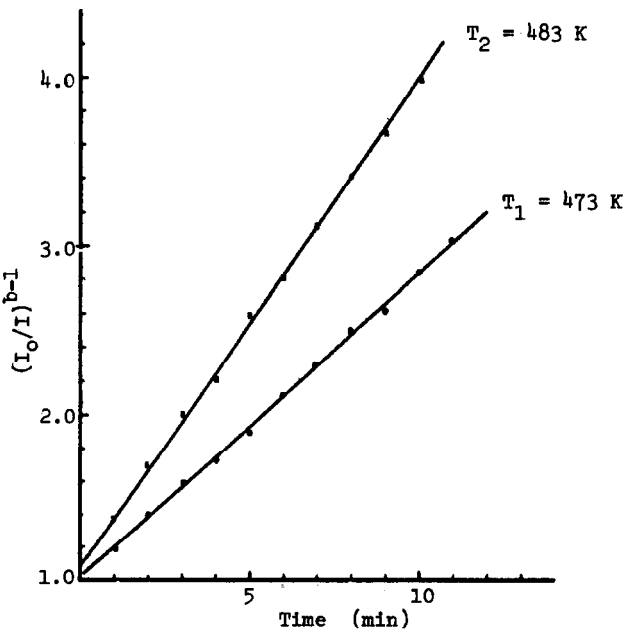

Fig. 2 - Linear plot between $(I_o/I)^{b-1}$ and t for $CaSO_4$:Dy+ PTFE dosimeters submitted to isothermal decay at 473 and 483 K.

Fig. 2 shows the plot of $(I_0/I)^{b-1}$ vs t for $CaSO_4$:Dy + PTFE dosimeters which were left to decay isothermally at 473 and 483 K. These straight lines have slopes m_1=0.1732 and 0.2732. From these slopes E and s values were obtained.

TABLE 1
TL parameters obtained by means of the two methods

Method		Kinetics order	E (eV)
Glow curve shape	δ	2.01 ± 0.08	0.88 ± 0.08
	τ	2.01 ± 0.08	0.88 ± 0.05
	ω	2.01 ± 0.08	0.87 ± 0.05
Isothermal decay		2.03 ± 0.08	0.87 ± 0.10

CONCLUSIONS

Table 1 shows the TL parameters obtained by means of the two methods used. From this table we can observe that E and s values as well as the order of the kinetics evaluated by the two different methods show a good degree of agreement.

REFERENCES

1 J.Azorin, R.Salvi and A.Moreno, Nucl. Instrum. Meth. 175 (1982) 81.
2 J.Azorin, G.Gonzalez, A.Gutierrez and R.Salvi, Health Phys. 48 (1984) 269.
3 J.Azorin and A.Gutierrez, Health Phys. (1988) in press.
4 A. Halperin and A.A.Braner, Phys. Rev., 117 (1960) 408.
5 C.B.Lunschik, Sov. Phys. JETP, 3 (1956) 390.
6 R.Chen, in "Thermoluminescence and thermoluminescent dosimetry" (Ed. Y.S. Horowitz) Ch. 3, pp. 49-88, CRC Press, Boca Raton.
7 P.D.Townsend, C.D.Clark and P.W.Levy, Phys. Rev. 155 (1967) 908.
8 R.Chen, J. Electrochem. Soc. 116 (1969) 1047.