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Analysis of the Glow Curves of Natural Salt by Thermoluminescence Technique

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Abstract— *Thermoluminescence (TL) is an ideal technique for obtaining information of the distribution of artificially created or naturally occurring point defect and is a well known phenomenon amongst the thermally stimulated processed. The TL glow curves of the natural salt obtained from a hilly district (Nungpi-Ukhrul district) of Manipur shows a prominent peak ~ 207°C and a small solder at ~ 119°C. But the glow cures when subjected to Computerized Glow Curve Deconvolution (CGCD) within the kinetic formalism after thermal correction, show that the glow curves are the combination of four peaks. The mean activation energies for the constituents peaks are 0.79±0.01, 0.88±0.01, 1.35±0.09 and 1.57±0.06 eV which are found to be well agreement to the values obtained by the analysis of the Various Heating Rate (VHR) methods. The realistic values of the frequency factor ~10^8 to 10^{13} s^{-1} justify the result, which is also supported by the low values of χ^2 and FOM.*

Keywords— *Thermoluminescence, frequency factor, trapping parameters, Computerized Glow Curve Deconvolution, activation energy.*

1. INTRODUCTION

Thermoluminescence (TL) is the thermally stimulated emission of light from an insulator or a semiconductor following the previous absorption of energy from ionizing radiation. This technique is widely used for obtaining information of the distribution of artificially created or naturally occurring point defect and is a well known phenomenon amongst the thermally stimulated processed. The TL analysis of single crystals and microcrystalline powder of alkali halides have been studied by various workers [1-3]. Recently many researchers also reported the luminescence properties of pure and rare earth doped alkali halides [4-5].

In TL the plot of the light intensity as a function of temperature known as glow curve may have one or more maxima corresponding to the energy level of the substance [6-7]. The shape, position and intensity of the TL glow curve are related to various trapping parameters of the trapping states responsible for the TL emission. These parameters include the frequency factor's' (s-1), the activation energy 'E' (eV) and the order of kinetics 'b'. Several methods exist in the literature to decode the glow curve and retrieve the desired parameters. Of these the Computerized Glow Curve Deconvolution (CGCD) becomes a quite popular to decode a glow curve in the framework of kinetic formalism [8], since essentially the total fitting of a glow peak or the entire glow curve provides a mathematical description of the process [9].

As early as 1954 many researchers suggested Various Heating Rate (VHR) method to retrieve trapping parameters of glow curves on repeated measurement of the curves [10-11]. Using several linear heating rates Hoogenstraaten [12] suggested the calculation of trapping parameters E & s and many workers also investigated theoretically as well as experimentally the effects of heating rate on the TL glow curves [13].

In this paper we carried out the spectroscopic investigation of the TL glow curves of the natural salt collected from one of the Hill District (Ukhurl District) of Manipur using CGCD and VHR methods.

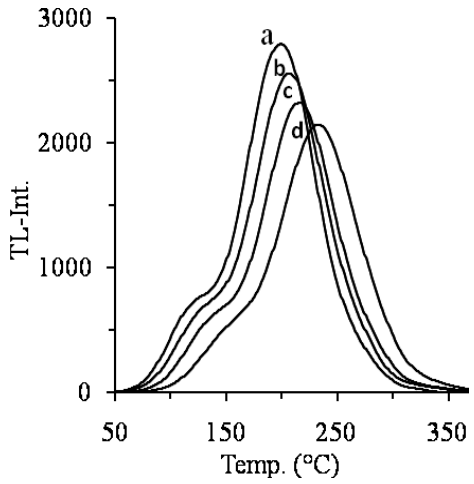

Fig. 1: TL glow curves of natural salt with different heating rates. (curves a, b, c, d corresponds to heating rates 0.5, 1, 2, 5 °C/sec)

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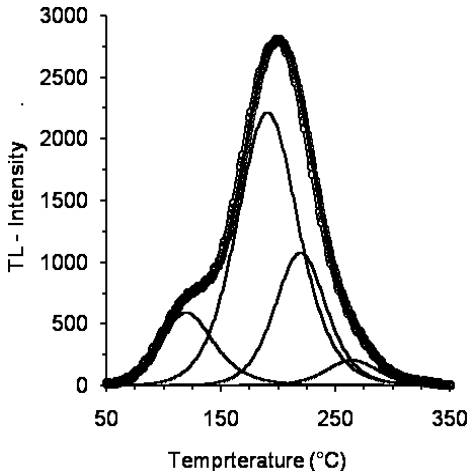
2. EXPERIMENT

The natural salt collected from Ukhrul district of Manipur was crushed into fine powder and heated for ~ 30min to the temperature of~ 500°C. The sample was irradiated by γ-ray from ^{60}Co source to a dose of 6Gy at Radiotherapy Department, RIMS, Imphal. TL glow curves of the sample at least three for each measurements were measured at Environmental Radiation Dosimetry Laboratory, Oriental College, Imphal by using the commercial TL Reader Model 1900I (Nucleonix Systems Pvt. Lt. Hyderabad, India) after 2 days of fading. In each measurement 10 mg of the sample was taken and the heating rates used in the present analysis were 0.5, 1.0, 2.0 and 5.0 °C/sec. Glow curves of low heating rates were used for suitable correction of thermal lag [14]. A second read out was also performed to record the background radiation which includes the black body radiation. The data presented are all with the background subtraction.

3. RESULTS AND DISCUSSION

The glow curves of the sample measured with different heating rates shows same pattern of glow curves with a systematic shifting of peak positions from lower to higher temperature region as the heating rates are increased. It was also observed that the height of the experimental main glow peak decreases with the increase of heating rates. A set of the glow curves is shown in Figure 1. The glow curves are subjected to CGCD within the framework of kinetics formalism [15] after thermal correction. These glow curves are deconvoluted to four constituent peaks. The location of the glow peak temperatures are determined by the minima of the second derivative plot of the curves. One of the typical fittings of the curve for heating rate 0.5°C/sec is shown in Figure 2.

The trapping parameters are also calculated by using VHR method. In this method the plot of $\ln\left(T_m^2/\beta\right)$ ~ $1/T_m$ are drawn for each constituent peaks and one of the plot is shown in Figure 3. The trapping parameters i.e., activation energy and frequency factor of each peak are calculated from the slope and intercepts. Finally, the activation energies of the constituent peaks are calculated by Booth's method by measuring the two peaks temperatures corresponding to the maximum TL intensity for the two heating rates.



oooo Experimetal data
------ Numerically generated best fit TL glow peaks
_____ Sum of generated glow peaks.

Fig. 2: CGCD of TL curve in the framework of kinetic formalism. (heating rate = 0.5°C/sec)

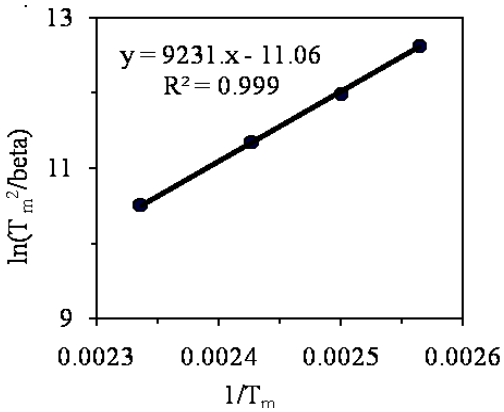


Fig. 3: Plot of ln (T_m^2/β) versus ($1/T_m$)

The results of the outcomes of the analysis are presented in Table 1. The values of the trapping parameter obtained from the different analysis of the glow curves found to be similar indicating the reliability of our results. The low values of FOM (1.20) and χ^2 accepted at 5% level of probability justify the deconvolution.

Table 1: Comparison of the trapping parameters of the best glow peaks of natural salt as obtained by CGCD and VHR analysis

CGCD					*VHR*			
					Booth method		*Hoogenstraaten*	
Peak	*T_m(°C)*	*E(eV)*	*s(s^{-1})*	*b*	*E(eV)*	*s(s^{-1})*	*E(eV)*	*s(s^{-1})*
I	136.33±7.01	0.79±0.01	$(5.31\pm0.09)\times10^{8}$	1.89±0.10	0.80±0.01	7.39×10^{8}	0.80	5.87×10^{8}
II	208.33±7.56	0.88±0.01	$(1.39\pm0.57)\times10^{8}$	1.51±0.19	1.00±0.02	3.05×10^{9}	1.01	3.01×10^{9}
III	241.67±6.59	1.35±0.09	$(3.19\pm.26)\times10^{12}$	1.73±0.06	1.34±0.11	6.45×10^{11}	1.31	6.96×10^{11}
IV	282.00±8.00	1.57±0.06	$(2.48\pm0.18)\times10^{13}$	1.84±0.06	1.56±0.33	1.42×10^{13}	1.56	1.40×10^{13}

4. CONCLUSION

The analysis of the glow curves of the natural salt obtained from a hilly district of Manipur by using CGCD technique as well as different VHR methods are found to follow non-first order kinetics. The activation energies and frequency factors are found to be similar in all the analysis. The activation energy is range from ~ 0.79±0.01 to 1.57±0.06 eV and frequency factor ~ 10^8 to 10^{13} s^{-1}.

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