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Spectroscopic Analysis of the Thermoluminescence Glow Curves of X-irradiated Sodalite Mineral.

Th. Tejkumar Singh[1] Th. Subodhchandra Singh[2]and *S. Nabadwip Singh[3]

[1]Department of Physics, Don Bosco College, Maram, Senapati, Manipur, India

[2]Department of Physics, Ideal Girl College, Akampat, Manipur, India

[3]Department of Physics, Oriental College, Takyel, Imphal, Manipur, India

ABSTRACT

The thermoluminescence (TL) properties of Sodalite ($Na_8Al_6Si_6O_{24}C_{l2}$), a natural silicate mineral have been investigated by Computerized Glow Curve Deconvolution (CGCD) technique in the framework of kinetic formalism. The samples irradiated with X-ray show a main peak structure around 153°C and a shoulder peak around 264°C. It was observed that the glow curve of non-faded samples can be deconvoluted in to seven constituent peaks whereas the glow curve of 24hrs and 72hrs faded samples can be deconvoluted in to five constituent peaks. The analysis was being cross checked by the standard error analyses i.e. FOM and$\chi 2$–test. The analysis reveals that the prominent peaks of the sample at temperature around 153°C, 184°C, 237°C, and 264° has a life time ~32.59 days, 2.65 years, 3.98 years, and 5.63 years respectively.

Key words: Thermoluminescence, trapping parameter, CGCD, kinetic formalism, activation energy.

INTRODUCTION

The phenomenon of thermoluminescence has been observed for many centuries. During the irradiation of a material, the excited electrons may be trapped at various imperfections. Subsequent heating of the material releases these electrons and the released energy is converted to luminescence. The physical mechanisms governing the trapping and release of electrons were discussed by many workers [1-5]. Experimentally observed glow curves are analysed by fitting them to the analytical expressions and parameters are determined by the fitting process.

The purpose of the present study is to investigate how well the curve fitting method, Computerised Glow Curve Deconvolution (CGCD), works in providing reliable values of trapping parameters of sodalite mineral. The selection of the mineral sodalite is because of the fact that radiation-induced electron and hole center in this system is already well studied [6] and defect centers in sodalite have acquired a special importance because it displays photochromism i.e. a reversible process of acquiring colouration following UV irradiation and bleaching under the action of visible light.

EXPERIMENT

Sodalite samples used in the present study have been collected from the Hindustan Minerals. The samples were heated to 500°C to erase any natural TL present in the samples. Then, the samples were irradiated with X-ray to induce defects creation from a Cu-target operated at 8000V, and 4mA for 4min. TL glow curves were measured with a heating rate 0.67° per second by TL reader TL-1404, Indotherm Instruments Pvt. Ltd. at the Department of Physics, Manipur University.

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RESULT AND DISCUSSION

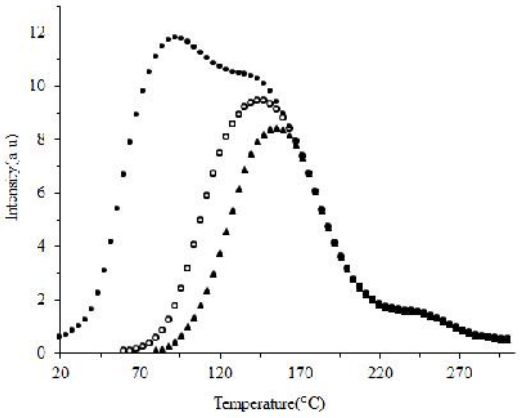

Figure 1: TL glow curve of X-ray irradiated sodalite.
●●●●●● Glow curve of sodalite without fading.
°°°°°° Glow curve sodalite measured after 24hrs of fading.
▲ ▲ ▲ Glow curve of sodalite measured after 72hrs of fading.

The TL glow curves of the sodalite samples irradiated by X-ray measured without fading and fading of 24 hrs.and 72hrs. are shown in Figure 1. The glow curves indicates main peaks around 90°C, 150°C and a shoulder peak around 264°C for non-faded samples, while both the faded samples (24hrs and 72hrs) indicate main peak around 150°C and the shoulder peaks around 264°C. But the peak around 150°C is shifting to the higher temperature side and the intensity also goes on decreasing. All the glow curves are subjected to GCCD in the framework of kinetic formalism from the program given the classical text of Chen and Kirsh [7], the modification incorporated here is the selection of the peak temperature within ± 2°C after thermal correction [8]. From the analysis, we observed that the glow curve measured without fading consists of seven constituent peaksand the glow curves with the fading of 24hrs and 72hrs consist of five constituent peaks.

The results of the CGCD analysis of the TL glow curves are presented in Figure 2 and 3 with the plot of

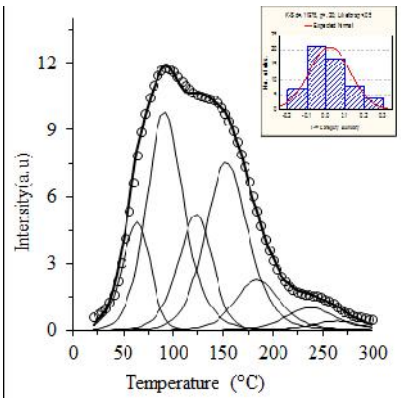

Figure 2: CGCD of Sodalite. Heating rate = 0.67°C/sec
–––––Numerically generated best fit TL glow curves.
▬ ▬ Sum of numerically generated best fit glow curve.
Inset: Histogram of error distribution

histogram error (inset). In all the cases of TL glow curves, show many overlapped peaks, the distinct peaks that can be identified by CGCD method are around 91°C, 153°C, 237°C, and 264°C for non-faded sample and 153°C, 184°C, 237°C, and 264°C for 24 hours and 72 hours fading samples. Thus, the existing peaks around (153-264)°C can be considered as a characteristic feature in the TL pattern of this material.

The results of the parameters of the CGCD are presented in Table 1. The activation energy of the peaks around 153°C, 184°C, 237°C, and 264°C are found to be 1.02eV, 1.13eV, 1.25eV, 1.32eV respectively. And,

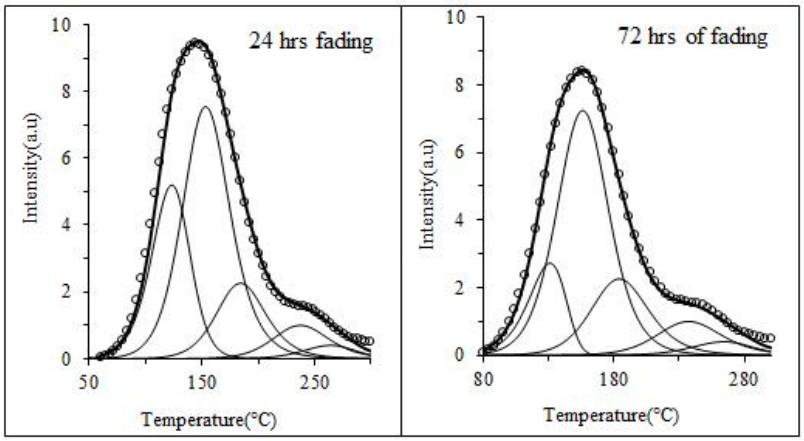

Figure 3: CGCD of TL curves of Sodalite fading with 24 and 72 hrs.
——— Numerically generated best fit TL glow curves.
▬ ▬ ▬ Sum of numerically generated best fit curve.

the life times of the peaks at room temperature are 32.59 days, 2.65 years, 3.98 years, and 5.63 years. Thus, it is found that deeper the trap, smaller will be faded at a given temperature.

Table 1: Trapping parameters of the sodalite determine by CGCDmethod.

Specification of Samples	Glow peak	Tm (°C)	E (eV)	b	s (sec^{-1})	FOM (%)	χ^2
Without fading	I	64	0.80	1.34	4.90E+10	0.57	0.95 d.f. =2
	II	91	0.89	2.00	1.03E+11		
	III	123	0.95	1.45	5.64E+10		
	IV	153	1.02	1.90	4.82E+10		
	V	184	1.13	1.90	1.15E+11		
	VI	237	1.25	1.90	7.96E+10		
	VII	264	1.32	1.50	8.44E+10		
24 hrs. fading	I	123	0.95	1.45	9.62E+10	0.4	0.40 d.f. = 1
	II	153	1.02	1.01	4.86E+10		
	III	184	1.13	1.90	1.15E+11		
	IV	237	1.25	1.90	7.96E+10		
	V	264	1.32	1.90	8.44E+10		
72 hrs. fading	I	123	1.00	1.05	1.42E+11	0.32	1.57 d.f=3
	II	156	1.06	1.76	1.13E+11		
	III	184	1.13	1.90	1.15E+11		
	IV	237	1.25	1.90	7.96E+10		
	V	264	1.32	1.50	8.44E+10		

The fittings are subjected to statistical analysis (FOM and χ^2-test) and found that FOM is less than 1% and χ^2-test passed at 5% level of probability. The frequency factors for all the peaks are of the same order of (10^{10}-10^{11}) per sec which is in the acceptable range.

CONCLUSION

Analysis of the TL peaks shows that the peaks at 153°C, 184°C, 237°C, and 264°C can be said to be prominent peaks of the sodalite system. The trap depths of the peaks are 1.02eV, 1.13eV, 1.25eV, and 1.32eV respectively. And the lifetime of the peaks at RT for 153°C, 184°C, 237°C, and 264°C peaks are 32.59 days, 2.65 years, 3.98 years, and 5.63 years respectively. Thus, from the above findings it can be concluded that mineral sodalite can be used as a dosimetric material.

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Reference

1. McKeever, S.W.S. 1985. Thermoluminescence of Solids, Cambridge University Press, Cambridge, 1985.
2. Chen.R.and McKeever, S.W.S. 1997. Theory of Thermoluminescence and Related Phenomenon, World Scientific, Singapore.
3. .Singh, A.N., Singh, S.N., and Singh, L.L. Analysis of thermoluminescence of $Li_2B_4O_7$:Cu, Ag, P phosphor by simplified General one Trap differential equation, Indian J Phys,
4. Singh,S.N., Sharma, B.A. and Singh,A.N. 2012. Thermoluminescence of $Li_2B_4O_7$:Cu and La, Indian Journal of Pure and Applied Physics, 358-362.
5. Chen, R. and Krish, Y. 1981. Analysis of thermally stimulated processes, Pergamon Press,London,
6. Marfunin, A.S. 1979. Spectroscopy, Luminescence and Radiation Centers in Minerals, Springer-Verlag, 274-282.
7. Chen, R. and Kirsh.Y. 1981. Analysis of Thermally Stimulated Processes (Pergamon Press, London, pp. 329-31.
8. Singh,L.L. and Gartia, R.K. 2014.Nucl. Nst. Methods B 319 39 .