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Heating Rate Effect on Thermoluminescence (TL) Glow Curves

DR. Praveen Kumar Singh E-mail: pk75singh@gmail.com

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***Abstract:** Thermoluminescence (TL) also called as thermally stimulated luminescence refers to a process in which a solid, usually in crystalline form, emits light while being heated following excitation. In the present work the samples of LiF: Mg,Cu,P powder were irradiated by the gamma radiation resource with varied exposed dose. The TL glow curves of material were observed with the different heating rates. The influence of heating rate on the thermoluminescence property of LiF: Mg,Cu,P was analyzed. From the result of this experiment it is clear that as the heating rate increases, the peak intensity decreases and shifts to higher temperature. It is also seen that the Thermoluminescence sensitivity of the material also changes and it has the maximum value at 60C/s. This value is well acceptable for the measurement of natural environmental and archaeological dose.*

Key words- Thermoluminescence dosimetry, Archaeology, TL.

1. INTRODUCTION- Thermoluminescence is the emission of light from some minerals and certain other crystalline materials. The light energy released is derived from electron displacements within the crystal lattice of such a substance caused by previous exposure to high-energy radiation. Heating the substance at temperatures of about 450°C and higher enables the trapped electrons to return to their normal positions, resulting in the release of energy. The intensity of the emission can be correlated to the length of time that a given substance was exposed to radiation; the longer the time allowed for the radiation to build up an inventory of trapped electrons, the greater the energy released. Because of this feature, thermoluminescence has been exploited as a means of dating various minerals and archaeological artifacts. Radiation dosimetric investigations in diagnostic radiology have been increasing in importance in the last two decades. The most widely used method in radioactivity dosimetry is thermoluminescence technique. Several types of thermoluminescent dosimeters (TLD) are commercially available for a wide range of applications: LiF:Mg,Cu,P has recently emerged as TL material with significant advantages which outperformed many other materials. Due to several important properties, such as tissue equivalence, relative low fading and low fading's high sensitivity, LiF has mainly been recommended for environmental measurements and radiotherapy. However, some disadvantages have also been described in previous work, mainly are poor reproducibility and high residual signal. Aim of this paper is illustrate that, in the experimental conditions of this study, LiF:Mg,Cu,P presents improved dosimetric characteristics that make it useful for study in medical and environmental problem.

2. METHODOLOGY- In this section we present the glow curve of the LiF:Mg, Cu, P with the different proposed heating profiles. The maximum temperature for LiF: Mg,Cu,P was a critical parameter and the temperature of 240°C should be maintained stable in the first phase of the annealing cycle. It was also found that rapid cooling improved the phosphor response. The glow curves of thermoluminescence material were received from four dosimeters of LiF: Mg,Cu,P which were previously annealed. They were protected from light. To eliminate the low temperature peaks, the data acquisition of dosimeters' thermoluminescence insensitivity was performed 24 hours after the irradiation. Before exposure to radiation, LiF:Mg,Cu,P powders received a standard annealing treatment. Depending on the type of thermoluminescence material, thermal annealing schemes were chosen to LiF:Mg,Cu,P. The method of slow cooling inside the muffle was used to reach room temperature for all cases. To study about TL responsibility material, 16 dosimeters of LiF:Mg,Cu,P were prepared, and they were divided into groups of 4. These dosimeter were

Associate Professor- Physics, Mahant Avaidyanath Rajkiya Mahavidyalay Jungle Kaudia Gorakhpur (U.P.), India

Corresponding Author/Joint Authors

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placed into capsules of latex, which are arranged adjacently to the gamma irradiation from Cobalt resource. These were irradiated with the following doses. In order to obtain the TL response as a function of the radiation dose, the TL intensities were plotted versus the obtained doses from gamma resource in the range of doses studied. The irradiation dosimeters were performed with a 60Co resource. The readings of the TL materials are performed in a reader RGD-3A. The reading cycles were varied depending on the material as shown in Table 1. In order to eliminate the contribution by thermoluminescence, all readings were performed in an atmosphere of high purity nitrogen gas(N2).

Fig 1. TLD 2000A Annealing Device.

Table - 1

Reading parameters for TLD materials:

Parameters	LiF:Mg,Cu,P
Preheating temperature	135oC
Preheating time	6s
Preheating speed(*It is chosen one of them*)	2; 4; 6; 8oC/s
Max. Heating temperature	240oC
Acquisition time	6s
Annealing temperature	240o C

3. RESULTS AND DISCUSSION- Fig.2 represents thermoluminescence glow curves for the LiF:Mg,Cu,P materials at low doses of gamma resource and read in heating rate 6oC/s.

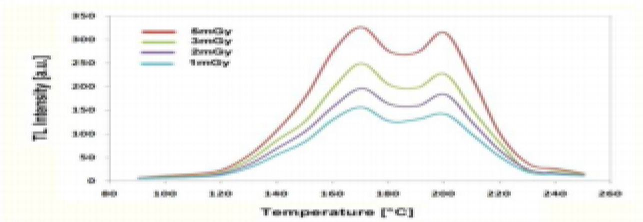

Fig. 2. The different glow curves of LiF: Mg, Cu, P

In the Fig. 2, dosimeter of LiF:Mg,Cu,P has two peaks centered at 1700C and 2150C. The dosimeters were readed at 24 hours post-irradiation. This results is also in correlation with Ginjaume's and Pradhan's investigation. In order to obtain the TL responsibility as function of the radiation dose for the materials, the TL intensities were plotted versus the obtained from gamma resource in the range of doses studies. To investigate on TL sensitivity, there were 16 thermoluminescence dosimeter prepared. They were dived into 4 groups, corresponding to exposed doses. The TL insensitivities collect from the glow curves with the canals between 1350C and 2100C temperatures. The results were averaged of 5 reading times and showed in the Table -2.

Table - 2

The TL insensitivities of the glow curves of LiF: Mg,Cu,P

Heating rate	Thermoluminescence intensity (a.u)			
(°C/s)	1mGy	2mGy	3mGy	5mGy
2	560 ± 20	820 ± 40	1150 ± 60	1870 ± 95
4	650 ± 30	1150 ± 50	1650 ± 85	2350 ± 110
6	880 ± 40	1380 ± 75	2180 ± 110	3310 ± 150
8	780 ± 35	1310 ± 60	1810 ± 90	3050 ± 140

As above present, the TL response of material was evaluated through TL intensity and irradiation dose. It is the angle of standard linear plotting versus the obtained doses and TL intensity (counts).

From Table 2, we have the plots to determinate TL response of LiF:Mg,Cu,P, as shown in the Fig. 3.

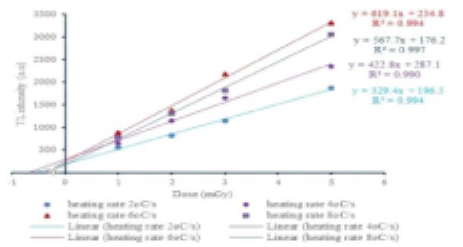

Fig. 3. The TL response plots of LiF:Mg,Cu,P with different heating rates.

Fig.3 have a good linearity of the TL intensity and the exposed doses in range studied values, with the relation factors (R2) are over 0.9 values. Fig.3 also illustrated, TL responsibility changed depending on the heating speed, and it obtained maximum value around 60C/s. This is shown in Fig.4.

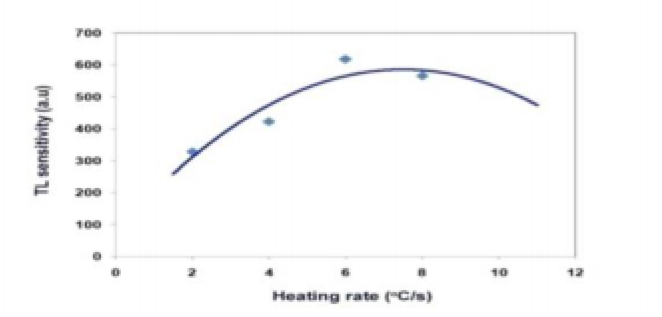

Fig.4. TL sensitivity versus heating rate.

Fig.4 shown that each thermoluminescence peak corresponds to energy level of electron trap in TL material [6, 8]. When it was excited by temperature (heating), the electrons will be released from the traps and transmit to basic energy level and radiates photons. Thus, released electrons from traps in TL material not only concern to co-referent energy level but also to heating rate.

To study about the repeatability of the material at the environmental conditions, the total amount of 5 dosimeters were used. The test was performed for fifteen consecutive cycles, i.e., thermal annealing treatment, irradiation and reading with the same readout proceduresfor each annealing cycle. Annealing technique was conducted according to the conditions of 2400C for 10 minutes, the irradiation was performed at a dose of 5mGy and readings were made at 24 hours post irradiation using the same parameters mentioned above section. Results of investigation on reproducibility are shown in Fig.5.

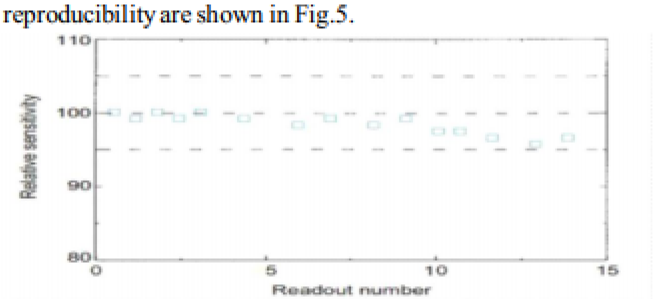

Fig.5. Reproducibility of LiF:Mg,Cu,P through reused times.

Fig.5. illustrates the relative sensitivity variation from TL materials as a function of the number of reuses. Its reproducibility after 15 successive cycles of annealing, irradiation, and readout presented a little decrease. In addition, the residual signal obtained after an initial dose of 5mGy was lower than 5% for the dosimeters with the proposed readout procedure. The decrease of TL response as function of time is shown in Fig.6.

In Fig.6. fading of peaks of glow curves for the LiF:Mg,Cu,P materials are shown in a period of 15 days. It is observed clearly the slight decrease in the intensity of the dosimetric peak of the materials. Storing the TL dosimeter causes depopulation of trapping states due to fading. Therefore, the TL glow peaks shift to higher temperature with increase in storage time.

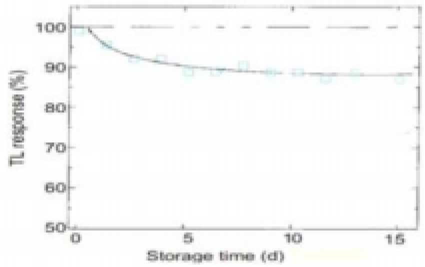

Fig.6. Fading of LiF:Mg,Cu,P while storage room temperature25°C

4. CONCLUSIONS- In the present study we find that, the Characteristics of LiF:Mg,Cu,P have been improved by working conditions in our laboratory. It is shown that because of its good energy response, low fading in natural environmental conditions and extended range of linearity. It is a suitable material for medical and archaeological applications. TL materials LiF:Mg,Cu, P were characterized to low doses, which correspond to radiological diagnosis by the following dosimetric tests: homogeneity batch reproducibility, sensitive factor, detection threshold, linearity and fading. To observe glow curve of LiF: Mg, Cu, P, we suggest that, choosing a parameter "heating speed" around 60C/s is suitable for determination low doses. Reading TL insensitivity of LiF:Mg,Cu,P need performed after 24 hours.

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