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Analysis of trapping parameters of $KCaSO_4Cl$:Eu phosphor prepared by acid method

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Abstract
This paper reports the systematic study of $KCaSO_4Cl$:Eu phosphor synthesised by acid distillation method. Single glow peak at 432 is observed in $KCaSO_4Cl$:Eu phosphor. The study of trapping parameters is done with the help of Chen's peak shape method.

Keywords: Phosphors; Thermoluminescence; Acid distillation.

INTRODUCTION

During the last two decades the application of thermoluminescence dosimetry (TLD) in radiation protection has grown steadily in parallel with the worldwide progress made in the development of solid thermoluminescent (TL) dosimeters [1,2]. Today, TLD is the dominant dosimetric method for the measurement of doses to human extremities and furthermore, roughly one-third of the personnel monitoring services operating today use a TLD badge exclusively for beta/gamma whole-body monitoring. For environmental monitoring TLD presents new possibilities for long-term monitoring on a broad scale [3].

Different preparation methods and properties of several thermoluminescent materials have been studied so far and it is found that mixed sulphates constitute a class of TL phosphors with good performances, especially when doped with proper activators. The mixed sulphate $K_2Ca_2(SO_4)_3$:Eu was developed by Sahare and Moharil and found to be highly sensitive TLD phosphor, which is about five times more sensitive than the commercially available $CaSO_4$:Dy [4]. There are reports by Stochioiu and Georgescu that this material is being used for environmental dosimetry[5]. Thermoluminescence glow curves of γ-ray irradiated nanomaterials were recorded at room temperature and studied in this paper.

EXPERIMENTAL

For the preparation of $KCaSO_4Cl$:Eu phosphor all starting materials used were of analytical grade. $KCaSO_4Cl$:Eu phosphor was prepared by dissolving the $CaSO_4$, KCl and europium in H_2SO_4. In acid distillation method, in addition to distilling out, acid vapours were subjected to condensation process over some time. After the completion of process, the solution was allowed to cool to room temperature. The sample phosphors thus prepared were repeatedly washed with double distilled water to remove the traces of acid and unwanted impurities. The prepared phosphors were then dried at 80°C for few hours. In this way the phosphors were prepared and made ready for further characterizations.

RESULTS AND DISCUSSION

X-ray diffraction

Fig. 1 shows the XRD pattern of pure $KCaSO_4Cl$ powder. X-ray diffraction pattern indicates the presence of crystalline $KCaSO_4Cl$ host lattices. The final product was formed in homogeneous form because the XRD pattern of $KCaSO_4Cl$ did not show the presence of the any starting materials like $CaSO_4$, KCl and other likely phases which is indirect indication for the formation of the desired compound. No additional data relating to this phosphor are available in the literature.

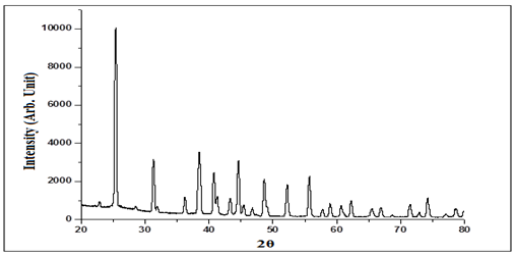

Fig 1. X-ray diffraction pattern of the $KCaSO_4Cl$ host lattice.

SEM study

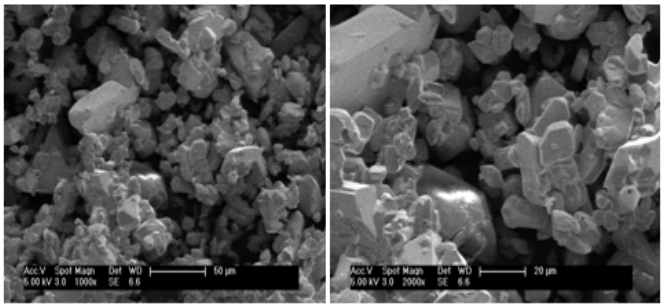

Fig 2 . SEM micrographs of $KCaSO_4Cl$ phosphor.

The morphology of the $KCaSO_4Cl$:Eu phosphor was analysed using SEM micrograph as shown in Fig. 2.The SEM micrograph shows that the particles were of irregular shapes. Whereas from photographs particles having smooth surface can be observed.

Thermoluminescence (TL) Characteristics

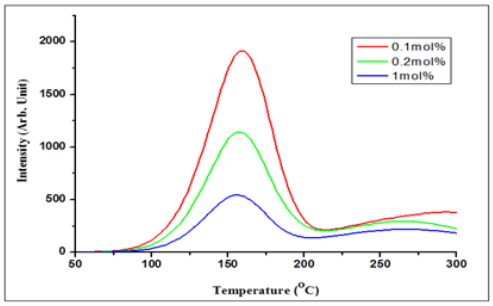

Fig 3. TL glow curves of $KCaSO_4Cl$:Eu at a heating rate of 5°C s^{-1}.

Fig. 3 shows the TL glow curves of $KCaSO_4Cl$:Eu phosphor materials exposed to gamma radiations from ^{60}Co source at room temperature. Thermoluminescence of the as prepared phosphor materials was recorded using Nucleonix TLD reader. The intensity of $KCaSO_4Cl$:Eu was found to decrease with Eu addition.

Thermoluminescence is a very simple technique used for estimation of doses of high-energy ionizing radiations absorbed by materials. The TL glow curves of $KCaSO_4Cl$:Eu compound show single glow peak indicating that only one type of traps are being activated within the particular temperature range with its own value of activation energy (E) and frequency factor (s). The shape of the glow curve remains almost the same for different concentration of Eu but the height of the glow peak change. The maximum TL intensity is observed for 0.1mol% of Eu.

Analysis of TL glow curve and calculations of kinetic parameters

Peak shape method

A popular method of analysing a TL glow curve in order to ascertain the kinetic parameters E, s, and b is by considering the shape or geometrical properties of the peak. TL glow peaks corresponding to second-order kinetics are characterised by an almost symmetrical shape, whereas first-order peaks are asymmetrical.

Order of kinetics can be evaluated from the symmetry factor (μ_g) of the glow peak. μ_g is calculated using the following Chen's equation,

$$\mu_g = \delta / \omega = (T_2 - T_m)/ (T_2 - T_1) \quad \text{.....(a)}$$

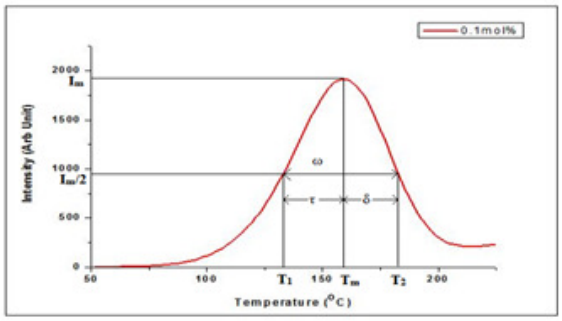

Fig. 4. TL glow curve of $KCaSO_4Cl$ for 0.1mol% Eu at a heating rate of 5°C s^{-1}.

The activation energy (E- the trap depth or the thermal energy needed to free the trapped electrons) was calculated by using the Chen's equations, which give the trap depth in terms of τ, δ, ω. A general formula for E was given by,

$$E = c_\gamma (kT_m^2/ \gamma) - b_\gamma (2kT_m) \quad \text{.....(b)}$$

Where, γ is τ, δ or ω.

As shown in fig.4 the intense peak was selected for trap parameter study. The values of τ, δ & ω are calculated from the three temperatures that is T_1, T_2 and T_m. By using values of δ and ω the value of μ_g found to be 0.46 which is near to 0.42. Hence we consider that the peak is obeying first order kinetics. The calculated value of activation energy is 0.63eV and frequency factor is 5.6×10^5.

CONCLUSION

The TL glow curve of $KCaSO_4Cl$:Eu shows a very simple structure of glow curve. The glow curve of $KCaSO_4Cl$:Eu phosphor obeys first order kinetics, trapping parameters of glow peak are calculated by Chen's peak shape methods. At present days, there is a great demand of the dosimetric phosphors which exhibit simple and sharp glow curves. The compound $KCaSO_4Cl$:Eu has been found to have simple and sharp glow peak and moreover it can be prepared very easily.

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