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Thermoluminescence Properties of $KAl(SO_4)_2:Eu^{3+}$ Phosphors

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ABSTRACT

In the present work, a series of Eu^{3+} activated $KAlSO_4$ phosphors were synthesized by solid state reaction method. The present paper reports thermoluminescence (TL) glow curves of the synthesized Eu^{3+} activated $KAlSO_4$ phosphors. TL glow curves were recorded for different concentration of Eu^{3+} ions by gamma exposure at a heating rate of 5 °C s^{-1}. The TL glow curve shows broad emission band at 6200 Gy irradiation of gamma rays in the temperature range of 50° to 400°C. It was found that the TL emission intensity increases linearly up to 0.7 mol% and then decreases with increasing concentration of Eu^{3+}. The TL glow curves show linearity with increasing exposure. The response curve of the synthesized phosphor showed linearity in the range 800–9300 Gy. All these results represent synthesized phosphor may be useful for future work in field of dosimetric application.

Keywords : Solid state reaction method; Thermoluminescence (TL); Gamma rays; TL response curve

I. INTRODUCTION

Rare earth doped phosphors material have many useful applications such as phosphor converted LEDs, thermoluminescence dosimeter, phototherapy lamp, solar cell, fingerprint detection, etc [1]. Thermoluminescence emission is also known as thermally stimulated luminescence. When the sample, which may be a semiconductor or an insulator containing defects, is irradiated by energetic ionizing radiations, energy gets stored at this sample. When this sample is heated, the stored energy is emitted in the form of light. Heating plays an important role of a stimulant or a trigger for initiating the emission of light. It is usually considered that TL is caused by electron-hole recombination, one of which is released thermally from a trap[2]. Thermoluminescence is a significant tool for evaluating the depth of the trap of solids and heating a crystal lattice that can result in the release of trapped electrons with associated emission of light. In the past few years, high-performance thermoluminescence (TL) materials gained more popularity in the field of radiation dosimetry due to the increasing demand for thermoluminescence dosimeters (TLDs), which have widespread application in the field of industrial, environmental, personal and clinical and radiation safety [1,3,4]. Generally, thermoluminescent dosimeters (TLD) badges are used in several radiations monitoring purpose. At present several oxide, fluoride, and sulfate-based phosphors have been prepared and they are used as cost-effective TL identification; however all prepared dosimeters are not perfect for radiation dose measurement [3]. Some of them are used for the low radiation dose field and some of them are used for high radiation dose field.

In the recent few years, many researchers and scientists are developed various rare earth doped phosphors to improve the dosimetric properties of existing materials for use as effective TLD materials over a wide range of radiation doses. Developments of new materials are being made very often to improve the properties of the materials and to find alternative precursors that can give attractive properties. Rare earth activated sulfate materials are widely investigated by the researchers because of their marked benefits as sulfate is an important host. In the category of sulfate materials $CaSO_4$:Dy is one of the most investigated materials to date and is frequently used as commercial TLD phosphor[5]. As per literature, upto till date various sulfate-based luminescence materials have been synthesized and reported by researchers for various applications. Sulfate based phosphors have amazing properties such as excellent chemical energy, large bandgap, low sintering temperature, flexible structure, fast ionic conductivity, moderate phonon energy, high stability [6–8].

In the luminescence process rare earth ions play vital role. Rare earth elements have partially filled 4f and 5f energy levels. Usually divalent or trivalent lanthanide ions used for luminance based applications. Eu^{3+} is one of them, it is well known and widely used rare earth ions in red emitting phosphors. In this paper we are dealing with Eu^{3+} ion doped $KAl(SO_4)_2$ phosphors. Trivalent europium possesses line emission and band emission gives line emission, it is also known as characteristic emission. This is due to 4f-4f transition. In this proposed work, we synthesis $KAl(SO_4)_2$ phosphors doped with trivalent europium with the help of Combustion synthesis route and perform thermoluminescence characterization.

II. METHODS AND MATERIAL

Synthesis of materials:

A series of Eu^{3+} activated $KAlSO_4$ phosphors were synthesized by solid state reaction method. In this work, K_2CO_3, Al_2O_3, $(NH_4)_2SO_4$ and Eu_2O_3 precursors are used as starting materials. All these starting materials weighed according to stoichiometric ratios. These weighed samples were crushed properly by a mortar pestle and converted into powder. The obtained powder was transferred to the crucible and placed in a furnace for heating at a temperature of 700°C for 24 hours. After 24 hours, turn off the furnace and leave it to cool. The obtained samples were again crushed after cooling to room temperature.

III. RESULTS AND DISCUSSION

3.1 XRD Measurement:

Figure 1 shows the XRD pattern of synthesized Eu^{3+} activated $KAl(SO_4)_2$ phosphor. The crystal structure and phase purity of as-synthesized Eu^{3+} doped $KAl(SO_4)_2$phosphor was analysed by XRD diffraction pattern shows all diffraction peaks are well match with the standard ICSD data file no. 98-017-3667. Some impurity peaks can also be observed which may be possible due to the presence of Eu^{3+} ions and instrumental noise. In addition, figure 1 depicts sharp XRD peaks which are indicated that the homogeneous and crystalline nature of the synthesized phosphor.

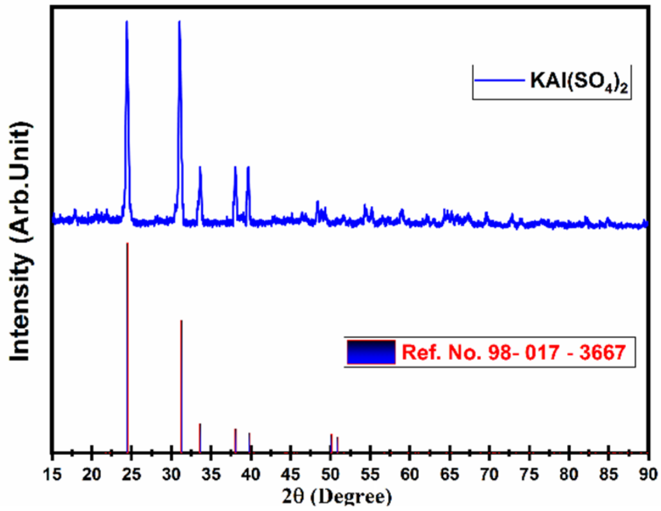

Figure 1: XRD pattern of synthesized Eu^{3+} activated $KAl(SO_4)_2$phosphor

3.2 Thermoluminescence Properties

The TL glow curves of the synthesized phosphors were irradiated with γ-rays from a ^{60}Co γ-ray irradiation source. The TL glow curve of this phosphor was obtained using a Nucleonix 1009I TL reader. The TL glow curves of the irradiated phosphors were recorded in the temperature range 50–400 °C and heating rate was 5 °C/s; 5 mg irradiated phosphors were used for each TL glow curve examination. Figure 2 (a) shows TL glow curve of the Eu^{3+} activated $KAl(SO_4)_2$ phosphor for different concentration of Eu^{3+} ions. TL glow curve shows broad emission band for each concentration of Eu^{3+} ions. The emission band depicts maximum emission intensity at 0.7mol% concentration of Eu^{3+} ion at around 300°C. It is clear from the figure, emission intensity varies with variation of Eu^{3+} concentration. The emission intensity increased up to 0.7mol% as shown in Figure 2 (b) after that TL emission intensity decreased due to concentration quenching effect. The emission intensity depends on the formation of defects in the conduction and valence bands. These defects occur up to a certain level, after which the defects overlap, and prohibit any increase in the emission intensity; this may be directly responsible for the concentration quenching effect [9].

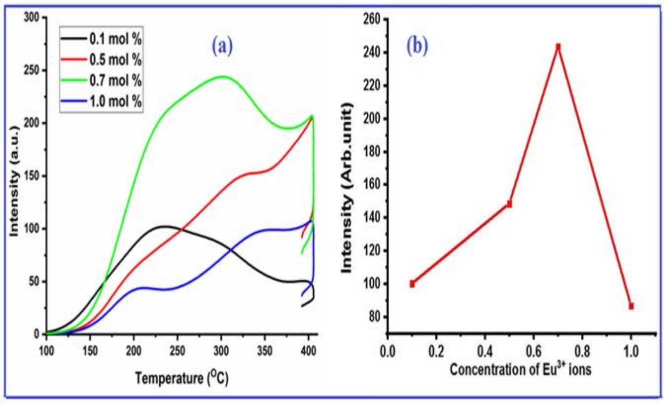

Figure 2 (a) Thermoluminescence (TL) glow curves of Eu^{3+} activated $KAl(SO_4)_2$ phosphor monitored under 6200 Gy γ-rays irradiation (b) Variation of emission intensity with concentration of Eu^{3+} ions

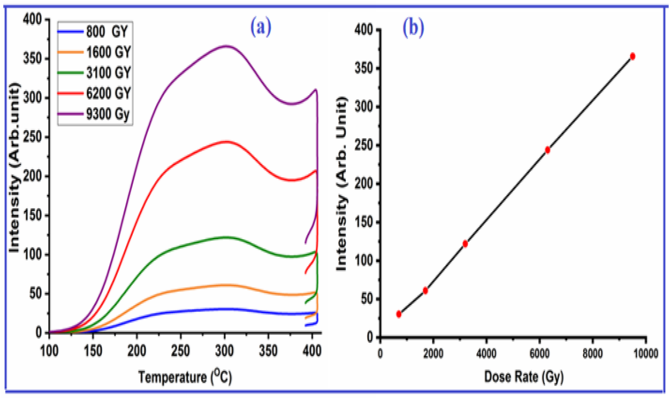

Figure 3 (a) TL glow curve of $KAl(SO_4)_2$:0.7mol%Eu^{3+} phosphor for different exposure of γ-rays irradiation. Figure 3(b) Linear Response curve of the $KAl(SO_4)_2$:0.7mol%Eu^{3+} phosphor

As per our study, we have maximum TL emission intensity at 0.7mol% concentration of Eu^{3+} ions. Therefore $KAl(SO_4)_2$:0.7mol%Eu^{3+} phosphor is irradiated with different doses of γ-rays irradiation. Figure 3 (a) shows glow curve of the synthesized $KAl(SO_4)_2$:0.7mol%Eu^{3+} phosphor for different exposure of γ-rays irradiation. The emission intensity of the glow curve increased with increase in irradiation dose in the range of 800 Gy to 9300 Gy. With the variation of gamma exposure only TL emission intensity increased but structure of the dosimetric peak remained the same. Figure 3 (b) shows the TL response curve of the synthesized $KAl(SO_4)_2$:0.7mol%Eu^{3+} phosphor at different irradiation doses. The response curve of the synthesized phosphor showed linearity in the range 800 Gy to 9300 Gy. In this study, saturation in intensity has not been observed; it is possible that, along with the increasing the exposure of γ-rays, intensity may increase.

IV.CONCLUSION

In this study, Eu^{3+} activated $KAlSO_4$ phosphors were synthesized by Solid state reaction method. The phase confirmation of synthesized phosphors is done with the XRD pattern. Further, their luminescence properties are characterized by thermoluminescence technique with irradiation of γ-rays using from a ^{60}Co γ-ray irradiation source. The glow curves shows broad emission band in the temperature range 50 °C – 400 °C. The TL glow curve spectra depict maximum emission intensity at 0.7mol% concentration of Eu^{3+} ions. The TL glow curves show linearity with increasing exposure. The response curve of the synthesized phosphor showed linearity in the range 800–9300 Gy. All these results represent synthesized phosphor may be useful for future work in field of dosimetric application.

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V. REFERENCES

[1]. Y.R. Parauha, S.J. Dhoble, Thermoluminescence study and evaluation of trapping parameter of rare earth activated Ca3Al2O6: RE (RE = Eu2+,Ce3+) phosphors, J. Mol. Struct. 1211 (2020) 127993. https://doi.org/10.1016/j.molstruc.2020.127993.

[2]. A. Duragkar, A. Muley, N.R. Pawar, V. Chopra, N.S. Dhoble, O.P. Chimankar, S.J. Dhoble, Versatility of thermoluminescence materials and radiation dosimetry – A review, Luminescence. 34 (2019) 656–665. https://doi.org/10.1002/bio.3644.

[3]. S.R. Bargat, Y.R. Parauha, G.C. Mishra, S.J. Dhoble, Thermoluminescence study of CaNa2 (SO4)2 phosphor doped with Eu3+ and synthesized by combustion method , Luminescence. 2 (2020) 0–2. https://doi.org/10.1002/bio.3940.

[4]. J. Singh, J. Manam, F. Singh, Synthesis and thermoluminescence studies of -irradiated Dy3+ doped, Mater. Res. Bull. 94 (2017) 113–121. https://doi.org/10.1016/j.materresbull.2017.05.052.

[5]. M.S. Bhadane, S.S. Dahiwale, K.R. Sature, B.J. Patil, V.N. Bhoraskar, S.D. Dhole, TL studies of a sensitive CaNa2(SO4)2:Dy nanophoshor for gamma dosimetry, Radiat. Meas. 96 (2017) 1–7. https://doi.org/10.1016/j.radmeas.2016.11.009.

[6]. A. Deshpande, N.S. Dhoble, S.C. Gedam, S.J. Dhoble, Photoluminescence and thermoluminescence of K2Mg(SO4)2:Eu and evaluation of its kinetic parameters, J. Lumin. (2016). https://doi.org/10.1016/j.jlumin.2016.08.003.

[7]. C. Ghanty, N.S. Dhoble, S.J. Dhoble, Thermoluminescence dosimetry properties and kinetic analysis of, 2 (2020). https://doi.org/10.1002/bio.3957.

[8]. A. Deshpande, N.S. Dhoble, S.C. Gedam, S.J. Dhoble, Photoluminescence and thermoluminescence of K2Mg(SO4)2:Eu and evaluation of its kinetic parameters, Luminescence. 32 (2017) 757–764. https://doi.org/10.1002/bio.3247.

[9]. G.B. Nair, S. Tamboli, S.J. Dhoble, H.C. Swart, Comparison of the thermoluminescence properties of NaCaPO4:Dy3+ phosphors irradiated by 75 MeV C6+ ion and γ -rays, 224 (2020) 1–11. https://doi.org/10.1016/j.jlumin.2020.117274.