International Journal of Luminescence and Applications (ISSN: 2277-6362)
Vol. 5, No. 1, February 2015. Article ID: 074. pp.134-136.

Synthesis and Luminescence Properties of Eu^{3+}-Doped SrY_2O_4 Phosphor

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Abstract— *The SrY_2O_4:Eu^{3+} phosphors have been successfully synthesized by aldo-keto gel method. In aldo-keto gel method two new organic chemical was used for gel formation. The X-ray diffraction pattern showed that all peaks were attributed to the orthorhombic SrY_2O_4 doped Eu phase at 1000 ℃ calcination temperatures with various concentrations. SEM micrographs reveal that samples are not uniform and having agglomeration. The photoluminescence (PL) nature were investigated on fluorescence spectrometer (F-7000). The CIE color co-ordinates diagram shows PL spectra in red-orange region.*

Keywords— *SrY_2O_4:Eu^{3+}, Aldo-keto gel method, photoluminescence spectroscopy, CIE diagram.*

PACS Code— *78.55-m*

1. INTRODUCTION

Photoluminescence (PL) has been observed when the ns^2 impurity ions are doped into wide band gap materials such as borate, aluminates, phosphates, tungstets, vanadates and silicates [1-6]. Inorganic Eu^{3+} ions doped in luminescence material has great demand in the field of optics because it has excellent high luminescence efficiency and chemical stability [7]. Mostly Eu^{3+} doped emitted light having sharp lines characteristic due to f–f transitions from various group of phosphors such as borates, aluminates, phosphates, tungstets, vanadates, silicates, give strong red emission and play an important role in emissive display technology, such as plasma display panel and field emission display, and in the lighting industry [8-14].

Now a days the other hand, strontium based phosphors are an important class of materials that have been investigated for long afterglow applications [15, 16]. SrY_2O_4:Eu^{3+} has good photoluminescence material [17]. SrY_2O_4:Eu^{3+} is in $CaFe_2O_4$-type crystalline structure material, it has great luminescent and magnetic properties and have many potential applications due to this the Eu^{3+} ions taken three nonequivalent sites, with one at the Sr site, one at the Y(1) site, and another at the Y(2) site. The solid state method was employed for the synthesis of SrY_2O_4:Eu^{3+} luminescence material for analyzing optical and spectral properties by Fu et al [18]. Dubey et al reported SrY_2O_4:Eu^{3+} phosphor was synthesized by solid state preparation method to study the thermo-luminescence and photoluminescence properties of SrY_2O_4:Eu^{3+} [1]. Pavitra et al studied SrY_2O_4 phosphor synthesized via citrate sol–gel method with sintering temperature 1300°C for White light application[19]. Zhang et al synthesized SrY_2O_4:Tb^{3+}, Tm^{3+}, and Dy^{3+} phosphor by Pechini-type sol–gel method for PDP application [20].

Inspiring from the above discussions, the present work planned to study the luminescent properties of SrY_2O_4:Eu^{3+} phosphor synthesized by novel aldo-keto method and studied PL properties and then characterized by powder X-ray diffraction (XRD), scanning electron microscopy (SEM), and photoluminescence (PL) intensity.

2. EXPERIMENTAL

The series of SrY_2O_4:Eu^{3+} phosphors were synthesized for the first time by a novel method of gelation named as aldo–keto gel method; offering a comparatively low temperature route [21]. The starting chemicals $Y(NO_3)_3$ (AR), $Sr(NO_3)_2$ (AR), and Eu_2O_3 (99.90%, AR) were mixed together in a china clay basin with addition of 20 ml water. Then acetone (AR) and benzaldehyde (AR) were added to the solution. The pale brownish yellow mixture obtained was stirred continuously and slowly heated to 130°C after that the process of gelation started with the evolution of dark yellowish brown fumes. On further slow heating, pyrolysis of foam was started at 450°C and shining black foam was formed at 600°C, which started burning from 1000°C. Final product appears as white crystalline powder of SrY_2O_4:Eu^{3+}.

The phase purities of SrY_2O_4:Eu^{3+} samples were studied using Rigaku miniflex II X-ray diffractometer with scan speed of 2.00°/min and Cu K_α (λ = 1.5406 Å) radiation in the range 10° to 90°.The photoluminescence (PL) and PL excitation (PLE) spectra were measured on (Hitachi F-7000) fluorescence spectrophotometer at room temperature. The parameters such as spectral resolution, width of the monochromatic slits (1.0 nm), photomultiplier tube (PMT) detector voltage and scan speed were kept constant throughout the analysis of samples. The color chromaticity coordinates were obtained by using radiant imaging software.

3. RESULTS AND DISCUSSION

3.1 Phase Characterization

Fig. 1 shows XRD pattern of $SrY_2O_4:Eu^{3+}$ synthesized by using aldo-keto gel method sintered at 1000°C for 3 hours in air. The XRD pattern shows all position of peaks and relative intensities of all the samples are indexed based on orthorhombic SrY_2O_4 and matches very well with ICDD PDF card No. 01-074-0264 at 1000°C. The lattice parameters of SrY_2O_4 powder were found to be a = 10.08 Å, b = 11.94 Å, c = 3.47 Å, V = 408.18.

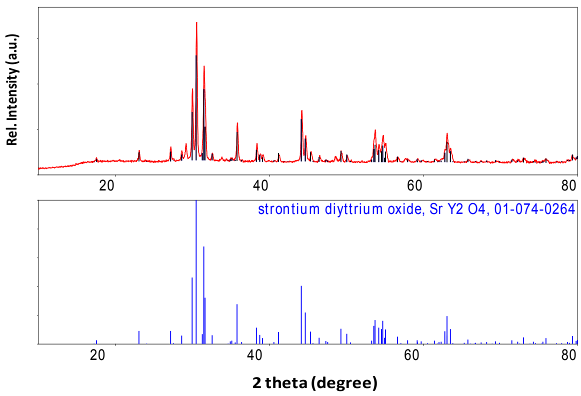

Fig. 1: XRD pattern of $SrY_{2(1-0.02)}O_4:_{0.02}Eu^{3+}$ calcined at different temperature

3.2 SEM Analysis

Fig. 2 shows SEM image of $SrY_2O_4:Eu^{3+}$ powders with 2 mol% Eu concentration at 1000°C) for 3h. The morphology of $SrY_2O_4:Eu^{3+}$ phosphor clearly shows that the particles sizes are not uniform having agglomeration is seen.

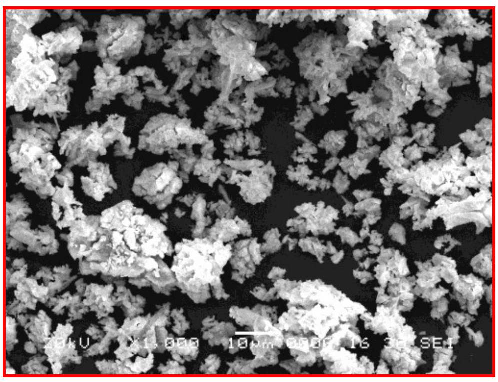

Fig. 2: SEM micrograph of $SrY_2O_4:Eu^{3+}$ calcined at 1000°C.

3.3 Photoluminescence Properties of $SrY_2O_4:Eu^{3+}$

Fig. 3 shows combine emission and excitation spectra of $SrY_2O_4:Eu^{3+}$ phosphor prepared by slow evaporation method. The excitation spectra consist of a broad band widening from 200 to 310 nm region of UV radiation and some sharp lines at near UV-Visible region. The broad band in UV region was attributed to fraction of the charge transfer band (CTB) of $O^{2-} \rightarrow Eu^{3+}$ bond. It was clearly seen that the emission spectra consist of number of peak in the range 500 to 700 nm corresponds to $^5D_0$ to ^7F_J (J= 1, 2 and 3) transitions of Eu^{3+} monitored at 272 nm. The emission peaks at 582, 590, and 594 nm in orange region of visible spectrum were corresponding to magnetic dipole of $^5D_0 \rightarrow {}^7F_1$ transition, whereas the peak at 613, 619 and 626 nm corresponding to $^5D_0 \rightarrow {}^7F_2$ transition of Eu^{3+} ions which were due to the electric dipole transitions. The small peak observed at 654 nm which is corresponding to $^5D_0 \rightarrow {}^7F_3$ transition of Eu^{3+} ions. The magnetic dipole transition and electric dipole transition exhibits almost equal PL peak.

All the powder samples of $SrY_{2(1-x)}O_4$:xEu (x=0.001, 0.002, 0.005, 0.01 and 0.02) were characterized for PL spectra. Fig. 4 shows the emission spectra of phosphors $SrY_{2(1-x)}$ $O_4:Eu^{3+}$ with different molar concentration of Eu^{3+} (x=0.001, 0.002, 0.005, 0.01 and 0.02) prepared by aldo-keto gel method. The emission intensity increases with the increase of Eu^{3+} concentration. This implies the dopant has not altered its position in the lattices with increase in concentration. Also the dipole moments of the Eu^{3+} were not affected by the increasing concentration.

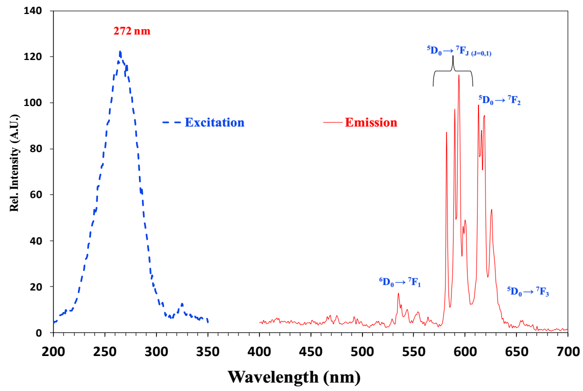

Fig. 3: Photoluminescence emission and excitation spectra of $SrY_{2(1-0.02)}O_4:_{0.02}Eu^{3+}$ at 1000°C.

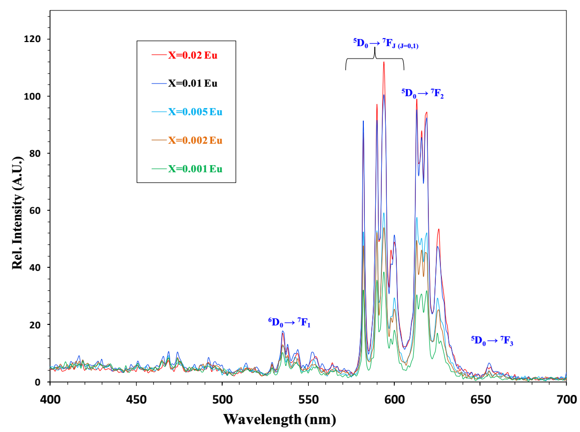

Fig. 4: Photoluminescence emission spectra of $SrY_{2(1-x)}O_4:xEu^{3+}$ (x = 0.001, 0.002, 0.005, 0.01, 0.02) at 1000°C.

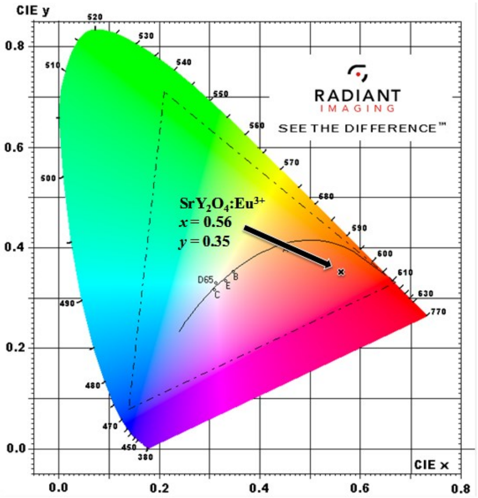

Fig. 5: CIE color space chromaticity diagram of $SrY_{2(1-0.02)}O_4{:}_{0.02}Eu^{3+}$ phosphor.

Fig. 5 displays the color coordinates for $SrY_{2(1-0.02)}O_4{:}_{0.02}Eu^{3+}$ compute by radiant imaging software based on the standard formulations made available by CIE (Commission International de I' Eclairage, France) which recognize that the human being visual system uses three colors (red, green and blue). The CIE color coordinates for $SrY_{2(1-0.02)}O_4{:}_{0.02}Eu^{3+}$ which was found to be x= 0.56, y=0.35.

4. CONCLUSION

The $SrY_2O_4:Eu^{3+}$ phosphors were successfully synthesized via aldo-keto gel method. Aldo-keto gel method, require cheap organic chemical for gel formation. Moreover, aldo-keto gel method is low temperature synthesis and requires less time and results in high luminescent intensity. The aldo-keto gel method is based on molecular synthesis and particles built up by molecule-by-molecule addition. The pure phase of crystalline $SrY_2O_4:Eu^{3+}$ phosphors were achieved at 1000ºC temperature. Therefore, aldo-keto method is a good method which may find suitable applications in preparation of phosphors.

ACKNOWLEDGEMENT

One of the author Kishor A. Koparkar is thankful to the Chairman of the FIST-DST Project at SGB Amravati University, Amravati, for providing XRD facility for this work.

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