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UV Photoluminescence of Eu^{3+}doped Na_3SO_4F Red Halosulphate Phosphor for White Light Emitting Diodes

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ABSTRACT

The high luminescent Na_3SO_4F: Eu^{3+} halosulphate phosphor with improved the color purity and high intensity of red phosphor for solid state lighting devices was reported. The halosulphate phosphor was developed by re-crystallization technique. Crystal structure and phase formation of the product was identified by powder XRD technique and particle morphology was studied by FE-SEM. The photoluminescence (PL) spectra were investigated under 393nm (UV) excitation. The prepared halosulphate Na_3SO_4F: Eu^{3+} phosphor showed a strong red emission around 617 nm. This is due to Eu^{3+} substituted for Na^{3+} occupied the non centro-symmetric position. The Eu^{3+} doped ion will increase the electric dipole $5F_0 \rightarrow 7D_2$ transition of Eu^{3+} in the crystal structure of Na_3SO_4F: Eu^{3+}. It can be concluded that re-crystallization technique can successfully employed to promising red phosphor for solid state lighting devices.

Keywords: Photoluminescence, Halosulphate Phosphors, Re-Crystallization

I. INTRODUCTION

Over the past two decades, there has been considerable research in the lighting community in an effort to fabricate white light sources using InGaN based LEDs. It is expected that these solid state light sources will eventually replace existing lighting technologies [1, 2]. White Lighting emitting diodes (WLEDs) have attracted great interests for general illumination because LEDs have advantages over the existing incandescent and halogen lamps in terms of power efficiency, reliability and long lifetime etc [3]. Halosulphate as important family of luminescent materials have been paid intense attention because of their excellent properties due to their intense luminescence intensities, high emission efficiencies and wide application fields in displays and UV devices [4-9]. White LEDs in which a near UV-LED is combined with blue, green, and red phosphors have been investigated due to less current droop and improved binning of the UV-LEDs, and a better control over color rendering index and color temperature through manipulation of phosphor blends. [10-12] Gedam *et al.* have studies photoluminescence properties of $KMgSO_4Cl:Ce^{3+}$, $KMgSO_4Cl:Ce^{3+},Dy^{3+}$, and $KMgSO_4Cl:Ce^{3+}$, Mn halosulphate phosphor. These halosulphate phosphor were successfully synthesized by wet chemical method and X-ray powder diffraction (XRD) and photoluminescence (PL) excitation and emission properties were investigated. To find novel efficient red emitting LED phosphors, the choice of the host is another key factor. Sulphate compounds have been widely studied due to their stability, various crystal structures, and relatively easy preparation [13]. In this article for red-emitting phosphors $Na_3SO_4F: Eu^{3+}$ with high efficiency and proper CIE chromaticity coordinates, the Eu^{3+} activated phosphors are primarily considered. The major emission of Eu^{3+} usually shows an intense orange light or red due to the transition of 5D0→7F1 or 5D0→7F2, which depends on the structure of the phosphor host, and it mainly shows sharp 5D0→7F2 red-emission lines around 610–625 nm when Eu^{3+} ions occupy the lattice sites without centro-symmetry.

II. SYNTHESIS AND EXPERIMENTAL

The sample Na3SO4F (pure and Eu doped) were prepared by re-crystallization method .while preparing the raw materials NaF and Na2SO4 of analar grade were taken in stoichimetric ratio and dissolved separately in double distilled de-ionised water resulting solution of Na3SO4F.For Na3SO4F:Eu3+ we used europium oxide (Eu2O3 Sigma, pure 99%) to obtain Na3SO4F:Eu3+, confirming that no undissolved constituents were left behind and that all the salts had completely dissolved in water and thus reacted.

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$$Na_2SO_4 + NaF \rightarrow Na_3SO_4F$$

The compound $Na_3SO_4F:Eu^{3+}$ in powder form were obtained by evaporating at 80⁰C for 8hrs. The dried samples were then slowly cooled at room temperature. The resultant polycrystalline mass was crushed to fine particle in a crucible, then the dry powder was used for further study.

The formation of $Na_3SO_4F:Eu^{3+}$ + compound was confirmed by powder XRD technique .X-ray diffraction of this compound was taken at room temperature in a wide range of Bragg angle 2θ using PAN analytical high resolution XRD-I, PW3040/60 at a scanning rate of 1.00 degree per minute. The particle morphology and grain size of prepared materials were examined by FE-SEM, SEM micrograph shows regular elongated and trapezoidal rod like structure ,disperse and densely agglomerates with typical diameter about 5-10 µm, which is suitable for coating and printing on display devices. Photoluminescence studies were made by using personal computer based fluorescence spectrometer (Hitachi, F-7000) with 150 W Xeon lamp light source. Emission and excitation spectra were recorded using a spectral slit width of 1nm.

III.RESULTS AND DISCUSSION

The XRD pattern of $Na_3SO_4F:Eu^{3+}$ phosphor is displayed in **fig.1**.The XRD pattern is matched with standard ICDD File No-00-75-1599. The position and intensity of main peaks are same. No impurity lines were observed indicating only crystalline nature of the sample.

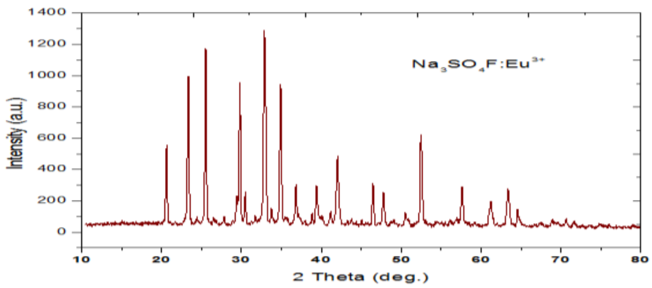

Fig.1. XRD Pattern of Na3SO4F:Eu3+

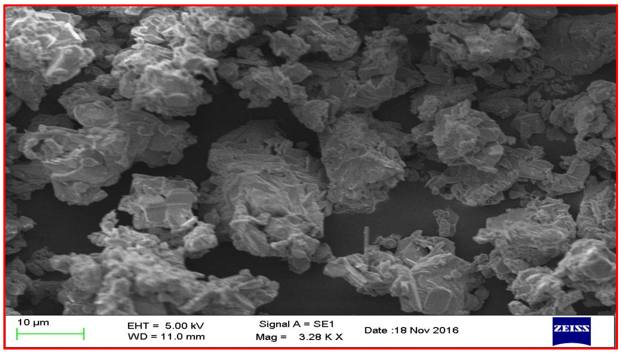

Fig.2. SEM image of $Na_3SO_4F:Eu^{3+}$ Powder Phosphor

The fig.2.shows SEM image of $Na_3SO_4F:Eu^{3+}$ phosphor. It is observed that microstructure of the phosphor with irregular grains with heavy agglomeration. The average particle size in submicron.

These sub-micrometers $Na_3SO_4F:Eu^{3+}$ phosphor plausibly suitable for coating purpose in lighting industry particularly, in solid state lighting [15-19]. In the re-crystallization process, we found the optimal shape and size of the phosphor using only the synthetic temperature. The surfaces of the foam showed many cracks and pores formed by the escaping gases during the reaction. Most particles showed sizes of a few micrometers. These results indicate that the final product is in crystalline forms.

Fig 3.shows excitation and emission (combined) spectrum of $Na_3SO_4F:Eu^{3+}$ phosphor shows intense red emission under UV-A excitation 393nm which revels the presence of Eu^{3+} in Na_3SO_4F halosulphate phosphor. The excitation spectrum for 617 nm emission consist of broad band in the wavelength range 200-300 nm and series of sharp lines at 310, 363, 377 and 393 nm correspond to the $^7F_0 \rightarrow {}^5H_3$, $^7F_0 \rightarrow {}^5D_4$, $^7F_0 \rightarrow {}^5L_7$ and $^7F_0 \rightarrow {}^5L_6$ transitions respectively. Out of all these peaks, the excitation at 393 nm is the strongest. The emission spectrum under 393nm UV-A excitation mainly consist of a two sharp intense lines peaking at 617 nm which corresponds to the $^5F_0 \rightarrow {}^7D_2$ (electric dipole) transition of Eu^{3+} and at 592 nm which attributed to $^5F_0 \rightarrow {}^7D_1$ (magnetic dipole). The other weak peak at 653 nm also occurs which corresponds to the $^5F_0 \rightarrow {}^7D_3$ transition of Eu^{3+} ions. The prominent emission line at 617 nm is due to $^5F_0 \rightarrow {}^7D_2$ transition of Eu^{3+} which indicates that the Eu^{3+} ions occupies a non centro-symmetric position in the Na_3SO_4F lattice. The red emission of Na_3SO_4F phosphor is comparable to the commercial red phosphor $Y_2O_3:Eu^{3+}$.Hence it could be a potential red phosphor for solid state lighting devices.

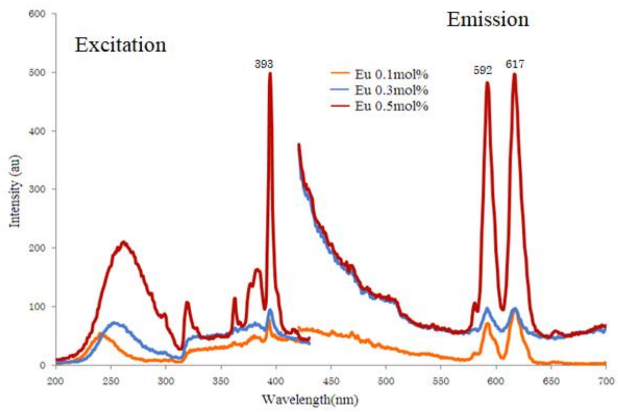

Fig.3. Combined Emission & Excitation spectrum of $Na_3SO_4F:Eu^{3+}$ Powder Phosphor.

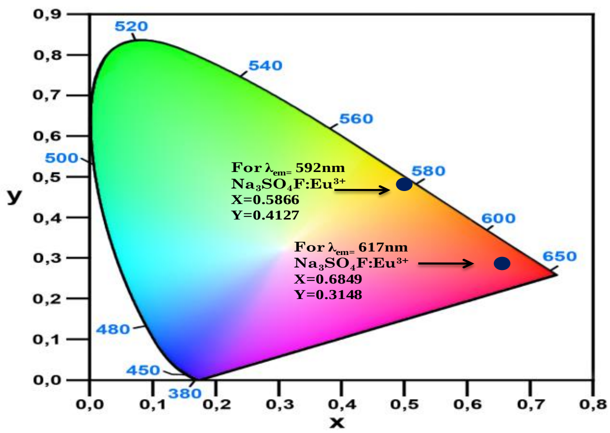

Fig. 4. CIE chromatic diagram showing the coordinate

By using 1931 CIE chromatic colour coordinates are specified lighting that recognize human visual system uses three colours red, green and blue. In this system the light sources are represented by (X, Y) coordinates and coloured are compared with1931 CIE diagram. The colour purity was compared to the 1931 CIE Standard Source C (illuminant Cs (0.3101, 0.3162)). The chromatic coordinates (x, y), was calculated using the colour calculator program radiant imaging [24]. In this article the coordinates of Eu^{3+} are doped Na_3SO_4F Phosphor are located (X = 0.68, Y = 0.31) as shown in fig. 4which indicates that the colour properties of the phosphor powder prepared by re-crystallization method is approaching those required for field emission displays. The dominant wavelength is the single monochromatic wavelength that appears to have the same colour as the light source. This result indicates that high colour purity of this $Na_3SO_4F:Eu^{3+}$ halophosphate phosphors because it is slightly near to the edge of the CIE diagram. Hence, such material may be an efficient photoluminescent material for solid-state lighting phosphors as a red component, and helpful in generating white light with a particular ratio of this phosphor.

IV. CONCLUSION

In present article synthesized $Na_3SO_4F:Eu^{3+}$ halophosphate based phosphor by using re-crystallization technique and characterized by XRD and spectrophotometer. We studied their photoluminescent properties and structure of this phosphor. Under the excitation around 393 nm $Na_3SO_4F:Eu^{3+}$ phosphor shows orange red emission by doped Eu^{3+} and that phosphor could be promising good candidate for white light LED application.

V. REFERENCES

[1]. S.Nakamuraand G.Fasol, Springer-Verlag, Berlin 8 (1997) 154.
[2]. S.D.More, M.N.Meshram, S.P.Wankhede, P.L.Muthal,S.M.Dhopte, S.V.Moharil, Phys.B:Cond.Mater,406 (2011)1178.
[3]. YangYang,Yuan-QingLi, Shao-YunFu, and Hong-Mei XiaoJ.Phys.Chem.C112 (2008)10553
[4]. Z.G.Xia,G.W.Li, D.M.Chen, H.Y.Xiao, Mater.Lett.63 (2009) 2600.
[5]. Z.G.Xia, J.Y.Sun, H.Y.Du,W.Zhou, Opt. Mater.28 (2006) 524.
[6]. K.N.Shinde, S.J.Dhoble, K.Park, Nano Micro Lett.4 (2012) 78.
[7]. S.P.Puppalwar, S.J.Dhoble, Animesh Kumar, Luminescence 27 (2012) 39.
[8]. K.N.Shinde, S.J.Dhoble, Luminescence 27(2012) 91.
[9]. K.N.Shinde, S.J.Dhoble, Micro Nano Lett.5 (2010) 340.
[10]. J.K.Sheu,S.J.Chang,C.H.Kuo,Y.K.Su,L.W.Wu,Y. C. Lin,W.C.Lai, J.M.Tsai, G.C.Chi, R.K.Wu, IEEE PhotonicsTechnol.Lett.15 (2003)18.
[11]. S.Neeraj, N.Kijima, and A.K.Cheetham Chem. Phys. Lett.387(2004)2.
[12]. S.H.M.Poort,W.Janssen,G.BlasseJ.Alloy.Comp.260 (1997) 93.
[13]. Xinguo Zhang, Jilin Zhang OpticalMaterials36 (2014) 850.
[14]. K.N.Shinde & S.J.Dhoble, JFluoresc.21(2011)2053.
[15]. K.N.Shinde, S.J.Dhoble, Kuma R. Animesh. J. Lumin.131 (2011) 1939.
[16]. B.Han, J.Zhang, Q.Cui,Y.Liu, PhysicaB.407 (2012) 3484.
[17]. J.T. Ingle, R. P. Sonekar, P. A. Nagpure, S. K. Omanwar, I J CR 5,529-531, (2013)
[18]. Color Calculator version2, software from Radiant Imaging Inc; 2007.
[19]. Shionoya S,Yen W M. Phosphor hand book. Phosphor Research Society, CRC Press;(1998).p.459.