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Photoluminescence Properties of Trivalent Europium Doped $Sr_2Y_2CeO_7$ Nano Phosphor

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ABSTRACT:-The present paper reports synthesis and photoluminescence characteristics of Eu^{3+} (0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mol %) doped red-emitting nano phosphors of $Sr_2Y_2CeO_7$. The phosphor were prepared using standard solid state diffusion reaction technique without and with citric acid as flux. The formation of single phase compound was verified through X-ray diffraction (XRD) studies. The photoluminescence excitation and emission spectra were investigated. The phosphor can be efficiently excited by 254nm to realize an intense and very narrow luminescence lines 582 and 595 nm corresponding to the magnetic dipole transition $^5D_0 \rightarrow {}^7F_1$ and 613, 625nm corresponding to the electric dipole transition $^5D_0 \rightarrow {}^7F_2$ of Eu^{3+} ions. The phosphor may find a potential application in the display and CFL lamps as one of the phosphor component for white light generation.

Keywords: **Photoluminescence [PL], Rare Earth ions [RE ions], X-ray diffraction [XRD], Solid State Diffusion Reaction [SSDR] .**

I. INTRODUCTION

The luminescence associated with Eu contained in different host lattices has found applications related to its red light emission which is important in the fields of displays, sensors and lasers. The past few decades have seen a lot of work reported on the use of divalent/trivalent Europium as a dopant in phosphors, as they have very good optical properties (in the blue to red regions), which make them part of many display devices. Among all the rare-earth ions, Eu^{3+} is the most extensively studied, owing to the simplicity of its spectra and also its use in commercial red phosphors [1-4]. The luminescence spectrum of Eu^{3+} reveals spectroscopic transitions from the visible to the near-infrared region.

In 1998, Danielson and co-workers reported unusual luminescence of the inorganic oxide compound Sr_2CeO_4 using combinatorial technique which exhibits the emission peak at 485 nm. Subsequently, several studies of this luminescent material were conducted, and some different routes have been developed to prepare the Sr_2CeO_4 powders and films, including traditional solid-state reaction [5-8]. This phosphor exhibits blue-white luminescence efficiently under excitation with UV light. Sr_2CeO_4 also acts as a sensitizer to transfer the absorbed energy to the dopants (activators) such as rare earth ions. Since Sr_2CeO_4 was found as a novel and promising blue luminescent material by combinatorial chemistry method. Even though we report the results of our investigations on Strontium Cerate by adding Yttrium oxide in the host and Eu ion as dopant in different concentrations as $Sr_2Y_2CeO_7$: Eu phosphors synthesized via solid state reaction.

II. MATERIALS AND EXPERIMENTAL METHODS

All the chemical reagents were analytically pure and used without further purification. The inorganic compounds like Strontium Carbonate ($SrCO_3$), Cerium Oxide (CeO_2) and Yttrium oxide (Y_2O_3) of purity (99.9%) were used as starting materials and Eu_2O_3 as dopant in different mole percents. We prepared $Sr_2Y_2CeO_7$: Eu phosphors by weighing, adding and ground into a fine powder using agate mortar and pestle about an hour. The grounded sample was placed in an alumina crucible and heated at 1200°C for 4 hours in a muffle furnace with a heating rate of 5°C/min. we ground in to powder after heating and cooling and did the following different characterizations on the prepared samples. The Photoluminescence (PL) emission and excitation spectra were measured by Spectrofluorophotometer (SHIMADZU, RF-5301 PC) using Xenon lamp as excitation source. The XRD analysis was carried out with a powder diffract meter (Rigaku-D/max 2500) using Cu Kα radiation. The microstructure of the sample was studied using a scanning electron microscopy (XL 30 CP Philips).

III. RESULTS AND DISCUSSIONS

A. XRD Study

The crystallinity and phase purity of the product were firstly examined by XRD analysis. X-ray diffract gram of the $Sr_2Y_2CeO_7$: Eu (3.0 mol %) phosphor prepared using solid state method. The crystalline structure of the $Sr_2Y_2CeO_7$: Eu(3.0 mol%) phosphor was analyzed by X-ray powder diffraction studies (XRD). Fig-1 is the XRD pattern of $Sr_2Y_2CeO_7$: Eu(3.0 mol%) phosphor. From the figure it is found majority of phosphor in single phase. It clearly indicates that the heat treatment temperature and time were sufficient to form single phase. The crystallite size calculated using Scherer's formula d=K.λ/ β cosθ, where 'K' is the Scherer's constant (0.94), 'λ' the wavelength of the X-ray (1.54060 Å), 'β' the full-width at half maxima (FWHM) (0.173), 'θ' the Bragg angle of the XRD big peak, is found **47.52nm.** **S**ample has some

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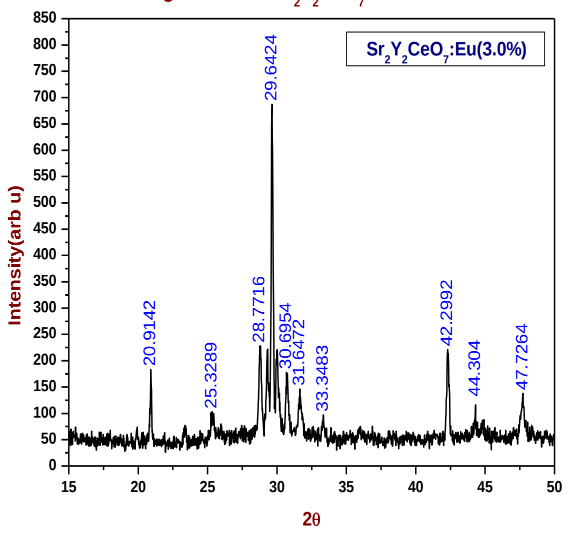
reflection peaks that can be assigned to the presence of $SrCeO_3$ and $SrCO_3$ as impurities.

Fig-1:-XRD of $Sr_2Y_2CeO_7$:Eu



B. Photoluminescence Study

The photoluminescence (PL) studies and characteristics of $Sr_2Y_2CeO_7$: Eu(0.5,1.0,1.5,2.0,2.5 and3.0 molar percent) prepared using stranded solid state reaction method with and without flux. Fig-2 is the emission and excitation spectrum of $Sr_2Y_2CeO_7$: Eu(0.5-3.0 mol%) without flux. Curve-1 is the excitation spectrum, curves 2-7 are the emission spectrums when excited with 254nm. It is found from the emission studies the photoluminescence (PL) emissions are mostly 400,467,582,595,613 and 625nm. As the Eu concentration increases the PL emission of 400 and 467nm gradually increases. But our main interest is the effect of Eu concentration in $Sr_2Y_2CeO_7$ phosphor, which is prepared without flux. Fig-3 is the photoluminescence (PL) emission due to Eu in the phosphor $Sr_2Y_2CeO_7$, the intensity of all the peaks 582,595,613and 625nm increases gradually as Eu concentration increases.

Table-1 is the Eu concentration verses intensity of various Eu emissions without and with flux is presented for better understanding. Fig-5 is the intensity verses various Eu concentration of observed Eu peaks in $Sr_2Y_2CeO_7$ phosphor. It is interesting to note all the observed peaks intensity growing linearly as Eu concentration increases from 0.5 to 3.0 molar percent. Fig-4 is the 3D graph of $Sr_2Y_2CeO_7$: Eu(0.5-3.0 mol%) prepared without flux, which is shown for better comparisons.

All the emissions are of allowed Eu^{3+} transitions, the emissions at 582nm and 595nm are due to $^5D_0 \rightarrow {^7F_1}$ transition which is due to magnetic dipole component. The emission at 613nm and 625nm are due to electric dipole component from $^5D_0 \rightarrow {^7F_2}$ transition. The intensity of 613nm is more this could be due to more electric dipole component [9-10].

Fig-2:-$Sr_2Y_2CeO_7$:Eu(0.5-3.0%) without flux under 254nm Ex

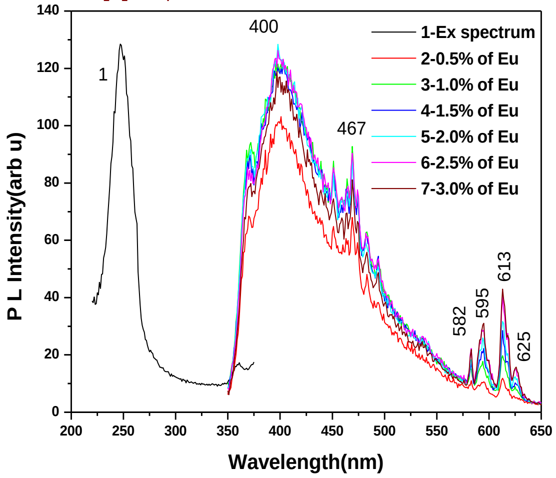


Fig-3:$Sr_2Y_2CeO_7$:Eu(0.5-3.0%) without flux under 254nm Ex

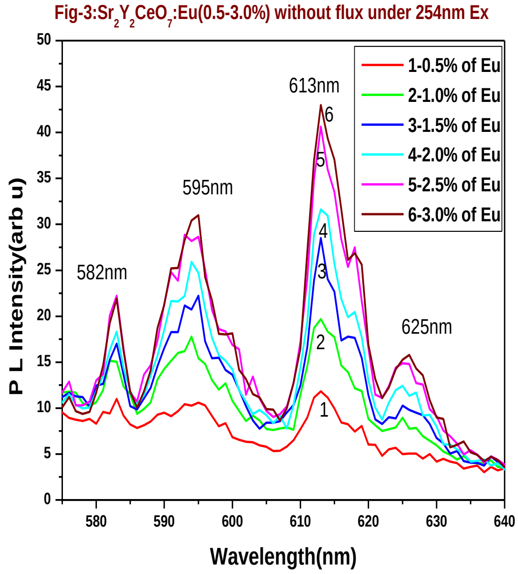


Fig-4:$Sr_2Y_2CeO_7$:Eu (0.5-3.0%) without flux under 254nm Ex

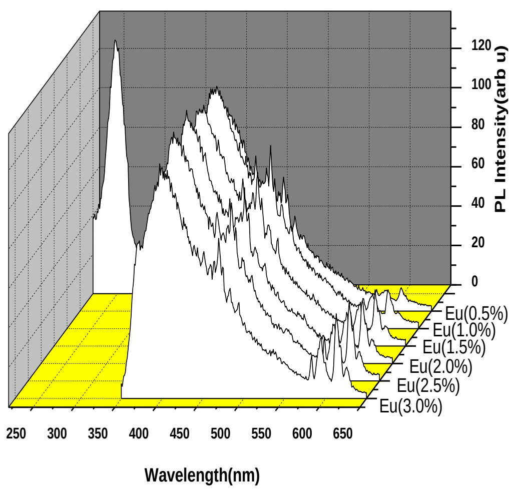


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Fig-5:Intensity verses Eu concentration of $Sr_2Y_2CeO_7$

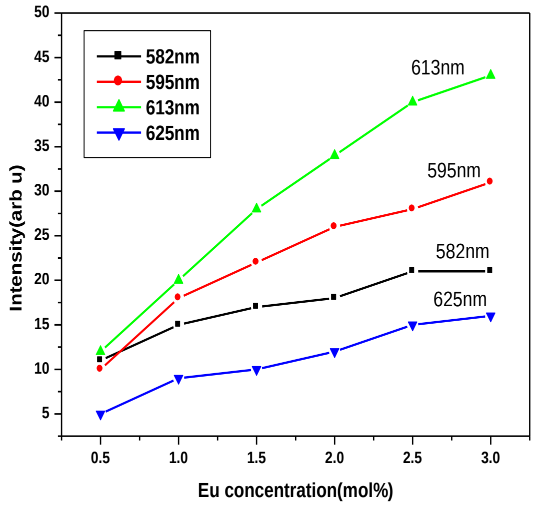


Fig-7:$Sr_2Y_2CeO_7$: Eu (0.5 to 3%) wih citric acid as flux under 254nm Ex

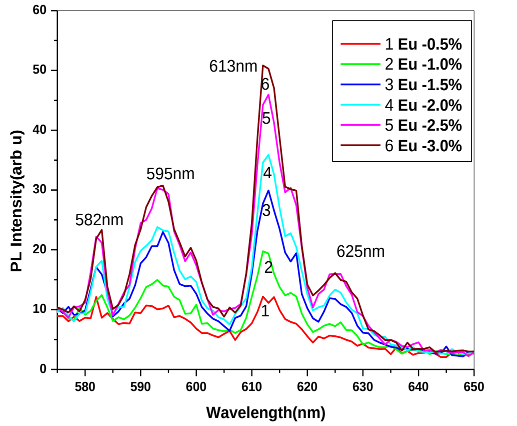


Fig-8:Intensity verses Eu concentration of $Sr_2Y_2CeO_7$

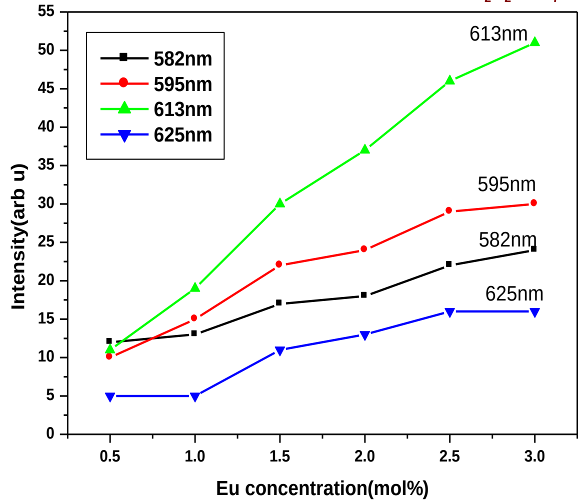


Fig-6 is the photoluminescence (PL) emission and excitation studies of $Sr_2Y_2CeO_7$: Eu(0.5-3.0 mol%) phosphor prepared using solid state reaction method with citric acid as flux. From the figure it is noted the emission intensity of 400nm is reduced by 50% when compare to fig-2 due to addition of citric acid as flux. However other peaks intensity and shape did not affect much except 613nm peak, it is raised by nearly 8 percent when compared without flux. Fig-7 is the emission of 582,595,613 and 625nm of various concentration of Eu in $Sr_2Y_2CeO_7$ phosphor prepared citric acid as flux, as the Eu concentration increased all the peaks intensity increases linearly, the same is presented in Fig-8 and also in table-1 for better understanding.

Fig-9 is the 3D graph of $Sr_2Y_2CeO_7$: Eu (0.5-3.0 mol %) phosphor with citric acid as flux, from the above graphs we found when Eu concentration is 3.0% in $Sr_2Y_2CeO_7$ maximum photoluminescence (PL) intensities are observed. From fig-8 it is found the photoluminescence (PL) emission of 582nm, 595nm, 613nm, and 625nm peaks are grown their intensity increase as Eu concentration increases.

Fig-6:$Sr_2Y_2CeO_7$: Eu (0.5 to 3%) with citric acid as flux under 254nm Ex

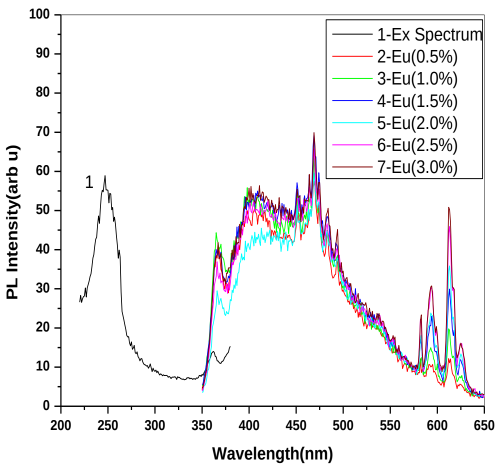
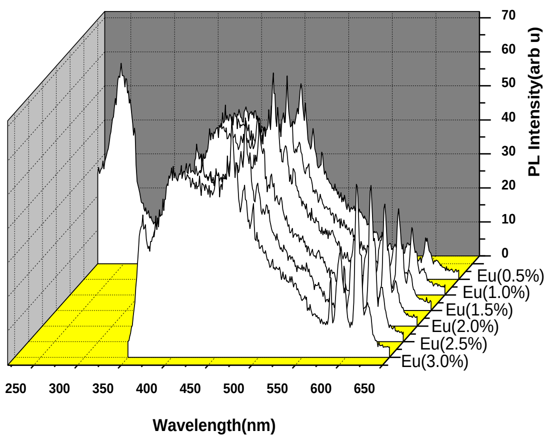


Fig-9:$Sr_2Y_2CeO_7$:Eu (0.5-3.0%) with flux under 254nm Ex



C. SEM Study

Fig-10, 11 are SEM micro graphs of Eu doped $Sr_2Y_2CeO_7$ phosphor particles for different resolutions. From SEM micro graphs it is found the particles looks agglomerated with various shapes. However particle size is approximately few microns to 2 um, From the SEM micrographs one can see that the morphology of the samples prepared by the solid state reaction method, it

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appears that the different shapes of the particles and they appear to be agglomerated.

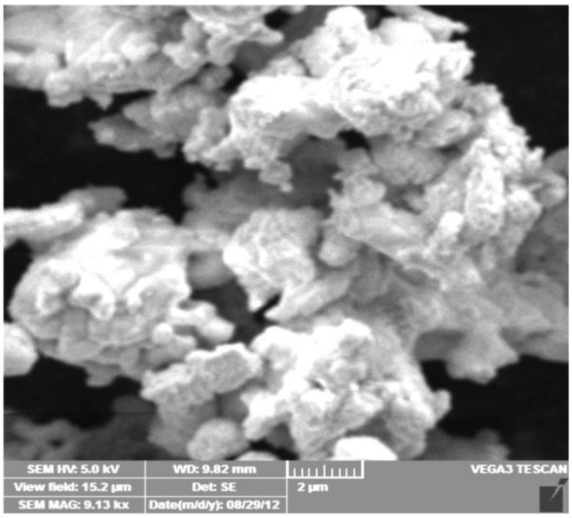

Fig-10 : SEM image of $Sr_2Y_2CeO_7$:Eu (9.13KX)

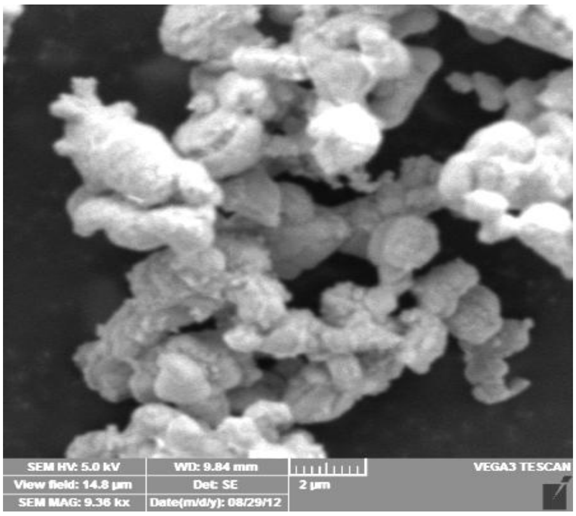

Fig-11:-SEM image of $Sr_2Y_2CeO_7$:Eu (9.36KX)

IV. CONCLUSION

$Sr_2Y_2CeO_7:Eu^{3+}$ nano phosphor powder was successfully synthesized by conventional solid state diffusion reaction technique. From XRD it is observed the phosphor is in single phase and the calculated crystallite size is nano (47.52nm) form, sharp peak indicates nanocrystalline behavior of the rare earth (RE) doped phosphor. The $Sr_2Y_2CeO_7:Eu^{3+}$ phosphor shows an orange-red emission under 254nm excitation. The peaks at 582 and 595nm are altered emissions of Eu which is attributed to magnetic dipole component, the emission at 613 and 625nm was also observed which is attributed to electric dipole component of Eu .The peaks at 582 and 595nm are due to $^5D_0$ - $^7F_1$, the peaks at 613 and 625nm are due to $^5D_0$ - $^7F_2$, and all the transitions are allowed transitions of Eu. The intensity of these peaks are increasing as increase the Eu concentration and also increasing intensity when added citric acid as flux[10-12]. The results indicate that $Sr_2Y_2CeO_7:Eu^{3+}$ phosphor can be selected as a potential candidate for phosphors can be easily applied in various types of lamp and display due to its good PL performance in blue-green and red regions of visible spectrum. This phosphor may be a potential application is in the display and lamps for white light generation.

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S No	Ex wavelength	Eu concentration (mol %)	PL Intensity for different emission peaks(nm)							
			Without flux				With flux			
			582	595	613	625	582	595	613	625
1		0.5	11	10	12	5	12	10	13	5
2		1.0	15	18	20	9	13	15	19	8
3		1.5	17	22	28	10	17	22	30	11
4	254	2.0	18	26	34	12	18	24	37	13
5		2.5	21	28	40	15	22	29	46	16
6		3.0	21	31	43	16	24	30	51	17

Table-1: PL Intensity of various emission peaks without and with flux of Sr2Y2CeO7: Eu(0.5-3.0 mol %) under 254nm Excitation.

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