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Research Article

LUMINESCENCE STUDIES OF EU DOPED $Y_3AL_5O_{12}$ PHOSPHOR

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ABSTRACT

The present paper reports the synthesis and Photoluminescence (PL) study of the $Y_3Al_5O_{12}$ phosphor doped with Eu(2.5 mol %) monitoring at 400nm, and shows emission peak at 254 nm. The phosphor was synthesized using the standard solid state reaction technique and ground using mortar and pestle, fired at 1200°C for 3 hour with heating rate of 5°C/min in a muffle furnace. The powder phosphors were characterized by X-ray diffraction and Scanning electron microscopy. The Photoluminescence (PL) excitation spectra were recorded for different Eu concentrations of (0.5 – 3.0 mol %) and shows emission peaks at 365, 399, 469, 535, 592, 610 and 631 nm with good intensity, these are mainly due to Eu^{3+} electron transitions. When Eu concentration increases all the Eu^{3+} emission intensities increases linearly. After 2.5% Eu in the host $Y_3Al_5O_{12}$ phosphor the intensity decreases. This is due to standard quenching effect.

INTRODUCTION

$Y_3Al_5O_{12}$:Eu(0.5 - 3.0mol %) has been good commercial green phosphor materials have been actively investigated to improve their luminescent properties and to meet the development of different display and luminescence devices. Inorganic compounds doped with rare earth ions form an important class of phosphors as they possess a few interesting characteristics such as excellent chemical stability, high luminescence efficiency, and flexible emission colors with different activators.

The useful applications of rare earth element compounds, especially lanthanide phosphate doped inorganic materials, have been touched upon broadly. Over the past a few years, they have been applied in many fields, such as optical display panels, cathode ray tubes, optoelectronic, sensitive device, electronic and plasma display panels due to their special chemical and physical properties.

Why Solid State Reaction Method

- It is better to prevent waste than to treat or clean up waste after it has been created.
- SSR method output gases are mostly CO2, H2O and NH4 etc., can be stabilized in atmosphere.
- Atom Economy is defined as synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
- Less Hazardous Chemical Syntheses wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment. Chemical reactions should be designed to affect their desired

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function while minimizing their toxicity which is nothing but designing safer chemicals

- If possible, synthetic methods should be conducted at ambient temperature and pressure.
- In SSR most of the above conditions are satisfied except the temperature.

Therefore SSR can be called green chemistry route.

MATERIALS AND EXPERIMENTAL METHODS

Analytically pure and used without any further purification. The phosphor $Y_3Al_5O_{12}$doped with Eufor various concentrations of 0.5 - 3.0 mole percentage, prepared using solid state synthesis method. Stoichiometric proportions of raw materials namely Y_2O_3, Al_2O_3 and Europium Oxide (Eu_2O_3) of assay 99.9% were used as starting materials and grinded in an agate motor and pestle, mixed and compressed into a alumina crucible and heated at 1200^{o}C for 3 hours with heating rate of 5^{o}C/min in the muffle furnace. The prepared samples were again grounded in to powder for taking the characteristic measurements. All the phosphor samples were characterized by X-ray diffraction (Synchrotron Beam Indus -II), SEM and the Photoluminescence (PL) emission and excitation spectra were measured by Spectrofluorophotometer (SHIMADZU, RF-5301 PC) using 150 watts Xenon lamp as excitation source. The emission and excitation slit were kept at 1.5 nm, recorded at room temperature.

General Flow Chart of Phosphor Synthesis

Raw Materials (Matrix, Activator) ⟹ Blending, Mortar and pestle (Laboratory scale) ⟹ Synthesis (firing 1200oC for 2 hours) ⟹ Coarse Crushing ⟹ Final Product ⟹ Characterization ⟹ Applications

RESULTS AND DISCUSSIONS:

Photoluminescence study of Eu doped $Y_3Al_5O_{12}$phosphor

Fig.1 is the excitation spectra of $Y_3Al_5O_{12}$ phosphor doped with Eu:(2.5%). The phosphor $Y_3Al_5O_{12}$:Eu is monitored at 400nm excitation and emission found at 254 nm. The PL peaks are observed at 365, 399, 469, 535, 592, 610 and 631nm with different intensities. However the red emission intensity at 610nm dominates all other emissions followed by 592 and 631nm. All the observed peaks are allowed transitions of Europium when excited with 254nm. Here 365,399,469nm peaks observed in undoped $Y_3Al_5O_{12}$ and also Eu doped phosphors the position and intensities are nearly same.

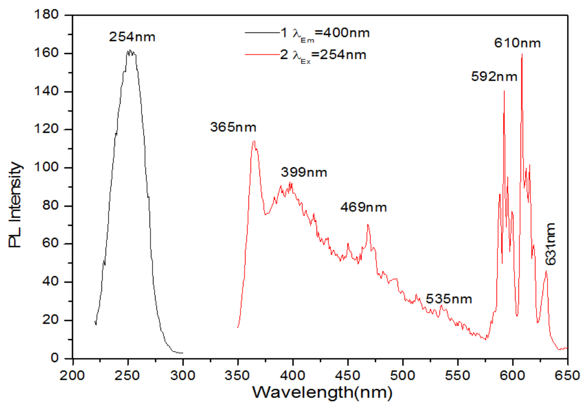

Fig 1 PLE and PL spectra of Eu (2.5%) doped $Y_3Al_5O_{12}$ phosphor

We studied the phosphors with varous concentrations of Eu [0.5,1.0,1.5,2.0and 3.0%] concentrations. All the doping of the Eu generates a hump in green region that is at 535nm whose intensity is nearly same for all the Eu concentration in $Y_3Al_5O_{12}$ phosphor. The other emissions from Eu^{3+} in $Y_3Al_5O_{12}$ phosphors are 592,610,631 along with other satellite peaks of Eu. As the Eu concentrations increases in $Y_3Al_5O_{12}$ phosphors the PL intensity of the 592,611,631nm peaks increases its intensity upto Eu(2.5%) in $Y_3Al_5O_{12}$ phosphor. After 2.5% of Eu in $Y_3Al_5O_{12}$ phosphor the intensity marginally decreased.

For better understanding the emission intensities of wavelength of Eu concentrations are presented in Table 1.

Table 1

S.No	Sample	Dopant Concentration Mol(%)	Emission peak intensities under 254nm Ex.						
			365	399	469	535	592	610	631
1	$Y_3Al_5O_{12}$	Eu(0.5%)	112	87	62	57	25	32	10
2		Eu(1.0%)	111	94	68	61	32	52	15
3		Eu(1.5%)	123	97	70	59	76	91	30
4		Eu(2.0%)	122	94	80	63	94	145	43
5		Eu(2.5%)	114	92	70	60	140	160	46
6		Eu(3.0%)	113	98	69	59	89	137	41

Table 2 is the effect of Eu on the intensities of 592,610 and 631nm peaks from the table it is found as the Eu concentration increases all the Eu3+ emission intensities increases linearly. After 2.5% Eu in the host $Y_3Al_5O_{12}$ phosphor the intensity decreases. This is due to standard quenching effect. Which is attributed to the columbic repulsion of near by Eu ions which leads to non-release of electron from 4F shells. The emissions 592,610,631 are standard Eu^{3+} ions which are attributed to the following transitions of RE 3+.

Table 2

Wavelength(nm)	Transitions	Energy(ev)
592	$^5D_0 \rightarrow ^7F_1$	2.103eV
610	$^5D_0 \rightarrow ^7F_2$	2.031eV
631	$^5D_0 \rightarrow ^7F_3$	1.961eV

It is interesting to note here the emissions below 600nm are considered magnetic dipole component and above 600nm components are attributed to hyper sensitive electric component of the phosphor material.

XRD Pattern of $Y_3Al_5O_{12}$: Eu (2.5 mol%) Phosphor:

From the XRD pattern it can be observed both the phosphors looks mostly in single phase. The crystallite size is calculated using Scherrer's formula d=Kλ/ 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), 'θ' the Bragg angle of the XRD big peak. Using the Schrieffer's formula the crystallite size.

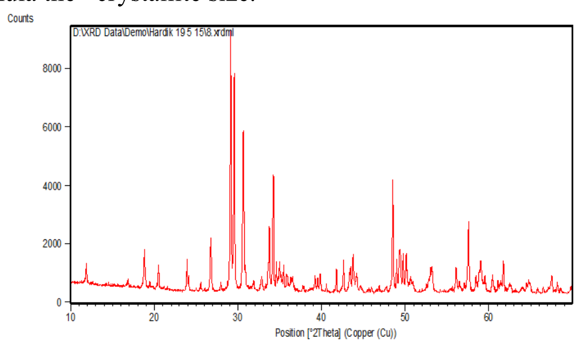

Fig 2 XRD pattern of Eu (2.5 mol%) doped $Y_3Al_5O_{12}$ phosphor

From the fig.2 the calculated crystallite size of Eu doped $Y_3Al_5O_{12}$ is 3.75nm.

SEM diagram of $Y_3Al_5O_{12}$: Eu (2.5 mol%) Phosphor

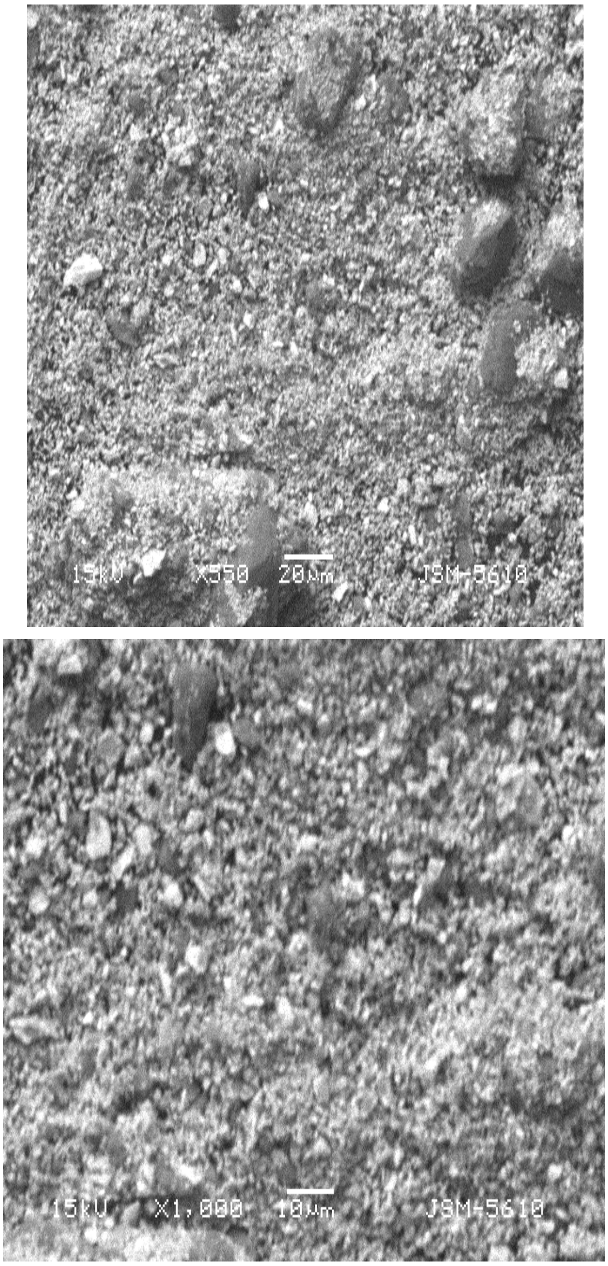

Fig 3 SEM image of Eu (2.5%) doped $Y_3Al_5O_{12}$ phosphor

Fig. 3 is the SEM micrograph of Eu(2.5%) doped in $Y_3Al_5O_{12}$ phosphor. From the micro graphs it is found that particles are mostly irregular shape and agglomerated of various sizes from micron to 10 microns.

EDS Spectrum of $Y_3Al_5O_{12}$: Eu (2.5 mol%) Phosphor

EDS is recorded in the SEM machine where in SEM micrographs are recorded. However in the few of the EDS spectrums strontium, calcium, copper and magnesium are seen which are adjacent elements of the host elements and their contribution to PL is negligible. Therefore in general it is normally concluded that the phosphorsunder EDS study are pure without any impurities.

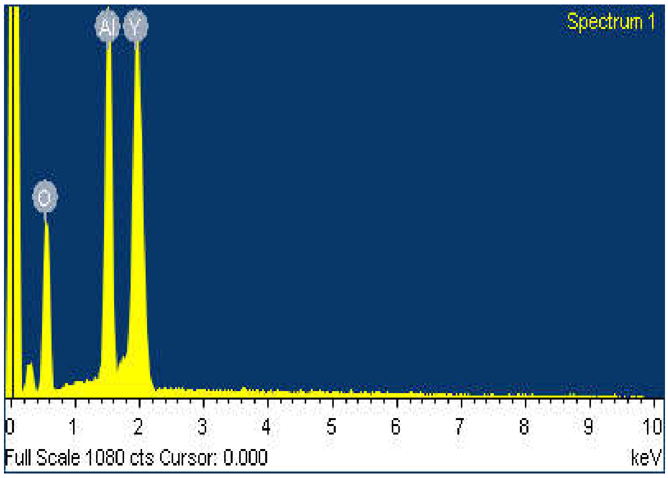

Fig 4 EDS of Eu (2.5%) doped $Y_3Al_5O_{12}$ phosphor

Particle Size Analysis

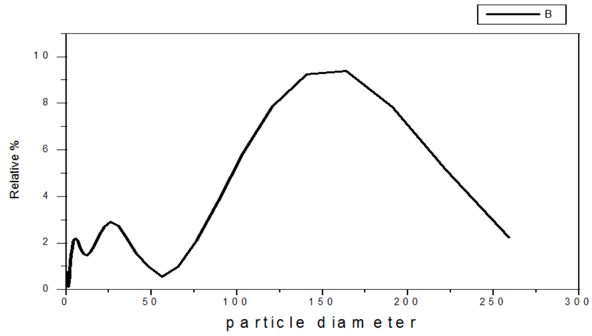

Fig 5 particle size histogram of $Y_3Al_5O_{12}$: Eu(2.5%) phosphor

Fig.5 is the particle size histogram of Eu(2.5%) doped $Y_3Al_5O_{12}$ phosphor whose particle size area is 8.303sqm/gm.

CONCLUSION

- Eu:(2.5 mol %) doped $Y_3Al_5O_{12}$ phosphor is monitored at 400nm excitation and emission found at 254 nm. The PL peaks are observed at 365, 399, 469, 535, 592, 610 and 631nm with different intensities.
- However the red emission intensity at 610nm dominates all other emissions followed by 592 and 631nm.
- All the observed peaks are allowed transitions of Europium when excited with 254nm.
- Here 365,399,469 nm peaks observed in undoped $Y_3Al_5O_{12}$ and also Eu doped phosphors the position and intensities are nearly same.
- After 2.5% Eu in the host $Y_3Al_5O_{12}$ phosphor the intensity decreases. This is due to standard quenching effect.
- XRD study the calculated crystallite size is 6.35nm.
- From the micro graphs it is found that particles are mostly irregular shape and agglomerated of various sizes from micron to 10 microns.
- From the EDS studyt the phosphor is pure without any impurities.
- From particle size analysis the particle size area is 8.303sqm/gm.

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