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Synthesis and Characterization of $Znal_2o_4$ Phosphor and its Luminescence Studies

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Abstract:
In the present paper we have reported Synthesis and Characterizations of Zinc Aluminate ($ZnAl_2O_4$) phosphors Doped with Dysprosium (Dy3+) for its Luminescence Properties. Using urea as fuel, $ZnAl_2O_4$ doped with Dysprosium (Dy3+) phosphors were made ready through a combustion method. Illuminating behaviour of the nanaophosphor was scrutinised under ultraviolet (UV) rays. unblended $ZnAl_2O_4$ appearance was established by urea-nitrate infusion by combustion synthesis manner at 550℃. The structural properties of Pure and Dy3+-doped $ZnAl_2O_4$ nanocrystallites were scrutinised by X-ray diffraction (XRD) with Cu Kα [40kV,15mA X-ray] at λ = 1.541862˚A and Fourier Transform Infrared (FT-IR) Spectroscopy(PEService) , Transmission electron Microscopy (TEM). The crystal size was computed by Scherer's equation. This phosphor exhibits strong green emission at λexci = 233 nm and 359nm. The green emissions are ascribed to 5D4-7FJ (where J =3,4,5 & 6) transformation of Dy3+ electrolytes respectively. These nanaocrystallites have proclaimed powerful, extended green ejection from 5D4-7F5 at 556 nm. The Thermoluminescence (TL) studies for the said samples were allotet and the TL spectra was obtained from Thermo WinREMS-TLD Reader wrw. The utmost peak of TL intensity were appeared at approximate channel numbers 60 and 150for $ZnAl_2O_4$ (Pure) and $ZnAl_2O_4$: xDy phosphors (x = 0.003mol). The outcome have designated that $ZnAl_2O_4$: Dy can be a possible contender as a green-ejecting pounce and Personnel Monitoring Devices or Radiation Worker..

Keywords: *Nanophosphors; Luminescence; Aluminate; XRD;FTIR.*

I. INTRODUCTION

$ZnAl_2O_4$ incorporate a normal an octahedron shaped with the space group Fd3m as shown by Sickafus et al. (1999). Due to giant chemical solidity and immense ejection properties in perceptible domain aluminate phosphors bounteously been studied [1-7]. Native metal electrolytes are extensively used as executor in diverse hosts because of their high incandescence coherences when the scale of their granulates is turned down to the nanoscale; these materials are widely employed in diverse applications, like in fluorescent lamps, cathode-ray tubes, light-emitting diodes (LEDs) for the industry, field-emission displays and X-ray imaging. Within the rummage stuff with adequate dose measuring retaliation, semiconducting nanocrystallites have enticed sizeable engrossment, materials peculiarly the 2-6 semiconducting compounds as they're uncomplicated to integrate within the footage radius required being that within nanometre footage radius. In the nanometre within acreage radius , which is half way between the elementary composition and volume acreage of the fabric, the smallest discrete quantity cramped effects are customarily distinguished which permit the calibration of optoelectronic effects of materials of the indistinguishable chemical composition just by modifying the particle footage radius (Cyr etal.,2003). Additionally innovative visual properties are also expressed, which are indubitably beneficial for technological implementation (Fang etal., 2011; Li and Zhang,2009; Lines, 2008) [8]. $ZnAl_2O_4$ (ZA) , may be semiconducting materials with an optical energy gap(Eg) of 1.44 eV determined by Tauc Plot Method as shown in Figure 2, a representative material in the descent of metal aluminates with an octahedron structure, is extensively used as a ceramic, electronic and reactionary material. Efforts are dedicated to studying the illuminating behaviours of in distinguished and doped $ZnAl_2O_4$. Results have proved that $ZnAl_2O_4$ may be encouraging domain with giant coherence and solidity.

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II. MATERIALS AND METHODS:

Phosphors within the equation of Zn Al_2O_4: xDy (x = 0.003mol) was made ready by the Combustion Synthesis mechanism. The starting ingredients, Zinc Nitrate (pure), Aluminium Nitrate (pure) Urea [NH_2-CO-NH_2] as fuel & Dysprosium oxide [Dy_2O_3] (pure), were assorted exhaustively in an agate mortar with the incorporation of an acid. The fusion were kept in an electrical muffle oven for through 20mins . at 550˚C. The appearance of the integrated granulate was recognised by XRD of the fine powder specimen, and was inspected on a granulate X-ray diffractometer with Cu Kα [40kV,15mA X-ray] at λ = 1.541862˚A , Fourier Transform Infrared (FTIR) Spectroscopy(PEService), Transmission electron Microscopy (TEM).

III. RESULTS AND DISCUSSION:

Figure 1 represents (a). Reference XRD Pattern of $ZnAl_2O_4$ (JCPDS card No 05-0669), (b) XRD pattern of $ZnAl_2O_{4\ (Pure)}$ and $ZnAl_2O_4$: xDy powders. As was anticipated, no patent relocation of the diffraction peaks was made out. The scale of the granulate has been enumerated from the total width half maximum (FWHM) of the extraordinary apex using Debye- Scherer's equation **.** The XRD analysis confirmed the average particle size to be 17.61nm for $ZnAl_2O_{4\ (Pure}$ and 12.82nm for $ZnAl_2O_4$: xDy powders. Equation deployed for estimation is

$$\mathbf{D=0.9\lambda/\beta COS\theta}$$

Here D is particle size
β is FWHM (full width half maximum)
λ is the wavelength of X ray source
θ is angle of diffraction.

Table 1 & 2 lists the crystallite sizes calculated by the Debye– Scherrer equation for Dy^{3+}- doped Zinc aluminate ($ZnAl_2O_4$:XDy) and Zinc Aluminate ($ZnAl_2O_{4(PURE)}$) respectively.

Table: 1Crystal information from X-ray diffraction patterns, Debye–Scherer equation for $ZnAl_2O_4$: XDy

2 Theta(deg)	Theta(Deg.)	FWHM(Deg.)	Theta(Rad.)	FWHM(Rad.)	Crystal Size(nm)
31.136	15.568	0.773	0.271568	0.013484	9.901988
34.32	17.16	0.2	0.299339	0.003489	37.96053
36.737	18.3685	0.81	0.32042	0.01413	9.309912
44.682	22.341	0.798	0.389716	0.01392	9.210091
47.44	23.72	0.35	0.413772	0.006105	20.78548
48.92	24.46	0.81	0.42668	0.01413	8.929723
55.515	27.7575	0.801	0.484202	0.013973	8.779118
56.442	28.221	0.47	0.492287	0.008199	14.89774
59.176	29.588	0.825	0.516133	0.014391	8.376251
62.81	31.405	0.32	0.547829	0.005582	21.19585
65.124	32.562	0.806	0.568012	0.01406	8.309893
65.21	32.605	1.99	0.568762	0.034714	3.364103
67.84	33.92	0.23	0.5917	0.004012	28.67239
73.99	36.995	0.96	0.645341	0.016746	6.612041
77.19	38.595	0.96	0.673251	0.016746	6.470544
82.75	41.375	1.08	0.721746	0.01884	5.522465
85.75	42.875	0.6	0.747912	0.010466	9.70813
				Avg:	12.8239

Table: 2 Crystal information from X-ray diffraction patterns, Debye–Scherrer equation for ZnAl2O4(PURE)

2 Theta(deg.)	Theta(deg.)	FWHM(deg.)	Theta(Rad.)	FWHM(Rad.)	Crystal Size(nm)
3.073	1.5365	1.13	0.027264	0.019712	7.028737
9.315	4.6575	0.25	0.082645	0.004361	31.67323

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19.18	9.59	0.57	0.170169	0.009943	13.73801
26.79	13.395	0.36	0.237686	0.00628	21.45012
31.466	15.733	0.391	0.279173	0.006821	19.53404
34.599	17.2995	0.2	0.306969	0.003489	37.87003
37.015	18.5075	0.39	0.328404	0.006803	19.28412
44.984	22.492	0.413	0.399107	0.007204	17.72635
47.78	23.89	0.42	0.423914	0.007326	17.2432
49.235	24.6175	0.384	0.436823	0.006698	18.74832
55.832	27.916	0.416	0.495353	0.007257	16.80383
59.54	29.77	0.425	0.528251	0.007414	16.14679
63.07	31.535	0.25	0.55957	0.004361	26.93447
65.411	32.7055	0.445	0.580339	0.007763	14.93162
68.66	34.33	1.29	0.609165	0.022503	5.051356
74.283	37.1415	0.48	0.659054	0.008373	13.08632
77.472	38.736	0.47	0.687347	0.008199	13.06654
82.8	41.4	0.51	0.734618	0.008896	11.56117
85.838	42.919	0.45	0.761572	0.00785	12.77893
				Avg:	17.61354

The stage emergence and naturalness of the outcome are further hardened by FT-IR spectroscopy .Figure 3 shows the FT-IR spectra of the as – amalgamated $ZnAl_2O_4$ (Pure) and $ZnAl_2O_4$:xDy powders phosphors in middle Infrared (IR) province (4000 to 500 cm^{-1}). The IR province (4000 - 500 cm^{-1}) is of the good significance in examining a compound. Since IR spectra accommodate an oversized quantity of loops, no two compounds will have the undifferentiated IR stretch. A stretch is customarily examined under two regions.

a) The Functional group region, 4000 - 1400 cm^{-1} - The higher frequency portion (4000 - 1400 cm^{-1}) is entitled as the Functional group region. The looks of strong incorporation loops within place of (4000 – 2500 cm^{-1}) customarily comes from stretching vibrations between hydrogen and some other atoms with a mass of 19 or less.

b) The Finger Print region, 1400 - 500 cm^{-1}- The province from 1400 - 500 cm^{-1} is entitled as the finger print region as the design of osmosis during this province is exclusive to any peculiar compound. This section of the scale (principally 1300 - 909 cm^{-1}) is customarily complicated as both stretching and bending modes create to osmosis during this province. The patterns of the spectrum during this region are very sensitive and alter even with minor chemical or stereo chemical alteration within molecule. Thus within the FT-IR spectrum the absorption bands of Aluminates groups were clearly evident.

The Transmission electron Microscopy review is the most effective gadget to grasp the provincial construction, constructional transfiguration, particle footage and morphology of the substance [9]. Transmission electron Microscopy scrutiny was supervised to research the provincial structure and also the nanocrystallinity of the amalgamated material. Figure 4 (i) and (ii) show the representative high-resolution (HREM) shining area nanographs for the sample and also the corresponding selected area electron diffraction (SAED) design. The high-resolution nanographs and also the SAED patterns show that the phase remains single for the parent end members of the first primary solid solution.

The excitation spectrum (Figure 5) of $ZnAl_2O_4$: Dy^{3+}shows extraordinary loops at 233 nm and 359nm. The loops at 260 and 286nm are accredited to the 4F8–4F7 5D1 (F-D) transfigurations of Dy^{3+} which are generated due to separation of positive and negative charges equally permissible transfigurations and also the opposite loops with the orientation from 300 to 400nm apply to the transfiguration between exuberance of the 4F8 configuration of Dy^{3+}**(**F–F transfigurations), which are designated to the electronic transfigurations (7F6-5D1) at 324 nm, (7F6-5L9) at 350 nm. Amidst these, the 233nm transfiguration has the foremost potency compared to the other transfigurations. The ejection scale of ZnAl2O4: xDy phosphors (x = 0.003mol) are assimilated in Figure 5. Each scale may be splited into two sections. The ejection between 400–450nm is because of transfiguration from the 5D3 elevated state. Above 480 nm, the ejection loops are emerged from 5D4 elevated state. The complementary ejection scale of $ZnAl_2O_4$: Dy^{3+} designate limited ejections which

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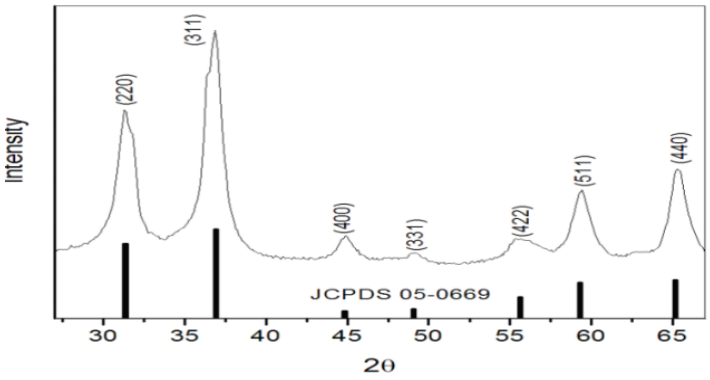
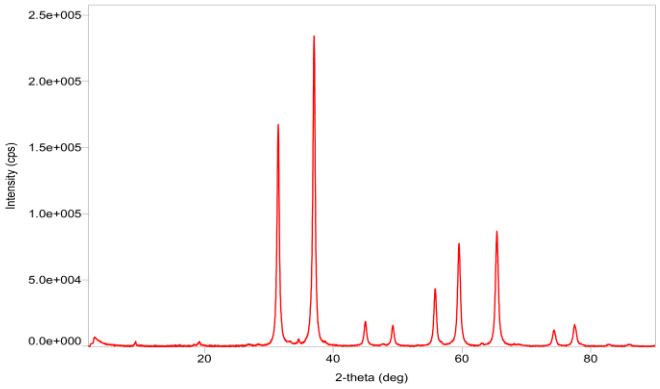
originate from 4F-4F transfiguration within Dy^{3+} electrolytes as assimilated in Figure 5. Amidst the measured ejection transfigurations, the green-ejection transfiguration 5D4-7F5 at 556nm has been more extraordinary in nature, thanks to the character of the dopant Dy^{3+} electrolyte within host grid, with elation at 233 nm. Ejection potencies from 5D3 elevated state decrease with increment of the Dysprosium agglomeration and manifest an extraordinary potency at 556 nm. The Thermo luminescence (TL) studied for the said samples were dole out and illustrated in Figure 5. The TL spectra were obtained from Thermo WinREMS-TLD Reader $_{wrw}$. Superficial traps, those are very close to the outermost band, are uncomplicatedly vacant at temperature, which leads to remarkable loss of the TL signal. The deeper traps need somewhat extra energy to knock-out imprisoned electrons, normally forming the height within which topmost TL emission is achieved and hence are used because the foremost loop in dosimetric assessment [10]. The profound imprisoned electrons need remarkable energy so as to be vacant, obtained by extreme temperature tempering. Figure 6 (a) shows the TL spectra of Pure Zinc Aluminates while (b) shows the TL spectra of doped Zinc Aluminates respectively are the samples of TL glow curve of absorbed dose of 300Gy of Gamma ray. The most peak of TL intensity were appeared at approximate channel numbers 60 and 150 for $ZnAl2O4_{(Pure)}$ and ZnAl2O4: xDy phosphors (x = 0.003mol). This indicates that the synthesized could even be used for Personnel monitoring devices for radiation worker and Radiation Dosimetry purposes.

IV. CONCLUSION AND FUTURE SCOPE:

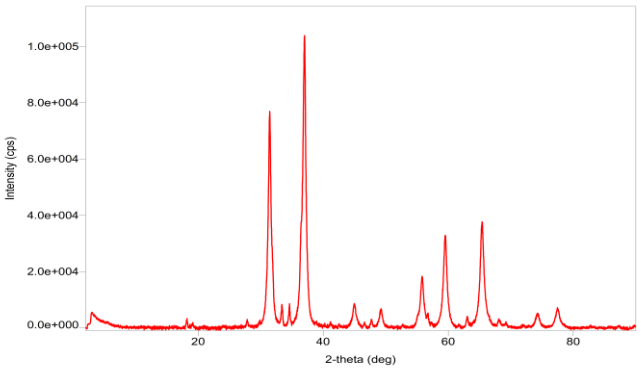
A newfound Green-ejecting phosphor Dy^{3+}-doped $ZnAl_2O_4$ phosphor was amalgamated and its illuminating behaviour was scrutinised. A unique-juncture phosphor granulate was achieved by expedient of XRD examination. The Photoluminescence scale shows a robust scintillation over 556nm (5D4-7F5) of Dy3+ . This phosphor dispense a scintillating Green ejection, which may be utilised as an encouraging nanophosphor for green illuminated array systems and personnel monitoring Devices.



(a)



(b)



(c)

Figure 1.XRD Pattern of $ZnAl_2O_4$ (a) Reference JCPDS Card No. 05-0669(b) Synthesized $ZnAl_2O_4$ (Pure) & (c) Synthesized $ZnAl_2O_4$ (Doped with Dy

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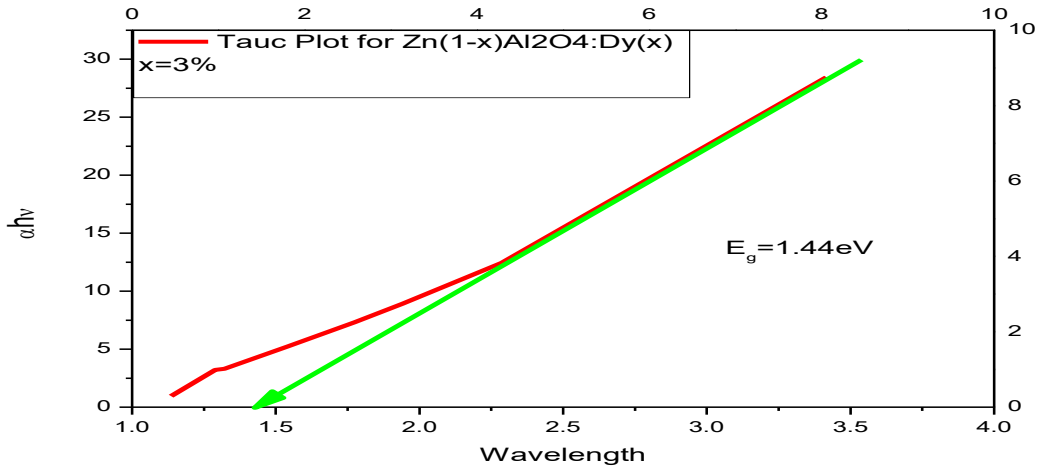


Figure 2.Optical Band Gap determination of Synthesized $ZnAl_2O_4$ (Doped with Dy) by Tauc Plot Method

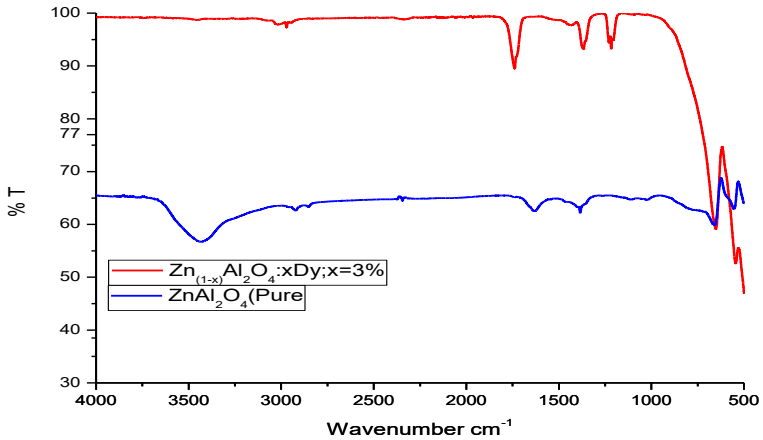
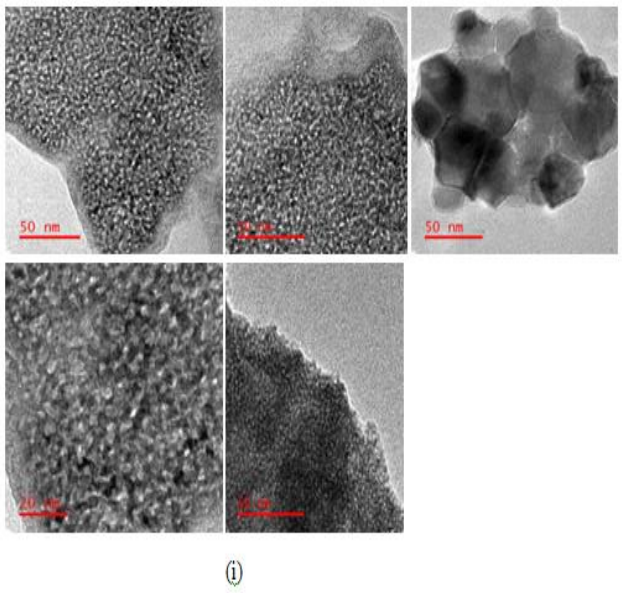
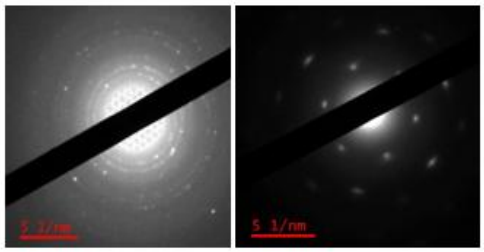


Figure 3.FTIR Spectroscopy of Synthesized $ZnAl_2O_4$ (Pure) & Synthesized $ZnAl_2O_4$ (Doped with Dy)



(i)



(ii)

Figure 4.(i) TEM and (ii) SAED pattern of $ZnAl_2O_4$ nanopowder.

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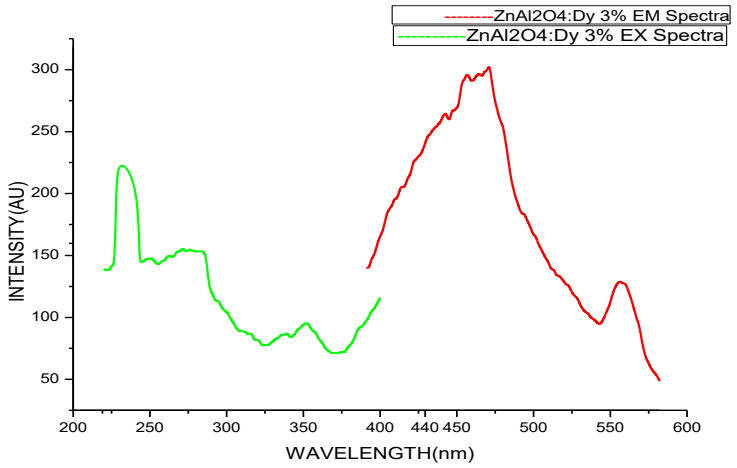
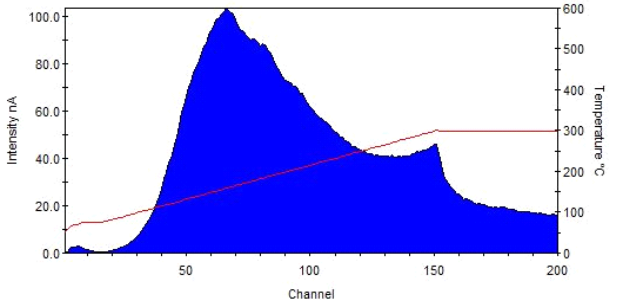
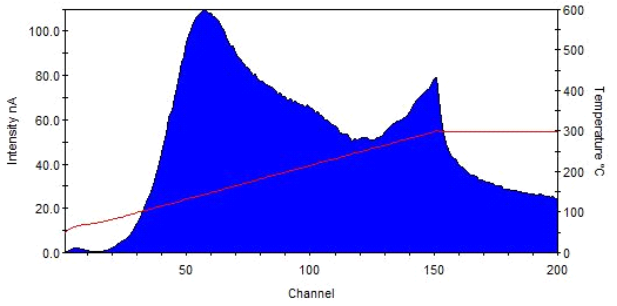


Figure 5. Shows the Excitation and Emission scale of Synthesized $ZnAl_2O_4$ (Doped with 0.003 mol of Dy)



(a)



(b)

Figure 6.shows the TL scale of (a) Synthesized $ZnAl_2O_4$ (pure) (b) $ZnAl_2O_4$ (Doped with 0.003mol of Dy)

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