Mimosa pudica (L) assisted green synthesis and photoluminescence studies of Y_2O_3:Mg2+ nanophosphors for display applications

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Abstract. For the first time green route method was used to synthesize pure and Mg^{2+}(1-11 mol %) doped Y_2O_3nanophosphors by using *Mimosa pudica* leaves extract as a fuel. The final product was well characterized by powder x-ray diffraction (PXRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), diffuse reflectance spectroscopy (DRS) and photoluminescence (PL).The PXRD results reveal that the formation of single phase, cubic structure of Y_2O_3 with crystallite sizes ~25 nm. The SEM results showed porous and agglomerated structures, TEM images showed the crystallite size of the material and was found to be around ~ 25 nm. DRS studies revealed that the band gap of the nanophosphors was found to be around 5.82 to 5.87 eV. PL emission spectra show the blue light emission under the excitation wavelength of 315 nm. The emission peaks of Mg^{2+}were observed at 428 nm, 515 nm and 600 nm corresponding to the transitions of $^4F_{9/2} \rightarrow {}^6H_{17/2}$ (violet),$^4F_{9/2} \rightarrow {}^6H_{15/2}$ (blue),$^4F_{9/2} \rightarrow {}^6H_{13/2}$ (yellow) respectively. The estimated CIE chromaticity co-ordinate was very close to the national television standard committee value of blue emission. CCT was found to be ~ 6891 K as a result the present phosphor was potential to be used for warm white light emitting display applications.

Keywords: Y_2O_3:Mg^{2+}; PXRD; *Mimosa pudica;* Photoluminescence.

1. Introduction

Yttrium oxide (Y_2O_3) received significant attention in the recent years in view of its possible integration into a wide range of scientific and technological applications such as luminescent displays, photoelectric devices, optoelectronics devices, biological, chemical probes etc. [1, 2]. Nanostructured Y_2O_3 shows exceptional physical properties such as wide energy band gap (~ 5.30 eV), high dielectric constant, optically isotropic and refractive index of about 1.91 [3-5].

Rare earth doped Y_2O_3 was considered to be the best phosphors for practical applications because of their excellent luminescent efficiency, color purity, chemical and thermal stability [4] they find variety of applications like display devices, up-conversion solar cells, white-light generation and detectors in medical diagnosis equipment etc. [5]. The development of a simple, environmental friendly method to prepare Mg^{2+}doped Y_2O_3 nanostructures with controllable morphology was essential to their practical applications. The facile bio-combustion method using *Mimosa pudica*

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plant extract as a fuel/surfactant offers a facile way for low cost and large-scale production. *Mimosa pudica* belongs to the family of *Mimosae* known as sensitive plant distributed throughout in India in moist locality. Present work focus on the synthesis of series of Mg^{2+}(1-11 mol %) doped Y_2O_3 NPs with different morphologies prepared *via* bio approach

2. Experimental Synthesis.

The extract of *MP* (1 gm) was mixed thoroughly in 90 ml of double distilled water using a magnetic stirrer. For the synthesis of Y_2O_3: Mg^{2+}(5 mol %) aqueous mixtures of yttrium nitrate and magnesium nitrate solutions were subsequently added to the required amount of MS (10 ml). Then it was introduced into the muffle furnace preheated at 400 ± 10 °C. The obtained product was grinded well to get fine powder. The resultant product was calcined at 700 °C for 3 h for better crystalinity.

3. Results and discussion

Fig.1 shows the Powder diffraction pattern (PXRD) patterns of Y_2O_3: Mg^{2+} (1-11 mol %) NPs prepared via *Mimosa pudica* plant mediated green combustion route. The PXRD pattern was well indexed to cubic Y_2O_3 with JCPDS No. 88-1040 [6]. The crystallite size (D) of Y_2O_3: Mg^{2+}NPs was estimated 19nm using Scherrer's equation also the effects of strain and crystallite size was estimated by Williamson – Hall (W-H) plots.

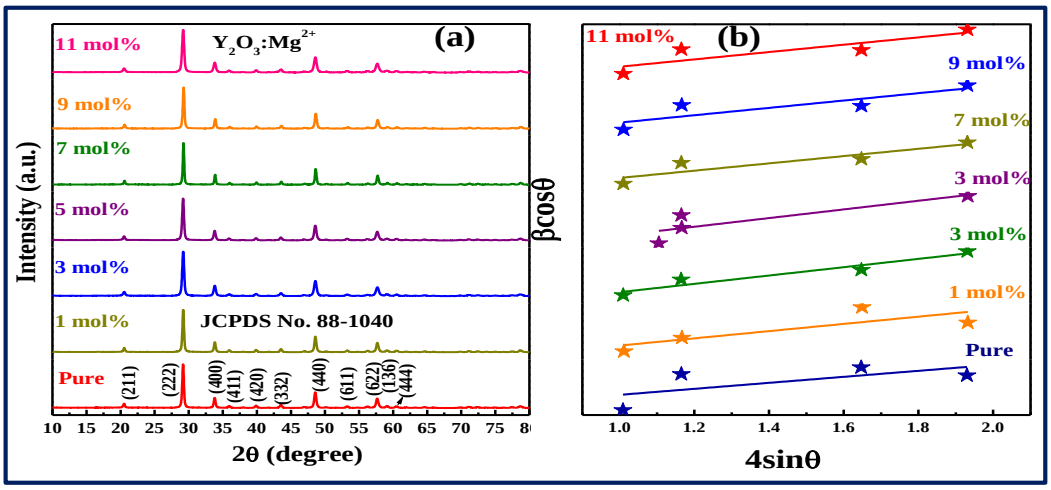


Figure 1 (a) PXRD patterns (b) W-H plots of pure and Mg^{2+} doped Y_2O_3nanophosphor.

Fig. 2 (a) shows the SEM micrographs of Y_2O_3: Mg^{2+}(7 mol %) nanophosphors. The NPs were seen with scattered dumb-bell shaped like structures, which were due to *Mimosa pudica* fuel effect. The chemical constituents present in the fuel acts as capping agents which binds the NPs to form different structures.

Fig. 2 (b) shows the TEM image of Mg^{2+} (7 mol %) doped Y_2O_3nanophosphors. From TEM image it is evident that the particle size is found to be around ~ 20 nm and which is in good agreement with the particle size estimated from Scherrer formula and W-H methods.

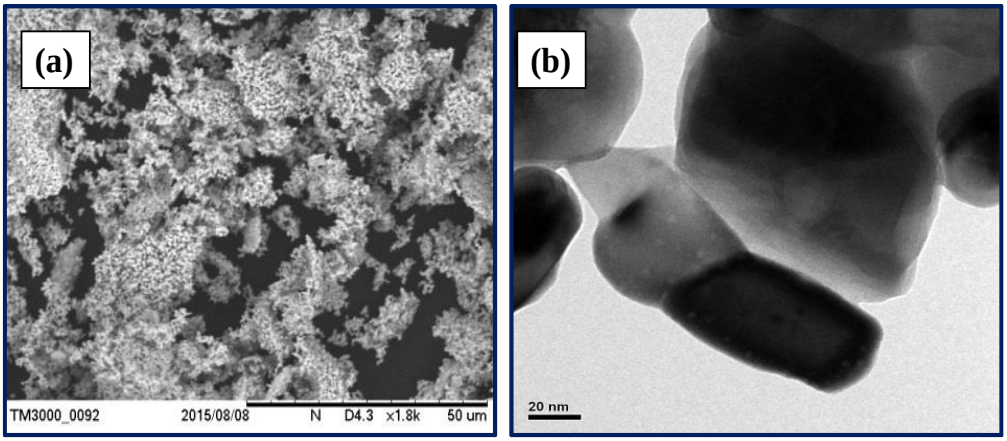


Figure 2(a) SEM micrograph (b) TEM image of Mg^{2+} (7 mol %) doped Y_2O_3nanophosphor.

Fig.3 (a) shows the excitation spectrum and (b) shows the emission spectra of Mg^{2+} doped Y_2O_3nanophosphors recorded at room temperature (RT). The emission spectrum consists of sharp bands at violet 428 ($^4F_{9/2}\rightarrow{}^6H_{17/2}$ transition), blue region 515 ($^4F_{9/2}\rightarrow{}^6H_{15/2}$ transition) and Yellow region 600nm ($^4F_{9/2}\rightarrow{}^6H_{13/2}$ transition). From the figure, it is observed that the blue emission was prominent compared to violet and yellow emissions. The transition corresponding to violet emission is magnetically allowed and hardly varies with the crystal field strength around the Mg^{2+} ion [7].Whereas the transition corresponding to blue emission belongs to the hypersensitive (forced electric dipole) transition with the selection rule $\Delta J = 2$, which is strongly influenced by the outside surrounding environment.

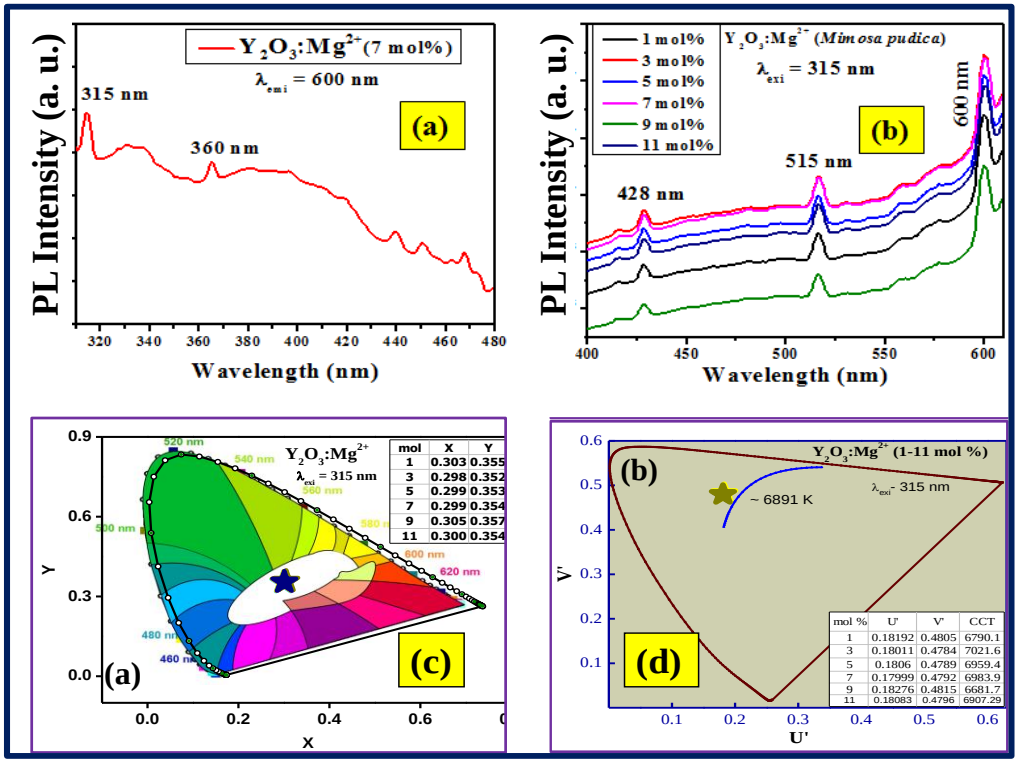


Figure 3 (a) Excitation spectrum (b) emission spectra, (c) CIE and (d) CCT diagram of Mg^{2+} (1-11 mol %) doped Y_2O_3 nanophosphor.

Commission International de I'Eclairage (CIE) 1931 x-y chromaticity diagram of Y_2O_3: Mg^{2+} (1-11 mol %) nanophosphors were presented in Fig.3 (c) excited under 350nm. As shown in the inset of Fig.3 (c), the CIE chromaticity coordinates were well located in the white region. To identify technical applicability of this bluish emission, CCT was also determined from CIE coordinates Fig.3 (d).In the present study, the CCT of Y_2O_3: Mg^{2+} at 350 nm excitation was found to be ~6891 K which was within the Plankian locus, thus it can be useful for production of artificial white light emitting devices [8].

4. Conclusion

For the first time, white light emitting cubic Y_2O_3: Mg^{2+} (1-11 mol %) NPs were synthesized by a facile, eco-friendly, inexpensive, bio-inspired solution combustion route using *mimosa pudica* leaves extract as a fuel. The structural, optical, morphology and PL emission properties were studied. Upon 350 nm excitation, Y_2O_3: Mg^{2+}nanophosphor exhibits sharp emission bands at violet ($^4F_{9/2}\rightarrow{}^6H_{17/2}$ transition), blue ($^4F_{9/2}\rightarrow{}^6H_{15/2}$ transition) and yellow region ($^4F_{9/2}\rightarrow{}^6H_{13/2}$ transition). CIE chromaticity co-ordinates falls in the white region and CCT was found to be 6891 K which was within the Plankian locus. Thus the present nanophosphor can serve as a potential candidate for white light illumination devices.

Acknowledgement

Author KNVenkatachalaiah thanks to the Associate Dean and Management of Amrita School of Engineering, Amrita university, Bengaluru Campus for their constant encouragement.

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