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Bio-Mediated Combustion Synthesis and Photoluminescence Studies of Y2o3: Tm3+ Nanoscale Superstructures

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Abstract- Y2O3:Tm3+ (5mol %) nanoscale superstructure was prepared using Mimosa pudica plant extract as a fuel and nitrate source as a precursors.The sample was characterized by advanced characterization techniques. The PXRD data shows the formation of single phase, cubic structure of Y2O3 with crystallite sizes ~35 nm. PL emission spectra show the blue light emission under the excitation wavelength of 358 nm. The major emission peak of Tm3+ was at 453 nm and two very weak peaks were observed at ~ 474 nm, corresponding to the transitions of 1D2 → 3 F4 and 1G4 → 3H6, respectively. The estimated CIE chromaticity co-ordinate was very close to the national television standard committee value of blue emission. Correlated color temperature was found to be ~ 4000 K as a result the present phosphor was potential to be used for warm white light emitting display applications.

Keywords: Y2O3:Tm3+; Superstructures; Mimosa pudica; Photoluminescence.

I. INTRODUCTION

Yttrium oxide (Y2O3) 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 Y2O3 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]. Rare earth doped Y2O3 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 Tm3+ doped Y2O3 nanostructures with controllable morphology was essential to their practical applications. The facile bio-combustion method using Mimosa pudica 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 Tm3+ (5mol %) doped Y2O3 NS with different morphologies prepared via bio approach.

II. EXPERIMENTAL

The raw materials, used in the present study were Yttrium nitrate (Y(NO3)3: H2O, Aldrich), Thulium nitrate (Tm(NO3)3.5H2O; 99% Aldrich) as a sources of Y and Tm respectively. Mimosa pudica (MP) leaf extract was used as a fuel / surfactant. The method of extracting the MP leaf extract was discussed elsewhere [6]. The extract of MP (1 gm) was mixed thoroughly in 90 ml of double distilled water using a magnetic stirrer. For the synthesis of Y2O3: Tm3+(5mol %) aqueous mixture of yttrium nitrate and thulium 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 750 ·C for 3 h for better crystallanity. The structural characterization of the sample was performed using Powder X–ray diffractometer (Shimadzu - 7000). The morphological features and particle size of nanostructures were observed by scanning electron microscopy (table top SEM, Hitachi – TM-3000),

transmission electron microscopy (TEM, JEOL JSM 2100). The photoluminescence (PL) emission spectra of the samples were recorded using Horiba Flurolog Spectrofluorometer at RT.

III. RESULTS AND DISCUSSION

Fig.1 shows the Powder diffraction pattern (PXRD) patterns of Y2O3: Tm3+ (5mol %) NS prepared via Mimosa pudica plant mediated green combustion route. The PXRD pattern was well indexed to cubic Y2O3 with JCPDS No. 88-1040. The crystallite size (D) of Y2O3: Tm3+NS was estimated using Scherrer's equation also the effects of strain and crystallite size was estimated by Williamson – Hall (W-H) plots. The crystallite size estimated from Scherrer's equation and W-H plots was found to be in the range ~19 nm. A small difference was observed in the estimated crystallite size determined from Scherrer's equation and W-H plots. The variation in the size was due to the fact that in Scherrer's equation the strain component was presumed to be zero.

Fig. 2 shows the SEM image of Y2O3:Tm3+ (5 mol %). It shows the nano superstructures with special arrangement of particles and agglomerated. Fig.3 shows the TEM image confirms the agglomerated NPs consisting large number of almost spherical and few cubic flakes type. The crystallite size of the NPs was found to be ~ 21 nm which was in good agreement with the crystallite sizes estimated by Scherrer's equation and W-H plot method.

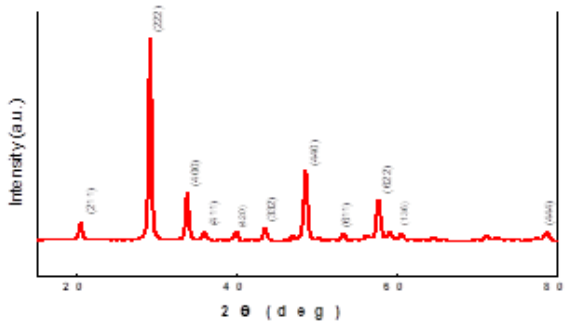

Fig.1 PXRD pattern of Y2O3:Tm3+ (5 mol %) nanophosphor.

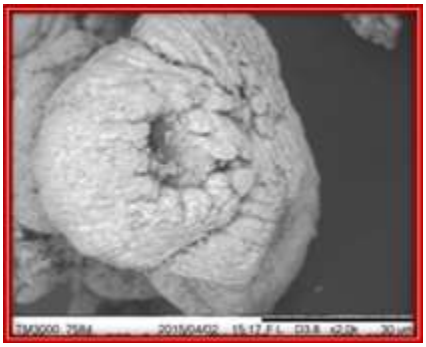

Fig.2. SEM image of Y2O3:Tm3+ (5 mol %) nanophosphor.

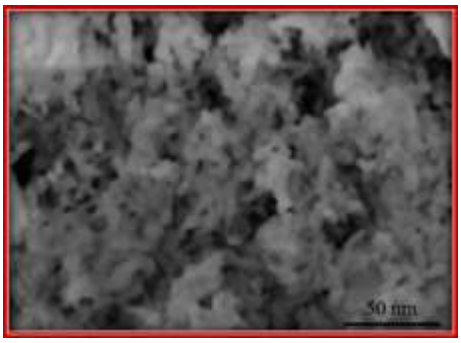

Fig.3. TEM image of Y2O3:Tm3+ (5 mol %) nanophosphor.

Fig 4 shows the PL emission spectra measured from 380 to 600 nm for Y2O3: Tm3+(5mol %) phosphors under the excitation wavelength at 359 nm. The emission wavelength is in the blue-light region. Commission International de l'Eclairage (CIE) 1931 x-y chromaticity diagram of Y2O3: Tm3+ (5 mol %) nanophosphor was presented in Fig. 5 excited under 359 nm. The CIE chromaticity coordinate was located in the blue region (0.2320, 0.2914) and found to be close to the standard NTSC coordinates. To identify technical applicability of this emission, correlated color temperature (CCT) was determined from CIE coordinates.

Fig. 5 shows the CCT diagram of Y2O3: Tm3+ (5 mol %) nanophosphor excited under 359 nm. The CCT was a specification of the color appearance of the light emitted by a light source, relating its color to the color of light from a reference source when heated to particular temperature. In the present study, the average CCT value of Y2O3: Tm3+ (1-11 mol %) nanophosphor was found to be ~4125 K which was within the range of vertical daylight. Thus

it can be useful for artificial production of lighting and display devices.

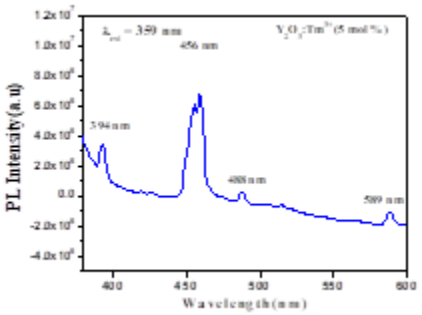

Fig.4. Emission spectra of Y2O3:Tm3+ (5 mol %) nanophosphor.

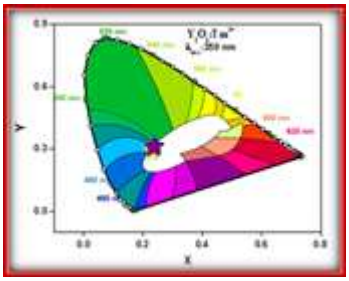

Fig.5. The CIE chromaticity diagram of Y2O3: Tm3+ (5 mol %)

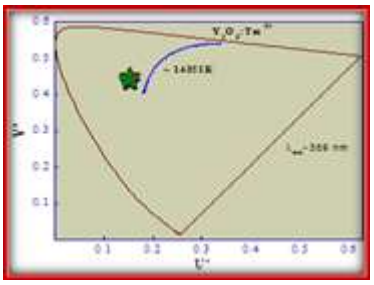

Fig.6. CCT diagram of Y2O3: Tm3+ (5 mol %) excited under 359 nm wavelength.

IV. CONCLUSIONS

In summary, blue light emitting cubic Y2O3: Tm3+ (5 mol %) NPs was synthesized by a bio-inspired solution combustion route using Mimosa pudica plant extract as fuel. The properties were sensitively dependent on the incorporation of Tm3+ ions into Y2O3 matrix. The emission wavelength was in the blue-light region. The major emission peak of Tm3+ was at 453 nm and two very weak peaks were observed at ~ 474 nm, corresponding to the transition of 1D2→ 3 F4 and 1G4 → 3H6, respectively. CIE chromaticity co-ordinates fall in the blue region and CCT (~ 4125 K for ▪exi-359 nm) which was within the Plankian locus. These results indicate that the present phosphor is quite useful in display device applications.

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