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Eco-friendly synthesis, characterization and photoluminescence studies of $Y_2O_3:Cr^{3+}$nanophosphor suitable material for WLED

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Abstract: We report the synthesis of $Y_2O_3:Cr^{3+}$ (1mol %) nanoparticles (NPs) with different morphologies via eco–friendly, inexpensive and low temperature solution combustion method using Leucas aspera gel as fuel/surfactant. The prepared compounds were characterized by PXRD, SEM, PL techniques etc. PXRD studies shows single phase nano cubic Cr^{3+} doped Y_2O_3 phosphor. The morphology of sample is found to be spherical flaky shaped. The CIE coordinates (0.33, 0.33) lies in the white region. Hence These findings show a great promise of $Y_2O_3:Cr^{3+}$ NPs as a phosphor in white LED application.

Keywords: Leucas aspera; $Y_2O_3:Cr^{3+}$ Nanophosphors; SEM; PXRD.

1. INTRODUCTION

The nanostructures with unique morphology and novel properties were of great attention to material scientists since the physical, chemical, optical, luminescence and catalytic properties strongly depends on morphology of the nanostructures. Yttrium oxide (Y_2O_3) received significant attention in recent years due to its wide range of scientific and technological applications namely luminescent displays, photoelectric devices, optical communication, biological and chemical probes [1–2]. Yttrium oxide (Y_2O_3) is a versatile interesting material which exhibits interesting physical properties namely wide energy band gap (5.3 eV), high dielectric constant (8-12), optically isotropic and refractive index of 1.91.

A low temperature combustion method was used for the synthesis of $Y_2O_3:Cr^{3+}$ (1mol %) using Leucas aspera gel as fuel .The solution combustion method is of low cost and large-scale production, which does not need expensive raw materials and complicated equipment.

2. EXPERIMENTAL

For the synthesis of $Y_2O_3:Cr^{3+}$ (1 mol %), aqueous mixture of yttrium nitrate and dyrsposium nitrate solution was subsequently added to the required amount of Leucas aspera gel (10 ml) by constant stirring on a magnetic stirrer for ~10 min. The dish was introduced into a furnace preheated at 400 ± 10 °C. The solution immediately started to boil and undergoes dehydration followed by decomposition of the metal nitrates. Finally product obtained was grinded well to fine powder. The resultant products were calcinated at 750 □ C for 3 h for better crystallinity.

3 RESULTS AND DISCUSSION

Fig. 1 show the PXRD patterns of $Y_2O_3:Cr^{3+}$ (0.5-9mol%) NPs. All diffraction peaks were well indexed to cubic Y_2O_3 with JCPDS No. 88-1040 [3]. As the Cr^{3+} concentration increases, the diffraction peaks broadens and shifts towards lower angle side. The broadening and shifting in (222) peak positions with increase in Cr^{3+} ions indicate a small variation in lattice constant. The intensity of (222) plane increases with increase in Cr^{3+} concentration up to 3 mol % and thereafter it decreases implying the degeneration of crystallinity at higher doping concentration and no characteristic peaks of any impurities were detected in the patterns, which indicates that all the samples have high phase purity. The crystallite size (D) of NPs was estimated using Scherrer's equation [4]. It is found be in the range of 9.30 -19.20 nm.

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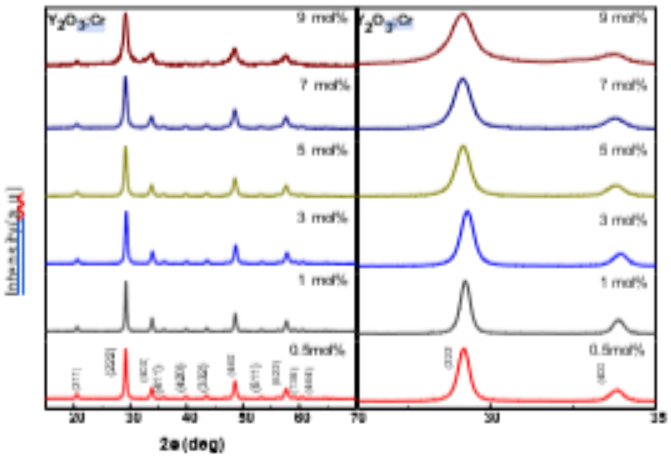

Fig.1 PXRD patterns of Y_2O_3: Cr^{3+} (0.5-9mol%) NPs

Fig. 2. Shows the SEM picture of Y_2O_3: Cr^{3+} (1mol %) NPs in the presence of 9 ml of Leucas aspera gel. It was observed that a spherical flaky shaped morphology was observed [5].

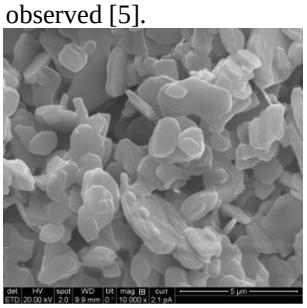

Fig.2 SEM image of Y_2O_3: Cr^{3+} (1mol %) NPs.

The PL measurements were performed to verify how the morphology of Cy^{3+} ion doping on Y_2O_3 affects their emission properties. Fig. 3 presents the excitation spectrum of Y_2O_3: Cr^{3+} (5mol %) monitored at 688 nm. The excitation spectra in the range 360 –420 nm corresponding to transition consists of excitation peaks at 361 nm ($^6H_{15/2}\rightarrow{}^4P_{7/2}$) and 419nm ($^6H_{15/2}\rightarrow{}^4M_{21/2}$)

A typical emission spectra of Y_2O_3: Cr^{3+} (0.5-9 mol %) NP prepared with green synthesis method under excitation wavelength of 361 nm is as shown in Fig. 3 (a). The emission spectra of Y_2O_3: Cr^{3+} (0.5-9 mol %) under 361 nm excitation presents sharp bands at 490,591 and 687 nm corresponding to $^4F_{9/2}\rightarrow{}^6H_{15/2}$, $^4F_{9/2}\rightarrow{}^6H_{13/2}$ and $^4F_{9/2}\rightarrow{}^6H_{11/2}$ transitions and lies in blue, orange and red region [6].

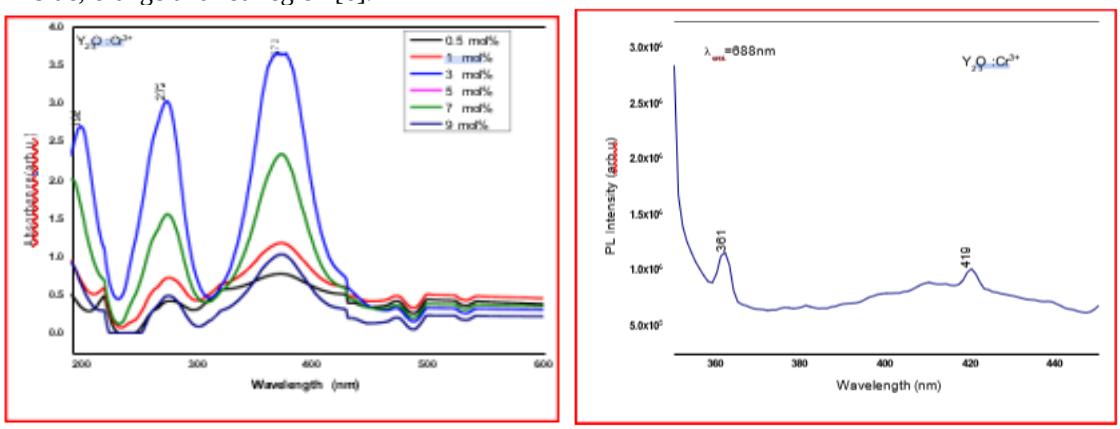

Fig. 3 The excitation spectrum of Y_2O_3: Cr^{3+} (5mol %) NP.
Fig. 3 (a) The emission spectra of Y_2O_3: Cr^{3+} (0.5-9 mol %) under 361 nm.

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The Commission Internationale de I'e clairage (CIE) coordinate of the NPs is calculated. It is found to be (0.35, 0.39) which is closed to that of the ideal white light. The emission of white light from this NP can be attributed to comparable intensities of Cr^{3+} emissions in the visible range of electromagnetic spectrum. Correlated color temperature (CCT) is determined from CIE coordinates and it is found to be 4693 K which corresponds to vertical day light. Fig. 4 (A-B) shows the CIE chromaticity and CCT diagram of Y_2O_3: Cr^{3+} (0.5-9 mol %) respectively[7].

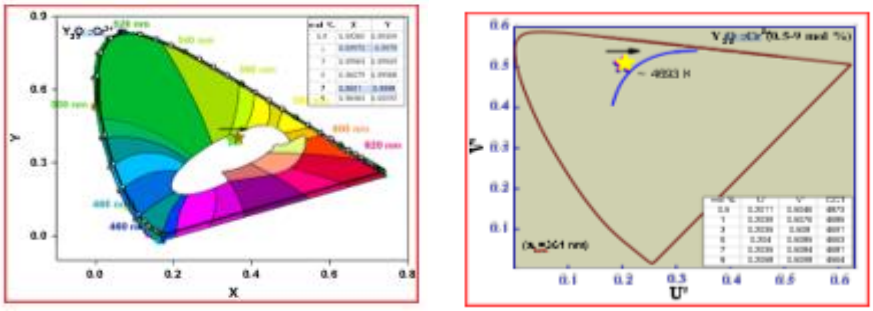

Fig. 4 (A-B): The CIE chromaticity and CCT diagram of Y_2O_3: Dy^{3+} (1-11 mol %) respectively.

4. CONCLUSIONS

In summary, Y_2O_3: Cr^{3+} (0.5-9 mol %) NPs were synthesized by a facile, ecofriendly, inexpensive, bio-approach solution combustion route using Leucas aspera gel as a fuel. The structural, optical, morphology and PL emissions were studied. Upon 361 nm excitation, Y_2O_3: Cr^{3+} nanophosphor exhibit an intense white emission with CIE co- ordinates (0.35, 0.39) and CCT (4693 K) which corresponds to vertical day light. Thus the present nanophosphor can serve as a better candidate for WLEDs.

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