Cationic Surfactant Assisted Sonochemical Synthesis of Nd^{3+} Doped Zn_2SiO_4 Nanostructures for Solid State Lighting Applications

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Abstract. For the first time cationic surfactant assisted ultrasound synthesis route has been used for the preparation of pure and Nd^{3+} (0.5-9 mol %) doped Zn_2SiO_4 nanophosphors. The shape, size and morphology of the products were tuned by controlling the various experimental parameters. The final product was well characterized by sophisticated techniques viz. powder X-ray diffraction (PXRD), Ultraviolet visible spectroscopy (UV-Vis) and photoluminescence (PL). The powder X-ray diffraction patterns confirmed that the synthesized samples exhibit hexagonal phase without any impurity. The DRS spectra showed major peaks at 275, 360, 529, 586, 680, 742 and 806 nm due to the transitions of the 4f electrons of Nd^{3+} from the ground-state $^4I_{9/2}$ to $^2F_{5/2}$, $^4D_{3/2} + {}^4D_{5/2} + {}^2I_{11/2}$, $^2K_{13/2} + {}^4G_{7/2} + {}^4G_{9/2}$, $^4G_{5/2} + {}^2G_{7/2}$, $^4F_{7/2} + {}^4S_{3/2}$, $^4F_{5/2} + {}^2H_{9/2}$ and $^4F_{3/2}$ respectively. The band energy gap (Eg) of the samples were estimated and found to be in the range 5.32 – 5.52 eV. Under 421 nm excitation, PL spectra exhibit strong near ultraviolet emission peaks at ~ 444 nm, 459 nm and 520 nm were attributed to $^2P_{3/2} \rightarrow {}^4I_{13/2}$, $^2P_{3/2} \rightarrow {}^4I_{15/2}$, $^1I_6 \rightarrow {}^3H_4$, $^2P_{1/2} \rightarrow {}^4I_{9/2}$ and $^4G_{7/2} \rightarrow {}^4I_{9/2}$ transitions respectively. The photometric studies indicate that the synthesized Zn_2SiO_4: Nd^{3+} nanophosphors can be tuned from blue to pale green by varying the dopant concentration. The current synthesis route is rapid, environmentally benign, cost-effective and useful for industrial applications such as solid state lighting and display devices.

Keywords: Sonochemical synthesis; Nanophosphor; Photoluminescence; Cationic surfactant;Solid state lighting.

1. INTRODUCTION

White light-emitting diodes (WLEDs) are fascinating huge attention as a promising solid-state light sources on account of their high brightness, low electric consumption, long operating life and eco-friendly features [1]. Recently, silicate nanomaterials doped with rare earth (RE) ions intended science community due to their role in WLEDs and also for their unique electronic, optical, chemical properties, thermal stability, visible-light transparency, high yield and multicolor phosphorescence [2]. The silicate based materials usually fabricated by precipitation or solid state reaction methods which have disadvantages such as calcination temperatures above 1200 °C, no uniform mixing and impurities [3, 4].

Ultrasound assisted route has been demonstrated to be a suitable technique for the synthesis of advanced materials with unusual properties. When liquids were irradiated with high-intensity ultrasound irradiation, acoustic cavitation (the formation, growth, and implosive collapse of the bubbles) provide the primary mechanism for sonochemical effects. During cavitation, bubble collapse creates intense local heating, high pressures, and

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