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Facile Ultrasound Route To Prepare Micro/Nano Superstructures for Multifunctional Applications

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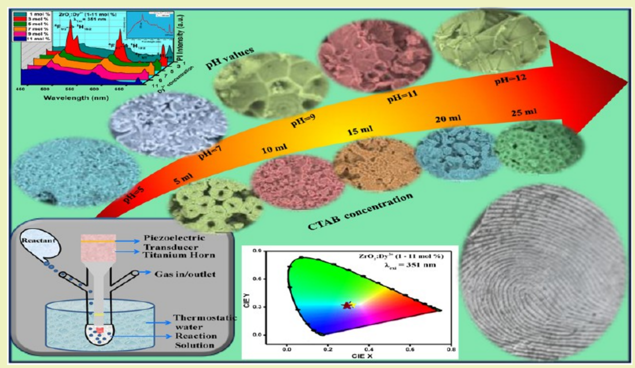
ABSTRACT: Dy^{3+} doped zirconium dioxide (ZrO_2) nanophosphors were prepared by cetyltrimethylammonium bromide (CTAB) assisted ultrasound method. The powder X-ray diffraction profiles showed pure cubic phase. Morphology changes were observed as there is a change in sonication time, CTAB concentration, pH and sonication power. The energy band gaps were varied from 4.13 to 4.53 eV. PL emission spectra exhibits sharp peaks at ∼483, 584 and 674 nm were ascribed to the transitions of $^4F_{9/2}\rightarrow{}^6H_{15/2}$, $^4F_{9/2}\rightarrow{}^6H_{13/2}$ and $^4F_{9/2}\rightarrow{}^6H_{11/2}$, respectively. The spectroscopic properties of the samples were evaluated by Judd−Ofelt theory. Photometric characterization of prepared samples shows white emission and suitable for light-emitting diodes. The optimized $ZrO_2:Dy^{3+}$ (3 mol %) nanopowders (NPs) was utilized to reveal latent fingerprint on various surfaces. The photocatalytic behavior of $ZrO_2:Dy^{3+}$ NPs was extensively studied by degrading hazardous methylene blue dye. Overall, results confirmed that the method of preparation was significant to achieve white light emitting diodes, UV-lasers, photodegradation and forensic applications.



KEYWORDS: *Latent fingerprints, Photoluminescence, Photocatalyst, Solid state lighting, Impedance spectroscopy, Judd−Ofelt analysis*

INTRODUCTION

Rare earth ions (RE) doped nanopowders (NPs) exhibit high color rendering index, energy efficient and stable towards radiations. Hence, they have uses in optoelectronics, catalysis and forensic fields.[1,2] The properties of these materials were mainly dependent on the synthesis routes where structural, morphological and optical properties can be tuned.[3] Due to the tunable hypersensitive transitions of Dy^{3+} in the yellow and blue regions, Dy^{3+} doped materials showed the possibility of obtaining the pure white light emission from single material.[4,5] Hence, these materials were promising materials for white light generation and possibility to use in various optoelectronic applications.[6]

ZrO_2 NPs are useful in various applications viz., optoelectronics, fuel-cell technology, gas sensing, coating to protect the optical components etc. which is due to its high melting point, wide band gap, low optical loss and transparent to EM waves of visible and near-infrared region.[2,7−10] ZrO_2 exhibits the stable monoclinic phase at room temperate (RT) and transforms into tetragonal at 1443 K and to cubic at 2643 K. At high temperature, tetragonal and cubic phases were unstable in bulk forms. Gu et al. investigated the influence of dopant (Dy^{3+}) and calcination temperature on ZrO_2 NPs which exhibited enhanced PL property for optimum dopant concentration of 3 mol %.[10] Effect of Dy^{3+} of 2 mol % in ZrO_2 shows prominent PL intensity at 480 nm was reported by Torres et al.[11] Presently modified ultrasound assisted sonochemical method was used to prepare various micro/nanostructured $ZrO_2:Dy^{3+}$ NPs. In this method of preparation, there is a production of intense heat and high pressure due to the collapse of cavitation bubbles within few nanoseconds which favors the formation of NPs with interesting surface modifications.

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