Eco Friendly Zinc Oxide Wurtzite Nanostructures and their Efficacy for Photocatalysis, Photoluminescence and Fluorescence Resonance Energy Transfer

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Abstract

In recent years, biosynthesized zinc oxide nanoparticles (ZnO NPs) are gaining importance due to their unique properties and tremendous applications. This study aimed to fabricate ZnO NPs by using extracts from various parts (i.e. stems, leaves, and inflorescences) of the traditional medicinal plant *Heliotropium indicum* (*H. indicum*) and to identify their photocatalysis, photoluminescence, and fluorescence resonance energy transfer (FRET) efficacy. The Ultraviolet-Visible (UV-Vis) spectrum was used to monitor the nanoparticles (NPs) formation, which exhibited a hypsochromic shifted absorption band between 360-370 nm. Fourier transform infrared (FTIR) analysis was carried out for the plant extracts and NPs to identify possible functional groups involved in the capping process. Transmission electron microscopy (TEM) analysis revealed NPs were spherical in shape and X-ray diffraction (XRD) results shown their wurtzite, hexagonal crystalline nature. Further, TEM and XRD consistently determined the average particle size ranging from 19 to 53 nm with more accuracy than scanning electron microscope (SEM). Dynamic light scattering (DLS) showed that the particles were well distributed and monodispersed. The maximum photocatalytic degradation of 95% was evaluated for biogenic ZnO NPs spectrophotometrically by monitoring the degradation of methylene blue (MB) dye (λ_{max} = 662.8 nm) under solar irradiation. Photoluminescence (PL) analysis, revealed differentiated spectra with high-intensity emission peaks for biogenic ZnO NPs compared to chemically synthesized ZnO NPs. Eventually, the highest efficiency of FRET (80%) was found in ZnO NPs synthesized from the leaves. This remains the first attempt to synthesize multifunctional ZnO NPs using *H. indicum* for potential environmental and biomedical applications.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Tables

Table 1 Green synthesized ZnO NPs on MB photocatalytic efficiency and half lifetime

ZnO NPs	Half-Lifetime (min)	Degradation efficiency (%)
HIS	97.30	95.00
HIL	135.00	93.09
HIF	100.00	95.08

Figures

Figure 1

Effect of $[Zn(CH_3COO)_2 \cdot 2H_2O]$ concentrations for biosynthesis of ZnO NPs. (a) ZnO NPs/HIS; (b) ZnO NPs/HIL; (c) ZnONPs/HIF

Figure 2

Effect of volume-dependent concentrations of plant extracts on ZnO NPs synthesis. (a) ZnO NPs/HIS; (b) ZnO NPs/HIL; (c) ZnO NPs/HIF

Figure 3

Effect of critical physical parameters for HIS mediated synthesis of ZnO NPs.

Figure 4

UV-Vis absorbance spectra obtained for the biosynthesized ZnO NPs at optimized conditions

Figure 5

FTIR spectra of plant part, and derived extract mediated ZnO NPs synthesis (a) ZnO NPs/HIS; (b) ZnO NPs/HIL; (c) ZnO NPs/HIF

Figure 6

SEM micrographs of ZnO NPs (magnification: 25x, scale bar: 200 nm) (a) ZnO NPs/HIS; (b) ZnO NPs/HIL; (c) ZnO NPs/HIF

Figure 7

XRD patterns of biosynthesized ZnO NPs (a) ZnO NPs/HIS; (b) ZnO NPs/HIL; (c) ZnO NPs/HIF

Figure 8

TEM images of ZnO NPs (magnification: 20x, scale bar: 200 nm) (a) ZnO NPs/HIS (b) ZnO NPs/HIL (c) ZnO NPs/HIF

Figure 9

ZnO NPs size distribution by DLS (a) ZnO NPs/HIS; (b) ZnO NPs/HIL; (c) ZnO NPs/HIF

Figure 10

ZnO NPs/HIS-mediated photocatalytic degradation in various physical-chemical conditions (a) catalytic load; (b) MB concentration at fixed catalytic load of 20 mg; (c) pH at fixed catalytic load of 20 mg and fixed dye concentration (5 ppm)

Figure 11

UV-Vis spectra of MB photodegradation under solar irradiation (a) Control; (b) ZnO NPs/HIS; (c) ZnO NPs/HIL; (d) ZnO NPs/HIF

Figure 12

Half-life of the photocatalytic degradation rate of MB dye by NPs as catalyst under optimized conditions (20 mg catalyst, 5 ppm MB, pH 6, at RT) (a) ZnO NPs/HIS, (b) ZnO NPs/HIL (c) ZnO NPs/HIF

Figure 13

PL spectrums of ZnO NPs recorded with an excitation wavelength of 295 nm

Figure 14

Biosynthesized ZnO NPs-mediated FRET with Flu/RhB dye mixture at an excitation wavelength of 430 nm (a) ZnO NPs/HIS; (b) ZnO NPs/HIL; (c) ZnO NPs/HIF

Figure 15

Variation of Fluorescence emission intensity of Flu and/or RhB in the presence of HIL derived ZnO NPs (1000 $\mu\text{g/mL}$) at an excitation wavelength of 430 nm