CHAPTER 4

Conclusions

4.1 Sonochemical synthesis, photocatalysis and photonic properties of Ce-doped ZnO nanostructures

Undoped ZnO and 1-3% Ce-doped ZnO nanoneedles were successfully synthesized from $Zn(NO_3)_2 \cdot 6H_2O$, $Ce(NO_3)_3 \cdot 6H_2O$ and NH_4OH solution by sonochemical process. The products, analyzed using XRD and SAED, were specified as pure ZnO with hexagonal wurtzite structure. Undoped ZnO and 1–3% Ce-doped ZnO show the same strong absorption bands at 426 cm^{-1} with the shoulders at 565 cm^{-1}, assigned as E_{2H} vibration and oxygen vacancies of wurtzite ZnO crystal, respectively. The 3% Ce-doped ZnO nanoneedles shows the 3.00 eV direct energy gap and 390 nm emission by UV-visible absorption and photoluminescence (PL) spectroscopy, including the most effective photocatalytic activity in the solution containing methylene blue (MB). The facile, reproducible and effective route presented a useful method for the RE^{3+}-doped ZnO system. High crystalline quality and good optical properties of the Ce-doped ZnO nanoneedles make the material to be a candidate for different applications in the future.

4.2 Ultrasonic-assisted synthesis of Nd-doped ZnO for photocatalysis

Undoped and Nd-doped ZnO nanoneedles were successfully synthesized from $Zn(NO_3)_2 \cdot 6H_2O$, $Nd(NO_3)_3 \cdot 6H_2O$ and NH_4OH solution by ultrasonic-assisted solution method. XRD and EM revealed the presence of wurtzite hexagonal ZnO nanoneedles grown in the [001] direction. FTIR spectra, the strong absorption bands at 435 cm^{-1} are attributed to the Zn–O stretching vibration of wurtzite hexagonal type ZnO crystal, belonging to the oxygen sublattice (E_{2H}) vibration of wurtzite ZnO crystal. Their photocatalytic activities were evaluated by the degradation of MB under UV light. The

1% Nd-doped ZnO exhibited the highest efficiency at 92% for 300 min and its photocatalytic performance was 2.5 times of the undoped ZnO.

4.3 Sonochemical synthesis of Dy-doped ZnO nanostructures and their photocatalytic properties

0–3% Dy-doped ZnO nanorods have been successfully synthesized from $Zn(NO_3)_2 \cdot 6H_2O$, $Dy(NO_3)_3 \cdot 6H_2O$ and NH_4OH solution via a sonochemical method. The concentration effect of Dy dopant on the phase, morphology, optical properties and photocatalytic activities of ZnO was investigated. XRD patterns indicated that the as-synthesized 0–3% Dy-doped ZnO were hexagonal wurtzite structure. SEM and TEM show that the products were nanorods with their growth direction along the c axis. The photoluminescence spectrum of 3% Dy-doped ZnO consists of three emission peaks, applied by Gaussian analysis, at 376 nm, 448 nm and 487 nm. The experimental results demonstrated that the as-synthesized 3% Dy-doped ZnO has an excellent optical property and higher photocatalytic activity than that of ZnO for degradation of methylene blue under UV light radiation. This research may provide guidance for the treatment of organic pollutants.

4.4 Synthesis and characterization of highly efficient Gd-doped ZnO photocatalyst irradiated with ultraviolet and visible radiations

In summary, Undoped ZnO and 1–3 mol% Gd-doped ZnO were successfully synthesized from $Zn(NO_3)_2 \cdot 6H_2O$, $Gd(NO_3)_3 \cdot 6H_2O$ and NH_4OH solution by a sonochemical method. The phase, morphology and photocatalytic activity of the products were intensively investigated. An XRD analyzer was used to reveal the as-synthesized 0–3 mol% Gd-doped ZnO with hexagonal wurtzite structure. The SEM and TEM images show the nanorod-shaped products with their growth along the c axis. The experimental results demonstrated that the as-synthesized 3 mol% Gd-doped ZnO has an excellent photocatalytic activity than that of undoped ZnO for the degradation of methylene blue under UV and visible radiations. This research may provide guidance for the treatment of organic pollutants.