

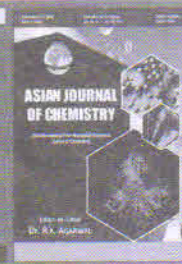


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ZnO Thin Films Synthesized by Ultra Spray Pyrolysis: Structural Characterization, Gas Sensing Behaviour and Antimicrobial Activity

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In this work, ZnO thin films were prepared using the ultra-spray pyrolysis technique at 300 °C, employing precursor (zinc acetate) molarities of 0.3 M, 0.4 M, 0.5 M and 0.6 M. The structural, morphological, optical and compositional properties of the films were systematically investigated using X-ray diffraction (XRD), UV-visible spectroscopy, energy-dispersive X-ray analysis (EDX), field-emission scanning electron microscopy (FESEM), X-ray photoelectron spectroscopy (XPS), and atomic force microscopy (AFM). XRD analysis confirmed the formation of polycrystalline ZnO films with a preferential orientation along the (101) crystallographic plane. AFM measurements revealed that the films deposited at higher precursor concentrations exhibited reduced thickness and improved surface smoothness, with a minimum roughness value of 8.94 nm. Optical studies showed that the band gap energy of the ZnO thin films varied between 3.0 and 3.4 eV, depending on the molarity. FESEM images indicated the presence of uniformly distributed nanometric grains with a hexagonal morphology across all samples. Gas-sensing devices fabricated from the ZnO films demonstrated effective detection of NO₂ gas, with the 0.6 M film exhibiting the highest response of approximately 43.6 toward 40 ppm NO₂ at an operating temperature of 463 K. The enhanced sensing performance is attributed to surface defects and oxygen vacancies induced by Zn²⁺-related non-stoichiometry, which facilitate charge transfer during gas adsorption and promote the sensing mechanism. Moreover, prepared ZnO thin films exhibited significant antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus subtilis*, attributed to reactive oxygen species generation and Zn²⁺-mediated cell wall disruption, with the 0.4 M film showing the highest efficacy.

Keywords: Ultra spray pyrolysis, ZnO Thin films, Optical band gap, Gas sensor.