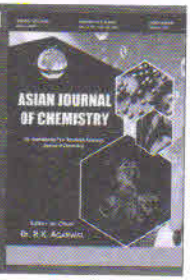
Asian Journal of Chemistry; Vol. 38, No. 2 (2026), 403-410

ASIAN JOURNAL OF CHEMISTRY

https://doi.org/10.14233/ajchem.2026.35011



Effect of Crystallinity and Optical Tuning in Sonochemically Synthesised ZnO Nanoparticles for Enhanced Photocatalytic Efficiency

VIKAS G. PATIL[1,2,*], MADHAV MANE[3], SANTOSH B. KATARIYA[3] and D.V. MANE[4]

[1]School of Sciences, Yashwantrao Chavan Maharashtra Open University, Nashik-420003, India
[2]Department of Sciences, K.J. Somaiya Polytechnic, Mumbai-400077, India
[3]Department of Chemistry, SIES College of Arts, Science and Commerce, (Autonomous) Sion, Mumbai-400022, India
[4]Department of Chemistry, Shri Chhatrapati Shivaji College Omerga, Dharashiv-413606, India

*Corresponding author: E-mail: vikasgpatil8@gmail.com

Received: 5 October 2025 *Accepted*: 30 December 2025 *Published online*: 31 January 2026 AJC-22257

In this work, phase-pure ZnO nanoparticles were synthesized *via* an ultrasonic-assisted sonochemical route and systematically characterized to elucidate their structural, thermal, optical, and photocatalytic properties. Thermogravimetric analysis revealed a minor mass loss (~3.5%) below 400 °C, attributed to the removal of surface-adsorbed organic species, confirming the subsequent thermal stability of ZnO NPs. X-ray diffraction analysis confirmed the formation of a single-phase hexagonal wurtzite structure (space group $P6_3mc$) with a lattice parameter a = 3.517 Å and an average crystallite size of 21.6 nm, as estimated by the Debye-Scherrer equation. Energy-dispersive X-ray spectroscopy verified the stoichiometric Zn:O composition, with trace carbon arising from residual surface species. Scanning and transmission electron microscopy revealed quasi-spherical polycrystalline aggregates with a mean particle size of 48.22 nm. High-resolution TEM analysis displayed well-defined lattice fringes with interplanar spacings of 0.28 nm (100) and 0.26 nm (002), indicating the presence of single-crystalline domains within the aggregates. FT-IR spectroscopy confirmed residual organic functional groups alongside characteristic Zn–O vibrational modes in the 848-404 cm^{-1} range. UV-visible spectroscopy demonstrated a widened direct bandgap of 3.27 eV, indicative of quantum confinement effects. Photocatalytic performance evaluated under 366 nm UV irradiation showed efficient degradation of methylene blue (10 ppm), achieving over 50% removal within 160 min and following pseudo-first-order kinetics. The combined effects of high crystallinity, bandgap modulation and surface reactivity underscore the potential of these ZnO nanoparticles as effective photocatalysts for advanced oxidation processes in environmental remediation.

Keywords: ZnO nanoparticles, Sonochemical method, Methylene blue dye, Photocatalytic activity.