

Synthesis and Characterization of Black Zinc Oxide Nanoparticles Using Ascorbic Acid and Sodium Borohydride as Chemical Reducing Agents

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Structured Abstract

Background: Zinc oxide (ZnO) nanoparticles are extensively studied for environmental remediation and energy applications because of their photocatalytic characteristics. The extensive bandgap of traditional ZnO constrains visible light absorption, hence impeding its efficacy. To resolve this, black ZnO produced via chemical reduction introduces defect states that improve light absorption and catalytic activity. This study investigates the synthesis of black ZnO nanoparticles utilizing two chemical reducing agents, ascorbic acid and sodium borohydride, and assesses their impact on the structural and optical properties of the resultant materials.

Methods: Black ZnO nanoparticles were produced independently utilizing ascorbic acid and sodium borohydride under regulated reduction conditions. The resultant samples were analyzed using BET for surface area, FESEM for morphology, XRD for crystallinity, and UV-Vis NIR for optical bandgap assessment. A comparative analysis was performed to assess the impact of each reducing agent on the particle size, porosity, and light absorption.

Results: Both reducing agents effectively converted ZnO into its black variant, each providing unique advantages. Sodium borohydride generated nanoparticles with reduced dimensions and increased surface area, signifying improved porosity. Conversely, ascorbic acid significantly enhanced absorption in the visible spectrum, indicating a more pronounced effect on electronic defect development. XRD data indicated diminished peak intensities, affirming structural modifications resulting from reduction. FESEM scans consistently demonstrated spherical particles exhibiting porous surface textures. UV-Vis NIR measurement revealed a reduction in bandgap in both samples relative to pure ZnO, indicating enhanced photocatalytic capability under visible light.

Conclusion: This study establishes that the selection of reducing agent is crucial in customizing the characteristics of black ZnO nanoparticles. Sodium borohydride is beneficial for increasing porosity and surface area, however ascorbic acid is more proficient at enhancing visible light responsiveness. These results create new opportunities for enhancing ZnO-based photocatalysts in environmental and sustainable energy applications.

Keywords: Black ZnO Nanoparticles, Ascorbic Acid, Sodium Borohydride, Photocatalysis, Characterization Techniques

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