

Synthesis and Characterization of Black Zinc Oxide Nanoparticles using Coffee and Tea Extract as Eco-Friendly Reducing Agents

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Structured Abstract

Background: Searching for green alternatives in photocatalysis has been driven by the need for ecologically friendly synthesis techniques and sustainable materials. A semiconductor with photocatalytic properties, zinc oxide (ZnO) is often synthesised via severe chemical processes. However, there are safety and environmental issues with these methods because they frequently use complicated equipment and harmful reducing chemicals. This study investigates the green production of black ZnO nanoparticles utilising tea and coffee extracts as natural reducing agents as a sustainable substitute. Because of their improved charge carrier separation and increased light absorption, these black ZnO nanoparticles are being studied as potential homojunction photocatalysts for environmental applications.

Methods: A simple heat treatment method was used to make black ZnO nanoparticles. To make two different ZnO samples (B-ZnO-C-600 and B-ZnO-T-600) and a clean white ZnO control (W-ZnO-600), coffee and tea extracts were used as eco-friendly reducing agents. We looked at the crystal structure with X-ray diffraction (XRD), the porosity with Brunauer-Emmett-Teller (BET) analysis, and the surface shape with field emission scanning electron microscopy (FESEM). Utilising these methods for characterising nanoparticles, we looked at how different reducing agents changed their structure and texture.

Results: XRD analysis confirmed successful synthesis, where coffee-extract-derived B-ZnO-C-600 exhibited reduced crystallinity and greater defect structures, while B-ZnO-T-600 retained a high crystalline phase. BET analysis showed that B-ZnO-C-600 had the highest surface area and the smallest pore diameter, implying enhanced mesoporosity. FESEM imaging further revealed a highly porous, loosely packed structure in B-ZnO-C-600 compared to the more compact forms of the other samples. These characteristics collectively suggest that coffee extract enables a more effective formation of black ZnO suitable for photocatalytic applications.

Conclusion: In conclusion, the findings of this study demonstrates that coffee and tea extracts can successfully act as green reducing agents for the synthesis of black ZnO nanoparticles. Particularly, the coffee extract enhanced porosity and surface area, making it a promising candidate for use in homojunction photocatalysts for environmental remediation applications.

Keywords: Black ZnO, Green Synthesis, Coffee Extract, Photocatalyst, Homojunction

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