Junior Science Communications
Faculty of Applied Sciences, UiTM Shah Alam
https://journal.uitm.edu.my/ojs/index.php/JSC

E-ISSN 2637-0689
Vol 53 2025

Colloquium on Applied Sciences 1 2025
20-24 January 2025, Faculty of Applied Sciences, UiTM Shah Alam, Malaysia

Synthesis and Characterization of Biogenic Tin (Iv) Oxide (Sno_2) from Soybean Extract for Potential Photodegradation of Methylene Blue Dye Molecules

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Structured Abstract

Background: Tin (IV) oxide (SnO_2) nanoparticles are widely studied for their applications in photocatalysis, gas sensing, and optoelectronic devices due to their excellent chemical stability, high surface reactivity, and wide bandgap. However, conventional synthesis methods often rely on hazardous chemicals, raising concerns about environmental sustainability. This study focuses on the green synthesis of SnO_2 nanoparticles using soybean extract as a natural reducing and stabilizing agent, providing an eco-friendly alternative to traditional methods. Four different soybean extract to $SnCl_4 \cdot 5H_2O$ ratios (1:1, 3:1, 5:1, and 7:1) were explored to evaluate their effects on the structural, chemical, and optical properties of the nanoparticles.

Methods: The synthesis involved mixing the precursor solution ($SnCl_4 \cdot 5H_2O$) with soybean extract and subjecting the mixture to stirring, filtration, drying, and calcination at 700°C for 3 hours. The synthesized nanoparticles were characterized using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and UV-Vis diffuse reflectance spectroscopy (UV-Vis DRS).

Results: XRD confirmed the formation of the tetragonal rutile phase of SnO_2, with crystallite sizes ranging from 6.14 nm to 12.58 nm, depending on the parameter. FTIR analysis revealed the presence of bioactive compounds from the soybean extract, which facilitated reduction and stabilization during synthesis. UV-Vis DRS also showed bandgap energies between 3.16 eV and 3.46 eV, with smaller crystallite sizes correlating with slightly higher bandgaps due to quantum confinement effects.

Conclusion: Among the parameters, the 7:1 extract-to-precursor ratio (parameter 4) exhibited the smallest crystallite size and lowest bandgap at 6.14 nm and 3.16 eV respectively, suggesting an increased surface area and better light absorption under UV light, making it the most suitable for photocatalytic applications. These results highlight the potential of biogenically synthesized SnO_2 nanoparticles for environmental remediation, specifically in the photodegradation of methylene blue dye. The findings also emphasize the viability of green synthesis as a sustainable approach to nanomaterial production, paving the way for further optimization and applications.

Keywords: Tin (iv) oxide nanoparticles, biosynthesis, photocatalytic, soybean extract

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