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Chemical Engineering Program

Preparation, Characterization and Applications of Zinc Oxide/Carbon Nanodots Hybrid

Graduation Project 2 (10626594)

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Abstract

In order to generate materials with better qualities, hybrid materials integrate various components. They are significant because they effectively combine desired qualities. These materials are used in buildings, aerospace, automotive, electronics, energy, and healthcare sectors. This study focuses on the synthesis and characterization of zinc oxide (ZnO), carbon nanodots (CNDs), and their hybridization, exploring their application in the photodegradation of methylene blue.

Zinc oxide nanoparticles (ZnO NPs) were successfully synthesized using a microwave-based technique, resulting in a high-quality product with a yield of 17.3%. Using glucose as the precursor, CNDs were simultaneously created using the same microwave-based technique, with a yield of roughly 9.5%. The ZnO-CNDs hybrid was prepared by a one-pot microwave-based technique, where both moieties were created at the same time and combined to form a hybrid with a pale-yellowish hybrid material with a product yield of 13.5%.

The hybridization was attributed to the adsorption of CNDs onto the surface of ZnO NPs, which was made by weak linkage interactions such as van der Waals forces or hydrogen bonds. Additionally, it was observed that using ammonium hydroxide (NH_4OH) instead of sodium hydroxide (NaOH) in the synthesis process significantly increased the yield of the products. Particularly, the yield for ZnO was 27.7%, while for CNDs, it reached 17.3%. The yield for the hybrid material increased even more, reaching 24.4%. Importantly, ammonium hydroxide proved to be a more effective reducing agent than sodium hydroxide in terms of increasing yield.

In the photodegradation application, ZnO and ZnO–CNDs hybrid thin films demonstrated effectiveness in degrading methylene blue. The ZnO-CNDs hybrid exhibits substantial photocatalytic activity, surpassing ZnO, with a degradation efficiency of 70%. while ZnO alone shows an efficiency of 60% after 120 minutes of light irradiation. Photodegradation kinetics reveal an increased rate constant for the hybrid, with values of 0.01162 min^{-1}, suggesting enhanced surface activity compared to ZnO (0.00943 min^{-1}). The apparent quantum yield calculations further emphasize the hybrid's superior performance, with values of 0.023 for the ZnO-CNDs hybrid and 0.019 for ZnO. The

stability of thin films is investigated through multiple cycles, revealing the sustained efficiency of the ZnO-CNDs hybrid, attributed to the homogeneity introduced by CNDs. These findings highlight the promising potential of the ZnO-CNDs hybrid as an efficient photocatalyst for the degradation of methylene blue.