

Copper-zinc oxide nanohybrids for advanced antimicrobial and photocatalytic applications

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ZnO exhibits remarkable photocatalytic and antimicrobial activity as a nanomaterial for diverse applications, including environmental remediation, healthcare, and sustainable energy solutions. However, a major problem with ZnO photocatalyst is that it is active only under UV irradiation owing to its high band gap. Doping transition metals like Cu into the ZnO lattice offers an effective solution to addressing the limitations of pure ZnO, especially lowering the band gap energy. In this research examines the enhanced photocatalytic sterilizing effectiveness of Cu-doped ZnO nanoparticles that are active in visible light. Using the co-precipitation method, Cu-ZnO nanohybrids ($Cu_xZn_{100-x}O$) have been generated using a range of dopant ratios ($x = 0, 3, 5, 7, \text{ and } 10$) at different calcination temperatures of 450 °C and 650 °C to compare their activities. They were characterized structurally by Fourier transform infrared (FTIR), Raman spectroscopy, and X-ray diffraction (XRD). Band gaps of nanohybrids were characterized by Ultraviolet-Visible diffuse reflectance spectroscopy (UV-Vis DRS). Scanning electron microscopy (SEM) images were used to characterize the morphology. The doped percentages of Cu into ZnO network were determined using atomic absorption

spectroscopy (AAS). The Cu 7%-ZnO synthesized at 450 °C nanohybrid, which has the lowest band gap (3.09 eV), exhibited the highest photocatalytic activity against Methylene blue under visible light. Moreover, the Cu 7%-ZnO exhibited the lowest IC50 value of 151 µg/ml compared to pure ZnO, indicating the highest radical scavenging activity. The highest inhibition zones were also shown by the Cu 7%-ZnO against the gram-positive bacteria; *S. aureus*, gram-negative bacteria *E. coli*, *S. sonnei*, *S. typhi*, and fungi; *C. albicans*, while showing its synergistic antimicrobial activity. In conclusion, the Cu 7%-ZnO exhibits enhanced photocatalytic and antimicrobial properties, making it a promising candidate for applications in environmental and healthcare fields.

Key words:

Zinc oxide, Copper, Photocatalytic activity, Antimicrobial activity, Band gap energy

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