



Designing g-C₃N₄/ZnCo₂O₄ nanocomposite as a promising photocatalyst for photodegradation of MB under visible-light excitation: Response surface methodology (RSM) optimization and modeling

Tao Hai^{a,b,c}, Rishabh Chaturvedi^d, Loghman Mostafa^e, Teeba Ismail Kh^f, Naglaa F. Soliman^g, Walid El-Shafai^{h,i}

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Abstract

Creating a Z-scheme heterojunction system can enhance the efficiency of separating and transporting charge carriers responsible for degrading pollutants. Hence, in this study, ZnCo₂O₄ was combined with g-C₃N₄ through a straightforward approach to create a novel Z-scheme heterogeneous nanocomposite. Various techniques were employed to inspect the photocatalysts' crystallinity, morphology, chemical composition, functional groups, band structure, and electrochemical properties. The Photocatalytic degradation of methylene blue reveals that the catalytic activity of g-C₃N₄/ZnCo₂O₄ nanocomposite ($414 \times 10^{-4} \text{ min}^{-1}$) is considerably greater than that of the individual building units (g-C₃N₄: $45.7 \times 10^{-4} \text{ min}^{-1}$ and ZnCo₂O₄ $79.5 \times 10^{-4} \text{ min}^{-1}$). The impact of operational parameters such as photocatalyst dosage (mg), pH, and dye concentration (ppm) on the photodegradation ability of the nanocomposite g-C₃N₄/ZnCo₂O₄ was assessed and optimized based on response surface methodology and central composite design model. The highest level of degradation, reaching 99%, was gained in the optimal condition, including pH=7, 90 mg of g-C₃N₄/ZnCo₂O₄ photocatalyst, and 5 ppm of MB. The photoluminescence and electrochemical impedance spectroscopy results revealed that the significant attenuation of the generated electron-hole pair recombination increased the nanocomposite photocatalytic performance. Also, extensive solar light absorption and adaptation of the band structures of the two semiconductors resulted in increased photocatalytic activity. The addition of scavengers to the photocatalytic test environment showed the importance of the contribution of each active species in the decomposition of methylene blue. The heterojunction photocatalytic system showed good reproducibility and reusability in the reaction solution.