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A Review on Semiconductor Doped Graphitic Carbon Nitride-Based Composites for the Degradation of Tetracycline

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Structured Abstract

Background: Tetracycline (TC) is a persistent presence in water bodies that presents significant risks to human health and the environmental due to their bioaccumulation and contribution to antibiotic resistance. Therefore, photocatalysis using graphitic carbon nitride (g-C_3N_4) based composites has emerged as a promising approach due to its visible-light activity, metal-free characteristics and chemical stability. However, pristine g-C_3N_4 suffers from limited surface area, rapid charge recombination and low efficiency of photocatalysis which brought about the extensive research into systems of semiconductor-doped g-C_3N_4.

Methods: This review was done according to the PRISMA-ScR guidelines. Published journals between 2020 and 2025 has been retrieved from Scopus and Web of Science databases using a combination of selected keywords of "semiconductor" AND "g-C_3N_4" AND "tetracycline". Following duplicate removal, title and abstract screening and full-text eligibility assessment, 31 studies were included in this review. Data has been extracted and analyzed to compare synthesis methods, heterojunction structures and degradation performance.

Results: Studies shows that semiconductor/g-C_3N_4 outperforms pristine g-C_3N_4 in TC degradation. Hydrothermal and solvothermal are the most employed synthesis methods due to their effectiveness in heterojunction formation. Z-scheme and S-scheme heterojunctions show high photocatalytic performance, often achieve over 90% degradation under visible-light irradiation. Retained redox potential, extended light absorption and better charge separation are the main reason for such improvement. Sulfide- and bismuth-based semiconductors remains to be efficient coupling counterparts despite having problems such as photocorrosion, metal leaching and experimental variability.

Conclusion: **S**emiconductor-doped g-C_3N_4 composites have shown as highly effective visible light-driven photocatalysts for TC degradation. Rational heterojunction design is important to overcome the inherent limitations of g-C_3N_4 and achieve high efficiency. However, challenges related with long-term stability, performance standardization and actual wastewater application remains. Future research should focus on standardized testing procedures, comprehensive charge-transfer characterization and scalable, environmentally friendly synthesis for practical treatment of wastewater.

Keywords: Tetracycline, photocatalysis, g-C_3N_4, semiconductor heterojunctions

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