

Photocatalytic Removal and Mechanistic Investigation of U(VI) Using BaTiO₃/g-C₃N₄ Heterojunctions with Enhanced Efficiency

摘要

随着核能的广泛部署，铀污染——尤其是六价铀 U(VI)——已对水生生态系统构成日益严峻的威胁。光催化还原技术作为一种绿色且可持续的环境修复策略应运而生。然而，如何实现高光催化效率并有效利用太阳能，目前仍是一个巨大的挑战。本研究通过简便的水热法，基于合理的能带排列，合成了一系列 BaTiO₃/g-C₃N₄ (BTO/CN) II 型异质结光催化剂，并评估了不同 BTO/CN 配比对 U(VI) 去除效率的影响。在测试的组分中，BaTiO₃/g-C₃N₄-4 表现出最佳的光催化性能，在可见光照射 20 分钟内，U(VI) 的去除效率高达 96.2%，显著优于单一组分及其他复合配比。这种优化的异质结有效地调控了电子能带结构，促进了光生电子-空穴 (e⁻-h⁺) 对的快速分离。此外，异质结界面的协同效应与 BaTiO₃ 固有的铁电特性，显著抑制了电荷载流子的复合，并拓宽了可见光吸收范围，从而大幅提升了系统的整体光催化效率。BaTiO₃/g-C₃N₄ 异质结的合理设计，为开发用于铀修复的高效光催化剂提供了极具前景的策略和坚实的实验基础。

关键词

石墨相氮化碳；钛酸钡；光催化；铀 (VI)；环境修复

Abstract

With the extensive deployment of nuclear energy, uranium contamination—particularly in the hexavalent form U(VI)—has become an escalating threat to aquatic systems. Photocatalytic reduction, has emerged as a green and sustainable strategy for environmental remediation. However, achieving high photocatalytic efficiency and effective solar energy utilization remains a significant challenge. In this study, a series of BaTiO₃/g-C₃N₄ (BTO/CN) type-II heterojunction photocatalysts were synthesized through a simple hydrothermal method with rational band alignment. The effect of different BTO/CN ratios on U(VI) removal efficiency was evaluated. Among the tested compositions, BaTiO₃/g-C₃N₄-4 exhibited the highest photocatalytic performance, achieving a U(VI) removal efficiency of 96.2% within 20 minutes of visible light irradiation—significantly outperforming both individual components and other composite ratios. The optimized heterojunction effectively modulated the electronic band structure, facilitating the rapid separation of photogenerated electron-hole (e⁻-h⁺) pairs. Furthermore, the synergistic effect between the heterojunction interface and the intrinsic ferroelectric properties of BaTiO₃ significantly suppressed charge carrier recombination and extended the visible-light absorption range. This, in turn, substantially enhanced the overall photocatalytic efficiency of the system. The rational design of BaTiO₃/g-C₃N₄ heterojunctions offers a promising strategy and a robust experimental basis for the development of high-efficiency photocatalysts of uranium remediation.

Keywords

Graphitic carbon nitride; Barium titanate; Photocatalytic; Uranium (VI); Environmental remediation

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