Design and optimization of titania-doped carbon nanocomposites for efficient cadmium removal from aqueous solutions

Inorganic Chemistry Communications • Article • 2026 • DOI: 10.1016/j.inoche.2026.116518

Asmaly, Hamza A. [a]; Elbager, Mosaab A. [b]; Kabashi, Nassereldeen [c]; Saleh, Tawfik A. [d]

[a] Interdisciplinary Research Center -Hydrogen Technology and Carbon Management, King Fahd University of Petroleum & Minerals, Saudi Arabia

Abstract

This research aimed to develop and optimize a titania-doped carbon nano-adsorbent composite (CNAs/TiO_2) for the removal of cadmium (Cd2+) from aqueous solutions. Carbon nanotubes and nanofibers were acid-treated and combined with varying ratios of TiO_2 using a controlled impregnation-calcination method. Optimization of synthesis parameters, including titania loading, sonication time, and calcination temperature, was conducted using Response Surface Methodology (RSM) with a Central Composite Design (CCD). Characterization via BET, SEM, TGA, FTIR, and XRD revealed enhanced surface area (increased from 92 to 184 m2/g), improved morphology, thermal stability, and the presence of oxygen-rich functional groups favorable for Cd2+ adsorption. Batch

adsorption experiments showed maximum adsorption capacities reaching 52.81 mg g–1 under optimal conditions. The Langmuir model (R2 = 0.994) best described the adsorption isotherm, while the pseudo-first-order model showed the highest correlation coefficient (R2 = 0.978) among kinetic models. This study fills a gap in the literature by demonstrating how RSM-optimized TiO_2 doping can significantly enhance the performance of carbon nanomaterials for heavy metal remediation, offering a scalable and cost-effective solution for wastewater treatment.

Author keywords

And RSM; Cadmium; Carbon Nano adsorbent; Conical carbon nanofiber; Multiwall carbon nanotubes; Titanium oxide

Funding details

Details about financial support for research, including funding sources and grant numbers as provided in academic publications.

Funding sponsor	Funding number	Acronym
King Fahd University of Petroleum and Minerals See opportunities by KFUPM ↗		KFUPM
Civil and Environmental Engineering Department in KFUPM		

Funding text

The authors confirm that no external funding was received to support this research. The authors sincerely express their gratitude to the Interdisciplinary Research Center -Hydrogen Technology and Carbon Management at King Fahd University of Petroleum and Minerals, as well as the Civil and Environmental Engineering Department in KFUPM (Saudi Arabia), for their invaluable support in facilitating this research.

Corresponding authors

Corresponding author	T.A. Saleh