



Asian Journal of Chemistry;

Vol. 38, No. 1 (2026), 249-264

ASIAN JOURNAL OF CHEMISTRY

<https://doi.org/10.14233/ajchem.2026.34783>



Application of Chitosan-based Zirconia Hybrid Composite Functionalized with Multi-Walled Carbon Nanotubes for Efficient Removal of Humic Acid from Water Samples

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Received: 1 September 2025

Accepted: 20 December 2025

Published online: 31 December 2025

AJC-22245

Humic acid (HA) is abundant in soil and aquatic systems and can hinder wastewater treatment by affecting the removal of heavy metals and other contaminants. Herein, this study presents chitosan-zirconia (CTS-ZrO₂) composites doped with functionalized multi-walled carbon nanotubes (f-MWCNTs) for HA adsorption. The composites were characterized using TGA, BET, EDX, XRD, FTIR and SEM. Batch experiments assessed the effects of pH (2-8), adsorbent dosage (1-5 g L⁻¹), initial HA concentration (10-50 mg L⁻¹), contact time (5-240 min), temperature (25-40 °C), ionic strength, reusability and binary systems. The CT-ZrO₂-f-MWCNTs composite exhibited a maximum adsorption capacity of 32.89 mg g⁻¹ at pH 3, dosage of 2 g L⁻¹, initial HA concentration of 10 mg L⁻¹ and 25 °C, achieving 99.04% removal within 30 min. The adsorbent remained effective after five cycles and isotherm studies indicated that adsorption followed the Langmuir Type II model, suggesting multilayer adsorption.

Keywords: Chitosan, Zirconia, MWCNTs, Humic acid, Adsorption.