

Regenerable Manganese Oxide Sorbents for Efficient Vanadium(V) Removal in Acidic Wastewater: Mechanistic Insights and Sustainable Application

MS. PEIROU LI, RICH CRANE, KAREN HUDSON-EDWARDS AND LAURA NEWSOME

University of Exeter

The remediation of vanadium (V) contamination in acidic aqueous environments remains a critical challenge for sustainable water treatment. This study investigates the efficacy of three distinct manganese oxide (MnOx) sorbents-naturally occurring, commercially sourced, and hydrothermally synthesized variants-for V(V) ion removal under varying physicochemical conditions. Experimental results reveal that MnOx exhibits optimal performance under acidic conditions (pH 2–3), with adsorption capacities significantly influenced by surface charge, pore structure, and crystallinity. Kinetic analyses indicate a hybrid adsorption mechanism involving both physical and chemical interactions, supported by model fits to pseudo-second-order and multilayer adsorption behavior. Remarkably, regeneration experiments using mild acid/base treatments demonstrate stable or enhanced adsorption efficiency over multiple cycles, underscoring the reusability of MnOx. Advanced characterization techniques, including XPS and BET analysis, elucidate the role of surface chemistry and structural properties in V retention. These findings highlight MnOx as a stable, cost-effective sorbent for acidic wastewater treatment, offering insights into scalable and eco-friendly strategies for mitigating vanadium pollution while advancing circular resource recovery.