INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Tailored Cerium-Based Metal Organic Frameworks for Preferential Adsorption of Fluoride Ions

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SHORT ABSTRACT

Activated carbon possesses a wide-ranging ability to absorb various pollutants, and its adsorption effectiveness can be heightened through chemical and physical modifications. Recently, there has been notable interest in adsorbents impregnated with metals, particularly rare earth metal cerium, due to their biocompatibility, non-toxicity, and redox properties. Cerium, abundant in the earth's crust, exhibits a robust bond strength with fluoride, making it effective for water treatment. Despite the efficiency of individual rare earth metals in fluoride removal, their small particle size often makes them impractical. Consequently, we employed cerium and iron to modify activated carbon, synthesizing an adsorbent using co-precipitation and ultrasonication. This research investigates the efficacy of a sonochemical method in synthesizing an adsorbent (AC/Ce/Fe-1) and studying its adsorption capacity for fluoride ions. Characterization techniques, including SEM, EDX, FTIR, and XPS, confirm fluoride capture and reveal enhanced kinetics via ultrasound activation. The adsorption process exhibits rapid fluoride removal, reaching equilibrium in 20 minutes with a maximum capacity of 52.3 mg/g. Additionally, the study introduces nanoporous Ce-based MOFs to further enhance the adsorption process by modifying material morphology, structure, and functional groups. Different Ce-based metal–organic–frameworks were synthesised and investigated for fluoride removal and Ce–Fu MOFs exhibit a maximum adsorption capacity of 64.2 mg/g. Ce–Fu MOFs maintain high adsorption capabilities over multiple cycles. The research continued to develop hybrid MOFs to further enhance the fluoride adsorption capacity. We explore the synthesis of bimetallic MOFs with inorganic nodes connected by a fumaric acid linker for fluoride removal. The adsorbent Ce@Fe1:1 shows rapid kinetics, achieving maximum capacities of 101.3 mg/g. Zeta potential analysis and XPS spectra confirm electrostatic attraction and ligand exchange reactions. The stability of bimetal MOFs under different pH levels suggests suitability for aqueous environments. This work explores promising adsorbents for fluoride removal from wastewater. Scaling up from batch results to fixed bed adsorption columns (FBAC), our study aims to utilize Ce@Fe1:1/PS beads. Parameters such as bed height, flow rate, and initial fluoride concentration significantly influence column performance. In practical application, Ce@Fe1:1/PS achieves successful fluoride removal from simulated Brahmaputra River water. Regeneration with a NaOH solution maintains column efficiency over three cycles. Ce@Fe1:1/PS proves effective for continuous fluoride removal, showcasing potential for industrial applications.