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MXene-Based Superabsorbent Polymer Microparticle (MX/SAPs) for biological Target Enrichment in Water Samples: Optimization and Characterization

Abstract:

Water solutions frequently contain diverse pollutants, including biological contaminants, which pose significant challenges for assessing water quality. Accurate detection and analysis require efficient separation, enrichment, and isolation of specific targets, such as bacteria, from these complex matrices. Absorption-based techniques have a promising potential for concentrating and isolating bacteria, facilitating subsequent detection processes. This study introduces a novel composite of MXene (Ti3C2Tx) and acrylic acid-based superabsorbent polymers (MX/SAPs) designed to markedly enhance bacterial concentration efficiency in water samples, boosting detection sensitivity. Characterization techniques includes scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), and thermogravimetric analysis (TGA). The efficiency of MX/SAP composites in bacterial enrichment was evaluated through concentration fold change (CFC) and recovery percentage (RP) measurements under varied experimental conditions: crosslinking density (Cr%), acrylic acid concentration (AA%), particle size, and MXene content. Each experiment involved adding 50 mg/mL MX/SAPs to 10 mL of solution for 10 minutes, followed by comparing bacterial concentrations before and after treatment. Increasing Cr% from 0.2% to 2.0% resulted in a decrease in CFC from 3.3 to 1.6, coupled with an improvement in RP from 60% to 80%. Elevating AA% from 10% to 50% increased CFC from 1.5 to 2.2 and RP from 60% to 90%. Particle size variation from 90 µm to 270 µm decreased CFC from 2.0 to approximately 1.5, while RP increased from 70% to 90%. Incorporating 1% MXene boosted CFC from 1.5 to 2.0 and RP from 80% to 95%, with further increments to 3% MXene yielding CFC of 2.2 and RP nearing 100%. Optimizing parameters—1.13% Cr, 50% AA, 140 µm particle size, and 1% MXene—resulted in a bacterial CFC of 5.0 and RP of 100%.

Biography

Ehsan Tabesh is a fourth-year PhD student in the Mechanical Engineering department at York University, Toronto, Canada. His academic journey commenced with degrees in Materials Science and Engineering at both the undergraduate and master's levels. Currently, his research focuses on hydrogels, superabsorbent polymers, and microfluidics, with applications in environmental and biological contexts. His research primarily centers on designing and fabricating microfluidic devices tailored for characterizing hydrogel microparticles. His contributions include advancements in superabsorbent polymer microparticles, biomimetic aerogel scaffolds, and nanocomposite coatings aimed at biomedical applications. These efforts are directed towards improving technologies for water quality assessment and enhancing biomedical materials. His work reflects a commitment to addressing global challenges through innovative engineering solutions, emphasizing the integration of materials science with environmental and biomedical engineering disciplines