Microwave-Assisted Synthesis of Al^{3+}-Modified Posidonia Oceanica Fibers for Sustainable Methyl Orange Removal

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Abstract:

This study reports the preparation of hybrid materials based on dried *Posidonia Oceanica* (P.O) fibers modified with 1%, 2%, and 4% aluminum (Al^{3+}) using a microwave-assisted synthesis. This approach offers rapid, energy-efficient, and eco-friendly conditions without the use of harmful solvents. The raw and modified fibers were characterized by point of zero charge (pH_pzc) and Boehm titration, while additional analyses including infrared spectroscopy (IR), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX) with mapping, and X-ray photoelectron spectroscopy (XPS) were performed to investigate their physicochemical properties.

The adsorption performance was evaluated through methyl orange (MO) removal. Kinetic modeling using pseudo-first order, pseudo-second order, and Brouers–Sotolongo models was applied to describe the biosorption process. The results demonstrated enhanced MO uptake, increasing from 0.768 mg g^{-1} for raw fibers to 0.973 mg g^{-1} for P.O–4% Al^{3+} fibers. Aluminum nanostructures were successfully anchored onto the P.O surface, increasing the number of active sites and improving dye removal efficiency. These findings highlight the potential of Al^{3+}-modified P.O fibers as sustainable biosorbents for wastewater purification applications.

Keywords: *Posidonia oceanica*, aluminum, microwave-assisted synthesis, biosorption, water purification