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# Removal of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) from water using novel electroconductive membranes in a hybrid membrane distillation and anodic oxidation process

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## ABSTRACT

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental pollutants that pose serious toxicity risks to both humans and ecosystems. Removing PFAS at trace concentrations remains a significant challenge in advanced oxidation processes (AOPs). This study presents a hybrid anodic oxidation (AO)–membrane distillation (MD) approach that enhances reaction kinetics by concentrating the feed solution. We developed a hydrophobic, electroconductive membrane that enables simultaneous water removal and perfluorooctanoate (PFOA) degradation while optimizing energy efficiency. The MXene-PVDF electroconductive membrane was fabricated via a one-step pressure-assisted deposition of $Ti_3C_2Tx$ (MXene) nanosheets, securely bonded using a carboxymethyl cellulose (CMC)/glutaraldehyde (GA) binder. By fine-tuning the MXene coating, we achieved a high electrical conductivity of 13,300 S/cm. Compared to AO alone, the integrated AO-MD system significantly enhanced PFAS breakdown and reduced total organic carbon (TOC) at ambient conditions. Increasing the current density from 50 to 500 A/m² led to a substantial rise in •OH radical generation, expediting PFOA degradation and mineralization. The oxidation process was initiated by direct electron transfer at the membrane interface, followed by hydroxyl radical-driven mineralization. Beyond improving degradation efficiency, this hybrid system also reduced energy consumption, making it a viable solution for large-scale applications. The MXene-PVDF membrane offers a sustainable strategy for capturing and degrading persistent micropollutants, ensuring safer and cleaner water for both environmental and potable use.

**Keywords:** Per and poly-fluoroalkyl substances (PFAS); MXene; PFOA removal; advanced oxidation processes (AOPs); Membrane distillation