Selective Electrocatalytic Destruction of PFAS using a Reactive Electrochemical Membrane System

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Challenge
Per- and polyfluoroalkyl substances (PFAS) is the umbrella term for a group of fluorinated compounds that have many commercial and industrial uses, and are now ubiquitous in the environment due to their wide-use and persistence to degradation. Research has shown that exposure to some PFAS may be linked to harmful health effects in humans and animals, even at exceedingly low concentrations. The current state-of-the-art for PFAS removal in water is adsorption by granular activated carbon, ion exchange, or reverse osmosis, however, these methods do not destroy the compounds and generate a PFAS-laden waste stream that requires subsequent disposal. Methods that remove and completely destroy PFAS compounds are needed.

Research Approach
This project will investigate the technical/economic feasibility of utilizing a titanium-based (TiO₂) nanoparticle electrocatalyst for simultaneous adsorption and destruction of PFAS in wastewater (see the Figure below). To that end, the research approach is as follows:

1. Electrocatalysts will be doped on selective PFAS adsorbents and deposited on a reactive electrochemical membrane (REM) support.
2. These materials will be thoroughly characterized and refined through computationally guided synthesis.
3. The synthesized materials will be screened at the bench-scale, and the most promising materials will be extensively studied for their reactivity, selectivity, and longevity in real and synthetic reverse osmosis and ion exchange concentrates.
4. Based on these results, a techno-economic analysis (TEA) and impact assessment will be conducted to compare this work to other treatment options and to identify efficient paths for technology scale-up.

Impact
Successful completion of this project will overcome technical limitations of existing PFAS destruction technologies by improving selectivity for PFAS destruction, minimizing toxic byproduct formation, and limiting short-chain PFAS formation. Furthermore, this work will demonstrate that PFAS can be separated and destroyed, in-situ, using two-orders of magnitude less energy than other technologies (e.g., electrochemical oxidation), and generating an effluent with PFAS concentrations below California’s Response Level. The knowledge gained from this work will provide a greater understanding of PFAS reaction mechanisms, which will allow more efficient technologies to be developed to combat this widespread problem.

Figure 1. Schematic of a cylindrical REM used for the treatment of PFAS. Reductive defluorination reactions occur on the Ni/Ti4O7 reactive electrochemical membrane cathode, and oxidation of water to oxygen gas occurs on the IrO2-Ta2O5 mesh anode.

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REFERENCES