RESEARCH BRIEF
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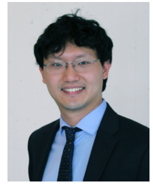
NAWI
National Alliance for Water Innovation

Redox-mediated electrodes for precision separation of nitrogen and phosphorus Oxyanions



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Challenge

Excess nutrients, such as nitrogen (N) and phosphorus (P), when discharged into waterways can lead to eutrophication, algal blooms, and dead zones. Regulatory agencies are limiting discharges from Water Resource Recovery Facilities (WRRF) by increasingly incorporating N and P removal requirements; however, the increasingly stringent regulations have created major engineering and financial challenges for sanitation utilities throughout the country. There is a clear motivation to implement treatment systems that simultaneously treat water and generate a nutrient dense fertilizer product. While coupling biological nutrient removal to chemical precipitation has proven effective in terms of treatment, nutrients are generally transmitted to the atmosphere (as N2 or N2O), or captured within biosolids, along with trace contaminants and pathogenic organisms, which limits their application. Finally, despite their advantages in terms of modularity and sustainability, current state-of-the-art electrosorption technologies (e.g. capacitive deionization) have low adsorption capacities and limited selectivity for N and P in the presence of competing ions. Therefore, there is a pressing need for the development of ion-selective electrochemical systems for the efficient treatment of N and P impact water streams.

Research Approach

The goal of this project is to design, develop, and test efficient and scalable functional redox-polymer electrodes, with high selectivity towards nitrate and phosphate, to overcoming existing limitations with traditional electrosorption materials and address the challenge of nutrient pollution and resource recovery. The team will first focus on the development of nutrient-selective electrodes with enhanced N and P selectivity for efficient capture and removal of nutrients from water streams. Next, we will combine computational approaches and in-situ electrochemical measurements to investigate ion-transport and binding, to understand the underlying mechanisms and guide materials optimization for nutrient removal. Finally, we will develop a process model and technoeconomic analysis framework to compare with existing nutrient removal technologies, and integrate the system with plant-wide modeling software to understand regions and plant capacity needs, to eventually guide deployment of the proposed technology.

Impact

Selective electrosorption technologies for the separation and concentration of charged nutrients could enable a sustainable water treatment paradigm, particularly for small communities that struggle to operate centralized facilities and highly sensitive biological removal systems. The combination of materials design and understanding of the mechanisms for binding will lead to the development of highly-selective electrochemical systems for nutrient removal and recovery. Finally, successful evaluation of these functional electrodes in electrochemical devices for relevant nutrient recovery contexts, and integration with process models could simultaneously minimize discharge and enable reuse, leading to pipe parity.

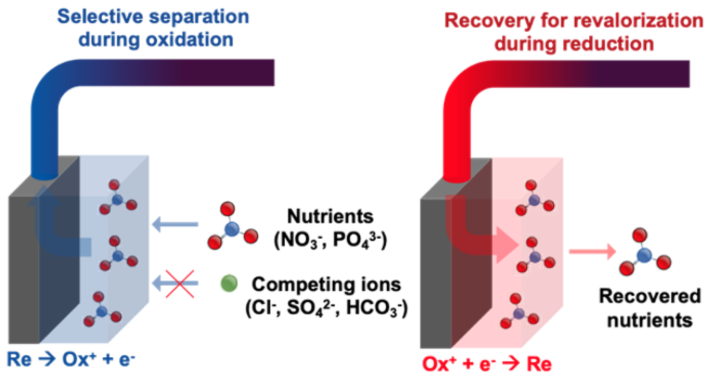

Figure 1. Concept for redox-mediated precision separations of nutrient for sustainable treatment and recovery of impacted water sources.

RESEARCH PARTNERS

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