Multifunctional Ceramic Reactive Electrochemical Membrane Filtrations for Water Purification and Biomass Separation

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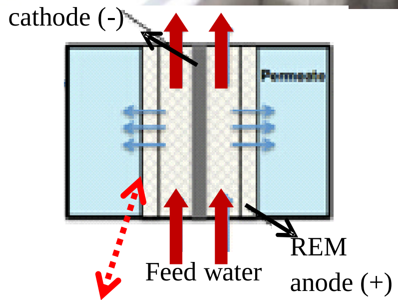
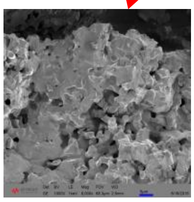
Developing sustainable and efficient membrane filtration technologies is not only critical for safe drinking water supply but also important for many chemical processing or refineries such as biomass separation and biofuel production. Traditional membrane filtration faces major challenges such as polymer aging, membrane fouling, and high costs. This project, under the funding support from NSF Chemical Biological Separation (CBS) program and NSF I-Corp program, will develop an innovative and multifunctional reactive electrochemical membrane (REM) that exhibit great antifouling characteristics and strong surface reactivity. Our research focuses on four aspects: (1) development and testing of a suite of tailored monolithic or nanofibrous REMs in biomass recovery; (2) evaluation of biomass separation efficiency, permeate water treatment, and anti-fouling properties using algae as model organisms; (3) elucidation of cellar disruption and underlying mechanisms of electrochemical oxidation using in situ microfluidic flow cell experiments; and (4) experimental and modeling assessment of membrane fouling and regeneration kinetics and mechanisms. The results will not only provide fundamental guidelines as to the rational design of REMs with controlled and efficient performance, flexible structure, and durability of operation for algal recovery, but also leads to an avenue for the development of a new generation of reactive membranes that can be applied in other disciplines in addition to algal separation (e.g., food processing, drinking water treatment, and biomolecule purification in pharmaceutical industries). Wen Zhang is leading this interdiciplinary resaerch project at NJIT in collaborations with Profs., Danmeng Shuai and Brian Chaplin at George Washinton University and University of Chicago at Illinois.

Biomass engineering such as algal recovery opens possibilities of algae-based renewable energy to potentially reduce our dependence on fossil fuels. This work will make unique contributions to this effort via developing emerging REM filtration systems that incorporate reaction and separation in synergistic ways. The research will further promote water and nutrient reuse in waste streams and microbial cultivation media, which enhances sustainability and reduces water or energy footprints of renewable energy production. Finally, the project is currently training a Ph.D. student (See photo to the right) and a large number of undergraduate and senior high school students to recruited from female and underrepresented groups in STEM via URI and summer research programs at NJIT. Students represent the future leaders of engineering and science, and their participation in this project will help prepare them for careers in academia, consulting, or government agencies.





Cross section view of the porous Ti_4O_7 electrode

Above: My PhD student (Likun Hua) monitored algal growth. Bottom: Schematics of the cross-flow REM filtration process.

The results will lead to ***transformative*** solutions to tackle the grand challenges at energy-water nexus. The project will not only provide fundamental guidelines as to the rational design of REMs with controlled and efficient performance, flexible design, and durability of operation, but also leads to an avenue for the applications of new generations of reactive transformative membranes in many fields in addition to algal separation. For example, REMs can be used in food processing (e.g., wine or milk purification), drinking water treatment, bacterial separation, cellulose separation and oxidation, and biomolecule purification in pharmaceutical industries. Inspired by the need of ***Sustainable Chemistry, Engineering, and Materials (SusChEM)***, the scope of this project aims to employ versatile, efficient, flexible, durable, and sustainable membrane systems to accomplish chemical-free bioseparation and treatment processes for biofuel productions, which also is highly relevant to the field of ***Energy for Sustainability***.