Surfactant-Enabled Nanoscale Modification of Microfiltration Membrane Materials for Wastewater Purification: Dramatic Increase in Selectivity and Productivity

PROJECT SUMMARY

Clean water supply is crucial to sustainable development of a modern society. Membrane technologies have matured as an advanced means of wastewater processing capable of producing of clean water of high purity. However, processing of large wastewater intakes to meet high quality standards established in agri- and aquaculture is expensive. Typically, this involves the use of spiral membrane elements relying significantly on reverse osmosis (RO) and nanofiltration (NF) membranes, and thereby featuring low productivity and high operation and maintenance costs. These factors limit advance of membrane technologies into agri- and aquaculture, where small manufacturers, such as farmers, can not support high water processing costs. In contrast, microfiltration (MF) and ultrafiltration (UF) membrane materials are affordable, productive and operation-friendly, but used by themselves, can not ensure high water quality.

This project is focused on development of chemical means and processes of chemical pre-treatment of MF membrane materials to enhance their selectivity to a degree when they could be used for obtaining treated waters of high quality, thus enabling economically sustainable and environmentally friendly membrane technologies for wastewater processing.

The project team plans to focus on various interatomic/ionic and intermolecular interactions (such as dipole-dipole, H-bonding, etc.) between ions and molecules present in treated waters, and those of pore walls, to develop novel surfactants and processes to:

- enhance pre-concentration at and adsorption on pore walls of a wide range of water contaminants to enable growth (in bi-layers at pore walls, on pore walls, etc.) of nanoparticles composed of the contaminants, so that the nanoparticle dimensions will be comparable to the pore width(s), thus reducing the ratios of the pore- to nanoparticle diameters to the values specific for nanofiltration processes;
- by adjusting chemical and water flow parameters (concentration of surfactants in pore volume and on pore surfaces, composition of bi-layers, pore wall coverage by surfactant(s) and water molecules, temperature, pressure, pore size), manipulate the pore flows into such flow regimes when contaminant nanoparticles and remaining molecular/ionic contaminants will concentrate in the vicinity of pore walls, while allowing uninhibited passage of water molecules through the pores.

The project will use all appropriate methods, devices and tools, including: **(i)** fundamental statistical-mechanical methods; computations, simulations, modeling and visualization of chemical interactions, and kinetic and transport processes in nanofluids confined in pores of polymer and ceramic membrane materials, **(ii)** synthesis and optimization of surfactants for treatment of the pore walls of MF membrane materials; **(iii)** characterization of the surfactant-modified polymer membrane materials; **(iv)** synthesis and characterization of ceramic membranes for the needs of this project; **(v)** field testing of the surfactant-modified membrane materials, and **(vi)** treated water chemistry analysis and quality control.

The project research and management plan includes close collaboration between all teams, information, data, samples, equipment, student and faculty exchange and sharing, project information and result dissemination (through the project web site, professional meetings, publications, patents, media), quarterly meetings of the senior personnel, internal 6-month group and project reports, and yearly project reports to NSF. **The education program of the project** features hands-on student training and exchange, development of new on-line modules, courses and an associate degree program. **Deliverables of the project** include novel surfactants, processes, experimental methodologies, theoretical methods, codes, software, publications, patents and devices that **will build a foundation for a future SBIR project.**

Due to a large work volume, the project duration is 5 years and total budget $2,400,000.