

IsoMemCat – Abstract for the general public

The world is facing a water scarcity problem in the coming years due to population growth and climate change, and there is an immediate need for efficient water treatment methods. Treatment of water is particularly challenged by emerging contaminants, which are continuously discovered in recent years (e.g., polychlorinated biphenyls (PCBs), phenolic compounds, and per- and polyfluoroalkyl substances (PFAS)). They pose a high risk to human health and environmental safety due to their bioaccumulation and environmental persistence; hence they are frequently referred to as “forever chemicals”. Conventional treatment methods, such as chemical coagulation or biological methods (e.g., activated sludge process), fail to remove these substances.

In this regard, membrane-based purification is currently the most effective technology. It is based on semipermeable membranes to separate contaminants. The process produces purified water and a concentrated brine stream. Reverse osmosis relies on membranes with the smallest pore size (ca. 0.1 nm), enabling the removal of all impurities, including mineral ions. This process is, however, extremely slow and requires high pressures, which contributes to high operational costs. Nanofiltration (pore size of 1-10 nm) and ultrafiltration (pore size of 2-100 nm) enable significantly higher flow rates at much lower pressures. As such, they are energetically more efficient. Unfortunately, larger pores reduce selectivity, and the removal of small organic pollutants is particularly challenging. Emerging strategies combine membrane-based purification with catalytical degradation of pollutants.

This project will address challenges associated with the catalytical degradation of pollutants within uniform-pore polymer membranes. Key challenges involve: (1) unclear effect of components of nanofiltration membranes on purification, (2) lack of reliable catalyst loading methods within polymer nanopores, and (3) little-known degradation mechanisms within nanopores. The membranes will comprise block copolymers and liquid crystal components, which will self-assemble into nanoporous structures. Catalytic nanoparticles, such as iron-based ones, will be formed from their precursors and adsorbed onto membrane pores. Fabricated membranes will be studied using advanced characterization techniques in close collaboration with Chinese partners from the University of Science and Technology of China and Donghua University. The methods include, among others, electron microscopy, X-ray scattering, atomic force microscopy, energy dispersive spectroscopy, and X-ray photoelectron spectroscopy. The performance of the membranes will be evaluated using emulated wastewater to assess the perspective of technological application.

Beyond its scientific endeavors, IsoMemCat holds substantial societal relevance. The development of more efficient wastewater treatment solutions has direct implications for public health and environmental protection.