RESEARCH INSTITUTE FOR SUSTAINABLE URBAN DEVELOPMENT (RISUD)

News Article for RISUD Emerging Frontier Area (EFA) Scheme

		Name	Department
1.	**Principal Investigator**:	Yi JIANG	CEE
2.	**Name of EFA:**	Nanotechnology, Environment, and Urbanization Nexus	
3.	**Project Title:**	New paradigm of water separation membranes	

4. **Annual Progress/Achievement (***in layman's language, no more than two A4 pages, pls attach photos***)**

By 2050, 6.5 billion people are projected to be living in urban areas, which then will account for more than two-thirds of the world's population. This rapid and massive urbanization requires the provision of adequate water infrastructure to achieve sustainable growth. The Guangdong–Hong Kong–Macao Greater Bay Area (GBA) is a region particularly susceptible to increasing water stress. The development of innovative water treatment technologies is therefore critical to the sustainable development of the GBA and beyond. Membrane separation is regarded as the most important unit process in the next-generation water and wastewater treatment facilities. A membrane acts as a selective barrier, which allows water to pass through but stops other constituents, such as salts (reverse osmosis), organic matter/bacteria (ultrafiltration), particles (microfiltration), and so forth. The development and application of membrane technology enable us to utilize conventionally underutilized or unexplored water resources such as municipal wastewater.

For the reuse of realistic wastewater, commercial UF membranes demonstrated good performance in removing suspended substances (e.g., TSS, turbidity, certain COD and TOC), but not dissolved ones (e.g., nitrogen, phosphorous, and dissolved COD/TOC). We developed a membrane chemical reactor (MCR) that has achieved high removal of wide-spectrum pollutants in advanced water treatment (***Zhong et. al., Water Research 2023, 231, 119603***). As a proof-of-concept, we report a hollow fiber membrane chemical reactor (HF-MCR) with high and sustainable catalytic reactivity, enabled by novel magnetic confinement engineering of the catalysts (**Figure 1**). Namely, the zerovalent iron (ZVI) nanocatalysts were spatially dispersed and confined to nearly parallel magnetic induction lines, forming forest-like microwire arrays in the membrane lumen. Such arrays exhibited ultrahigh hydrodynamic stability. The HF-MCR integrated sequential membrane separation and Fenton-like catalysis, thus being capable of high and synergistic wide-spectrum decontamination. The membrane separation process completely removed large nanoplastics (NPs) via size exclusion, and thus the subsequent Fenton-like catalysis process enhanced the removal efficiency of otherwise permeated bisphenol A (BPA) and phosphate (P) by in situ generated reactive oxygen species (primarily $^1O_2$) and iron (oxyhydr)oxides, respectively.

Furthermore, highly dispersed ZVI arrays and their continuous surface depassivation driven by magnetic gradient and hydrodynamic forces conferred abundant accessible catalytic sites (i.e., Fe^0 and Fe^{II}) to stimulate Fenton-like catalysis. The consequent enhancement of BPA and P removal kinetics was 3–765 and 49–492 folds those in conventional (flow-through or batch) systems, respectively. Periodic ZVI reloading ensured sustained decontamination performance of the HF-MCR. This is the first demonstration of the magnetic confinement engineering that enables efficient and unlimited catalyst (re)loading and sustainable catalytic reactivity in the MCR for water treatment, which is beyond the reach of current approaches. We have patented this technology (***PCT/CN2023/105929***).

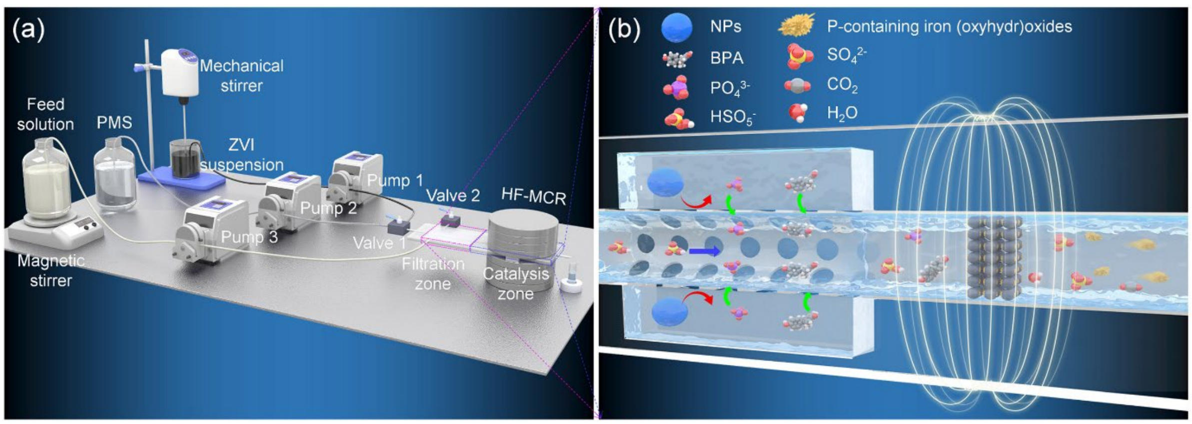

Figure 1. (a) The experimental apparatus and (b) a schematic of multiple decontamination in the HF-MCR. The HF-MCR sustains highly efficient BPA and P removal by (magnetic/flow field-assisted) continuous surface depassivation and (magnetic field-assisted) periodic reloading of ZVI.

This is our latest research output from the EFA project, which represents an important breakthrough in membrane-based water treatment processes. This EFA project aims at developing a new paradigm of membranes that have novel composite structures, by incorporating new functional materials (i.e., carbon nanomaterials and biopolymers) and using advanced manufacturing methods (e.g., 3D printing).