RESEARCH INSTITUTE FOR SUSTAINABLE URBAN DEVELOPMENT (RISUD)

News Article for RISUD Emerging Frontier Area (EFA) Scheme

		Name	**Department**
1.	**Principal Investigator**:	Dr. 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**

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. According to a recent report by CLSA Research, 8 of the 11 Great Bay Area (GBA) cities are already as dry as the Middle East (Guangzhou, Shenzhen, Hong Kong, Macao, Zhuhai, Zhongshan, Foshan, and Dongguan). The 8 cities' per capita water resources fall well below the World Bank's Water Poverty Mark, yet they account for 92% of the GBA's GDP in 2018. The development of innovative water treatment technologies is 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 matters/bacteria (ultrafiltration), particles (microfiltration), and so forth. In spite of its technological advantages, the current hurdle for the large scale application of membrane separation is its high cost and inherent technical flaws, which can be solved by developing a new paradigm of low-cost, high-performance, tailorable water separation membranes.

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) using advanced manufacturing methods (e.g., 3D printing). In the second year of the project implementation, significant progress has been made to achieve such goal. Among many exciting new results obtained, here we highlight two research outputs.

Firstly, we developed a simple yet scalable approach to incorporating functional engineered nanomaterials that enables multi-function and enhanced performance of water treatment membranes. Nanotechnology has offered unique opportunities to advance current polymeric filtration membranes. The application of functional engineered nanomaterials (ENMs) has been shown to enhance water permeability, increase selectivity, and improve anti-fouling performance. Nevertheless, existing membrane modification approaches suffer from low material efficiency, long processing time/tedious processes, and/or no precise control of nanomaterial distribution/location. We developed an efficient and controllable single-step modification approach via electrospray-assisted deposition and incorporation of ENMs (**Figure 1**). The novel method created a new form of membrane surface composite structure via fusion bonding of polymers. This approach relies on no complicated molecular reactions (i.e., anchor sites), has high material deposition efficiency (up to 92%), achieves fast modification (in minutes), and can have scalability using multi-jet electrospray systems. This new approach acts as a technical platform for the synthesis of novel nanocomposite membranes with diverse structures and multiple functions. Further, its scalability using multi-jet electrospray systems sheds light on its potential commercial applications in advancing water treatment and industrial separation membranes. A patent application has been filed for this technology.

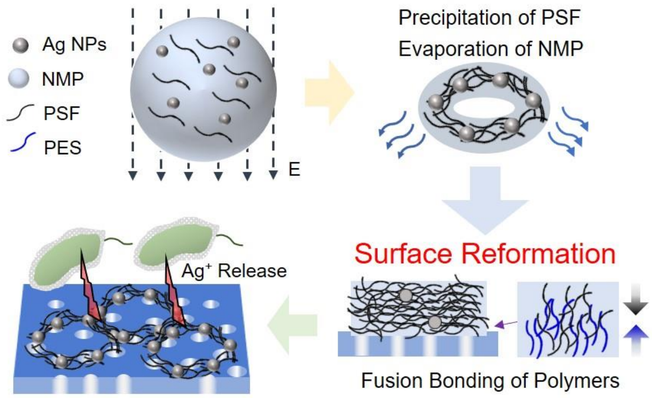

Figure 1. Schematic illustration of the developed membrane surface nanoengineering approach.

Secondly, we developed an ultra-stable, high-performance carbon nanomaterial (nanocarbon) filter for water purification (**Figure 2**). The water filter utilizes the unique material features of graphene oxide, including high specific surface area (e.g., the highest reported values for graphene), tunable surface chemistries (e.g., oxygen functional groups (OFGs) and surface charge) for high adsorption of heavy metals and organic micropollutants, and inherent antibacterial properties (which kill bacteria and viruses). Most importantly, we designed a new, simple filtration system that consists of a (magnetic) carbon nanomaterial filter, magnetizable transition supports, and commercial magnets. With this system, the carbon nanomaterial filter is highly stabilized in a weak magnetic field ($\leqslant$ 0.5 T), and remains intact without any leakage issue, while maintaining the superior filtration/adsorption performance towards typical aquatic contaminants.

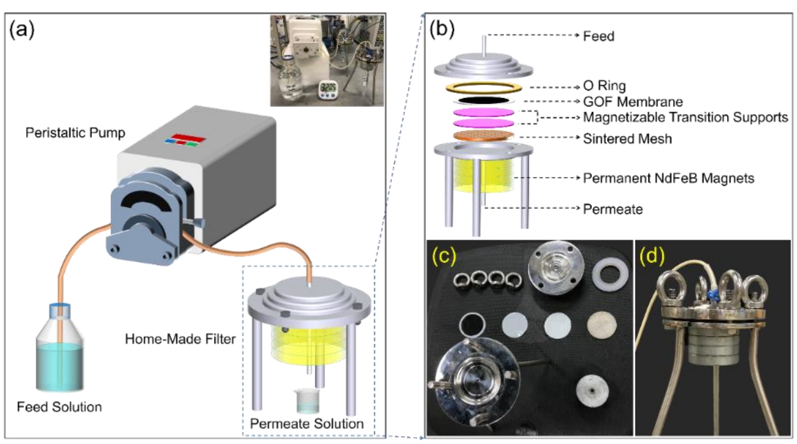

Figure 2. (a) Schematic illustration of the home-made filter setup in a weak magnetic field (inset shows the photographic filtration setup); (b) schematic assembly of the home-made filter setup by parts; parts (c) and assembly (d) of the home-made filter setup.

The success of this project will ultimately produce technology and knowledge that will help the building/upgrading of drinking water and wastewater treatment facilities in Hong Kong (and the rest of the world) in the future.