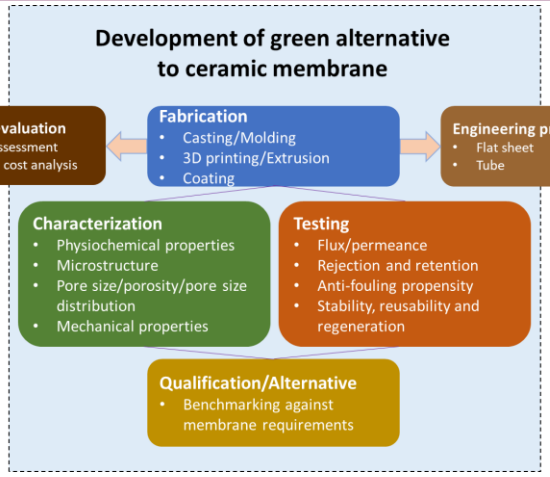
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Nanyang Environment and Water Research Institute

PUB PROGRAMMATIC PROJECTS

NEWRI - Water Programme RIE2025 (NEWRI-PF0022)

- Ceramic membranes have been increasingly used in water treatment, owning to the advantages of ceramic membrane such as lower fouling and higher chemical/thermal stability.
- The high-cost and high-temperature (around 1000 °C) fabrication steps of ceramic membranes impede their widespread applications.
- **Geopolymer membranes** have received much attention, attributed to their low fabrication cost in terms of inexpensive raw materials and curing process (below 100 °C) with low energy consumption.
- To realize large-scale deployment of geopolymer membrane as an alternative filtration medium, three key challenges are identified :
  - I. **Tunability of pore size and porosity**
  - II. **Robust mechanical properties**
  - III. **Scalability of membrane area**
- Exploration of geopolymer membranes as a low-cost alternative to microfiltration (MF) and ultrafiltration (UF) ceramic membranes in water treatment.
- Project methodology:
  - I. **Membrane fabrication.** Various strategies are taken to investigate effects of geopolymer fabrication parameters, e.g., formulation and annealing
  - II. **Membrane characterization**
  - III. **Filtration performance** testing and benchmarking



- Low-cost and green raw materials Low carbon-footprint fabrication process
- TD filed; NTU ref: 2025-352
- Publication in-preparation

PI: Prof. Hu Xiao

NEWRI - Water Programme RIE2025 (NEWRI- PF0004A)

- Continuation from previous IXOM Operations Pte Ltd (now a part of Keppel) funded research collaboration agreement (RCA) project (approximately $1.5M SGD) to undertake a pilot-scale evaluation of **Magnetic Ion-Exchange (MIEX) technology** at PUB's CCK. which led to development of zero liquid discharge (ZLD) solutions.
- Based on the high-value data collected, the joint team has identified new opportunities for near-term research to further optimize the process, reduce/eliminate waste, and increase the resource recovery.
  - I. Evaluation of HF-NF to recover NaCl from MIEX regeneration brine.
  - II. Demonstration of the application of **alternative coagulants** and/or flocculants for DOC solids removal in order to produce cake amiable for fertilizer applications.
  - III. Productization of **post-BORAC (or BORAC alternative) sludge** or post-VSEP COR obtained through the process for applications in agriculture/aquaculture and as sorbent for nutrient recovery.
  - IV. Successful removal of perfluoroalkyl substances (PFAS) from water to meet recommended levels through the MIEX process, and demonstration of MIEX resin regeneration containing elevated concentrations of PFAS.

NEWRI – Water Programme RIE2025 (NEWRI-PF0008)

- Electrochemistry offers a climate-friendly alternative for producing water treatment agents such as hydrogen peroxide (H_2O_2) and ozone (O_3), which are normally made through energy-intensive methods.
- By generating these reactive substances electrochemically from water and oxygen, this approach avoids the need for transport and storage while reducing environmental impact.
- The challenge lies in **improving efficiency and selectivity**, which this project addresses by **developing low-cost catalysts, optimizing electrolyzer parameters, and scaling up to an industrially relevant cell design.** The ultimate goal is to integrate this technology into water treatment systems for sustainable, on-site production of key chemicals for climate-neutral water treatment.
- Novelty:

✓ Low-cost **carbon catalyst** for H_2O_2 electrochemical production from O_2

✓ Structurally-engineered **Pb-based catalyst** to boost Ozone production

✓ Scaled-up **electrolyzer prototype** with reaction surface area > 40cm²

Focuses of Environmental Chemistry and Materials Domain

Sludge volarization

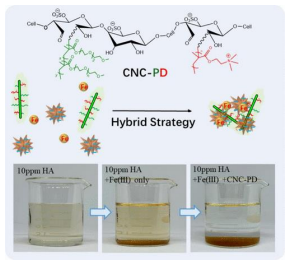
- Waterworks sludge valorized into nano-materials for enhanced nutrient delivery

ACS ES&T Water **2025,** *5* (6), 3230-3240.

- OS: original
- DS: desalt
- DSH: desalt + hydrothermal

Green coagulant

- Biomass-derived high-performance coagulant for dissolved organic compounds



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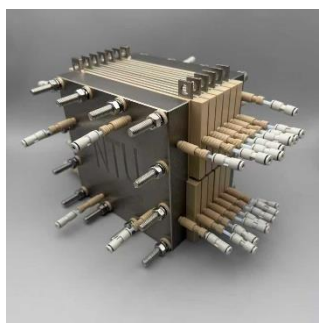
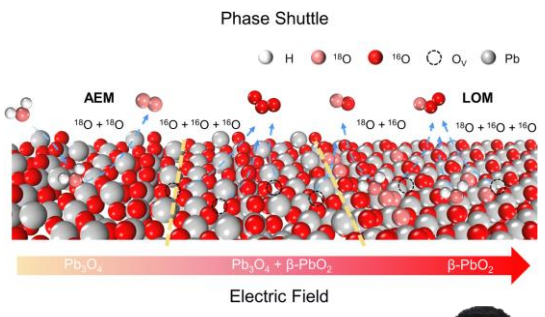
Co-PI: Prof. Hu Xiao

Electrolyzer Prototype



TD: NTU ref: 2025-449

Ozone Production Catalyst



EES Catalysis **2023,** *1* (3), 301-311.

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