Novel High-Throughput Screening Techniques for Membrane Evaluation

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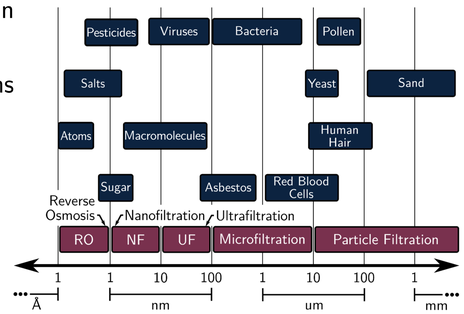
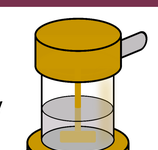
Introduction & Motivations

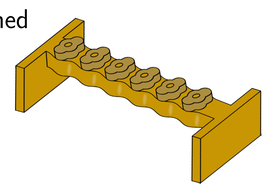
- **Membranes** are used in a wide variety of separations applications
- A critical example involves the use of membranes for **water treatment processes**
- There is a global need for technologies which can **easily** and **economically** remove aqueous contaminants
  - Heavy Metals
  - Pathogens
  - Toxic Chemicals
- The **efficient design** of membranes with **tunable properties** may enable the creation of enhanced water purification devices



❶ High-Throughput Membrane Screening

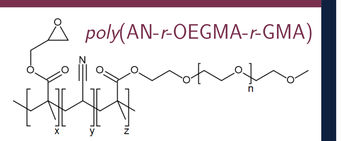
- Traditional membrane performance tests involve a standard *Amicon 8000*-series **stirred cell** apparatus
- However, stirred cell evalution tends to be limited by its **high unit cost** (~$800) and **sequential testing approach**
- To overcome these challenges, we have designed an alternative testing apparatus, the **high-throughput stirred cell (HTSC)** unit:
  - ✓ Up to **six experiments** may be performed simultaneously
  - ✓ Amenable to small sample volumes
  - ✓ Compatible with standard **96-well microplates**





❷ Chemically-Tunable Membrane Adsorbers

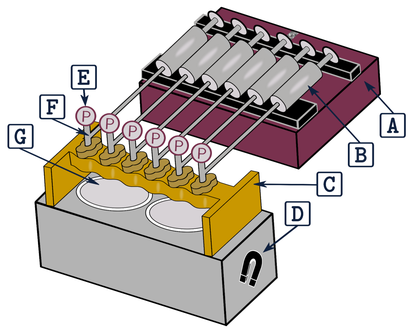
- Using the self-assembly and nonsolvent induced phase separation **(SNIPS)** procedure, we can create copolymer membranes with **tunable, well-defined nanostructures**
- Facile post-fabrication chemical functionalization can precisely tailor the **membrane surface chemistries**
- Precise tuning enables the removal of **specific contaminants**



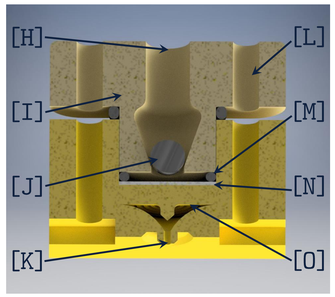
poly(acrylonitrile-*r*-oligo(ethylene glycol) methyl ether methacrylate-*r*-glycidyl methacrylate) copolymer

High-Throughput Screening

❶ HTSC Apparatus Design



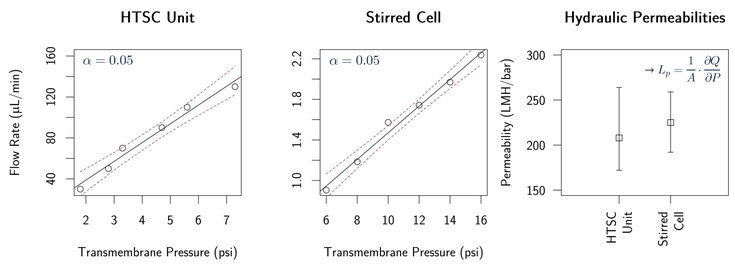
- [A] Multi-rack syringe pump producing constant flux
- [B] Syringes; feed solutions
- [C] 3D-printed HTSC unit
- [D] Magnetic tumble stirrer
- [E] Pressure transducers
- [F] Splitter tees
- [G] Collection plate, or 96-well microplate
- [H] Feed port
- [I] Top manifold
- [J] 5 mm magnetic stir disc
- [L] Clearance holes for bolts
- [K] Exit port
- [M] O-ring seals
- [N] 14 mm membrane disc
- [O] Support grid



Half-section view of an individual HTSC unit.

❷ The HTSC Apparatus as a Stirred Cell Alternative

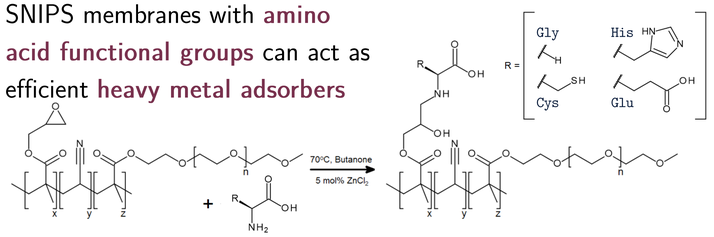
- The HTSC device was validated by **evaluating the permeability** of a standard commercial membrane in parallel with a stirred cell
  - ✓ Millipore Biomax **30 kDa MWCO** PES membrane
  - ✓ **HTSC**: vary volumetric flow rate, measure steady-state transmembrane pressure
  - ✓ **Stirred cell**: vary applied pressure, measure mass flow rate



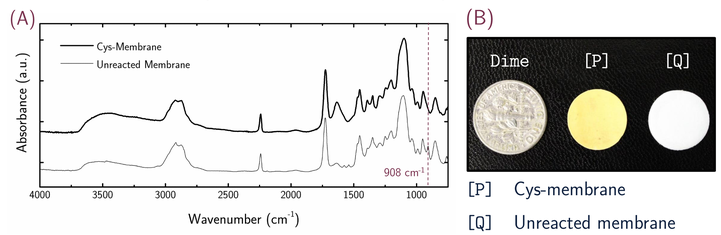
- The HTSC and stirred cell record **comparable permeability** values
- **Future work**: further validate the HTSC through the computation of **sieving coefficients** for model polysaccharide solutions

Membrane Adsorbers

- SNIPS membranes with **amino acid functional groups** can act as efficient **heavy metal adsorbers**



- Reaction of *poly*(AN-*r*-OEGMA-*r*-GMA) membrane with **cysteine**:

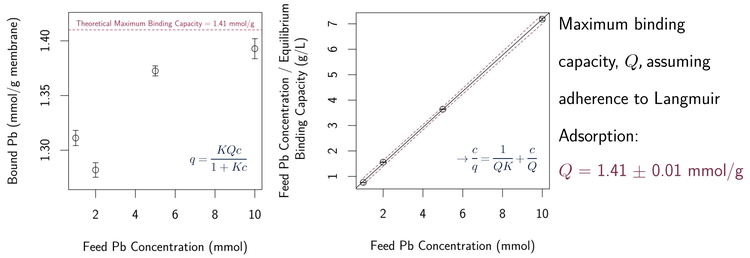


[P] Cys-membrane
[Q] Unreacted membrane

(A) FTIR results indicate that the **epoxide ring**—found in the GMA group of the unreacted copolymer—opens during the reaction

(B) Cysteine groups form **complexes with Au^+ ions** ($KAuCl_4$); the gold-colored membrane suggests the presence of cysteine

- Preliminary results of Cys-membranes used for **Pb capture:**



Maximum binding capacity, Q, assuming adherence to Langmuir Adsorption:

$Q = 1.41 \pm 0.01$ mmol/g

- **Future work**: use the HTSC to **evaluate absorber chemistries** on their heavy metal uptake to **optimize heavy metal capture**

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