# Copper Recovery from Mining Process Waters with Ion-Selective Electrodialysis

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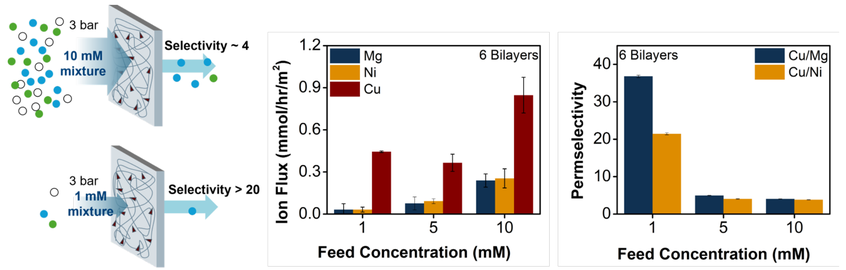
## Introduction

The goal of this project is to develop a **scalable, energy-efficient separation process for recovery of copper** from mining process waters. To achieve this goal, we developed membranes that are strongly permselective towards copper over other dissolved ions, both monovalent and divalent. This was achieved by incorporating the strongly copper-chelating functional group iminodiacetic acid onto the surface of a nanofiltration membrane and using it for copper recovery through a pressure driven process.

## PEG/IDA Membranes

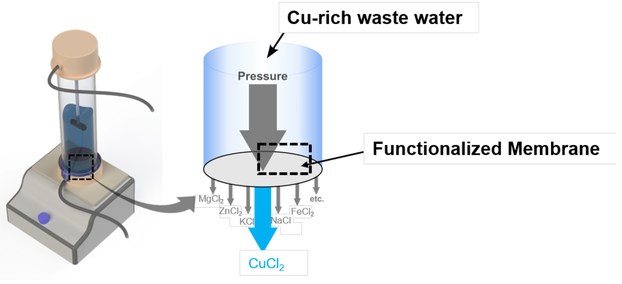
### 1. Overview:

Membranes potentially offer low-cost and scalable routes to critical materials recovery and separation. However, membranes lack sufficient selectivity, in particular when ions of similar size and charge are present in solution. Ligands provide exceptional binding and selectivity, and therefore ligand-functionalized membranes have been of interest for the development of membranes with excellent ion-specific selectivity. In this work, we demonstrate that functionalizing the surface of a membrane with an ion-binding ligand can provide exceptional selectivity, even in mixed feeds and complex matrices such as real mining wastewater. We detail the performance of the membranes and present a mechanism for exceptional selectivity. We also demonstrate the use of our membranes for enrichment of copper from mining waste feed. This work demonstrates an approach for designing ligand-functionalized membranes with exceptional selectivity towards a specific ion, which is relevant for critical materials recovery and other separation processes.




Schematic for ligand-functionalized membrane with selectivity towards Cu. Pressure-driven separation studies show a higher flux for Cu over other divalent cations. The permselectivity increases with decreasing feedwater salt concentration

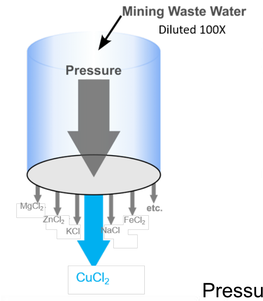
### *Pressure-driven separation and recovery of Cu*

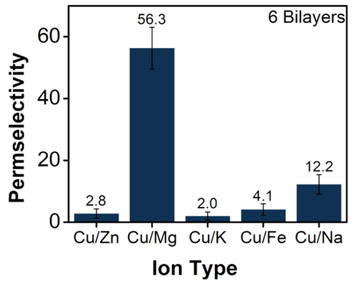


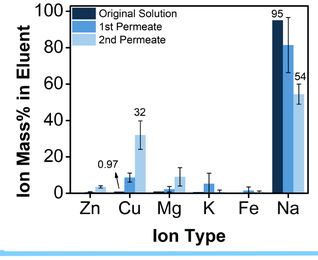

### *Overview of Cu-recovery from Mining Wastewater*

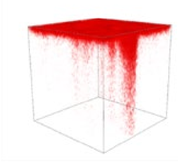
**Mining Wastewater (Freeport McMoran)**

| Element | Concentration (ppm) |
|---|---|
| Zn | 313.74 |
| P | 1735.65 |
| Fe | 571.27 |
| Mg | 1922.30 |
| Ca | 3355.66 |
| Cu | 1830.03 |
| Na | 179025.24 |
| K | 1352.77 |




Pressure-driven separation studies from mining wastewater demonstrated the membranes provided strong selectivity for Cu over other divalent and monovalent cations. Using a two-stage separation process, The Cu mass % among dissolved solids increased from initially 1 wt % to 32 wt %. Surface analysis revealed Cu enrichment on the surface of the membrane, demonstrating the basis for strong selectivity. This work demonstrates that surface functionalization of membranes with ion-selective ligands can provide strong ion-specific permselectivity.

## NAWI CONNECTIONS

**Period of Performance:** October 2022 – December 2025

**Challenge Area/Topic Area:** This project will advance the development of ion-selective charged membranes for use in electric-field driven separations.

**NAWI Leverage**

We have leveraged the expertise of a diverse group of academic, national lab, and industrial collaborators to develop new materials, perform testing, and produce application-relevant advances.

## KEY FINDINGS AND CONCLUSIONS

1. Ion exchange membranes can be surface-modified using thin polymeric coatings to produce strong selectivities towards $Cu^{2+}$
2. Membranes can be used in a pressure-driven process to selectively recover Cu from a real mining wastewater feed.
3. The membrane provides selectivity towards Cu over other divalent cations (Mg, Ni, Fe) and monovalent ions (Na, K).
4. Ongoing work is investigating an electric-field driven selective separation approach.

## REFERENCES

1. *Environ. Sci. & Tech.*, under review

## ACKNOWLEDGEMENTS

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