RESEARCH BRIEF
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NAWI National Alliance for Water Innovation

Copper Recovery from Mining Process Waters with Ion-Selective Electrodialysis

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Challenge

Copper is essential for renewable energy supplies and sustainable development[1]. The copper mining industry utilizes more than 1.3 billion m^3 of water per year, but it is not technologically or economically feasible to selectively extract copper from mining process waters due to the lack of effective copper-selective technologies. State-of-the-art ion-selective processes are non-continuous and require chemical additives, such as precipitation and ion-exchange. Ion-exchange is a simple and established technique for extracting ionic contaminants, but it is generally not selective towards copper and requires regeneration, which can be costly and produce large quantities of brine. Precipitation requires chemical additives (such as NaOH) and suffers from co-precipitation of other heavy metal ionic species, and techniques such as electrocoagulation or galvanocoagulation are still under development. Furthermore, these methods are batch processes which require large amounts of water and chemical additives and produce water that requires further processing.

Research Approach

This project aims to develop an energy-efficient method for the precise separation and recovery of copper ions from mining process water streams through the development and integration of copper-selective membranes in a continuous-flow, electrodialysis (ED) process. We will develop ion-selective cation exchange membranes (CEMs) and coatings by leveraging recent work in which we demonstrated polymeric coatings with strong selectivity towards copper over other metallic ions[2]. We will optimize the composition of the CEMs and coatings for permeability selectivity towards copper and incorporate these materials in an ion-selective ED process. In collaboration with industrial partners, we will test our process on real water samples and with multi-stack ED systems. We will produce a device-scale model for the process and provide a detailed economic analysis[3]. Our work will produce an economically viable, continuous flow approach to the recovery of copper ions.

RESEARCH PARTNERS

Rice University: Rafael Verduzco; University of Texas, El Paso: Shane Walker.

Impact

If successful, copper recovery could achieve pipe parity with conventional treatment of mining process waters and/or reuse at copper mines and refineries while simultaneously improving environmental sustainability. Our work could serve as a platform technology and be used to develop additional ion-selective CEM, targeting other ionic contaminants of interest, such as lead and cadmium.

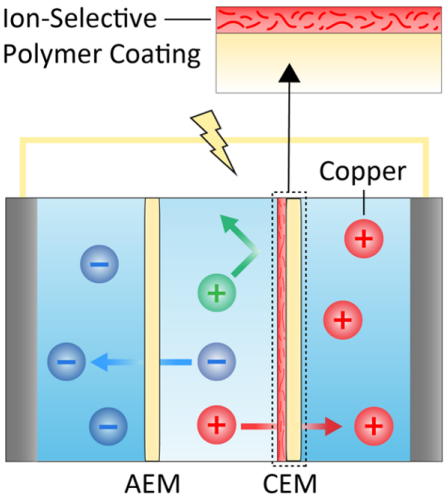

Figure 1. Schematic of the proposed testing system showing selective transport of Copper (red) through the ion-selective cation exchange membrane (CEM).

REFERENCES

1. Moreno-Leiva, S.; Haas, J.; Nowak, W.; Kracht, W.; Eltrop, L.; Breyer, C. Integration of Seawater Pumped Storage and Desalination in Multi-Energy Systems Planning: The Case of Copper as a Key Material for the Energy Transition. *Applied Energy* 2021, 299, 117298. Link here.
2. DuChanois, R. M.; Heiranian, M.; Yang, J.; Porter, C. J.; Li, Q.; Zhang, X.; Verduzco, R.; Elimelech, M. Designing Polymeric Membranes with Coordination Chemistry for High-Precision Ion Separations. *Science Advances* 2022, 8 (9), eabm9436. Link here.
3. Hyder, A. G.; Morales, B. A.; Cappelle, M. A.; Percival, S. J.; Small, L. J.; Spoerke, E. D.; Rempe, S. B.; Walker, W. S. Evaluation of Electrodialysis Desalination Performance of Novel Bioinspired and Conventional Ion Exchange Membranes with Sodium Chloride Feed Solutions. *Membranes* 2021, 11 (3), 217. Link here.

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