Docket #: S23-145

Bipolar Electrodes With Gas-Transporting Layers

Stanford researchers have developed a cost effective replacement for bipolar membrane (BPM) electrodialysis, called bipolar electrode (BPE) that more efficiently splits water into separate streams of protons and hydroxide ions.

The use of acid and base reagents in industrial chemical processes often leads to the production of large amounts of salt by-products. Instead of treating the salt as waste, electrochemical technology can be employed to regenerate acid and base from the salt and water. However, the current state-of-the-art technology, bipolar membrane (BPM) electrodialysis, is neither efficient nor durable for splitting water into protons and hydroxide ions.

To address this issue, Stanford researchers invented the bipolar electrode (BPE) comprised of two catalyst layers surrounding a gas-transporting layer. One catalyst generates a gaseous product (e.g., hydrogen) that is transported to the other layer for oxidation, resulting in separate streams of protons and hydroxide ions. The BPE's performance scalability depends on thermodynamic potentials and electrocatalyst effectiveness, and its design prevents parasitic ion crossover, eliminating the need for ion-exchange membranes, presenting significant advantages over BPMs.

Stage of Development - Prototype

Applications

- Production and recovery of organic acids and bases
- Purification of mineral ores
- Production of cementitious materials

Advantages

- Total blockage of ion crossover
- Lower overpotential
- Increased energy efficiency
- Higher throughput with reduced capital cost
- Easier manufacturing
- Greater durability
- Low cost

Publications

- Wright, J. G., & Kanan, M. W. (2025). Electrochemical Production of > 1 M Acid and Base from Neutral Salt at High Current Density and Low Energy Demand. *ACS Energy Letters, 10*(11), 5328-5335.
- Charnay, B. P., Chen, Y., Misleh, J. W., Wright, J. G., Agarwal, R. G., Sauvé, E. R., ... & Kanan, M. W. (2025). Membrane-free electrochemical production of acid and base solutions capable of processing ultramafic rocks. *Nature Communications, 16*(1), 9759.

Patents

- Published Application: WO2025038149
- Published Application: 20260273993

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