RESEARCH BRIEF
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NAWI National Alliance for Water Innovation

Novel Bipolar Membrane Assisted Electrosorption Process for the Selective Removal of Boron

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Challenge

Boron is ubiquitous in seawater in the form of boric acid at low concentrations (4-6 mg/L) but is toxic for humans and crops, necessitating effective boron removal in seawater desalination. Reverse osmosis (RO) membranes are ineffective in removing uncharged boric acid to the levels acceptable for agricultural use and require additional RO passes operated at high pH for effective boron removal (e.g., Carlsbad, California, desalination plant and all five major desalination plants in Israel). These additional RO passes increase the overall energy consumption by an estimated 10-15%,[1,2] and are non-selective in their separation of boron, removing virtually all solutes (including beneficial minerals that must be subsequently reintroduced), rather than just the few milligrams per liter of boron. An improved method of removing boron would obviate the need for multi-pass RO configurations, reducing energy consumption, capital cost, and chemical dosing requirements.

Research Approach

To this end, the overall goal of the project is to develop a novel bipolar membrane (BPM) assisted electrosorption technology (see Figure) that can selectively remove boron over competing anionic species, is electrified and thus chemical free in operation, and is energy efficient. The project will involve the fabrication of novel boron-selective anodes, performance testing of the boron-selective anodes, process modeling to optimize operating conditions and energy consumption, upscaling the process from bench-scale to pilot-scale, and technoeconomic analysis.

Impact

The proposed work will overcome the persisting inefficiencies in the current state-of-the art boron removal strategies. Successful completion of the work will also provide a demonstration of an effective method for electrosorption of weak acid/base species and selective removal of trace contaminants, critical areas which have yet to be addressed in the electrosorption field. The proposed technology has the potential to largely transform boron removal, particularly in seawater desalination. Additionally, the technology relies on readily available and relatively inexpensive materials which can be used over extended durations. Thus, the levelized cost of water for desalinated seawater will be reduced, improving upon accessibility to seawater desalination and pipe parity.

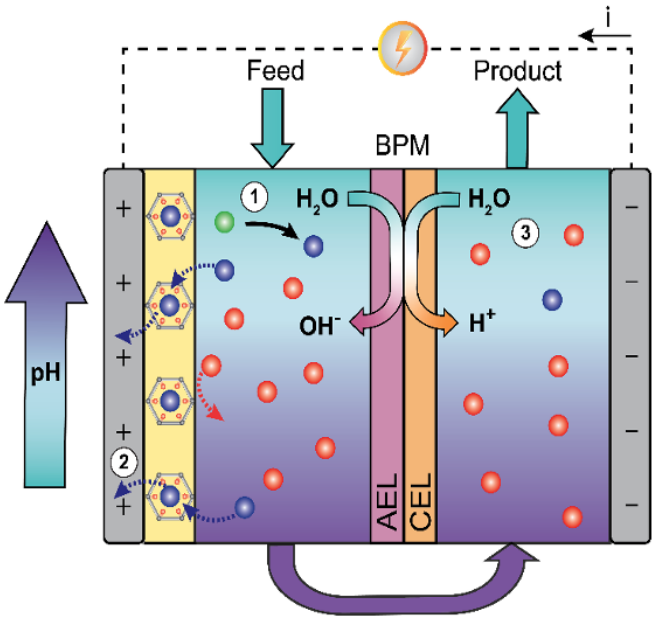

Figure 1. Bipolar membrane (BPM) assisted boron electrosorption process. (1) boric acid (green sphere) is converted to borate ion (blue spheres) under the high pH conditions produced by the BPM on the anode (+) side. (2) the produced borate is selectively electrosorbed by the functionalized anode, while chloride (red spheres) electrosorption is less favorable. (3) the high pH of the boron-depleted effluent is neutralized on the cathode (−) side.

RESEARCH PARTNERS

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