RESEARCH BRIEF
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NAWI National Alliance for Water Innovation

Controlling the Effects of Antiscalants on the Nucleation of Highly Soluble Salts in Reverse Osmosis Concentrate

Young-Shin Jun | Washington University in St. Louis ysjun@wustl.edu

Challenge

To improve membrane-based desalination, various antiscalants (e.g., polyphosphates, organo-phosphonates, and polyelectrolytes) have been added to mitigate Ca-bearing scales.[1] To further achieve zero liquid discharge (ZLD), reverse osmosis concentrate (ROC) that contains antiscalants is sent to a brine concentrator (e.g., a mechanical vapor compressor or electrodialysis) followed by a brine crystallizer where salts precipitate. Indeed, the brine crystallizer is the most energy-intensive unit in the treatment train towards ZLD. A brine crystallizer typically consumes 50–60 kWh_e per m^3 (subscript e stands for electricity) of treated brine, significantly more than a brine concentrator (20–25 kWh_e per m^3) and RO (<10 kWh_e per m^3).[2,3] Reportedly, brine crystallizer processing of the last 12% of the brine volume accounts for 41% of the total treatment cost for ZLD.[4] Inhibiting the formation of sparingly soluble minerals is critical in membrane-based desalination, whereas promoted precipitation of solids is favored in brine crystallizers. However, we lack sufficient knowledge about how antiscalants affect the efficiency of brine crystallizers. This knowledge gap prevents us from improving energy efficiency and reducing the economic cost of ZLD.

Research Approach

In this project, we will systematically examine how antiscalants regulate the nucleation and crystallization of highly soluble salts. Based on the obtained fundamental knowledge, we will develop a predictive model of ROC treatment systems. To promote salt nucleation in brine crystallizers, we will design a new electrochemical approach that controls local pH and degrades antiscalants. Then the subsequent, separately targeted precipitation of sparingly soluble minerals and highly soluble salts will be conducted to reduce energy cost and increase valorization. Our experimental and modeling results will be integrated into techno-economic analysis (TEA) and translated into NAWI's WaterTAP. Ultimately, the proposed work will improve ROC treatment and directly address the needs in Technical Opportunity Area 2: Wastewater and Brackish Water Reverse Osmosis Concentrate (ROC) Treatment Systems.

Impact

The new knowledge from this project will guide the selection of antiscalants and their electrochemical removal, improving the efficiency of brine crystallizers. Rational selection of antiscalant types and doses will significantly reduce the energy consumption and cost of ZLD desalination and enable ROC valorization based upon the reuse of salt crystals. Electrochemically removing antiscalants and scaling ions from ROC will eliminate their unintended negative effects and improve water recovery.

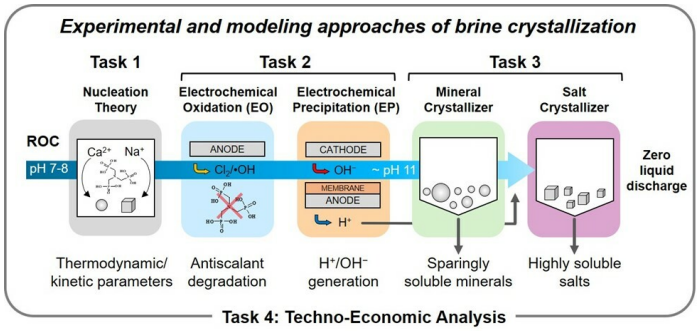

Figure 1. Proposed research task structure with ROC treatment processes.

RESEARCH PARTNERS

Young-Shin Jun, Sang Soo Lee, Tiezheng Tong, Jason Quinn, Yang Yang, Taeyoung Kim, Leslie Miller, Ezequiel Vicent, John Pagan, Bruce Bolliger, Richard Gardner, Charles McCaughey, Patrick Moore, Timothy Bartholomew, Alexander Dudchenko, Argonne National Laboratory, Colorado State University, Clarkson University, OLI Systems, Element Six, Public Utilities, City of Clearwater, FL, Bureau of Reclamation, Swenson Technology, National Energy Technology Laboratory, SLAC National Accelerator Laboratory.

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