RESEARCH BRIEF
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NAWI National Alliance for Water Innovation

Kinetic Modeling and Experimental Validation of Mineralization in High Salinity Brine Solutions with and without Scale Inhibitors

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Challenge

Management of the brine generated as a waste product of reverse osmosis is a major environmental and technical challenge. To achieve high water recovery, brines must be concentrated to high salinities (up to 250 g/L). At these high solute concentrations, unwanted precipitation, called "scaling", limits the efficacy and lifespan of both membrane and evaporative technologies. Anti-scalants suppress the formation of minerals even when solutions are super-saturated and can limit precipitation. However, these can be costly, and the impact of anti-scalants at high salinities are not well characterized.

Research Approach

The goal of this research is to develop a kinetic model to better predict the amount of time it takes for minerals to begin forming in supersaturated brines of various compositions, which ultimately improves the capability of brine concentrators. Advanced synchrotron-based X-ray methods will be used to characterize rates of mineral (calcium, barium, and strontium sulfate and silica) nucleation and growth in a high-throughput fashion, enabling exploration of a large brine chemistry matrix. Moreover, X-ray methods will be used to characterize the chemistry, structure, and morphology of mineral scale in the presence/absence of membrane surfaces under selected conditions. Results will be used to develop and refine kinetic and thermodynamic models that predict the type and rate of mineral scale accumulation. Finally, the models will be validated for laboratory-based membrane systems.

Impact

Current modeling programs are limited in their ability to predict rates of mineral formation under the conditions relevant to RO brine treatment; in particular, at high salinities, in the presence of anti-scalants, and in the presence of surfaces that can induce heterogeneous precipitation. This work will provide foundational knowledge on the rates and mechanisms of silica and sulfate scale, providing a platform for understanding scaling on numerous surfaces, a problem throughout desalination and brine concentration processes. The ability to assess how long it will take for minerals to precipitate will allow operators to predict scaling during development of novel treatment processes and to lower chemical costs and waste volumes.

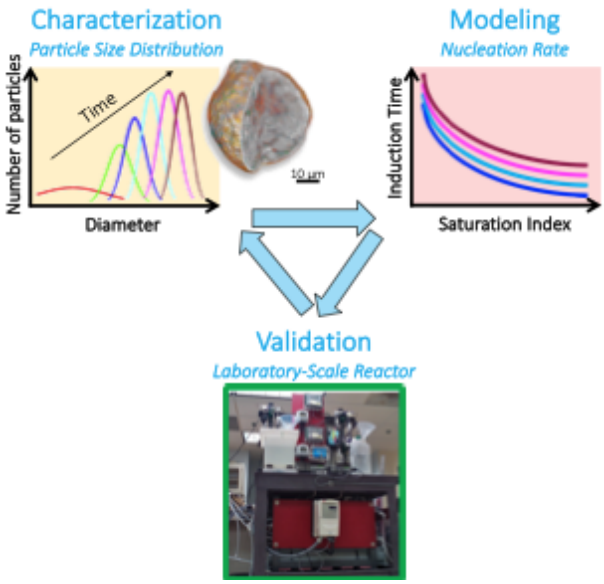

Figure 1. Schematic of approach to predicting mineral scale formation. The rate of mineral scale formation will be monitored to determine the rate of particle nucleation and growth (top left; Meirer et al., Wu et al.). These data are used to generate rate constants that are incorporated into modeling software (top right). The accuracy of newly developed kinetic model is validated by predicting whether and which types of mineral scale form in labor-based reactors (bottom).

RESEARCH PARTNERS

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