5.12 Electromagnetic Field for Membrane Scaling Control

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NAWI National Alliance for Water Innovation

PROJECT SUMMARY

Membrane scaling is a key impediment to the successful implementation of desalination technologies. Conventional chemical treatments for scale control are expensive and may cause health concerns and ecological implications. Electromagnetic field (EMF) treatment is a simple, low-cost, chemical-free, modular, anti-scaling technology with low or no energy demand. However, there are no systematic studies of the fundamental science of EMF treatment. The mechanisms of how EMF works and the underlying complex physicochemical mechanisms involved in water treatment processes are not well understood. This project will focus on modeling, bench-scale experiments, and developing a suite of real-time, advanced characterization methods to elucidate the mechanisms and limitations of EMF for membrane scaling control

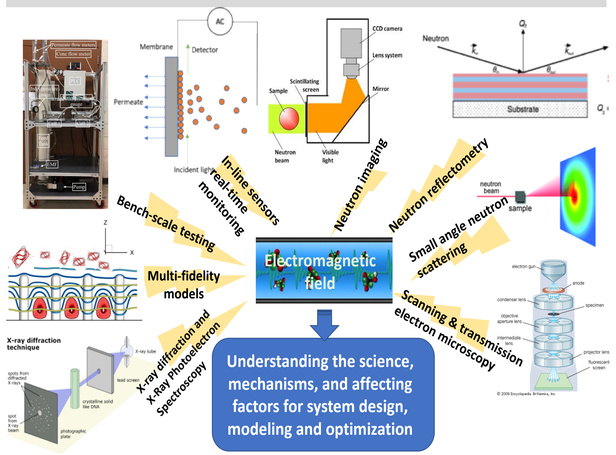


Figure 1. Systematic approach of the study

RO membrane scaling experiments: Gypsum and silica

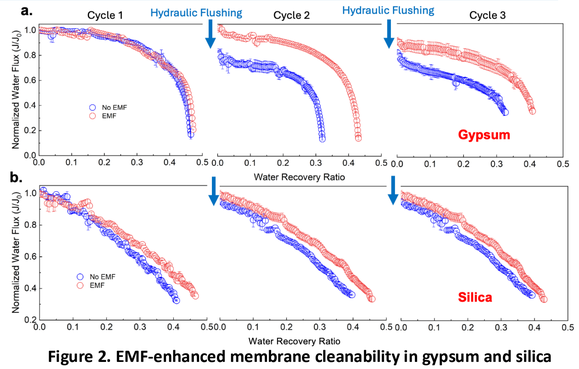


Figure 2. EMF-enhanced membrane cleanability in gypsum and silica desalination

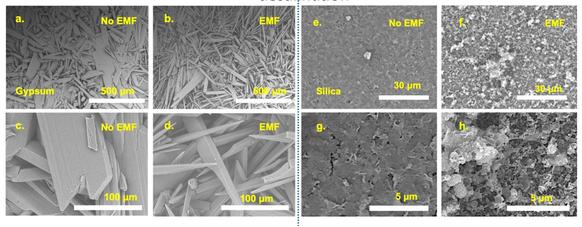
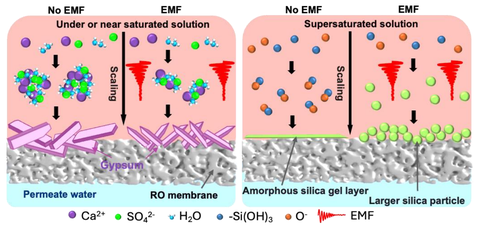
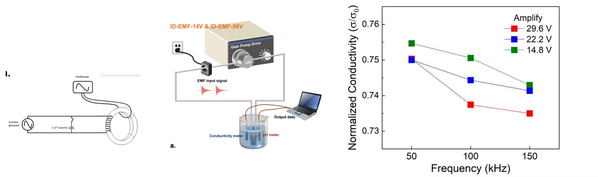


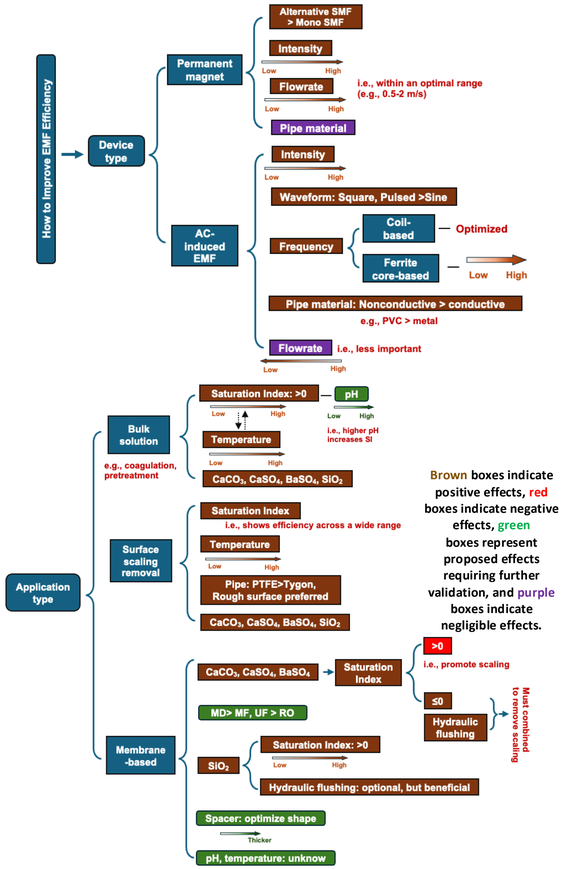
Figure 3. EMF altered gypsum and silica scale morphology



$CaCO_3$ crystallization experiments using self-made EMF device



Optimizing operational parameters to enhance EMF efficiency in scaling control



KEY FINDINGS AND CONCLUSIONS

- EMF forms porous gypsum crystals and larger silica particles, enhancing membrane cleanability and reducing flux decline.
- EMF mitigates gypsum scaling with hydraulic flushing and silica scaling under both HF and non-HF conditions.
- Higher voltage, frequency, and custom waveforms enhance ferrite-core AC-EMF efficiency, while coil-based devices require experimental frequency optimization.
- This study offers the first comprehensive guide linking EMF design, field parameters, and water chemistry for effective scale control.

NAWI CONNECTIONS

Period of Performance: April 1, 2022 to March 31,2025

Challenge Area/Topic Area: Process Innovation & Intensification (PI&I)
This project focuses on fundamental research associated with the NAWI Electrified Treatment Process Challenging Area E1. It aims to develop a novel, low-cost, modular, chemical-free EMF pretreatment for removing hardness and other weakly charged ions (e.g., dissolved silica) from membranes through an improved understanding of the mechanisms affecting the EMF efficiency for PRIMA water qualities. The long-term goal is to develop energy-efficient, low-cost EMF technologies to reduce the carbon footprint and chemical use of water treatment and infrastructure, e.g., membranes, heat exchangers, and pipelines.

NAWI Leverage
NAWI has enabled utilizing the resources at national labs to determine the changes in fluid structures and dynamics leading to the EMF effect. We also used Small Angle X-ray (SAXS) measurements at SLAC for real-time monitoring of nucleation in EMF and with antiscalants.

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