Enabling Roll-to-Roll Manufacturing of Bipolar Membranes Using Microscopy

Abstract Number:165

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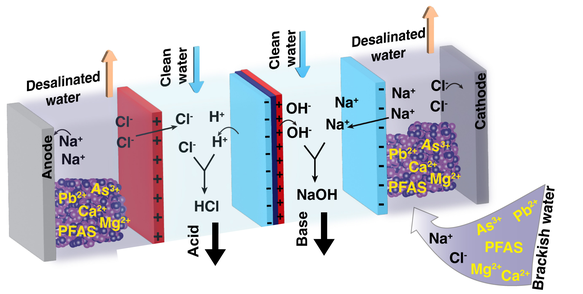
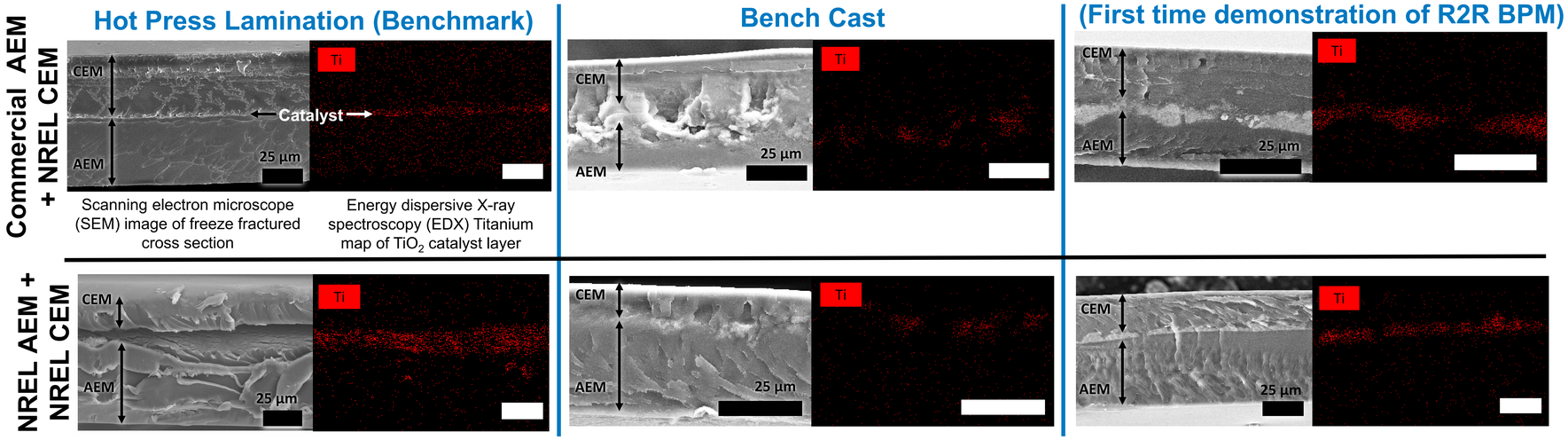
Microscopy can identify key processing parameters to be optimized to ensure bipolar membrane interface junction quality at the micro and nanoscale during manufacturing

Electrification of Water Treatment for Inland Desalination



Bipolar membrane electrodialysis (BMED) system for brine valorization

- BMED Advantages: Small area footprint, lower energy input compared to evaporation technology, recovers more water and valuable resources compared to deep well-injection
- BMED Challenges: Scalable manufacturing of bipolar membranes, interface stability
- BMED provides a solution for water and resource recovery from sources such as inland desalination brine that are difficult and expensive to dispose of using conventional methods such as evaporation ponds or deep well injection



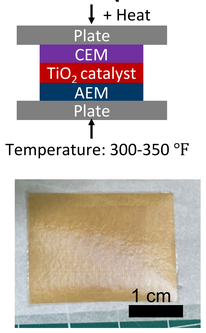
- Hot pressed membrane catalyst layers are uniform and continuous
- Hot pressed NREL AEM + NREL CEM delaminated at the interface easily due to incompatible catalyst binder material – need to optimize material choice

- Catalyst layer is visually nonuniform for both bench cast BPMs
- Thickness of NREL CEMs and NREL AEMs vary due to different polymer properties– need to optimize processing parameters (e.g. polymer solution concentration, coating thickness) to ensure optimal membrane performance

- R2R catalyst layers look more continuous than bench cast catalyst layers
- Thickness of layers vary – need to optimize processing parameters to ensure repeatable manufacturing and membrane performance

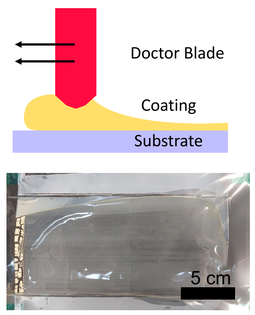
Bipolar Membrane (BPM) Fabrication

Method 1. Hot Pressing Lamination (Benchmark)



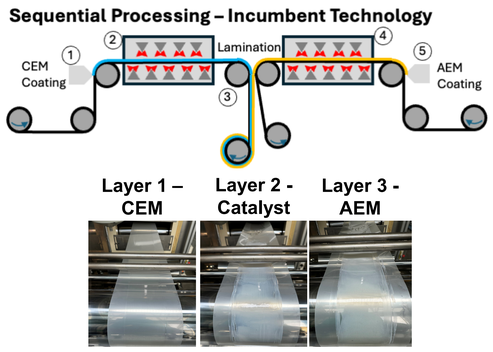
Method 2. Bench-Scale Solution Casting

(Used for obtaining processing parameters before R2R)



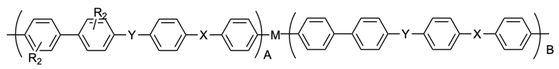
Method 3. Roll-to-Roll (R2R) Casting

Goal: Scalable BPM fabrication technique

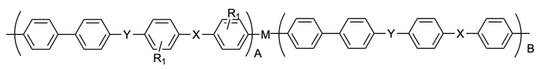


Membrane Materials

- Commercial ion exchange membranes (IEMs):
  - Proprietary commercial AEM (fluorinated)
- NREL-fabricated IEMS (all hydrocarbon, fluorine-free chemistries) :
  - Novel block copolymer AEM



  - Sulfonated Polysulfone CEM



Significance & Future Work

- Microscopy can examine BPM interface junction quality to enable high quality, scalable manufacturing of BPMs using commercializable R2R technology
- Need to determine a quantifiable parameter from microscope images to describe interface junction quality
- Microscope images can be used to compare interface junction pre- and post- electrodialysis operation to determine changes due to mechanical or chemical degradation
- Establishing structure-performance relationships requires correlating interface morphology to BPM electrodialysis performance

This work was authored by the National Laboratory of the Rockies for the U.S. Department of Energy (DOE), operated under Contract No. DE-AC36-08GO28308. Funding provided by National Alliance for Water Innovation (NAWI). The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

This poster was produced when the laboratory operated as the National Renewable Energy Laboratory (NREL). The laboratory is now the National Laboratory of the Rockies (NLR).

North American Membrane Society
Nashville, Tennessee
May 19-21, 2025
NLR/PO-5900-94747