Ameliorating interfacial transport resistances in electrochemical desalination cells using patterned ion-exchange membranes and ionomer infiltrated electrodes

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US Marine missions require technologies that produce potable water from various water sources including both seawater and ground water. Reverse osmosis (RO) is widely used, it is only cost-competitive and practical when deployed in large, centralized production facilities and is not conducive for marine squad units. Membrane capacitive deionization (MCDI) is an alternative water desalination platform that is enticing to military missions as it does not require high pressure piping and it does not generate significant acoustic, thermal, or electromagnetic signals. MCDI removes ions from the liquid solution using electrical energy, and the commercialized variant, flow-by MCDI, feature two porous electrodes covered by ion-exchange membranes. During deionization, the positively biased electrode has an AEM in front of it while the negatively biased electrode contains a CEM in front of it. Our previous research improved the energy efficiency of MCDI by using IEMs with lower area-specific resistance (ASR) values and porous ionic conductors in the spacer channel that augment solution conductivity and curtail ohmic losses. This talk highlights our recent work examining ionic charge transport resistance at the membrane electrode interface in MCDI. We studied the impact of this resistance on MCDI performance metrics (salt removal and ENAS) by systematically changing the interfacial area of the ion-exchange membrane-electrode interface via patterning of the ion-exchange membrane surfaces using soft-lithography. Micropatterned AEMs and CEMs based upon poly (phenylene alkylene) backbones were fabricated with periodic line and cylinder topographies and lateral feature sizes that vary from 9 to 20 μm. The patterned membranes were also combined with ionomer infiltrated electrodes.