Hawai'i Natural Energy Institute Research Highlights

Advanced Materials

Forward Osmosis Draw Solutions for Seawater Desalination

OBJECTIVE AND SIGNIFICANCE: The objective of this project is to fabricate a forward osmosis (FO) system and develop novel inorganic salts and ionic liquid draw solutes for use as energy efficient, high water flux, and low toxicity draw solutions in FO water purification. If successful, the novel draw solutes would lead to efficient sea water and brackish water purification using minimum amount of electrical energy compared to current state of art reverse osmosis (RO) or FO technologies.

BACKGROUND: FO is a promising low pressure water purification technology with low electrical energy use potential that is less hindered by the drawbacks of high hydraulic pressure of RO water purification technology. The widespread commercialization of FO technology is challenged by a lack of practical, cost competitive draw solute materials with high osmotic pressure and low reverse draw solute diffusion that can be efficiently separated from the desalinated water.

FO offers opportunities for higher water recovery efficiencies and lower membrane fouling. FO uses the osmotic pressure of a concentrated draw solution to pull water at low pressure with subsequent recovery of the fresh water from draw solute. A variety of draw solutes, including metal salts, organic compounds and synthetic materials (e.g. polymers, hydrogels) have been studied to date. Responsive solutes that can facilitate the separation of the draw solute from the desalinated water offer the greatest promise. For instance, the state of art ammonia/carbon dioxide thermally responsive draw solute is efficient in water recovery. However, the draw solute is hindered by the incomplete recovery of the ammonia, therefore, the desalted water remains contaminated with residual ammonia. Hence, novel draw solutes are needed in order to fully realize the intrinsic benefits of forward osmosis water purification technology compared to state of art technologies.

PROJECT STATUS/RESULTS: Our research is focused on fabricating a precise and accurate FO water purification system, followed by development of inorganic salts and ionic liquid based draw solutes with high desalination performance that can be efficiently separated from water utilizing thermal, electrochemical, or magnetic draw solute recovery processes incorporating renewable energy sources or low grade energy sources, such as waste heat.

Over the last year, we finalized the benchmarking of the performance of the custom fabricated FO system using commercial draw solutes (potassium chloride and ammonium chloride) to allow for in-depth draw solutions (DS) development and evaluation. We screened the performance of various draw solutions (including potassium lactate, EMIM acetate, glucose and potassium gluconate) on the optimized FO system using DI water or seawater obtained from Ala Moana beach as feed solutions. The performance evaluation of draw solutions using seawater as feed solution, indicated relatively high-water recovery and water flux with the new draw solutions of potassium lactate and EMIM acetate ionic liquid. The non-toxicity of the potassium lactate draw solution makes it usable for multiple applications. Further work will include optimizing the potassium lactate water recovery and regeneration process.

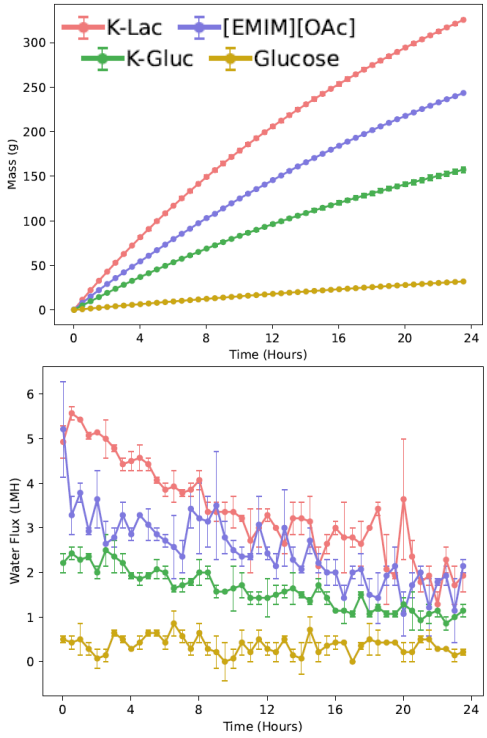

Figure 1. Mass of water recovered from Ala Moana Seawater feed solution over time (top) and the corresponding change in water flux (bottom).

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