Hawaii Natural Energy Institute Research Highlights

Electrochemical Power Systems

Water Purification with Ion Exchange Membrane and Porous Media

OBJECTIVE AND SIGNIFICANCE: To develop a novel, low-cost water purification technology with ion exchange membrane and porous media. The novel method utilizing low-grade heat may reduce the energy consumption to less than 1 kWh/m³ for seawater desalination. It will benefit to more than 50% of the U.S. population lives within 50 miles of the coast, and contribute towards meeting the worldwide increasing demand for fresh water.

BACKGROUND: The demand for fresh water is increasing due to the rapid population growth and economy development. Brackish water desalination and wastewater reuse are the potential solutions to addressing the water shortage and sustainability. Currently, there are around 20,000 desalination plants with a total capacity of hundred million cubic meters of water per day. These systems utilizing either membrane or thermal processes include: reverse osmosis (RO), nanofiltration, forward osmosis, electrodialysis (ED), membrane distillation (MD), multi-stage flash (MSF) distillation, multiple-effect distillation, dew-vaporation, directional solvent extraction, and thermal-ionic desalination. Among the four mature technologies, RO and ED are two membrane processes, whose advantages are offset by the large consumption of high-grade energy (electrical or mechanical energy) for maintaining high pressure and the limited current density due to ion depletion at the solution–membrane interface, respectively, as well the scaling and fouling issues. MSF distillation is a thermal process operated within 90 -110 °C with a highest energy consumption since the phase changes. MD is a relatively new technology, utilizing porous hydrophobic membranes and thermal process derived by vaper pressure differential. But the processes still involve phase changes, which reduce the energy efficiency and the wetting issue increases the fouling risk.

At HNEI, a novel water purification method is being developed based on both membrane and thermal processes. The method is applying an ion selective membrane and porous media and operated below 80 °C. Similar to MD, hot brine or waste water is fed in one side of the membrane and permeate comes out from another side as fresh water; the salts, particles and other undesirable molecules are blocked and flow out as concentrate or waste. Compare to MD, the novel method employs a dense hydrophilic ion selective membrane other than a porous hydrophobic membrane. The separation processes are suspected subject to a specific driving force of water activity but not the vaper pressure, though both differentials are originally from thermal gradients. The benefits of the novel method include:

- No phase change lowers energy consumption;
- Operation below 80 °C facilitates low-grade heat utilization;
- Ion selective membrane increases ions rejection rate;
- Simple process reduces pretreatment requirements.

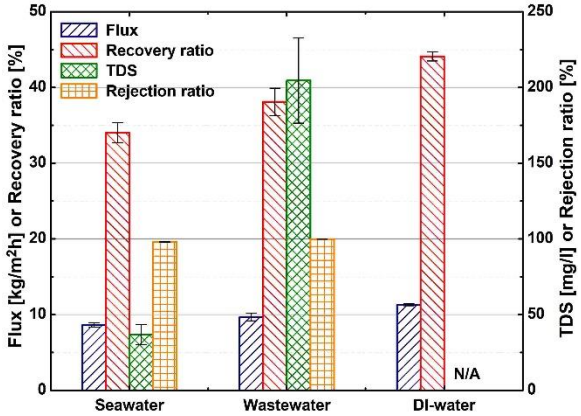

Figure 1. Purification performance of the novel method

PROJECT STATUS/RESULTS: Initial tests indicate less than freshwater standard (500 mg/l) of total dissolved solid (TDS) in permeate, significantly improved recovery (> 30% with > 99% ions rejection) and productivity (~ 8.6 or 9.7 kg/m2h for desalination and wastewater treatment) comparing to the state-of-the-art MD system. In future, low-grade heat will be applied for a lab-scale prototype; components will be optimized for better performance and efficiency.

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