Electronic Supplementary Material (ESI) for RSC Advances

Integrated Salinity Reduction and Water Recovery in an Osmotic Microbial Desalination Cell

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Supplementary Information

Materials and Methods

OsMDC setup and operation

Both OsMDC and MDC were made of glass reactors with three chambers, anode, middle and cathode. In the conventional MDC, an anion exchange membrane (AEM, Membrane International Inc., Ringwood, NJ, USA) was installed between the anode and the middle chambers; in the OsMDC, the AEM was replaced by an FO membrane (Hydration Technology Innovations, LLC, Albany, OR, USA). The cathode and the middle chambers were separated by a cation exchange membrane (Membrane International Inc.) in both MDCs. The liquid volumes of the anode and the cathode chambers were ~ 60 mL each. The middle chamber was linked to an external storage bottle and the total saline water volume was 75 mL. Both the anode electrode and cathode electrode were carbon brush (Gordon Brush Mfg. Co., Inc., Commerce, CA, USA). Before use, the brush electrodes were pre-treated by immersion in acetone overnight and heated at 450 ºC for 30 min.

The OsMDC and MDC were operated at a room temperature of ~ 20 ºC. The anode was continuously fed with a solution (artificial wastewater) prepared containing (per L of tap water): sodium acetate, 4 g; NH_4Cl, 0.15 g; NaCl, 0.5 g; $MgSO_4$, 0.015 g; $CaCl_2$, 0.02 g; $NaHCO_3$, 0.1 g; KH_2PO_4, 0.53 g; K_2HPO_4, 1.07 g; and trace element, 1 mL.[1] The cathode was continuously fed with (per L of tap water): K_3FeCN_6, 32.926g, KH_2PO_4, 5.3 g and K_2HPO_4, 10.7 g. The flow rates of anolyte and catholyte were both 0.17 mL per min, resulting in a hydraulic retention time of 5.9 h in each chamber. The anolyte was recirculated at 30 mL/min. The saline water was prepared by dissolving either NaCl (5, 10 or 20 g/L) or aquarium sea salt (35 g/L. Aquarium Systems, Inc., Mentor, OH, USA) in tap water. The middle chamber was operated as a fed-batch with a cycle of three days and the saline water was recirculated at 15 mL/min. The OsMDC was operated for more than 5 months and a “3-day” cycle of a batch was adopted for data collection.

Measurement and Analysis

The cell voltage was recorded every 180 seconds by a digital multimeter (2700, Keithley Instruments, Inc., Cleveland, OH, USA). The pH was measured using a benchtop pH meter (Oakton Instruments, Vernon Hills, IL, USA). The conductivity was measured by a benchtop conductivity meter (Mettler-Toledo, Columbus, OH, USA). The ionic concentrations were measured using two ion chromatographs (Dionex, Sunnyvale, CA, USA). Water flux into the middle chamber was measured by using digital scales for the change of water weight during the course of experiments. Water flux was either expressed in mL or calculated as liter per surface area of the membrane per hour (L m^{-2} h^{-1} - LMH).

Electrochemical impedance spectroscopy measurements were performed in a cell of two compartments separated by the membrane to be measured. We measured the impedance across the membrane using a potentiostat (Gamry Instruments, Warminster, PA, USA) in a four-electrode mode, which includes two platinum electrodes as the working electrode and the counter electrode, and two Ag/AgCl as the reference electrodes. The frequency was set at the range of 0.01Hz~100kHz. The electrolyte was a NaCl solution of 35g/L. The resistance measured at high frequency represents the combined solution and membrane resistance R_{m+s}. To obtain the pure membrane resistance R_m, the combined resistance is deducted by the solution resistance R_s obtained from a blank experiment without the membrane over the same frequency range.[2] To assure accuracy, we immersed the membrane in the electrolyte for 24h before measurement.

References

1. Z. He, N. Wagner, S. D. Minteer and L. T. Angenent, *Environ. Sci. Technol.*, 2006, **40**, 5212-5217.
2. J.-S. Park, J.-H. Choi, J.-J. Woo and S.-H. Moon, *J. Colloid Interface Sci.*, 2006, **300**, 655–662.

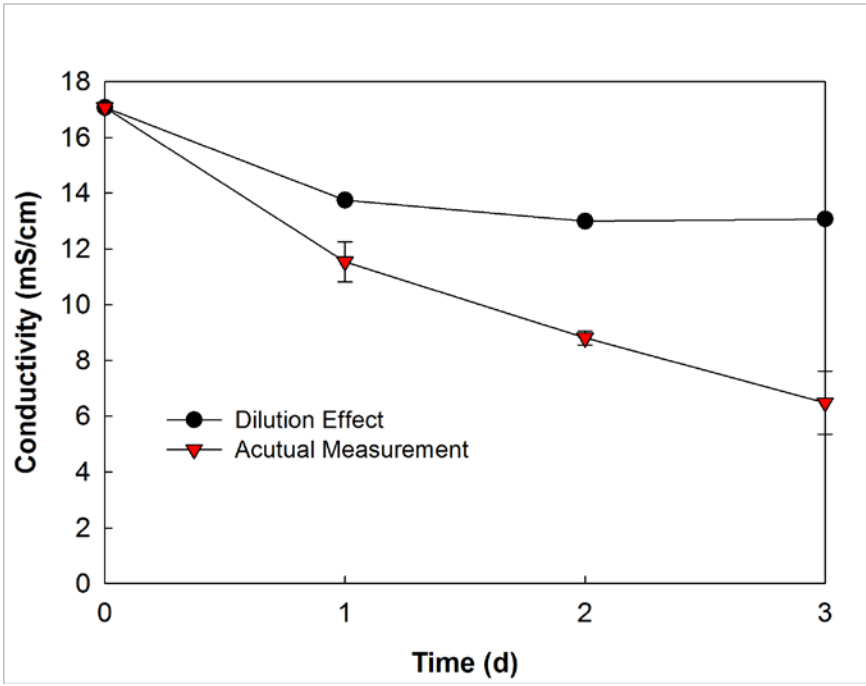

FIGURE S1. The conductivities of the saline water (initial concentration of 10 g/L) from the actual measurement and the estimation with dilution effect only.

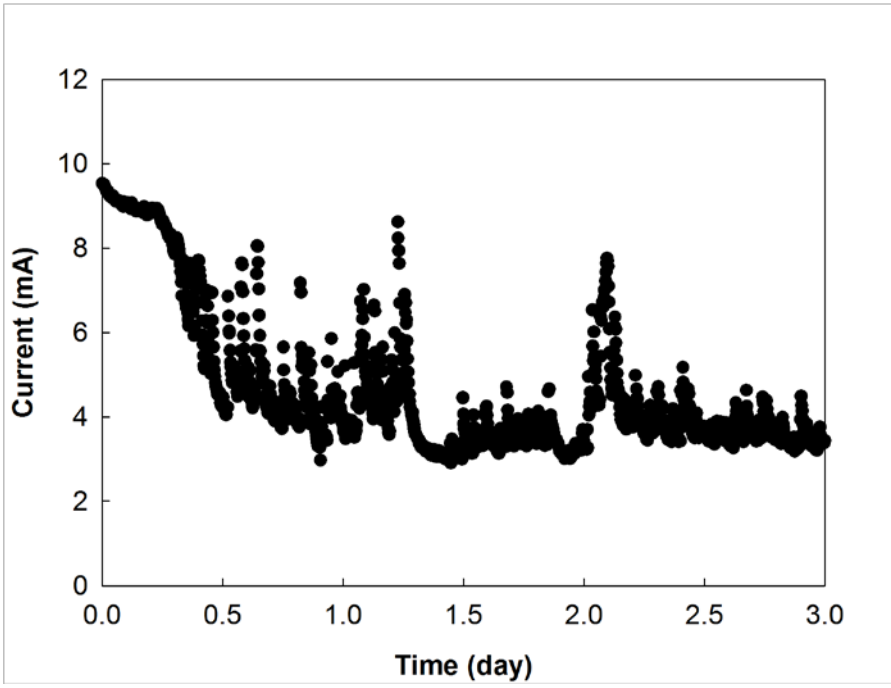

FIGURE S2. Current generation in the OsMDC treating 10 g NaCl/L saline water in an operating cycle of three days. The external resistance was 1 Ω.

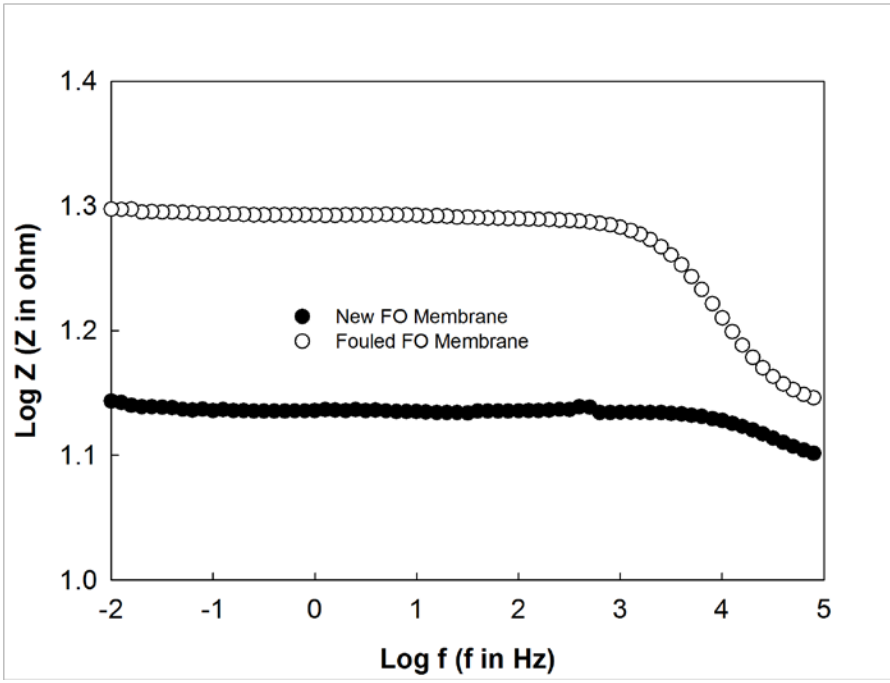

FIGURE S3. The Bode plots of the membrane impedance measured by electrochemical impedance spectroscopy.