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Improving Recovery: A Concentrate Management Strategy for Inland Desalination

Desmond F. Lawler, Principal Investigator

Benny Freeman, Lynn Katz, and Kerry Kinney, co-PIs

In the last two months, we have working on **Tasks 1b, 1c, and 3a**. In the last report, we focused on the work done as part of Task 1; in this report, we focus most of the attention on the development of the laboratory electrodialysis (ED) system. A schematic diagram of various operational strategies was presented in the previous report.

The laboratory ED system has been outfitted with a data acquisition system that has included customizing National Instruments LabVIEW® software to control and monitor the system in real time. The graphical user interface (GUI) that serves as a virtual control panel is shown in Figure 1. The pump driver, DC power supply, pH and conductivity meters, and digital mass balance are controlled and monitored through this software. During operation, the software retrieves data from each device, displays it on the GUI, and archives it for subsequent analysis.
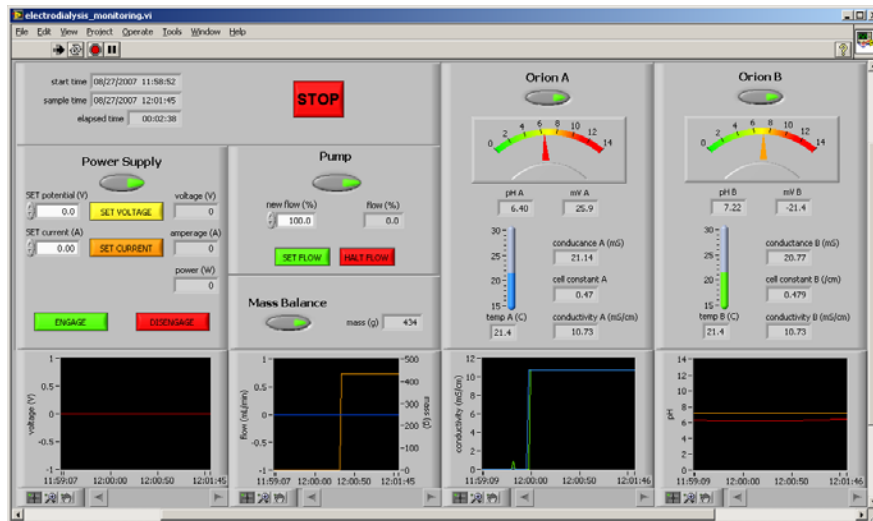

Figure 1. Control panel for electrodialysis system control and monitoring

Further development of this system is underway. We are in the process of purchasing pressure transducers to monitor the head loss through both of the diluate and concentrate sides of the system, so as to be able to estimate the Reynolds number or turbulence in the system under different flow conditions. Maintaining a small laminar boundary layer near the surface of the ED membranes, especially on the diluate side, has advantages in terms

of electrical and ion removal efficiency; the measurement of the head loss should enable us to estimate the extent of the boundary layer.

Results from one experiment with the three-reservoir, batch-recycle electrodialysis system are shown in Figure 2. The three reservoirs are for the dilutate, concentrate, and electrode rinse. Data were obtained every 2 s, so that the points form a continuous curve. The experiment was started with equal volumes of 0.1M sodium chloride solutions in the concentrate and diluate streams, and as time progressed, ions migrated from the diluate stream into the concentrate stream. Theoretically, the concentration of the concentrate stream should have approached twice the initial concentration because all of the electrolyte mass would have been transferred from the diluate stream. However, because the concentration difference between the concentrate and diluate streams increased as the experiment progressed, some osmosis of water occurred through the ion exchange membranes, leading to a gradual increase in the concentrate volume and a corresponding decrease in the diluate. The experiment was run at constant voltage between the electrodes, so that the current gradually dropped as the overall resistance dropped due to the decreasing diluate concentration; these data are also shown in Figure 2.
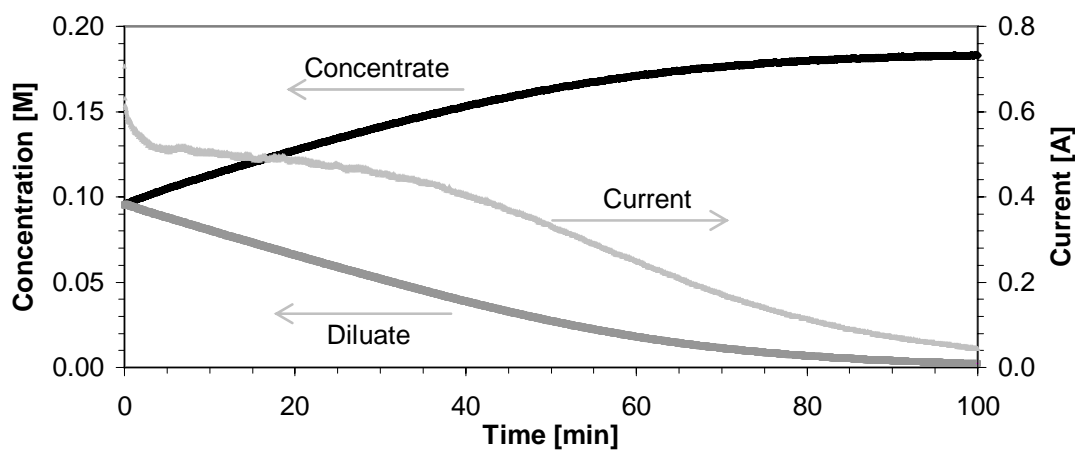
Figure 2. Electrodialysis experimental results (batch-recycle) (Performed at constant voltage (5 V), experiment began with 1 L of 0.1 M NaCl in each reservoir of a three-reservoir (dilutate, concentrate, and electrode rinse) batch-recycle system)

Relevant to all tasks on the project, we have also been working on the use of an ion chromatography instrument. Because the experiment whose results are shown in Figure 2 was performed for the single salt (NaCl) system, the results of the ion transfer from the diluate to the concentrate could be quantified completely through the use of conductivity measurements. However, real waters (and their synthetic analogs) have several different ions in them, and it is important to know about the behavior of specific ions. Ion chromatography allows one to quantify the individual behavior. An example standard curve for one ion (sulfate) in a mixture of three (chloride, nitrate, and sulfate) present at very different concentrations in our synthetic RO concentrate is shown in Figure 3.

While the standard curves for the other two ions were not quite as superb as the one shown in Figure 3, all three gave acceptable results. Therefore we believe that we are ready to quantify several ions after either ED treatment (Task 3) or oxidation followed by precipitation (Task 2).

$y = -20.831 + 692.09x \quad R^2 = 0.99998$