Chem E 461
Fuel Cell Characterization

This technology experiment utilizes the TVN Systems UO-1000 hydrogen/oxygen fuel cell and test stand in the Chemical Engineering Unit Operations Lab.

The basic chemistry at the anode is

$$H_2 \text{ ——> } 2H^+ + 2\,e^-$$

and at the cathode,

$$1/2\,O_2 + 2H^+ + 2e^- \text{ ——> } H_2O \ ,$$

thereby providing the same overall reaction as one finds in the combustion of hydrogen in oxygen

$$H_2 + 1/2\,O_2 \text{ ——> } H_2O \ ,$$

but here we extract energy by the flow of electrons in an external circuit, rather than the production of heat.

The fuel used is 5% H_2 in 95% N_2, for safety reasons, and the oxidant is bottled air (21% O_2), The 3-cell stack used in this experiment has 16 cm^2 of active area per cell, and has a membrane 2 mils thick (nominal). You have independent control of the stack temperature, fuel and oxidant flow rates, temperature of gas humidifiers, and the stack pressure, as well as the load applied to the stack. For durability reasons, we ask that students always maintain a near ambient pressure in the stack.

In this experiment, you should generate polarization and power curves for a wide range of operating conditions. The current-potential behavior should show three regimes as one increases the current. Starting from open circuit, one moves from charge transfer-limited, to membrane resistance-limited, to mass transfer limited states. In the charge transfer limited regime you can use a Tafel plot analysis to determine the exchange current density and transfer coefficient for oxygen reduction at the cathode. It is possible to estimate the membrane resistivity in the membrane-limited region, whereas mass transfer effects and extent of fuel/oxidant utilization is accessible in the mass transfer limited region.

Assess and quantify these properties of the fuel through careful experimentation. Can you predict the entire response of the system for any current?