Design and Simulation of Sensors to Detect Methanol

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DMFC, Direct Methanol Fuel Cell Technology, can be used for fabrication of methanol sensor. A fundamental limitation in DMFC technology is methanol crossover. In this process methanol diffuses from the anode through the electrolyte to the cathode, where it reacts directly with the oxygen and produces no electrical current from the cell. Poisoning of the cathode catalysts is also another major problem. We have used a passive mode design protocol using COMSOL Multiphysics to seek solutions for these problems. The design and simulation would involve optimization of various parameters, in the construction of the sensor. This would optimized the overall power density and hence the sensitivity of the sensor by the modification of various parameters like the area of the working electrodes and, separation distance and the electrode-electrolyte interface.

A passive mode design, of about a cm area, using various parametric functions, and interfacing Darcy's law of fluidic flow through a porous medium, under specific pressure and temperature, was applied.

The designing involves the construction of gas diffusion layers using carbon cloth for anode and cathode with various parametric variations. Nafion membrane was selected as proton exchange membrane for the construction with different interface structure to analyze the sensor's performance. Platinum and various alloy catalysts like Pt-Ru, Pt – Fe was chosen as the working catalysts.

There is contributes to the loss of cell voltage potential, due to cross over as any methanol that is present in the cathode will be oxidized. The change in the overlap length and porosity optimizes the power density of the cell and hence the sensitivity. The obtained anode polarization curves indicate the drop in cell potential due to methanol crossover from anode to cathode due to oxidation occurred at cathode. This determines a strong anode activation control that was reflected in the overall polarization curve. The terminal voltage of the cell is deconvoluted into the anode and cathode polarizations: the actual $E_{cell} = E_{cathode}-E_{anode}$.

Alternatively, the anode polarization can be measured in the driven mode and the cathode curve is calculated from the above equation. In the driven mode, hydrogen is fed to the cathode that acts as both counter and reference electrode. Besides the strong activation control at the anode, the effect of the mixed potential on the cathode polarization curve is clearly observed. The parametric functions of the cell were optimized to obtain good order of sensitivity. A cell was fabricated and compared with the simulation results. The results show fair convergence.