

Cell Performance Distribution in a PEMFC Stack during Contamination

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Proton exchange membrane fuel cells (PEMFC) have gained a noteworthy place among alternative power systems owing to favorable figures of merit and environmental benefits (1). However, efforts are still needed to reduce cost, increase performance and durability to ensure commercial competitiveness. Fuel cells are expected to be exposed to many air contaminants (2). Most contamination studies were completed with single cells. As a result, it is not currently known whether or not all cells in a stack will equally be impacted.

An organic contaminant that has a significant impact on cell performance was selected partly because upon recovery from a temporary exposure an unusual gain in performance has been observed with a single cell (3,4). It was deemed relevant to duplicate prior results with a stack to also ascertain this observation.

A proprietary 36 cells stack with an active area of ~ 21 cm² and active section length of ~ 11 cm was used. Operating conditions were: air/H₂, 2.5 stoichiometry/dead end, 75/0 % relative humidity, ambient/ambient pressure outlets, 55 °C, 1 A cm⁻². Propene was injected for a fixed period after the stack reached a steady state voltage. After the scheduled exposure to 50 ppm propene was completed and the stack reached a steady state voltage, the stack was allowed to recover until a new steady state voltage was attained.

Fig. 1 illustrates the average cell voltage evolution during the test. During the first phase, the stack has a steady state output (0.641 V). In the subsequent phase, the propene is injected and the average cell performance immediately decreases. The average cell performance loss rate decreases until a steady state is reached (0.398 V). In the last phase, only air is circulated and the average cell performance recovers at a rate which is greater than the decay rate observed during the second phase. The average cell performance recovery rate also decreases until a steady state is reached (0.647 V). The average cell performance after recovery is larger than the initial value by ~ 6 mV. The transient behavior as well as the larger average cell performance after recovery are consistent with prior single cell experiments (3,4).

Fig. 2 shows steady state cell voltage change distributions obtained at 3 h and 20 min (contamination phase) and 7 h and 30 min (recovery phase) dimensionalized by first stage data at 2 h (baseline). The cell voltage distribution during contamination is characterized by two main features. End cells are more affected and have lower performance than their contiguous cells. This is ascribed to the lower local temperature (5) and its significant effect on contamination (4). The loss in cell performance for propene is approximately 0.0086 % °C⁻¹ ppm⁻¹ (4). Therefore, the decrease in temperature is equal to 8.6 and 5.3 °C for an initial performance of 0.641 V, end cell losses of respectively 24 and 15 mV and a 50 ppm concentration. The performance change for the non-end cells decreases from the air inlet to the outlet (0.57 mV

cell⁻¹). This effect is ascribed to the manifold flow resistance and resulting reactant flow distribution (6) leading to variations in contaminant dosage. The cell voltage distribution during recovery is identical to the distribution observed before the contamination stage with the exception that cell voltages are higher by ~ 6 mV on average. It is remarkable that such a small stack reveals such clear effects during contamination (24 and 15 mV for respectively the outlet and the inlet end cells, 19 mV along the stack core from cells 2 to 35). Contamination effects are expected to be even more significant in larger automotive or stationary stacks because it is relatively more difficult to control operating conditions over much larger volumes.

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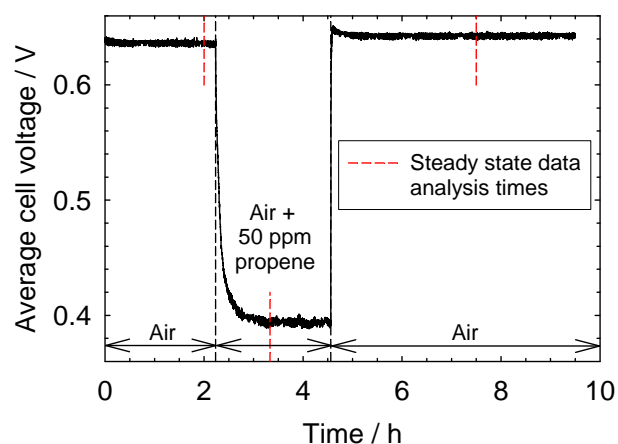


Fig. 1. PEMFC stack average cell voltage before, during and after a 50 ppm propene in air exposure.

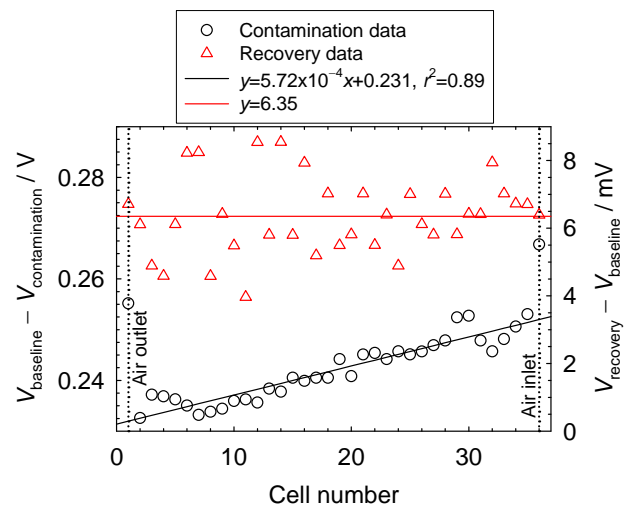


Fig. 2. PEMFC stack contamination and recovery stages steady state cell voltage change distributions.