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PEMFC Cathode Contamination with Acetylene - Potential Dependency

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Proton exchange membrane fuel cells (PEMFCs) are considered as a promising clean energy technology (1). However, the effect of air pollutants is still largely unknown and several species have been proven detrimental (2, 3). Recently, 21 species were down selected from a list of more than 200 airborne pollutants (4) for single cell evaluations. Results showed that contaminants differently affected cell performance. Seven organic contaminants with different functional groups were chosen for extensive characterization tests: acetonitrile, acetylene, bromomethane, iso-propanol, methyl methacrylate, naphthalene and propene.

The effect of contaminant concentration, cell temperature and current density was determined for all 7 organic species. Results showed that: i) lower temperatures significantly increase the effect of all contaminants with the exception of bromomethane; ii) the cell performance effect is more sensitive to acetylene, naphthalene, or acetonitrile concentration; iii) the impact of current density is minimal. Acetylene results also indicated the presence of potential dependent processes.

In this presentation, the potential dependency of acetylene contamination was investigated by operating MEAs in H_2/N_2 and H_2/air modes with or without contaminant in the cathode stream. For the H_2/N_2 mode, the N_2 electrode potential was controlled with the H_2 electrode acting as the reference electrode. Acetylene was injected into the N_2 stream at a concentration of 300 ppm until the cell current reached a steady state. During each test period, before, during and after contamination, cyclic voltammograms were acquired to detect the presence of adsorbates on the Pt surface. For the H_2/air mode, the cell voltage was controlled. Acetylene conversion was also analyzed by measuring cell inlet and outlet gas compositions by gas chromatography.

Fig. 1 shows the cell current response with a temporary acetylene injection in N_2 at different cell voltages. Before exposure, the 2.7 mA cm^{-2} current density is attributed to the oxidation of crossover H_2. With acetylene injection, the current density initially increased but settled to a lower value at steady state. At 0.5 V, acetylene adsorption on the catalyst decreased the real active area and the current below the value ascribed to the oxidation of crossover H_2. By contrast, at 0.65 and 0.9 V, the steady state current exceeded the current associated with H_2 oxidation. This behavior was ascribed to increased levels of acetylene oxidation. After acetylene injection was stopped, the current was restored to its initial value before acetylene injection. Cyclic voltammetry analyses corroborate these results and provide additional information on acetylene oxidation.

Fig. 2 shows similar experiments as displayed in Fig. 1 but for the H_2/air case. Before acetylene injection, and as expected, the current was larger at a lower voltage. After acetylene injection was initiated and in all cases, the current decreased in reverse proportion to the cell voltage. These results support the hypothesis that acetylene adsorption as well as acetylene oxidation products cover the Pt catalyst and, decrease the active area and cell performance. After acetylene injection was interrupted, the performance recovered for the lower cell voltages. For 0.85 V, a recovery was observed but the performance was lower than the initial value owing to other superimposed degradation mechanisms. Gas chromatography as well as cyclic voltammetry data will also be presented. All results will be synthesized into a reaction mechanism.

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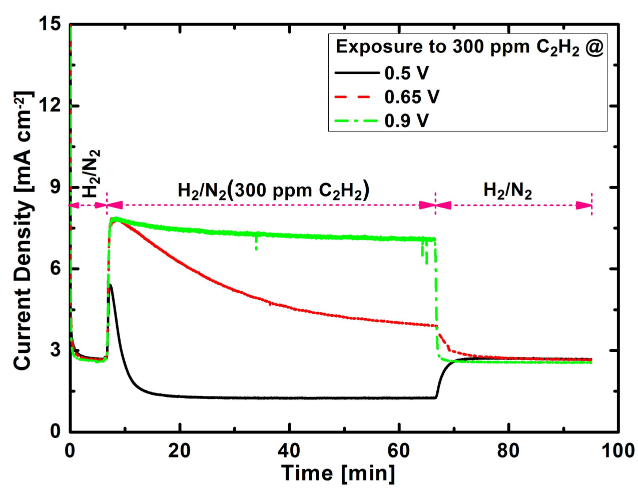

Fig. 1. MEA current response with a cathode exposure to 300 ppm acetylene in N_2 at different cell voltages.

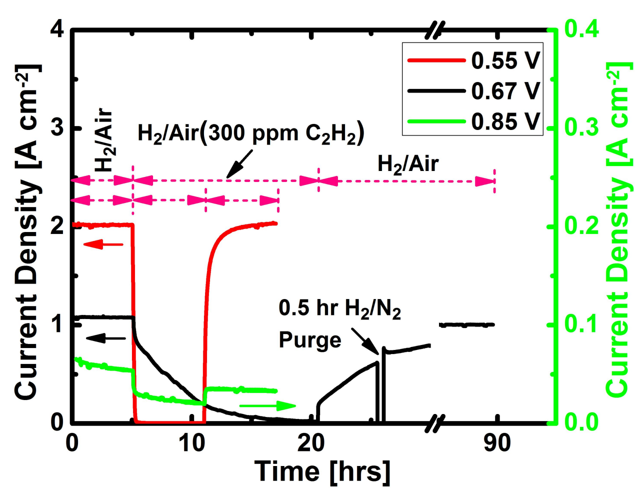

Fig. 2. MEA current response with a cathode exposure to 300 ppm acetylene in air at different cell voltages.