The Effect of NaCl in Cathode Air Stream on PEMFC Performance

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Real world PEM fuel cell applications most probably will use ambient air as the cathode oxidant. Besides the needed oxygen, the immediate atmosphere may contain many impurities, which may have an adverse effect on fuel cell performance. These impurities include vehicle and industry exhausts, fine particles and natural impurities. This is especially true in urban environments and produces concern in applications where air filters are troublesome due to weight or volume considerations. There are few previous studies on oxidant impurities. Pino *et al.* investigated the effect of CO, NO_2 and SO_2 [1], and Moore *et al.* included also some common chemical warfare agents [2].

Schmidt *et al.* have investigated the oxygen reduction reaction on typical carbon supported Pt fuel cell catalyst in the presence of different anions, including chloride [3]. However, they performed their measurements in a liquid electrolyte using a thin-film rotating disk electrode, not under actual fuel cell operating conditions. We present here preliminary results from a study, where NaCl solution was injected into the cathode air stream of a PEM fuel cell. NaCl was chosen as the impurity, because it is present in the atmosphere as aerosol in coastal areas and is also used as a deicer on roads during wintertime.

All measurements were conducted using a 0.459 molar NaCl solution, which was injected into the cathode side air stream at 4 ml/min. A 50 cm^2 PEM fuel cell with single serpentine channel flow field plates and an in-house thin film MEA with platinum loadings of approximately 0.2 $mgPt/cm^2$ at each electrode was used. The cell was operated at 80 °C and the anode and cathode gas humidification temperatures were 105 and 85 °C, respectively. Reactant flows were 500 sccm/min for hydrogen and 2100 sccm/min for air.

Figure 1 shows the change in fuel cell performance while injecting 0.459M NaCl into cathode air stream and recovery with neat air. NaCl injection was initiated at 1 h. Performance degradation was observed after ca. 0.1 mol NaCl had been injected into the cell. IR-compensated polarization curves and resistance data measured before, during and after the NaCl injection are presented in Figure 2. These clearly show that the presence of NaCl produces performance losses. Cyclic voltammograms of the cathode electrode before and after NaCl poisoning are shown in Figure 3. A small decrease in the Pt active surface area can be seen from the diminished hydrogen desorption currents.

Changes in performance stem from a multitude of phenomena. Cl^- ions adsorb onto the catalyst surface and reduce oxygen reduction reaction activity. Furthermore, the presence of Cl^- promotes peroxide production, which in turn is detrimental to the ionomer stability. Also, electrolyte resistance is increased by the presence of Na^+ ions, which replace ionomer protons both in the electrodes and the membrane. Additionally, NaCl intercalates into graphite in the gas diffusion backings changing their water management properties, thus making the cell more prone to flooding.

References

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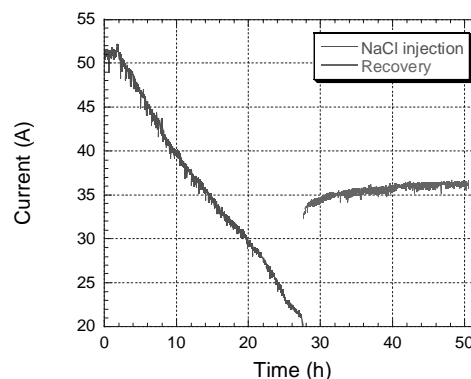
Acknowledgments

Figure 1. Life test at constant voltage (0.6 V), while injecting 0.459M NaCl into cathode air stream at 4 ml/min, and recovery using neat air. 50 cm^2 cell. Loading: 0.2 $mgPt/cm^2$ at each electrode.
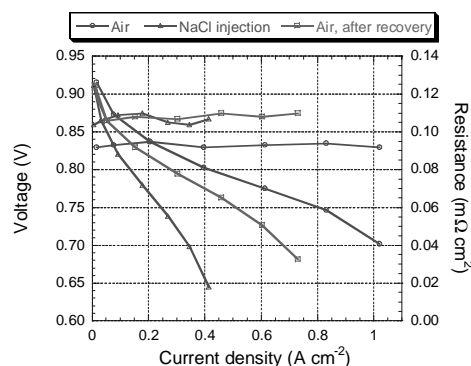

Figure 2. IR-corrected polarization curves before, during and after NaCl injection into the cathode. 50 cm^2 cell. Loading: 0.2 $mgPt/cm^2$ at each electrode.
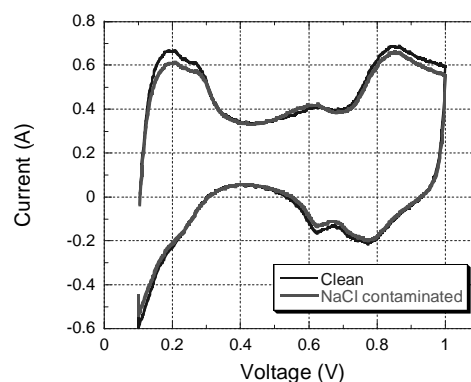

Figure 3. Cyclic voltammograms of the cathode electrode before and after NaCl injection. 50 cm^2 cell. Loading: 0.2 $mgPt/cm^2$.