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ENDURANCE TESTING WITH Li/Na ELECTROLYTE

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Abstract

The Institute of Gas Technology (IGT), under subcontract to M-C Power Corporation under DOE funding, has been operating bench-scale fuel cells to investigate the performance and endurance issues of the Li/Na electrolyte because it offers higher ionic conductivity, higher exchange current densities, lower vapor pressures, and lower cathode dissolution rates than the Li/K electrolyte. These cells have continued to show higher performance and lower decay rates than the Li/K cells since the publication of our two previous papers in 1994.(1,2)

In this paper, test results of two long-term 100-cm² bench scale cells are discussed. One cell operated continuously at 160 mA/cm² for 17,000 hours with reference gases (60H₂/20CO₂/20H₂O fuel at 75% utilization and 30CO₂/70 air oxidant humidified at room temperature at 50% utilization). The other cell operated at 160 mA/cm² for 6900 hours at 3 atm with system gases (64H₂/16CO₂/20H₂O at 75% utilization and an M-C Power system-defined oxidant at 40% utilization). Both cells have shown the highest performance and longest endurance among IGT cells operated to date.

Results and Discussion

IGT Cell-934 operated continuously at 160 mA/cm² for 17,000 hours (about 2 years) with reference gases, including one thermal cycle, with a decay rate of 2 mV/1000 hours. It reached a peak performance of 809 mV. Its performance lifegraph is shown in Figure 1. The thermal cycle occurred after about 6000 hours of operation: the cell was cooled down, clamped between flanges, and moved to another test facility where it was restarted. Toward the end of the 17,000 hours operation, cell performance had decreased to about 720 mV due to decreased anode wet seal efficiency and OCV and increased N₂ crossover.

Figure 1. Cell-934

Cell-941 operated for 6900 hours at 3 atm with system gases at 160 mA/cm^2 . It had a peak performance of 765 mV and a decay rate of 3 mV/1000 hours until a cathode overpressure incident occurred at about 5300 hours of operation. Thereafter, the cell decayed more rapidly. Its lifograph is shown in Figure 2. Post test examination showed that corrosion of the anode wet seal was mild as was the case with the 17,000-hour cell. Wet seal leakage in the latter cell was related to the matrix and not due to wet seal corrosion.

Figure 2. IGT CELL-941

Sensitivity to fuel and oxidant utilizations for Li/Na have been discussed before.(1,2) They are indications of the magnitude of the anode and cathode polarizations and of the uniformity of gas flow distribution across the electrodes. They were determined to be $1.5 \text{ mV}/\%U_f$ and $0.5 \text{ mV}/\%U_{ox}$, respectively. These values are slightly greater than those of Li/K. The performance sensitivity to temperature has also been determined. Although internal resistance (IR) varies with temperature similarly for Li/Na and Li/K, the electrode polarization of Li/Na, especially when a stabilized cathode(SC) is used, was found to decrease at a greater rate with decreasing temperature below 650°C than Li/K (Figure 3). This could be due to poor carbonate distribution in the cell components or to different reaction kinetics.

Carbonate loss from the porous components of Cell-934 was determined to be 3.7 grams or 2.2 g/10,000 hours. This is higher than the loss observed for Li/K electrolyte under similar operating conditions, which was 1.6 g/10,000 hours (Figure 4). White salt deposits on the external surface of the anode flange of Cell-934 were evident indicating carbonate creepage. There were 1.5 grams carbonate accounted from the washings of this cell's hardware, therefore, just 2.2 grams or 1.3 g/10,000 hrs carbonate were unaccounted.

Carbonate loss from the porous components of the 3 atm Cell-941 was determined to be 1.8 grams or 2.6 g/10,000 hours, comparable to that observed for Cell-934. Heavy salt deposits on the external surface of the cell's anode flange were also observed.

Figure 3. CELL POLARIZATION AND IR vs. TEMPERATURE

Figure 4. CARBONATE LOSS FROM 94-cm² CELLS

The amount of Ni in the matrix was determined to be 17.1 mg/cm² for the 17,000-hour cell and 14.6 mg/cm² for the 3 atm 6900-hour cell. There was no sign of cell shorting either from the CO₂ analysis of the fuel outlet gases under OCV condition or from the microscopic examination of the matrix cross sections. Although the cathodes of these two cells were stabilized, the observed rates of cathode dissolution are higher than those observed with Li/Na cells with an unstabilized cathode (Figure 5).

Figure 5. CATHODE DISSOLUTION IN 100-cm² CELLS

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