Diagnostics of automotive PEM fuel cells

Ivan Pivac, Željko Penga, Boris Šimić, Nikolina Pivac, Gojmir Radica, Frano Barbir

FESB, University of Split, R Boskovic 32, 21000 Split, Croatia

WP1 Objectives

- Define experimental protocols
- Improve understanding of degradation phenomena in stacks and BoP components
- Develop diagnostics for stacks and BoP components
- Develop stack rejuvenation techniques

Degradation

Accelerated degradation tests and diagnostics results

Figure 1. a) Potential cycling profile in accelerated stress test (AST) for electrocatalyst degradation; b) Experimental setup with investigated ElringKlinger’s single PEM fuel cell.

Figure 2. a) Polarization curves during the AST with red-marked EIS measurement points; b) EIS spectra at different current densities obtained at the BoL and after 5000 AST cycles.

Figure 3. a) Cyclic voltammograms with the loss of cathode electrochemical active surface area (ECSA) during the AST; b) Linear sweep voltammograms during the AST.

Figure 4. a) 11-element impedance model used for EIS analysis; b) Results of measured and simulated low-frequency EIS intercepts at different current densities during the AST.

Key findings and conclusions on fuel cell degradation

- The cell has shown excellent performance and low degradation rate.
- CV measurements indicated a slight loss of the ECSA caused by platinum dissolution due to intentionally frequent voltage cycling, which apparently resulted in structural changes within the CL as the increase in mass transport in EIS suggests.
- The low-frequency EIS intercept increased most significantly during the AST with a rising and similar trend at every measured current density → useful and perhaps sufficient indicator of degradation.

Rejuvenation

Impact of shutdown procedures on rejuvenation phenomena

Figure 5. a) The scheme of the complete rejuvenation testing schedule; b) Comparison of different fuel cell shutdown procedures performed before soak time steps during the AST.

Figure 6. Degradation and rejuvenation during the AST extracted from: a) polarization curves at different current densities; b) cyclic voltammograms through the ECSA normalized values; c) impedance spectra at low frequency EIS intercept.

Key findings and conclusions on fuel cell rejuvenation

- The cause of the reversible degradation could be accumulated water within the cell and/or presence of oxygen within the CL leading to formation of platinum oxides on the catalyst surface.
- The prolonged soak time step reduces recovery effect.
- Rapid reduction of the cell temperature with ice counterproductive for performance recovery.
- Shutdown without shortly-connected R has no effect on recovery.
- Shutdown without N2 purge proved to be the most effective for performance recovery.
- The low-frequency EIS intercept proved to be efficient and consistent measure of degradation and recovery effect.

Hannover Messe 2019, 1–5 April 2019, Hannover, Germany

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 700101. This Joint Undertaking receives support from the European Union’s Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY.