

# Effect of catalyst layer and electrolyte membrane on high temperature and low humidity operation of PEFC

Sana Kawashita <sup>1)</sup> Hiroyuki Kanesaka <sup>1)</sup> Hiroki Kusakabe <sup>1)</sup> Li Chunyan <sup>1)</sup>

*1) FC-Cubic, Nesrad, 3147 Shimomukoyama-cho, Kofu, Yamanashi 400-1507, Japan (E-mail: s-kawashita@fc-cubic.or.jp)*

**KEY WORDS:** EV and HV systems, Fuel Cell, High temperature operation [A3]

Polymer electrolyte fuel cells (PEFCs) are being studied for application in heavy duty vehicles (HDVs). However, PEFCs for HDVs are expected to operate in high temperature environments for extended periods compared to those used in conventional passenger cars. Therefore, this study evaluates the effects of high temperature and low humidity on the catalyst layer and electrolyte membrane under continuous operation.

The polymer electrolyte membrane (PEM) used in this study was GORE-SELECT® MEMBRANE M765.08 (8 μm). Anode catalyst was TEC10EA50E (TKK), and two cathode catalysts were examined: TEC10E50E (TKK) and TEC36F52 (TKK). The Pt loadings of the catalyst layers were Cathode/Anode (0.2/0.1 mg/cm<sup>2</sup>). A gas diffusion layer (GDL) with a microporous layer (MPL) of model SGL22BB was used. This report investigates PEFCs degradation at high temperature, low humidity.

To evaluate degradation at high temperature, steady-state power generation was conducted under conditions of 120 °C, 40% RH, and a current density of 2 A/cm<sup>2</sup>. During this operation, electrochemical diagnostics and IV characteristic evaluations were performed periodically as interim evaluations to monitor performance changes. All measurements were conducted in accordance with the NEDO PEFC Cell Evaluation and Analysis Protocol (2025 edition). The increase in crossover current (COC) was used as an indicator of electrolyte membrane degradation, while the retention of electrochemical surface area (ECSA) and mass activity were used as indicators of catalyst layer degradation.

Fig. 1 shows that COC increased significantly within a relatively short period. Examination of the membrane after testing revealed that thinning and rupture at the edges were the primary causes. This is attributed to the softening of the electrolyte membrane at 120 °C, which caused greater deformation in areas subjected to mechanical stress—an effect that was not observed under conventional temperature conditions—thereby accelerating membrane degradation. Furthermore, cross-sectional observation revealed areas where the electrolyte membrane had melted and penetrated into the catalyst layer, suggesting that the mechanical properties of the electrolyte membrane deteriorated, particularly in regions exposed to high temperatures and high current densities.

Even in membrane electrode assemblies (MEAs) that did not exhibit early membrane degradation, a decline in performance was observed after several hundred hours of operation. Fig. 2 shows that, in high temperature constant-load tests, the decline in mass activity was significantly. Furthermore, the SEM and XPS results revealed that the thickness of the catalyst layer decreased after the test, along with a reduction in the ionomer on the catalyst layer surface, changes in its distribution, and carbon corrosion. These results, indicate that significant degradation of the catalyst layer occurs within several hundred hours during high temperature testing, leading to a decline in power generation performance.

In summary, commercially available fluorinated electrolyte membranes exhibit significant degradation in a 120 °C/40% RH environment. In future work, we plan to investigate the degradation behavior of fluorinated electrolyte with improved high temperature stability, hydrocarbon-based electrolyte, and other high-temperature-stable materials.

The content of this research was obtained as a result of a commissioned project (JPNP25002) by the New Energy and Industrial Technology Development Organization (NEDO). We express our sincere gratitude to all those involved for their tremendous cooperation.

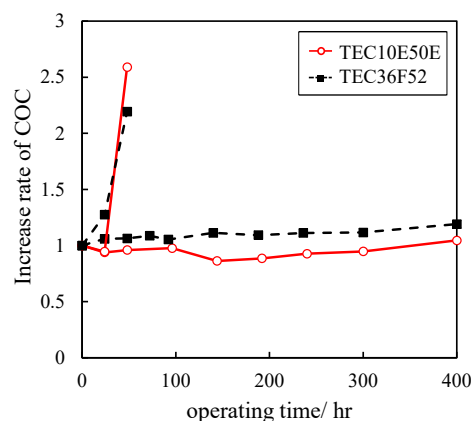


Fig. 1 Increase of COC

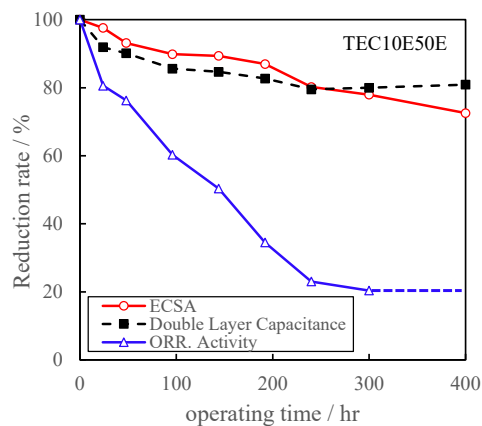


Fig. 2 Change in ECSA, Double Layer Capacitance, and ORR Activity