November 27th, 2023

Evaluation of correlation between catalyst surface hydrophilicity and ionomer dispersion and durability in water-generating load cycle tests on polymer electrolyte fuel cells:

Revealing that the control of functional groups through surface treatment of Pt/C catalysts helps improve the ionomer dispersibility and durability

N.E. CHEMCAT CORPORATION (Headquarters: Minato-ku, Tokyo, Japan; President: Susumu Endo) announced results from an evaluation of correlation between the functional groups and hydrophilicity for a fuel cell catalyst in a water-generating load cycle for polymer electrolyte fuel cells (PEFCs). The study demonstrated that optimal ionomer (electrolyte polymer) dispersion and improved durability may be achieved through appropriate control of the catalyst surface condition, including surface treatment for platinum carbon (Pt/C) catalyst to control functional groups. These results have been reported in an article in a journal of the American Chemical Society (ACS), *ACS Applied Energy Materials*, published on November 27th and selected as a Supplementary Cover Art.

■ Key points of the announcement:

- The study evaluated how the dispersion and durability of the ionomer might be influenced by changes in the hydrophilicity of Pt/C catalyst as a result of its surface treatment that controls the functional groups on its surface
- Compared to the excessively hydrophilic Pt/C catalyst, one with moderately decreased hydrophilic properties demonstrated greater ionomer dispersibility and superior I-V performance
- In durability tests under conditions where water was generated during power generation, which were similar to the actual operating environment of fuel cell vehicles (FCVs), the Pt/C catalyst with moderately decreased hydrophilic properties was also associated with improved durability compared to one with excessively hydrophilic properties
- These results suggest that the control of catalyst surface condition may contribute to the optimization of MEA structure and improvement in its durability

Fuel cells are clean power generation systems that generate electricity without emitting CO_2 and other greenhouse gases, holding promise as a technology to help achieve carbon neutrality. Among them are PEFCs, which have found different applications such as fuel cell vehicles (FCVs), owing to their high-power generation efficiency. As countries seek to apply them to large-sized commercial vehicles, they are calling for an improved performance and durability of membrane-electrode assemblies (MEAs), which are a core component of fuel cells, to achieve higher output density and a final guaranteed distance exceeding one million kilometers. In addition, we are seeing increasing demand for lower prices through reduced use of precious metals such as platinum (Pt), with the U.S. Department of Energy (DOE) setting a target to achieve fuel cell systems costs to $60/kW by 2040.

In this study, correlation between the functional groups and hydrophilicity of fuel cell catalyst constituting the MEAs was tested.

The study first found that the hydrophilicity of catalyst was influenced primarily by the amounts of functional groups and Pt oxide, rather than by Pt surface area. It further revealed that the amounts of functional groups and Pt oxide on the Pt/C catalyst could be controlled using a proprietary surface treatment method (Figure 1) to adjust the hydrophilic properties of the catalyst surface (Figure 2).

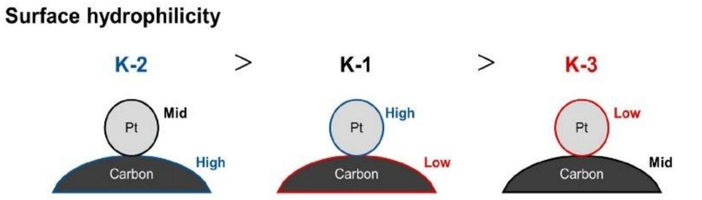


Figure 1. A schematic diagram of Pt/C catalysts with surface treatment

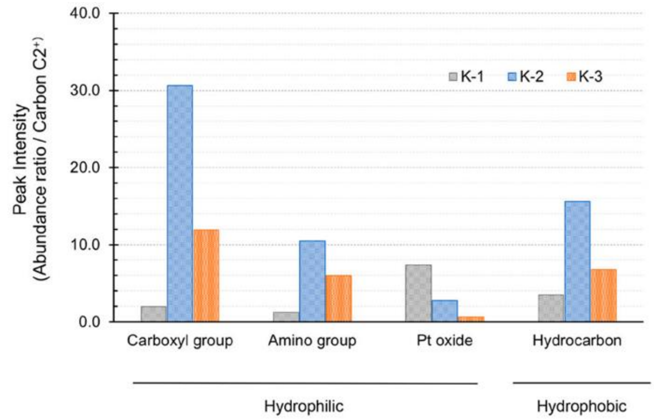


Figure 2. Results of analysis on functional groups and Pt oxide present on the surface of different Pt/C catalysts

In an impact evaluation of the adjusted hydrophilicity of catalyst surface, achieved through the proprietary surface treatment, on the dispersion and durability of ionomers, excessively hydrophilic Pt/C catalysts demonstrated poor ionomer dispersion and reduced gas diffusivity due to water accumulation. Pt/C catalysts for which the hydrophilicity was controlled so that they had decreased hydrophilic properties, on the other hand, exhibited optimal ionomer dispersibility (Figure 3) and superior I-V performance. Additionally, in a water-generating load cycle test conducted under the conditions that mirrored the actual operating conditions, Pt/C catalysts with controlled and moderately-reduced hydrophilicity appropriate were found to have appropriate wettability, which resulted in improved durability compared to excessively hydrophilic Pt/C catalysts.

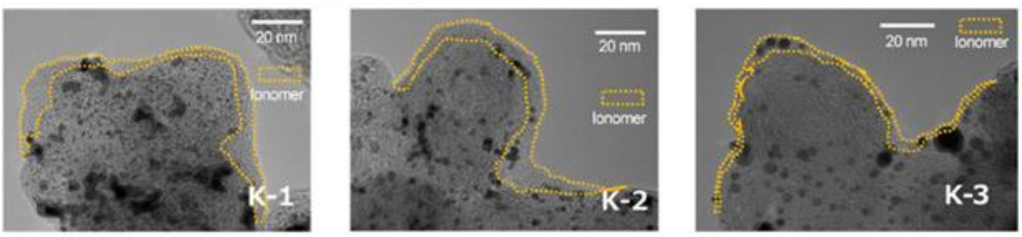
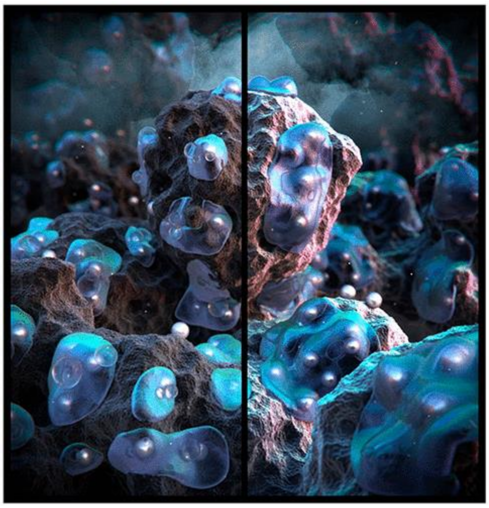


Figure 3. Observation of ionomer dispersion on surfaces of different Pt/C catalysts

These results demonstrate that appropriately control of the surface state of catalysts helps optimize the MEA structure and enhance durability. They offer a potential indicator for more straightforward, quantitative MEA optimization with respect to ionomer dispersion and durability based on catalyst hydrophilicity.

For more details on the announcement, please visit the link:
https://pubs.acs.org/doi/10.1021/acsaem.3c01706/



A 3D model depicting hydrophilic/hydrophobic state of catalyst surface

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■ Title of article: Impacts of Pt/Carbon Black Catalyst Surface Hydrophilicity on Ionomer Distribution and Durability during Water-Generating Load Cycling of Polymer Electrolyte Fuel Cells

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These are the results from joint research conducted by N.E. CHEMCAT CORPORATION and Professor Makoto Uchida and his research group at Hydrogen and Fuel Cell Nanomaterials Center, University of Yamanashi.

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The performance of polymer electrolyte fuel cells (PEFCs) is influenced significantly by the structure of

the MEAs and the dispersion of the ionomer.
In this study, we adjusted the hydrophilicity of commonly-used porous carbon-supported catalyst through surface treatment, and investigated how it influenced the dispersion and durability of the ionomer. Our results showed that decreased hydrophilic catalysts with moderate functional groups exhibited optimal ionomer dispersibility and superior I-V performance.

In addition, durability tests using water-generating load cycles revealed that catalysts with decreased hydrophilicity exhibited improved durability thanks to moderate wettability. Our findings suggest that by appropriately controlling the catalyst's surface conditions, we can enhance the MEA structure and improve its performance and durability.

The groundbreaking aspects of this study include:
(i) It proposes a straightforward method for evaluating the hydrophilicity of a catalyst layer;
(ii) It involved power generation as part of durability evaluation, with the effects of water management on durability taken into account in the analysis assessment; and
(iii) It achieved a significant improvement of the performance and durability of widely-used carbon-supported catalysts through surface modification treatment; the study has drawn acclaim for this novel, advanced approach.

■ About N.E. CHEMCAT CORPORATION:

N.E. CHEMCAT CORPORATION is engaged in the development, manufacturing, and distribution of chemical catalysts, auto exhaust catalysts (including three-way catalysts and diesel auto catalysts), and fuel cell catalysts, and collection/refinement of precious metal catalysts.

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