July 18, 2025

N.E. CHEMCAT Unveils the Produced Water during Polymer Electrolyte Fuel Cell (PEFC) operation to Prevent Catalyst Deactivation by Ionomer-Specific Adsorption

～Elucidating the Reaction Mechanism of Platinum Catalysts on Mesoporous Carbon under High and Low Humidity conditions —Opening New Frontiers in Material Design for FCVs' Real World Application～

N.E. CHEMCAT CORPORATION（Head office：Minato, TOKYO、President: Susumu Endo）has analyzed the catalytic mechanism under high and low humidity conditions and revealed that water generated during the operation of polymer electrolyte fuel cell (PEFC) mitigates the deterioration of catalytic performance in platinum catalysts supported on mesoporous carbon.

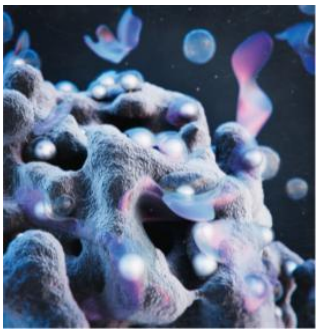
The findings of this study were published in the July 14 issue of the American Chemical Society (ACS) journal "ACS Applied Energy Materials" and selected as Supplementary Cover Art.

Mesoporous carbon, which has many ordered mesopore structures, is a carbon material that has recently attracted attention as a platinum catalyst support for high-power PEFC cathodes because of its high specific surface area and controllable structural composition. Previous studies have focused on evaluating the high performance of mesoporous carbon in oxygen reduction reactions under highly humidified conditions. Although it has been pointed out that the phenomenon of "catalyst poisoning," in which protons are not distributed throughout the catalyst layer and catalytic activity is reduced, has been observed under low humidification conditions, discussion on the behavior of such poisoning is limited.

We have analyzed the behavior mechanism of platinum catalysts under high and low humidification conditions that simulate actual usage conditions using our unique evaluation method.

In particular, we analyzed the effects of gas diffusion and reaction rate analysis using Tafel plots, and identified changes in the rate-limiting step and the state of surface reactions based on Tafel steps that appear depending on humidity.

As a result, we clarified (1) differences in catalytic activity depending on the type of pores in the carbon supports and the position of platinum, (2) the relationship between rapid water loss under low humidification conditions, and (3) the fact that water generated during PEFC operation mitigates ionomer poisoning of Pt particles.



3D model image showing catalysis in mesoporous carbon under low humidity conditions

This study has demonstrated that stable application designs are possible even under low humidification conditions, which were previously considered unstable. These findings will provide guidelines for optimizing conditions for the practical application of mesoporous carbon and for designing next-generation materials.

For more details on this research, please refer to the following link.
■**Publication:** *ACS Applied Energy Materials* (July 14, 2025, issue) *WEB edition published on July 1
■**Paper Title**：*"Analysis of Ionomer Distribution and Reaction Mechanisms on Polymer Electrolyte Fuel Cell Pt Catalysts Supported on Mesoporous Carbon under Various Humidity Conditions"*

■**DOI**：10.1021/acsaem.5c01411
■**Details of the paper (PDF version)**
https://pubs.acs.org/doi/pdf/10.1021/acsaem.5c01411?ref=article_openPDF

This research is the result of joint research between N.E. CHEMCAT CORPORATION and Professor Makoto Uchida and his research group at Yamanashi University.

■Coauthor:
Makoto Uchida – Manager, Professor, Hydrogen and Fuel Cell Nanomaterials Center, University of Yamanashi

■**Author:**
Kiyotaka Nagamori – Senior Manager, Fundamental Technology R&D Dept., R&D Center
Satoshi Aoki − Fundamental Technology R&D Dept., R&D Center
Mayumi Ikegawa − Fundamental Technology R&D Dept., R&D Center
Yasuhiro Seki – General Manager, Fundamental Technology R&D Dept., R&D Center
Hiroshi Igarashi – Former Fellow

■**Comments from Professor Makoto Uchida of The University of Yamanashi, Coauthor:**
This study conducted a detailed investigation of the humidity effects on cathode performance of mesoporous carbon-based catalysts (Pt/MPC catalysts), which have attracted considerable attention as promising materials for solid polymer fuel cells (PEFCs), focusing on their pore structure and ionomer distribution. The three groundbreaking points of this study are as follows:

1) The high ORR activity is mainly determined by Pt located on the outer surface and near the pore opening.
2) Pt/MPC exhibits rapid water loss even under moderate humidity conditions.
3) It was clearly shown that the performance degradation due to specific adsorption of ionomers under low humidity conditions is mitigated by the produced water.

This study presents a new perspective on the sulfonic acid poisoning phenomenon of platinum at the Pt/ionomer interface. Currently, mesoporous carbon is generally proposed as a strategy to mitigate sulfonic acid poisoning of ionomers by distributing platinum within its internal pores. However, this study emphasizes the need to examine this phenomenon from a dynamic perspective that considers the

influence of water generated during power generation.

Based on Tafel analysis, this study demonstrated compelling results showing that water generated during fuel cell operation can mitigate Pt sulfonic acid poisoning. This finding is expected to drive a paradigm shift in the understanding of this phenomenon and has been highly evaluated for its novelty and progressiveness.

These results indicate that under operating conditions with a current density of 0.1-0.2 A/cm2 or higher, ionomer poisoning is neutralized by the generated water, ensuring the effectiveness of the Pt catalyst on the outer surface of the MPC. This provides important insights for future catalyst structure design.

■ 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 recovery of precious metal catalysts.

[Head Office] 27th floor, World Trade Center Building South Tower, 2-4-1 Hamamatsucho, Minato-ku, Tokyo 105-5127
[Numazu Plant]] 678 Ipponmatsu, Numazu-City, Shizuoka-Prefecture 410-0314
[Tsukuba Plant] 25-3, Kohshindaira, Bando-City, Ibaraki-Prefecture 306-0608
[Representative] Susumu Endo, President & Representative Director
[Foundation] April 1964 [Capital] 3.4235 billion yen
[URL] https://www.ne-chemcat.co.jp/

■ For inquiries on this release, please contact:
Public Relations, N.E. CHEMCAT CORPORATION; E-mail: info-pr@ne-chemcat.co.jp