

## FC catalyst with mesoporous carbon

Mikihiro Hori<sup>a</sup>, Hisao Kato<sup>a</sup>, Shinichi Matsumoto<sup>a</sup>,  
and Nobuyuki Nishi<sup>b</sup>

<sup>a</sup>Toyota Motor Corporation

1, Toyota-cho, Toyota, Aichi, 471-8572, Japan

<sup>b</sup>Institute for Molecular Science

Myodaiji, Nishigo-naka 38, Okazaki 444-8585, Japan

<sup>b</sup>Kanazawa University

Kakuma, Kanazawa 920-1192, Japan

### Introduction

It is still a great challenge to decrease the cost of PEFC (Polymer Electrode Fuel Cells). A lot of effort has been put into improving catalytic activity in order to reduce platinum (Pt) usage. But, recent studies show that Pt catalysts are poisoned by the sulfonate anions of ionomer [1, 2]. So it is suggested that the apparent catalytic activity should be improved by separating Pt particles from the ionomer. Early studies have suggested that the ionomer micelle sizes were more than about 10 nm [3]. Therefore, it is expected that catalyst poisoning will be suppressed if the Pt particles are loaded into mesopores that are only a few nm in diameter.

### Experimental

In this study, we used Mesoporous Carbon Nano-Dendrites (MCND) [4] as the carbon support. MCND has ultra-thin graphitic walls and a number of mesopores under 10 nm (BET surface area: 1600 m<sup>2</sup>/g). The MCND support was dispersed in a nitric acid aqueous solution, followed by addition of Pt(NH<sub>3</sub>)<sub>2</sub>(NO<sub>2</sub>)<sub>2</sub> / nitric acid solution and ethanol. Subsequently, the mixture was refluxed for 3 h while stirring. After cooling, the mixture was filtered and washed using distilled water. Finally the solid was dried and calcined at 700 °C under argon gas flow. The prepared catalyst, denoted as Pt/MCND, was analyzed by XRD and 3D-TEM. The electrode was manufactured by mixing the catalyst and ionomer, then hot-pressing onto the membrane (Nafion<sup>®</sup> NRE211) to prepare the MEA. The catalytic activity of Pt/MCND was measured as the ORR current of the MEA. As a reference, a conventional Pt catalyst using Vulcan carbon as the support was synthesized using the same procedure.

### Results and Discussion

According to XRD analysis, the Pt crystallite diameter of Pt/MCND was 2.2 nm, which was smaller than the 3.5 nm particles observed in Pt/Vulcan. Higher Pt dispersion is likely caused by the higher surface area of MCND, 1600 m<sup>2</sup>/g, compared to that of Vulcan, 230 m<sup>2</sup>/g.

Figure 1 shows the cross-sectional TEM images of both catalysts. Almost all of the Pt particles in Vulcan were located on the external surface. In contrast, 88 percent of Pt particles in MCND existed inside of the mesopores. The mean pore diameter of MCND is about 2 nm, and almost all pores are less than 10 nm in diameter. Therefore, Pt particles dispersed in MCND should avoid contact with the ionomer.

The ionomer coverage of Pt was derived from the humidity dependence of the measured Electro Chemical Surface Area (ECSA). All electro-active Pt sites area could be measured at 100%RH. Meanwhile, at low humidity, only Pt active sites in contact with the ionomer are measured. The ratio of the ECSA at 20%RH to the ECSA at 100%RH, indicating ionomer coverage, was 1.0 for Pt/Vulcan, and 0.49 for Pt/MCND respectively. Then the poisoning of Pt/MCND is expected to be suppressed.

Catalytic activities for the MEAs are shown in Table 1. Pt/MCND showed 1.3 times higher ECSA and 3.7 times higher Specific Activity (SA) than Pt/Vulcan. Higher ECSA should be attributed to high Pt dispersion of Pt/MCND. Meanwhile, higher SA should be caused by the inhibition of ionomer poisoning.

Catalytic activity and corrosion durability of Pt/MCND will be discussed in the poster presentation.

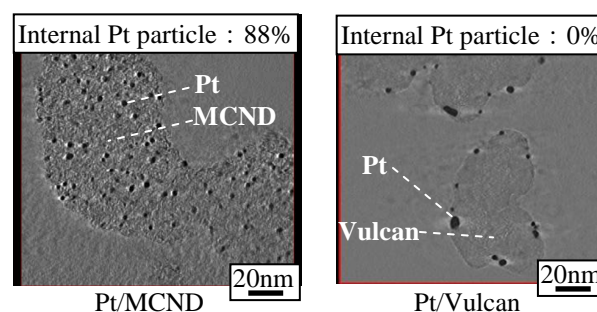


Fig.1 Cross-sectional TEM images

Table. 1 Catalytic activities of MEAs

	ECSA (m <sup>2</sup> /g)	SA (μ A/cm <sup>2</sup> )	MA (A/g-Pt)
Pt/MCND	88	131	116
Pt/Vulcan	69	35	24

Anode gas: 4% H<sub>2</sub>/N<sub>2</sub> humidified at 72 %RH  
Cathode gas: 100%O<sub>2</sub> humidified at 72 %RH  
ORR current was measured at 0.9V vs. RHE

### References

- [1] N. M. Markovic, et al, *J. Phys. Chem. C*, **114**, 8414(2010)
- [2] Atsushi Ohma, et al, *Electrochimica Acta*, **55**, 8829(2010)
- [3] Y. S. Kim, et al, *DOE Hydrogen Program Merit Review and Peer Meeting*, FC16, (2009)
- [4] N. Nishi, et al, *Carbon*, **47**, 306, 3750(2009)