

Carbon-supported Pt nanowires catalyst for oxygen reduction reaction in PEMFC

Bing Li^{†,‡}, Zeyu Yan[‡], Daijun Yang[†], Zhuoping Yu[‡],
Jianxin Ma^{‡*}

[†]School of Mechanical Engineering, 4800 Caoan Road,
Tongji University, Shanghai 201804, China

[‡]School of Automotive Studies, 4800 Caoan Road,
Tongji University, Shanghai 201804, China

*Corresponding author. Tel: +86-21-6958-9480.

Fax: +86-21-6958-9121. E-mail: jxma@tongji.edu.cn

The development of polymer electrolyte membrane fuel cells (PEMFCs) is an ongoing field of research towards the development of sustainable energy technologies, with potential for practical usage in stationary, back-up and vehicle propulsion applications. ¹With respect to the Pt or Pt-based electrocatalyst materials utilized in PEMFCs, state of the art carbon supported platinum nanoparticles (Pt/C) are still considered the best performing; however, the current challenges reside in the need to significantly improve the electrocatalytic activity and durability of these materials towards the sluggish kinetics of the cathodic oxygen reduction reaction (ORR). Several different nanostructure control strategies have garnered success in the development of new age electrocatalysts with improved utilization, mass transport properties and operational durability, including one-dimensional Pt-based nanostructures, de-alloyed nanoparticles and Pd supported monolayers of Pt. Recently, Andy Sun group has found that Pt-based nanowires synthesized by the chemical reduction method have demonstrated significantly improved specific and mass based activities, coupled with improved operational durability compared with commercial Pt/C. ²However, the aforementioned studies have relied on half-cell accelerated degradation testing (ADT) protocols to investigate electrocatalyst stability, with no reports investigating the performance and durability of these materials during actual fuel cell operation.

In the present work, we report the synthesis of carbon-supported platinum nanowires (Pt NWs/C) using a surfactant-free procedure. The deliberately controlled nanostructure of Pt NWs/C can serve to effectively enhance mass transport and electron transport, leading to improved electrocatalyst activity and Pt utilization, while the one-dimensional anisotropic morphology can lead to enhanced stability under the harsh operating conditions encountered at the cathode. Thus, this paper involves the investigation of a novel catalyst electrode design and fabrication technique using highly active Pt NWs/C as a new class of electrocatalyst materials for PEMFC applications. ³Moreover, the performance of a single cell membrane electrode assembly (MEA) is reported.

Figure 1 shows the XRD patterns of Pt NW/C and commercially available Pt/C catalysts. The presence of diffraction peaks at 39.7°, 46.7°, 67° can be assigned to Pt(111), Pt(200), and Pt(220), consistent with the face-centered cubic (fcc) structure of Pt. Similarly, the diffraction peaks at the corresponding positions were also observed for the Pt/C. From the Figure 1, it was also found that the diffraction peak (200) of the Pt NWs/C is shifted slightly to a higher value as compared with the Pt/C. Figure 2 shows the MEA performance results for the study of cathode catalyst with Pt NWs/C and commercial Pt/C. The performance of a membrane electrode assembly

(MEA) prepared with a loading of 0.35 mg_{Pt} cm⁻² Pt NWs/C as the cathode catalyst generated a maximum power density of 646.1 mW cm⁻² at 70 °C, which is higher than that of commercially available Pt/C with a loading of 0.4 mg_{Pt} cm⁻² at air/H₂ test condition. This strongly suggests that the more catalyst active sites could be achieved due to nanowire structure of Pt. Herein, Pt NWs/C material is presented as promising replacements to conventional platinum based materials for utilization as cathode electrocatalysts for PEMFC applications.

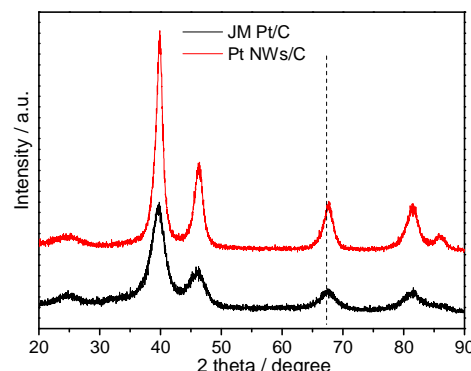


Figure 1: XRD patterns of Pt NWs/C and commercial Pt/C catalysts.

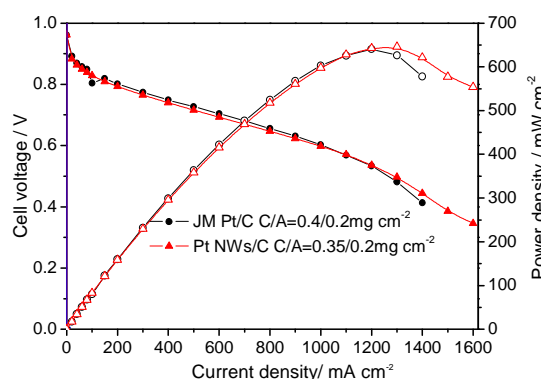


Figure 2: Single cell performance using Pt NWs/C and commercial Pt/C.

References

1. B. Li, D. C. Higgins, D. J. Yang, Z. P. Yu, J. X. Ma, *Int. J. Hydrogen energy*, **38**, 5813(2013).
2. S. H. Sun, G. X. Zhang, D. S. Geng, Y. G. Chen, R. Y. Li, M. Cai, X. L. Sun, *Angew. CHEM. Int. Ed.*, **50**, 422 (2011).
3. B. Li, D. C. Higgins, S. M. Zhu, H. Li, H. J. Wang, J. X. Ma, Z. W. Chen, *Catal. Commun.*, **18**, 51(2012).