

Carbon Supported Metallic Nanoparticle Architectures as Electrocatalysts for PEM Fuel Cells

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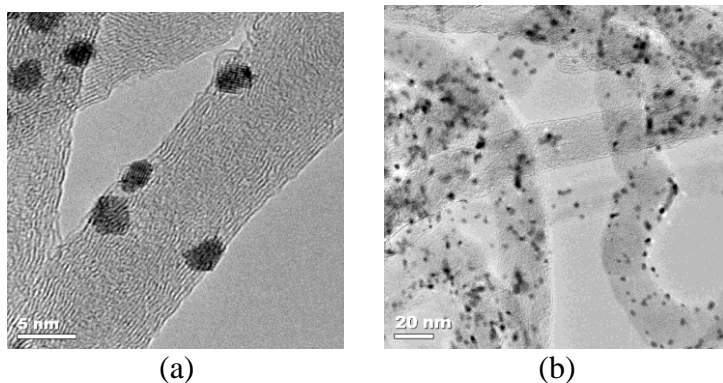
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A proton exchange membrane fuel cell (PEMFC) is comprised of a membrane electrode assembly (MEA) typically with an ionically conducting polymeric membrane sandwiched between two electronically conducting electrodes. Typical electrodes for PEMFC applications are made of a gas diffusion layer (usually porous carbon paper or carbon cloth) supporting a layer of finely dispersed platinum on carbon catalyst. The high cost of platinum is prohibitive for commercialization of PEMFCs and research efforts are directed to reduce the amount of platinum by improving membrane electrode assembly preparation techniques or structures of carbon supported catalysts [1].

In the past, several methods were utilized to deposit platinum on different carbon supports, such as impregnation-reduction, microemulsion based synthesis and ion exchange. The carbon supports included Vulcan XC 72 R, MWCNT, carbon aerogel, activated carbon, BP2000 and carbon cryogel. In all these techniques, it has been targeted to decrease the average size of Pt particles in order to increase the catalytic surface area per mass of Pt and also to disperse the Pt particles uniformly on the support.

Supercritical fluids have been receiving increasing attention lately in preparation of a wide variety of materials for fuel cells [2]. This promising catalyst preparation technique results in small particle sizes and homogeneous dispersion [3, 4, 5]. Additional advantage of this technique is the ability to thermodynamically control [6, 7] the metal loading.

In this study, by using supercritical carbon dioxide (scCO₂) deposition method Pt based electrocatalysts were prepared on different carbon supports such as MWCNT, VXR and BP2000. The synthesized catalysts were compared with commercially available Pt/C-E-TEK and Pt/C-Tanaka catalysts by means of XRD, TEM and cyclic voltammetry measurements. The bright field and HRTEM images for the synthesized and commercial catalysts are presented in Figure 1 for Pt/MWCNT (a),(b), Pt/VXR (c),(d), Pt/BP2000. It can be seen that a small Pt particle size of about 1-2 nm and uniform Pt distribution can be achieved as a result of scCO₂ deposition method.



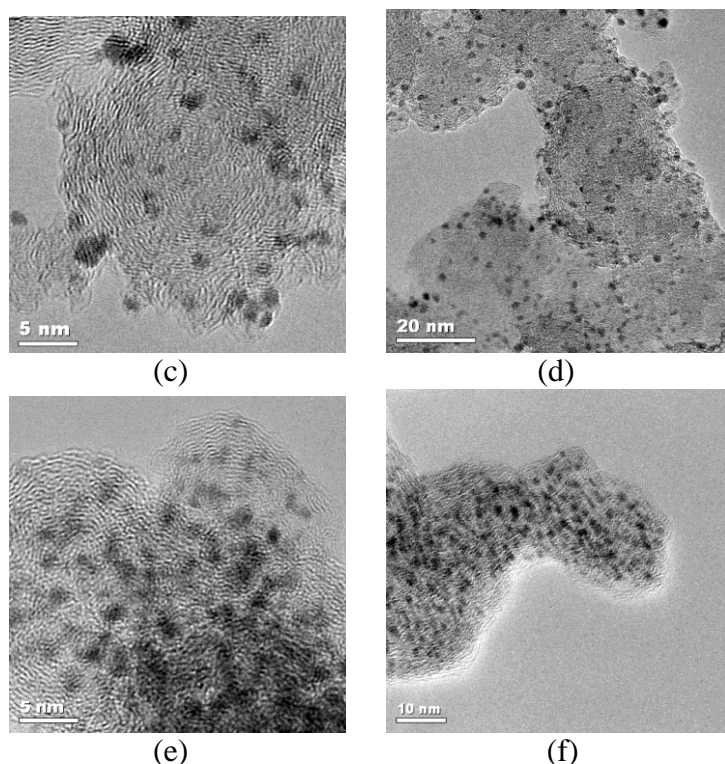


Figure 1

As demonstrated by CV data, the catalytic activity of the synthesized Pt/VXR regarding electrooxidation and reduction of hydrogen is superior to the other commercial and synthesized catalysts. However, although the prepared Pt/BP2000 has the same particle size as Pt/VXR, its ESA is lower which could be due to the difference in the structures of Pt/BP2000 and Pt/VXR. The reason for that can be the structural differences between the carbon supports. Since BP2000 has higher microporous surface area than VXR, the accessibility of the Pt can be lower for BP2000. Although Pt/VXR (scCO₂) has the highest ESA and small particle size, the Pt utilization is 74% only. It can be assumed that in the case of small (~1 nm) Pt particles, the accessibility of the metal particles even in liquid electrolyte is more critical due to the partially hydrophobic nature of the carbon support. For Pt/MWCNT (scCO₂) having larger particles (2 nm), the utilization of Pt seems to be higher.

References:

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