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Nanoscale graphite-supported Pt catalysts for oxygen reduction reactions in fuel cells

Mei-xian Wang, Fan Xu, Hong-fang Sun, Qi Liu, Kateryna Artyushkova, Eric A. Stach, Jian Xie

Abstract

The nanoscale graphite particles were prepared and the Pt catalysts supported on such graphites were developed for oxygen reduction in the polymer electrolyte membrane fuel cells. Catalytic activity and carbon corrosion of the developed catalysts were evaluated using rotating disc electrode techniques and results were compared with those of a state-of-the-art commercial E-TEK Pt catalyst supported on carbon black Vulcan XC72. The results showed that the particle distribution and the structure of the developed Pt nanoparticles supported on the nanoscale graphite were similar to those of the commercial catalyst. The accelerated degradation testing results showed that the electrochemical active surface area losses after 1500 cycles were 46.92% and 62.2% for the developed catalyst and the commercial catalyst, respectively, while mass activity losses were 45.3% and 84.2%, respectively. The temperature-programmed oxidation results suggest that the developed catalysts had better corrosion resistance than the commercial catalyst. The developed Pt catalysts had similar catalytic performance to the commercial catalyst; however, the developed catalysts had much better corrosion resistance than the commercial catalyst. Overall, nanoscale graphite can be a promising electrocatalyst support to replace the currently used Vulcan XC72 carbon black.

1. Introduction

With the pressing environmental requirements for reducing automobile emissions, finding an alternative automotive propulsion system with fewer emissions than an internal combustion engine has become more urgent than ever. Recently, rising oil prices have accelerated the efforts and exploration – not only for emissions, but also for higher energy efficiency and the use of alternative fuels. Polymer electrolyte membrane fuel cells (PEMFCs) are the best candidates for automobile propulsion due to their ultimate cleanliness – zero emissions, low operating temperatures (e.g., 80°C), high energy efficiency (i.e., >65%) [1] and their use of alternative fuels (i.e., hydrogen). As PEMFCs are being driven toward commercialization, the challenge of high durability has emerged, while PEMFCs are still being pushed to have higher performance and lower cost. High durability is not only a requirement for PEMFC applications in automobiles; it is also the most effective way to reduce the cost of PEMFCs. Improving the durability of PEMFC components can effectively reduce the cost of implementing PEMFC systems, making widespread commercialization more realistic due to a reduced stack replacement frequency. PEMFC performance loss during long-term operations under steady and dynamic conditions has been attributed to the corrosion of carbon blacks (as catalyst supports), the degradation of Pt and Pt alloy catalyst nanoparticles, the Nafion ionomer network inside the catalyst layer, and the Nafion membrane [2–7].

In PEMFCs, platinum and platinum alloy nanoparticles are usually dispersed on the surface of porous carbon blacks (e.g., Vulcan XC72) to function as PEMFC anode and cathode catalysts [8,9]. Carbon black supports are easily oxidized when the potential is greater than 0.8 V [10,11]. Corrosion is accelerated when Pt nanoparticles exist on the surface of carbon blacks [12]. Thus, carbon corrosion contributes to a great performance loss in the PEMFCs. In particular, when the PEMFCs are operating under an automobile driving cycle [13], both the anode and the cathode experience a sharp potential spike, as high as 1.20 V (vs. normal hydrogen electrode potential) [14], causing severe carbon corrosion.

One strategy to reduce fuel cell performance degradation from carbon corrosion is to use a more stable catalyst support than carbon black [15]. For example, it has been proposed that carbon materials with more graphitic components can be more stable, such materials include but not limited: graphite carbon nanofibers [16], carbon nanotubes [17], ordered uniform porous carbon networks [18], and graphenes [19]. These carbon materials have been shown...
to be more corrosion-resistant than carbon blacks, but the cost of manufacturing is a concern.

In this paper, the nanoscale graphite particles were prepared first, and then, the nanoscale graphite-supported Pt catalysts were developed. The catalytic activity of the nanographite-supported Pt catalysts was evaluated using a rotating disc electrode (RDE) for oxygen reduction, while the carbon corrosion of such catalysts was developed. The catalytic activity of the nanographite-supported Pt catalysts were both compared with those of the state-of-the-art commercial E-TEK catalyst with the same Pt loading.

2. Experimental

2.1. Preparation of the nanoscale graphitic particles

An isotropic petroleum pitch from a refinery was heat-treated in a device consisting of a cylindrical stainless steel reactor fitted with an anchor-type stirrer and a thermocouple connected to a temperature controller. The reactor was heated with nitrogen in a cylindrical furnace. The reactor was loaded with the precursor pitch, and heated at 3 °C/min up to the final temperature of 420 °C. The reactor was then kept for 2 h at 420 °C. During the heat treatment, an agitation of 70 rpm was maintained, and a nitrogen flow of 0.5 m³/h was used for the removal of volatile materials. In order to separate the spherical particles from the parent pitch, first, the heat-treated pitch was mixed with wax oil and filtered at 100 °C, and then it was washed with toluene three times in a 75 °C water bath and centrifuged for separation. The particles were dried and oxidized in air at 200 °C for 5 h and carbonized at 1000 °C for 15 min in nitrogen. Finally, these particles were graphitized at 2800 °C in argon. The obtained graphite powders were then etched by a mixture of nitric acid (70%, EMD), sulfuric acid (98%, EMD), and perchloric acid (60%, Fisher) with the ratio of 1:6:1 (v/v) to make nanoscale graphite particles. For each batch of etching, 5 g of graphite powder were put into the etching acid and heated for different lengths of time while stirring. Two samples were prepared: graphite powders in mixed acid heated for 1 h and 2 h, respectively. For the separation of the nanoscale graphite particles from the etching acid, the mixture was centrifuged at 15,000 rpm, and each sample was washed with distilled water at least 5 times.

2.2. Preparation of the catalyst

The catalysts were prepared by the ethylene glycol (EG) method [21]. For the catalyst preparation, 100 mg of the nanoscale graphite, obtained after 2 h etching, was suspended in 20 mL of an ethylene glycol solvent and was stirred under ultrasonication for 20 min. Then, 1.5 mL of a hexachloroplatinatic acid EG solution (15 mg Pt/mL in EG) was added to the solution dropwise while stirring mechanically for 4 h. NaOH (0.01 M in EG) was added to adjust the pH of the solution to above 13; then, the solution was heated at 140 °C for 3 h to ensure that the Pt was completely reduced and the entire EG solution had a DI water content of less than 5 vol.%. The solution under reflux to keep water in the synthesis system. The whole preparation process was conducted under a flow of nitrogen to eliminate oxygen and organic byproducts. The solid was separated from the solution by centrifuging; then the solid was washed with DI water 5 times and dried at 70 °C for 8 h. The obtained catalysts were 20 wt.% Pt on nanoscale graphite.

2.3. Characterization of the nanoscale graphite and Pt-supported catalysts

The structures of the nanoscale graphite and Pt catalysts were characterized using X-ray wide angle diffraction (XRD). The diffractionometer utilized Cu Ko radiation (40 kV and 30 mA). The data were collected as continuous scans, with a step size of 0.02° (2θ) and a scanning rate of 2° (2θ)/min between 10° and 90° (2θ). The surface chemistries of the raw graphite spheres and the acid-etched graphite were analyzed using a Kratos AXIS Ultra X-ray photoelectron spectrometer (XPS). The spectrometer used monochromatic Al Kα X-ray source. An electron flood gun for charge neutralization and a hemispherical analyzer with 8 multichannel photomultiplier detectors were employed for analysis. The area of analysis was 700 μm × 300 μm. The morphologies of the catalysts and the acid-etched graphite were examined using a Philips Tecnai 20 transmission electron microscope (TEM) and a Hitachi S-4800 scanning electron microscope (SEM). The exact Pt loading of the catalysts was determined using thermal gravimetric analysis (TGA) by oxidizing the catalysts in a ceramic basket under a flow of air heated to 900 °C at a rate of 25 °C/min with a Netzsch Sta 449 F3 thermal analyzer. The specific surface areas of the nanoscale graphite particles were measured by a Brunauer–Emmett–Teller (BET) method using nitrogen sorption at a liquid nitrogen temperature (77 K) with a Quantachrome autosorb-1 surface area analyzer. The particle size distribution of different nanoscale graphite particles was measured using a Malvern Nano-ZS-90 Nanosizer.

2.4. Electrochemical characterization

2.4.1. Preparation of the electrode

A glassy carbon rotating disk electrode was used as the working electrode. The glassy carbon electrode was polished with a 0.3 μm alumina suspension followed by a 0.05 μm alumina suspension to give a mirrored finish. Sonication was used to suspend 35 mg of a catalyst in a solution of 200 μL 5 wt.% Nafion, 3 mL propanol, and 47 mL DI water for 5 mins. A total of 10 μL of the Pt suspension (loading: 7 μg Pt/cm²) was pipetted onto the glassy carbon electrode and was dried at room temperature overnight. Electrochemical measurements were carried out using a three-compartment electrochemical cell with a Pt wire as a counter electrode, and an Ag/AgCl as a reference electrode. All potentials cited in this article were normalized with respect to normal hydrogen electrode potential (NHE).

2.4.2. Electrochemical measurements

All experiments were performed at room temperature. After preparing the catalyst on the glassy carbon electrode, the catalyst was electrochemically cleaned by cycling the potential between 0.05 and 1.20 V with a scan rate of 1 V/s for 200 cycles in a N₂ saturated 0.1 M HClO₄ electrolyte. To conduct the performance testing, a cyclic voltammogram (CV) was used with a scan rate of 20 mV/s between 0.05 and 1.20 V. The area under the absorption and desorption peaks of hydrogen on Pt in a CV curve was used to determine the electrochemical active surface area (ECASA) of the Pt catalyst on the electrode. Polarization curves for oxygen reduction reactions (ORRs) on the RDE were recorded using a PARSTAT 2273 advanced electrochemical system (Princeton Applied Research, Oak Ridge, Tennessee) and the ORR mass activity was obtained by scanning the potential from 0.05 to 1.00 V at 20 mV/s in oxygen-saturated 0.1 M HClO₄. The rotating speed of the RDE was 1600 rpm controlled by a controller (Pine Instruments, Grove City, Pennsylvania). The mass activity current density, iₘ₉ (A m⁻²), is defined as the kinetic current per unit mass of Pt catalyst which is obtained using kinetic current density, iₙ (A cm⁻²), divided by the Pt loading (mgPt/cm²) of catalyst in the thin film on the surface of RDE as
shown in Eq. (1). The kinetic current density, \( i_k \), is obtained using Eq. (2) which is corrected for the diffusion effect:

\[
\begin{align*}
\dot{i}_m &= \frac{\dot{i}_k}{m_{\text{Pt}}} \\
\dot{i}_k &= \frac{i_L \times i}{i_L - i}
\end{align*}
\]

where \( i_L \) is the limiting current density (A cm\(^{-2}\)); \( i \) is the measured current density (A cm\(^{-2}\)), \( i_m \) is the mass activity current density [22].

2.4.3. Accelerated degradation test (ADT)

Different inks were prepared for ADT. Sonication was used to suspend 35 mg of the Pt/graphite catalyst in a solution of 200 \( \mu \)L 5 wt.% Nafion, 3 mL propanol, and 2 mL DI water for 5 mins. A total of 10 \( \mu \)L of the Pt suspension (loading: 0.35 mg Pt/cm\(^2\)) was pipetted onto the glassy carbon electrode and was dried at room temperature overnight. Electrochemical measurements were also carried out using a three-compartment cell as mentioned before. To perform the ADT, a CV was used with a scan rate of 20 mV/s between 0.85 and 1.40 V. The procedure of the ADT was carried out by running 1500 consecutive ADT cycles; the ECASA and the polarization curves were measured before and after the ADT (for details on the ADT method, please see Ref. [20]).

3. Results and discussion

3.1. Characterization of the graphitic particles

Liquid-phase carbonization is an important process for preparation of highly graphitic carbon materials [23]. Mesophase pitch is an important product from the liquid carbonation process that exhibits discotic liquid crystalline structure properties. Such mesophase pitch with liquid crystal properties plays a unique role in synthesizing carbon materials due to its characteristic graphitization and deformability, as well as its very high carbon content [24,25]. During the mesophase pitch preparation process, the isotropic precursors were heat-treated in an inert atmosphere and the molecules grew bigger, as shown schematically in Fig. 1. As heating time increased, the polyaromatic molecules connected to each other and grew to hexagonal planes, then, a large number of these planes stacked together and finally formed broadly spherical particles as a result of surface energy minimization (spherical shape with minimum surface energy). The formed spherical particles coalesced together and formed bigger particles. These spherical particles were highly graphitic in nature after the graphitization (i.e., treated at 2800 °C), but were in the range of micrometers. If these particles were separated directly from the precursor (i.e., pitch), it was very difficult to obtain particles with nanometer scale dimensions.

SEM and TEM micrographs of these spherical particles are presented in Fig. 2. The size of the spherical particles separated from the isotropic pitch was not uniform, and was in the range of 100 nm to 1 \( \mu \)m. These particles were graphitic materials after graphitization, as demonstrated in the XRD spectra in Fig. 5. The layered structure on the surface of these particles is also a characteristic of graphitic carbon (Fig. 2A). It is believed that these graphitic layers are the stacking of hexagonal planes derived from polyaromatic molecules of the parent pitch. After the acid etching, the particle size was significantly reduced, as shown in Fig. 2B, and was below 200 nm. It seems that the particles aggregated together.

\[\text{Fig. 1. Formation process of hexagonal planes in isotropic precursor.}\]

\[\text{Fig. 2. The structure of nanoscale graphite particles. (A) SEM image of the spherical particles separated from the isotropic pitch (graphitized); (B) SEM image of the particles in (A) etched for 1 h; (C) TEM image of the particles in (A) etched for 2 h; (D) high-resolution phase contrast TEM image of the nano-graphite particles in (C).}\]
Fig. 3. Average particle size distribution of etched nanoscale graphite particles as a function of etching time (measured using Malvern Nano-ZS-90 Nanosizer).

The mean particle size of the nanoscale graphite particles was below 100 nm after etching for 2 h, which is consistent with the TEM results (Fig. 2).

3.2. Characterization of the Pt/NG and Pt/XC catalysts

The Pt nanoparticles were prepared on the nanoscale graphite particles, which were prepared by 2 h acid etching. These catalysts are denoted as Pt/NG. The commercial (E-TEK 20% Pt) Pt catalyst supported on Vulcan XC72 was used as a reference for the comparison and is denoted as Pt/XC. The XRD spectra of the two catalysts
are shown in Fig. 5. The average diameter of the Pt particles was estimated from the broadening of the Pt diffraction line corresponding to the 220 plane. The average Pt particle diameters were 2.3 nm and 2.5 nm for Pt/NG and Pt/XC, respectively, which is very close to the particle sizes obtained from the TEM micrographs in Fig. 6. It is well known that the 0 0 2 peak of the XRD spectrum is very sharp for highly graphitic carbon materials. It can be seen that in Fig. 5, the 0 0 2 peak of the nanoscale graphite particles was much sharper than that of the Vulcan XC72, suggesting that the acid-etching produced nanoscale graphite particles have a graphitic structure. The graphitic carbon layer structure can also be found in the high resolution TEM micrograph in Fig. 6A, in which graphene sheets can
be clearly seen. However, the XC72 particles that were used as the catalyst support (shown in Fig. 6) have an amorphous structure.

In order to evaluate the chemical stability of the prepared catalysts in terms of the corrosion of the carbon supports, temperature programmed oxidation (TPO) tests were performed. The structural difference of the supported catalysts was also reflected in their TPO analysis. The differential thermogravimetric curves of the two supported catalysts in an air atmosphere are shown in Fig. 7. It can be seen that the Pt/NG maximum weight loss rate occurred at a higher temperature than that of the Pt/XC (Fig. 7), suggesting that nanoscale graphite has a higher oxidation temperature than XC72 carbon black, and thus, a higher corrosion resistance. The Pt particle sizes on the catalyst supports also had an influence on the oxidation temperature of the supports [15]; however, the two catalysts had the same Pt loading and similar Pt particle sizes. Thus, the higher corrosion resistance of the Pt/NG must have come from the higher degree of graphitic structure. The difference of the differential thermogravimetric curves in the air atmosphere gives important information about the corrosion resistance of the catalyst layers in PEFC electrodes. The corrosion process is not easy to evaluate in situ during PEMFC single cell degradation testing because it is difficult to decouple the corrosion process from the cell degradation process. In addition, the PEMFC cell degradation testing takes a longer period of time to complete. Thus, the TPO tests can provide a faster comparison of the carbon supports of different catalysts in terms of carbon corrosion.

3.3. Effects of the carbon supports on the electrochemical performance

The performance and the corrosion resistance of the nanoscale graphite-supported catalyst, Pt/NG, and the commercial Vulcan XC72-supported catalyst, Pt/XC, were tested using a rotating disk electrode. Assuming the hydrogen adsorption–desorption process was on a polycrystalline Pt surface, the electrochemical active surface area (ECASA) was determined by integrating the \( H_{up} \) and \( H_{down} \) peak for the average value. The pair of peaks observed between 0.05 and 0.30 V (vs. NHE) corresponded to the desorption–adsorption of hydrogen on the Pt surface. The typical CV and polarization curve results are shown in Fig. 8A and B for commercial 20% Pt/XC and 20% Pt/NG, respectively. The electrochemical parameters are listed in Table 2, and as can be seen, the ECASA of Pt/NG was 102.56 m²/gPt, which was bigger than that of the commercial catalyst (98.27 m²/gPt). This difference might have been caused by the smaller Pt particle size on the graphite [27], which was confirmed by both XRD and TEM results. Double Layer Charging (DLC) is directly propositional to carbon surface area, which was obtained here by integrating the CV curve from 0.32 to 0.38 V (vs. NHE) for Pt/XC and Pt/NG. Results show that the DLC was similar for both XC72 carbon black and graphite, which was also confirmed by the BET results (the BET surface area for NG and XC72 Carbon black is 234 and 254 m²/g, respectively). The polarization curves are shown in Fig. 8A. When the cell voltage was higher than 0.75 V, the mass activity of the Pt/NG was very close to that of the Pt/XC. The Tafel slopes of Pt/NG and Pt/XC were close to each other, indicating that the catalyst activities on nanoscale graphite are as good as the catalyst activities on the commercial catalyst. When the cell voltage was below 0.75 V, which is in the ohmic control region, the mass activity of the Pt/NG was better than that of the commercial catalyst. This could be ascribed to the higher electrical conductivity of graphite [21].

To further investigate the corrosion resistance of Pt/XC and Pt/NG, an ADT (1500 cycles) was carried out. Fig. 9 shows the results

---

**Table 2**

Electrochemical performance of both Pt/NG and Pt/XC catalysts.

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>ECASA (m²/gPt)</th>
<th>DLC (0.4–0.65 V) (C/cm²)</th>
<th>Tafel slope (mv/dec)</th>
<th>i₀ (A/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-TEK 20% Pt/XC72</td>
<td>98.27</td>
<td>245</td>
<td>80.3</td>
<td>10E–6.54</td>
</tr>
<tr>
<td>20% Pt/NG</td>
<td>102.56</td>
<td>292</td>
<td>81.2</td>
<td>10E–6.14</td>
</tr>
</tbody>
</table>

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Fig. 7. Differential thermogravimetric curves in air atmosphere.

Fig. 8. (A) Polarization curve (on a rotating disk electrode) of Pt catalysts supported on different carbon supports in 0.1 M HClO₄ purged with O₂ at room temperature with a sweep rate of 20 mV s⁻¹ and RDE at 1600 rpm. (B) CV curves for different Pt-based carbon supports in 0.1 M HClO₄ purged with N₂ at room temperature at a sweep rate of 20 mV s⁻¹. The catalyst layer consisted of a total Pt loading of 350 μg/cm².
of the activity and durability of Pt/NG and Pt/XC toward ORRs before and after the ADT (1500 cycles). It can be seen that the hydrogen adsorption/desorption peaks (0.0–0.4 V (vs. NHE)) in the CVs were suppressed after the ADT, indicating that the ECASA decreases after the ADT. After 1500 consecutive cycles, the ECASA loss of Pt/XC was almost 62.2%, which was more than that of Pt/NG, 46.92% (Table 3). An interesting phenomenon can be seen in Fig. 9D, which a redox couple appeared at 0.55 V and 0.60 V in the CV of the Pt/XC catalyst after 1500 cycles. This redox couple corresponds to the redox reaction of quinone/hydroquinone, \( \text{C} + \text{O}_2 \rightarrow \text{quinone} \) [28]. However, as seen in Fig. 9C, such a redox couple was not obvious in the CV of the Pt/NG after cycling, which suggests a higher corrosion resistance from the nanoscale graphite. The polarization curves for Pt/NG and Pt/XC before the ADT corrosion in Fig. 9A and B shows that the mass activity of the Pt/NG catalyst was very close to that of the Pt/XC, however after 1500 ADT cycles, the mass activity of Pt/NG was much better that of Pt/XC. The mass activity (at 0.75 V vs. NHE) loss of Pt/NG and Pt/XC was 45.3% and 84.2%, respectively.

As can be seen in Table 3, the difference between the Tafel slopes before and after 1500 ADT cycles for both Pt/XC and Pt/NG were very small, suggesting that the change in catalytic activity of both catalysts was minimal. In other words, the degradation of the catalyst Pt nanoparticles during ADT cycling was not the dominating process. So the loss of the mass activity of the two catalysts (Fig. 9A and B) was mainly coming from the carbon support corrosion. Table 3 shows the durability of Pt/NG and Pt/XC, which were characterized with the retaining percentage of the ECASA and ORR after the degradation test under the same ADT conditions. These tests have been shown to effectively measure the durability with an emphasis on the carbon support [29]. From the durability test data (Table 3), it can be concluded that the corrosion resistance of Pt/NG is much better than that of Pt/XC (the ECASA losses of Pt/NG and Pt/XC were 46.92% and 62.2%, respectively, and the mass activity losses at 0.75 V of Pt/NG and Pt/XC were 45.3% and 84.2%, respectively, after 1500 ADT cycles). In particular, in the high current region (mass activity at 0.65 V), the mass activity losses of Pt/NG and Pt/XC were 29.4% and 80.7%, respectively. This strongly suggests that nanoscale graphite has much stronger corrosion resistance than XC72 carbon black. The Pt nanoparticle size and the crystallinity were similar for Pt/NG and Pt/XC catalysts, as seen from the TEM and XRD patterns (the only difference between the two catalysts was the carbon supports); therefore, it can be concluded that the enhanced durability of Pt/NG is mainly due to the specific properties of the nanoscale graphite: the intrinsic high degree of graphitization. It is well known that the electrochemical durability of carbons depends on its graphitic property:
the carbon with a higher degree of graphitic structure exhibits higher durability [30]. This is because the corrosion of carbon usually starts from the structure defects [31], and carbons with a higher degree of graphitization have fewer defects [32]. As shown in Figs. 2 and 5, the nanoscale graphite is a highly graphitic carbon material; the graphene layers are perfectly stacked together. However, the most widely used Vulcan XC72 carbon blacks have an amorphous structure [33]. It can be deduced that the carbon layers of XC72 carbon blacks have much more defects than that of the nanoscale graphite. Therefore, the XC72 carbon black is easier oxidized than the nanoscale graphite. After 1500 ADT cycles, the mean particle sizes of catalyst Pt nanoparticles increased from 2.3 nm and 2.5 nm to 4.41 nm and 4.83 nm, respectively, for both Pt/NG and the Pt/XC catalysts as shown in Fig. 6. It can be clearly seen that the Pt nanoparticles were agglomerated together to form big agglomerates after ADT testing (Fig. 6C and D), which suggests that the particle growth was through the surface migration of Pt catalyst nanoparticles rather than the dissolution and redeposition mechanism [14]. The carbon corrosion features were not clearly observed in Fig. 6C and D because the existence of Pt nanoparticles which blocks the observation of the corrosion features on carbon surface. As we pointed in the introduction, it is difficult to decouple the carbon corrosion in the catalyst layer. However, in our previous work, it has been studied the corrosion of carbon supports with different structures using the steam etching approach and the results did show that a carbon corrosion mechanism depended on the structure of carbon materials and carbons with highly graphitic structure had better corrosion resistance [34]. In other words, Pt/NG is much more stable than the Pt/XC under the same electrochemical conditions. Carbon nanotubes, carbon nanofibers and other chemical vapor deposition-derived graphitic carbon materials-supported Pt catalysts also show better durability in fuel cell applications [35]. The manufacturing cost of nanoscale graphite is relatively low, and therefore, it will be a promising catalyst support with higher corrosion resistance for fuel cells.

4. Conclusions

Nanoscale graphite particles have been developed using an acid-etching method. It is expected that there will be a variety of potential applications for these new nanoscale graphite particles, especially as catalyst supports for fuel cell applications. Nanoscale graphite-supported Pt catalysts were prepared using the EG method. The structure and particle size distribution of the nanoscale graphite-supported Pt catalyst, Pt/NG, was found to be similar to that of the commercial catalyst, Pt/XC, but with slightly smaller Pt particle sizes. The polarization curves and the CV curves of the nanoscale graphite-supported catalyst, Pt/NG, and the carbon black supported commercial catalyst, Pt/XC, show that both catalysts had similar mass activity; however, the Pt/NG catalyst had a better ECASA. The electrochemical oxidation behavior of the two catalysts was investigated by our ADT method under the same conditions. After 1500 ADT cycles, the nanoscale graphite-supported catalyst, Pt/NG, showed better corrosion resistance. TPO tests also revealed that catalysts supported on the nanoscale graphite were more stable against corrosion than those supported on the carbon black. The better corrosion resistance of the nanoscale graphite-supported catalysts is ascribed to the ordered graphite structure.

References