Journal of Power Sources 285 (2015) 76–79

Contents lists available at ScienceDirect

Journal of Power Sources

journal homepage: www.elsevier.com/locate/jpowsour

Short communication

Graphene oxide aerogel-supported Pt electrocatalysts for methanol oxidation

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HIGHLIGHTS

- Graphene oxide aerogel is used as the support of Pt nanoparticles.
- Pt/GOA catalyst has higher catalytic activity than as-prepared Pt/rGO.
- Pt/GOA catalyst has higher stability than as-prepared Pt/rGO.

ARTICLE INFO

Article history:
Received 4 December 2014
Received in revised form
27 February 2015
Accepted 9 March 2015
Available online 11 March 2015

Keywords:
Graphene oxide aerogel
Platinum
Electrocatalyst
Methanol electrooxidation

ABSTRACT

Graphene oxide aerogel (GOA) was prepared to serve as catalyst support for Pt nanoparticles for methanol electro-oxidation. Analyses by X-ray diffraction (XRD) and scanning electron microscopy (SEM) were conducted to physically characterize the Pt/GOA catalyst. The results show that Pt/GOA has a 3D macroporous structure, which can not only accelerate mass transfer but also provide a larger efficient surface area for methanol oxidation. The results of electrochemical tests reveal that Pt/GOA has an electrochemical surface area as large as 95.5 $m^2\ g^{-1}$, and its peak current density toward methanol oxidation is as high as 876 mA mg^{-1}_{Pt}.

1. Introduction

As single layers of carbon atoms, graphene nanosheets have a large surface area, excellent electronical conductivity, and stable physical and chemical properties [1]. These properties make graphene an ideal candidate for support materials for Pt-based catalysts in direct methanol fuel cells (DMFCs) to improve the performance and reduce the cost-to-efficiency ratio of the Pt catalysts [2–5]. However, the aggregation between the separated graphene sheets can substantially decrease the high intrinsic specific area of graphene and thus limit the enhancement of catalytic activity [6].

To obtain graphene as individual sheets, some other carbon materials have been used as spacers to attach onto the sheets to reduce aggregation [7,8]. Recently, the synthesis of 3D graphene materials, graphene oxide aerogel (GOA) and graphene aerogel (GA) provide a new way to avoid the restacking of graphene sheets. GOA can be obtained by supercritical CO_2 drying or freeze–drying of graphene oxide hydrogel prepared by crosslinking graphene nanosheets with multivalent metal ions or amino groups. A subsequent reduction process can change GOA into GA. Moreover, GA can also be prepared by supercritical CO_2 drying or freeze–drying of graphene hydrogel that is prepared by hydrothermal treatment of graphene oxide. The as-prepared GOA or GA not only maintains the intrinsic properties of 2D graphene sheets but also exhibits some other excellent functions with improved performance. Hence, this kind of material has been used in DMFCs [9], Li-ion batteries

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http://dx.doi.org/10.1016/j.jpowsour.2015.03.064
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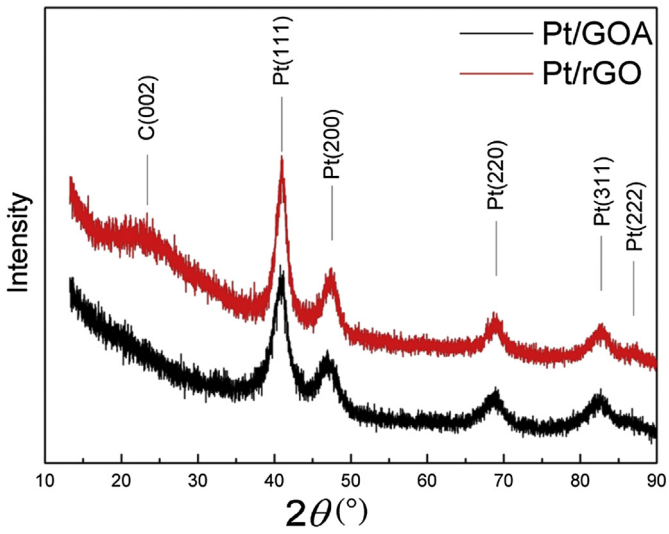

Fig. 1. X-ray diffraction patterns of Pt/GOA and Pt/rGO.

[10], supercapacitors [11], and other applications [12–16].

In this study, we firstly dispersed Pt nanoparticles on GOA, which is a kind of 3D graphene material, prepared in our lab. The physical properties of the obtained catalysts were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). The electrochemical activity and stability of the catalysts toward methanol electrooxidation were evaluated by cyclic voltammetry (CV) and chronoamperometric test.

2. Experimental

2.1. Materials preparation

Graphene oxide aerogel (GOA) was prepared by the method described in Zhang's study [17]. Pt nanoparticles were dispersed on GOA using the following steps. First, 20 mg of GOA powder was mixed with a specific amount of ethylene glycol solution of chloroplatinic acid. The mixture was dispersed into 30 mL of ethanol in a 100-mL beaker under stirring for 1 h and was subsequently subjected to ultrasonic treatment for 0.5 h to form uniform ink. A sufficient amount of sodium borohydride was added to the mixture drop by drop. The resulting mixture was stirred for 2 h, filtered, and dried under vacuum at 70 °C overnight. For comparison, Pt nanoparticles were also dispersed on reduced grapheme oxide (rGO) in the similar procedure.

2.2. Preparation of the working electrode

The catalyst slurry was prepared by ultrasonically dispersing 4 mg catalyst in the solution of 1 mL ethanol and 20 μL Nafion (5 wt % solution in a mixture of lower aliphatic alcohols and DuPont water) for 20 min. A glassy carbon electrode (GCE) with the diameter of 4 mm was polished with alumina suspensions and served as the underlying substrate for the working electrode. A quantity of 5 μL of the dispersion was dropped onto the top of GCE, which was subsequently dried under room temperature for 2 h.

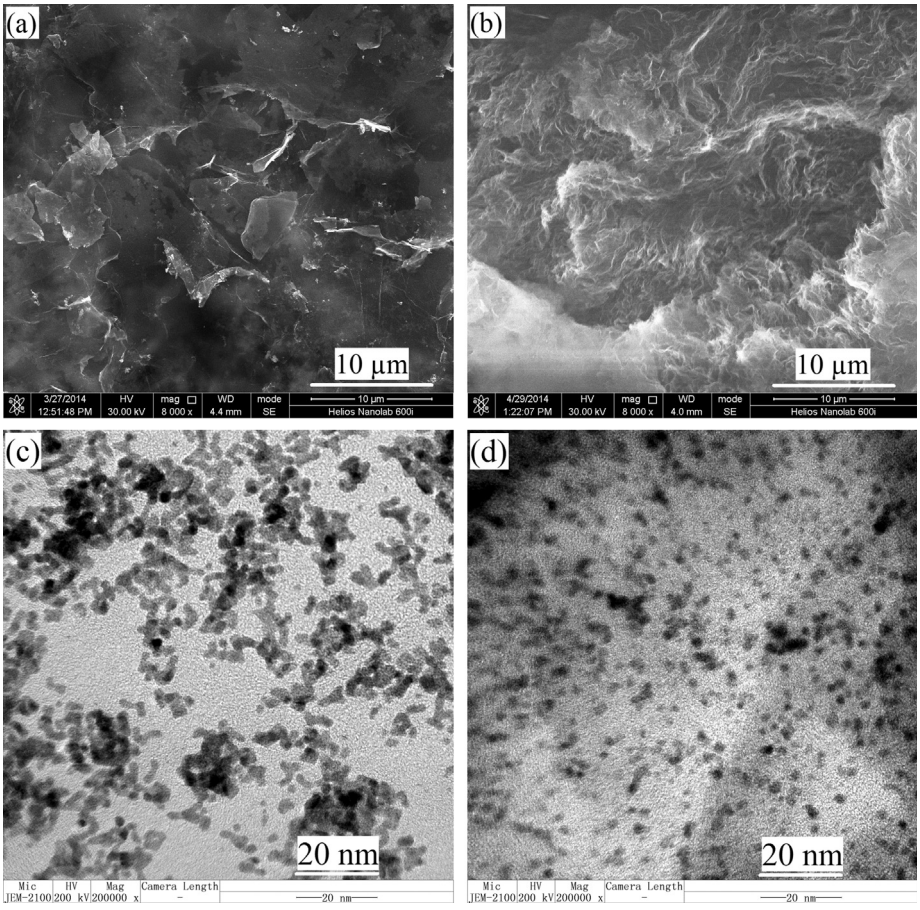

Fig. 2. SEM (a, b) and TEM (c, d) micrographs of Pt/rGO (a, c) and Pt/GOA (b, d).