Pt-decorated graphene foam for electrochemical oxygen reduction with high mass activity

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1. Introduction

Graphene is a single atomic layer of carbon, with great interest to researchers due to its strength, thickness, large surface area and high electronic and thermal conductivity.[1] These properties make ideal for applications such as composite materials, sensors, photo-electronics, electromechanical systems, hydrogen storage, energy conversion and storage, batteries and in drug delivery systems.[2]

Polymer electrolyte membrane fuel cells (PEFCs) are a highly efficient and potentially carbon-neutral energy source, with promise for transport, stationary, and portable applications. However, high cost and low catalytic activity are still major obstacles for commercialization. Graphene is an exciting new material which is being explored for PEFC applications. [3][4][5]

2. Experimental

Graphene foam was synthesized by careful ignition of sodium ethoxide in air followed by repeated washing and pyrolysis in various gases. Samples were used before and after hydrogen reduction treatment at 800˚C. The morphology and structure were studied using BET surface area analysis, X-ray diffraction (XRD), Raman spectroscopy, scanning electron microscopy (SEM), and X-ray photoelectron spectroscopy (XPS). Platinum was decorated on the graphene foam with platinum (II) acetylacetonate as a precursor. Cyclic voltammetry (CV) and linear sweep voltammetry (LSV) were performed using a rotating ring-disk electrode (RRDE) cell in 0.1M perchloric acid.

3. Results and discussion

SEM shows that the graphene foam has a highly porous structure (Fig.1), and BET reveals a surface area of >1500 m^2/g, which is higher than the commercial graphene or carbon black (Vulcan XC-72) reference. XPS and EDX shows reduction in oxygen content from ~12at.% to ~9 at.% after hydrogen reduction treatment.

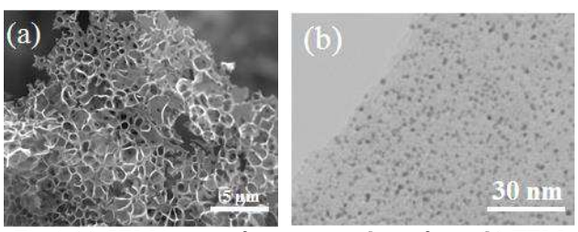

Fig.1 (a) SEM image of porous graphene foam (b) TEM of Pt-decorated graphene foam

CV is shown in Fig. 2(a). The electrochemical surface area (ECSA) for the Pt-decorated graphene samples is higher than that of commercially sourced graphene or carbon black, and the ECSA of H_2-reduced graphene foam (100.7 m^2/g) shows the highest value. The high ECSA is due to the large surface area of the samples.

LSV revealed that the mass activity of the Pt-decorated hydrogen-reduced graphene foam was 176.1 mA/mg, which is higher than that of the commercial graphene (168.7mA/mg) and carbon black (137.8mA/mg) reference samples.

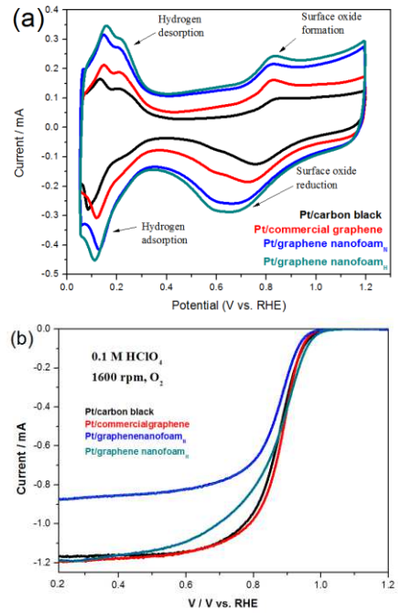

Fig. 2 CV(a) and LSV (b) of Pt-decorated graphene foam after heat treatment in nitrogen, or hydrogen gas, compared with commercial graphene and carbon black.

Pt-decorated graphene foam demonstrated large BET surface area, ECSA, and high mass activity for oxygen reduction, indicating that this is a potential material for use as a catalyst support in PEFCs.

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