Microwave Preparation of XC-72 and Carbon Nanotube Supported Pt Nanoparticles for Fuel Cell Applications

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Pt nanoparticles supported on carbon materials are known for their high activity in fuel cell and general catalysis. Here we present a microwave-assisted polyol preparation of uniformly dispersed Pt nanopartlces on XC-72 carbon and carbon nanotubes (CNTs). Preliminary results showed that the Pt/C nanocomposites were highly effective for the electrochemical oxidation of liquid methanol at room temperature.

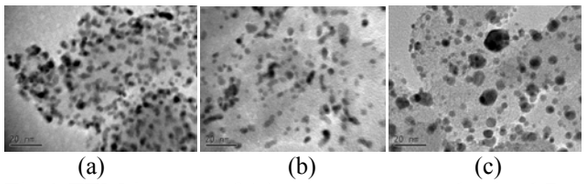
Experimental

A 100 mL beaker, containing a homogeneous mixture of ethylene glycol solution of H_2PtCl_6, KOH and Vulcan carbon XC-72 or CNTs, was placed in the center of a microwave oven (National NN-S327WF, 2450 MHz, 700W) and heated for 60 s. The resulting suspension was filtered and the solid residue was washed with acetone. The samples were inspected by TEM (JEOL JEM 2010); and the Pt contents in them were determined from EDX measurements (JEOL JSM-5600LV). Cyclic voltammetry of the electro-oxidation of methanol in the presence of the Pt/carbon catalysts was carried out on an EG&G model 273 potentiostat/galvanostat, following the procedures described in [1].

Results

EDX measurements indicated Pt loadings of 18.6 wt.% for Pt/XC-72 and 18.5% for Pt/CNT. Fig. 1 shows the TEM images of Pt/XC-72 and Pt/CNTs in comparison with a commercial E-TEK Pt/C catalyst with nominal Pt loading of 20 wt% (18.8 wt.% by EDX). Fig.1 shows that the microwave -synthesized Pt nanoparticles are spherical particles with significantly smaller mean diameters and a narrower particle size distribution than those in the E-TEK catalyst. The diameters for most of the particles are between 3.0 and 4.0 nm, with only a few particles larger than 5.0 nm. It is generally agreed that the size of the metal nanoparticles is determined by the rate of reduction of the metal precursor. Ethylene glycol with high dielectric constant and dielectric loss is rapidly heated under microwave irradiation, and acts as a reducing agent to convert the metal ions into metal powders [2]. The fast heating by microwave accelerates the reduction of the metal precursor and the nucleation of the metal clusters. Additionally the homogeneous microwave heating provides a more uniform environment for the nucleation and growth of metal particles. The carbon surface may contain sites suitable for heterogeneous nucleation and the presence of a carbon surface may interrupt particle growth. Hence smaller and more uniform Pt nanoparticles are produced and deposited on XC-72 carbon and CNT.

Fig.2 shows the cyclic voltammograms of methanol oxidation. The current peak at about 0.70 V in the forward scan is attributed to methanol electrooxidation on the Pt/C catalyst. Fig. 2 clearly shows significantly greater extents of oxidation from the microwave-synthesized Pt/carbon catalysts. The microwave-assisted preparation is therefore a good method for preparing effective supported Pt catalysts. The increased activity is likely due to the better utilization of Pt when the latter exists as uniform small particles stabilized on XC-72 or a CNT surface.



(a) (b) (c)

Fig.1 TEM images of (a) microwave-synthesized Pt/ XC-72, (b) Pt/CNT and (c) E-TEK Pt/C.

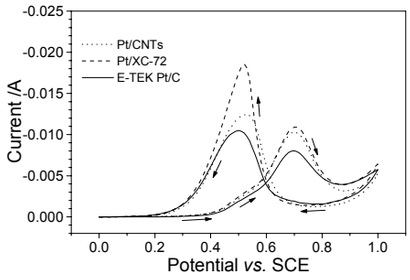


Fig.2 Cyclic voltammograms of methanol electro-oxidation on Pt/C catalysts in 2M CH_3OH / 1M H_2SO_4 electrolyte at 20 mV/s at room temperature.

References

[1] Z. L. Liu, J. Y. Lee, M. Han, W.X. Chen, L. M. Gan, J. Mater. Chem. 2002, 12, 2453
[2] F. Fievert, J. P. Lagier, M. Figlaz, MRS Bull. 1989, 24, 29