Structure Characterization of Pt/CS Composite Nanoparticles

WANG Xiao-min[1,2], YAO Yan-li[1], YANG Xiao-wei[1], MA Ai-li[1], GUO Jun-jie[1], XU Bing-she[1,2]
(1. College of Materials Science and Engineering, Taiyuan University of Technology, Taiyuan 030024, China;
2. Key Laboratary of Interface Science Engineering in the Advanced Materials, Taiyuan University of Technology, Ministry of Education, Taiyuan 030024, China)

Abstract: Carbon spheres (CS) were synthesized by traditional method-chemical vapor deposition (CVD), with a novel precursor as phaltene. Pt/CS composite nanoparticles were prepared by the method of impregnation reduction. The structure images show the CS particles with quite smooth surface were dispersed with an average diameter of ca. 300 nm, without nanotubes and others. SEM image of Pt particles were on the CS from 3 ~ 4 nm. This implies that the Pt particles tended to disperse homogeneously on the surface of CS when the Pt/CS catalyst had been prepared in the solution. Pt content in the catalysts was 18% for Pt/CS. So the size distribution of Pt/CS was in the ideal range to get a good performance of the catalyst in fuel cells electrodes.

Key words: Pt/C; carbon spherules (CS); fuel cells; Characterizations
CLC number: O644 Document code: A Article ID: 0529-6579 (2007) S1-0318-02

Fuel cells are widely seen as key elements of future energy systems such as decentralised networks for electricity generation or the "hydrogen economy"[1]. Platinum (Pt) seems to be the best choice of the catalysts for the electroreduction of oxygen in acidic media at cathode[2]. The electrocatalytic activity of platinum catalyst is dependent on many factors such as catalyst supports. Several papers have focused on carbon materials as supports due to their high accessible surface area, low resistance and high stability properties[3]. In this paper, carbon spheres (CS) in large quantity have synthesized using asphaltene. Pt/CS composite nano particles benefit the structural changes of CS after loading of Pt and also help study the applications of CS in the fuel cells.

1 Experimental

Being a raw materilas, asphaltenes were vaporized after heated at 1237 K for 1 h and its vapor were carried to hot zone by CVD method. After cooling, the carbon spheres (CS) were collected from the tube furnace. Pretreatment and metal attachment procedure on CS resembled the experiment by Tang et al[4]. After a series of chemical treatment, Pt/CS with metal loading were obtained. The samples were checked by XRD, field-emission scanning electron microscopy (FESEM) and high resolution transmission electron microscopy (HR-TEM).

2 Results and discussion

XRD pattern of CS and Pt/CS are shown in Fig. 1, where the diffraction peak corresponding to the (002) plane of graphite was clearly visible at $u = 24.27$. The d value of the C (002) was used to estimate the carbon crystallinity.

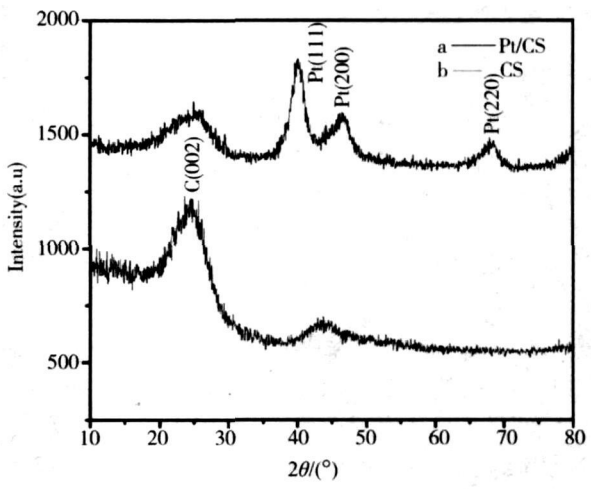

Fig. 1 XRD patterns of Pt/CS (a) and CS (b)

①收稿日期: 2007-01-10
基金项目: 国家 "973" 计划资助项目 (2004CB217808); 山西省自然科学基金资助项目 (2006011054, 20063005)
作者简介: 王晓敏 (1968年生), 女, 副教授; 通讯联系人: 许并社; E-mail: xubs@public.ty.sx.cn

Moreover, Pt set out the characteristic patterns of FCC diffraction. The 2θ value of the Pt(111) peak for Pt/CS is 39.95°, Pt(200) 45.8°, and Pt(220) 67.95°. The average size was calculated to be 3.0 ~ 4.0 nm for Pt/CS. The size of Pt was in the ideal range to get a good electrochemistry[5].

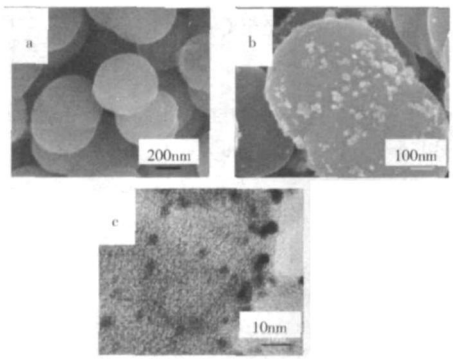

Fig. 2　Pt/CS synthesized with asphaltene (a) SEM image of carbon spherules; (b) SEM image of Pt/CS; (c) HRTEM image of Pt/CS

The structure images of the carbon sphere are shown in Fig. 2. From Fig. 2a, the CS particles with quite smooth surface were dispersed with an average diameter of ca. 300 nm, without nanotubes and others. Fig. 2b is the SEM image of Pt/CS particles. Pt nanoparticles were on the CS from 3 ~ 4 nm. This implies that the Pt particles tended to disperse homogeneously on the surface of CS when the Pt/CS catalyst had been prepared in the solution. There are two factors in the loading process[11]. First, the surface morphology of the carbon support affected the dispersion of the Pt particles. Second, the CS full of active sites also lead to the high dispersion of Pt particles on its surface. According to the EDS analyse, the Pt content in the catalysts was 18% for Pt/CS.

As observed from Fig. 2c, the spherical platinum particles on CS were uniform and well distributed. Based on the measurements of 300 particles in random regions, the average particles size was estimated to be 3 ~ 4 nm, which is in good agreement with the SEM.

3　Conclusions

Carbon Spheres (CS) were synthesized by CVD using asphaltene. The Pt particles were supported by impregnation-reduction method. The CS particles with quite smooth surface are dispersed with an average diameter of ca. 300 nm. The Pt nanoparticles, which were highly dispersed on CS, had an average diameter of 3 ~ 4 nm. The size distribution of Pt/CS showed that it might be a good candidate for catalyst in fuel cell electrodes.

References:

[1] MANASIL P A, GULAR E. Selective CO oxidation over Pt/alumina catalysts for fuel cell applications[J]. Appl Catal B Environ, 2002, 37: 17-25.

[2] JOON K. Fuel cell-a 21st century power system, 1998, 7: 12-18.

[3] MA Z, JETER S, ABDEL-KHALIK S I. Modeling the transport processes within multichannel molten carbonate fuel cells[J]. International Journal of Hydrogen Energy, 2003, 28: 85-97.

[4] TANG H, CHEN J H, HUANG Z P, et al. High dispersion and electrocatalytic properties of platinum on well-aligned carbon nanotube arrays[J]. Carbon, 2004, 42: 191-197.

[5] YANG R Z, QIU X P, ZHANG H R, et al. Monodispersed hard carbon spherules as a catalyst support for the electrooxidation of methanol[J]. Carbon, 2005, 43: 11-16.

Pt/CS复合纳米颗粒的结构表征

王晓敏[1,2]，姚延立[1]，杨晓伟[1]，马艾丽[1]，郭俊杰[1]，许并社[1,2]

(1. 太原理工大学 材料科学与工程学院，山西 太原 030024；
2. 太原理工大学 教育部新材料界面与工程重点实验室，山西 太原 030024)

摘　要：采用化学气相沉积 (CVD) 法制备得到纳米碳微球 (CS)，采用浸渍还原法合成了 Pt/CS纳米颗粒。电镜观察表明颗粒具有光滑的表面，其平均粒径在 300 nm左右，同时在产物中没有观察到纳米管和其它杂质。从 HRTEM表征结果得出 CS上的 Pt颗粒分散均匀，直径分布在 3~4 nm之间。表明在溶液中使用 Pt/CS催化剂时 Pt颗粒可以均匀的分散于 CS表面。在催化剂中 Pt的含量为 18%。这种较为理想的 Pt/CS颗粒分布结果有利于其在燃料电池电极中的电催化作用。

关键词：Pt/CS；燃料电池；表征

中图分类号：O644