

Effect of surfactant addition on the synthesis of spherical carbon particles by sol-gel method

Kazuo Fukuda¹, Hideki Sano², Guo-Bin Zheng^{2*} and Yasuo Uchiyama²

¹Graduate School of Science and Technology,

²Department of Materials Science and Engineering, Faculty of Engineering,
Nagasaki University, 1-14 Bunkyo-machi, Nagasaki 852-8521, Japan

*Tel: +81-95-819-2657, Fax: +81-95-819-2656, E-mail: gbzheng@nagasaki-u.ac.jp

Introduction

Carbon aerogels(CAs), which were prepared from the sol–gel polymerization of resorcinol (R) and formaldehyde (F) and subsequent carbonization, possess high surface area, large pore volume. Therefore, they are promising in applications such as electrodes for supercapacitors, advanced catalyst supports and adsorbents for gas. By addition of surfactant in the precursor solution of the sol-gel process, spherical carbon particles can be synthesized. It is believed that the surfactant could be absorbed on the surface of RF particles and prevent shrinkage during drying. In this report, different surfactants including cation, anion and non-ionic surfactants were used in the synthesis of RF particles. The effect of the surfactant on the pore structure and electrochemical characteristics of carbons was investigated.

Experimental

RF solutions were prepared from resorcinol (R), formaldehyde (F), surfactant and sodium carbonate, which acts as a catalyst. The solutions were sealed in a flask and kept at $85 \pm 3^\circ\text{C}$ for 2 hours, while stirring. The RF gels were held at 85°C for 24 h. The carbon particles were formed by carbonization of the dried gel in nitrogen at $900\text{--}1000^\circ\text{C}$ for 1 h, with heating and cooling rates of $5^\circ\text{C}/\text{min}$. The surfactants used in this work were glycol non-ionic P123 and cetyltrimethylammonium bromide (cationic CTAB), respectively. The composition of precursor solution is listed in Table 1. The morphology of the carbon particles was

Table 1 Preparation condition of samples

sample	RF solution			
	Molar ratio of	Molar ratio of	Surfactant (mass%)	
			CTAB	P123
C1	0.5	50	1.2	0
C2			2.4	0
C3			4.8	0
P3			0	4.8
C1P2			0.4	0.8
C1P1			0.6	0.6
C2P1			0.8	0.4

observed using field emission scanning electron microscopy (FE-SEM). Galvanostatic

charge/discharge behavior was performed under the constant current of 2-20 mA by a cell test system.

Results and Discussion

Fig.1 showed FE-SEM images of a) C1, b) P3 and c) C1P1. It is estimated that spherical carbon particles of C1, P3 and C1P1 have the average sizes of 131 ± 27 nm, 398 ± 211 nm and 476 ± 86 nm, respectively. When different types of the surfactants were compared, the mean particle size of the sample that added only CTAB was 100-230 nm, which was the smallest and the most narrowly distributed in size. It is thought that this is attributed to micelle formation in the RF solution by the addition of cationic surfactant (CTAB). As for the samples with mixing CTAB and P123, the average particle size is much larger than those obtained with only CTAB.

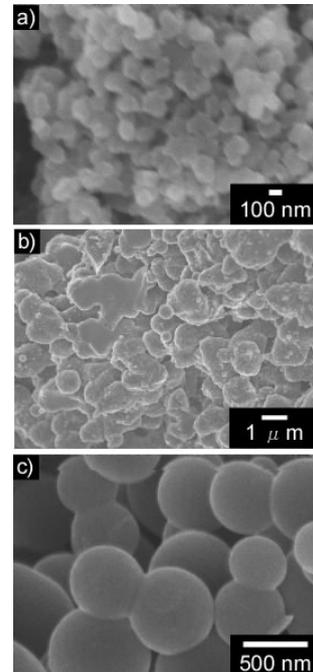


Fig.1 FE-SEM images of the samples a) C1, b) P3 and c) C1P1.

Fig.2 showed specific capacitances of CAs (C1,C2,C3 P3,C1P1,C1P2,C2C1). Specific capacitances of C1, 72 F/g in current of 2 mA, is the highest value in all the samples (C1, C2, P3, C1P1, C1P2, C1P2). The value of specific capacitance decreased with increasing sweeping rate.

Conclusion

The average particle size of the carbon particles with cation surfactant CTAB was small, and the value of the capacitance was high. Addition of P123 resulted in much larger particles and low capacitance.

Reference

1. Jianhua Zhou, Yajun Ji, Jianping He, Chuanxiang Zhang, Guiwang Zhao *Microporous and Mesoporous Materials* 2008, vol. 114, pp. 424-430

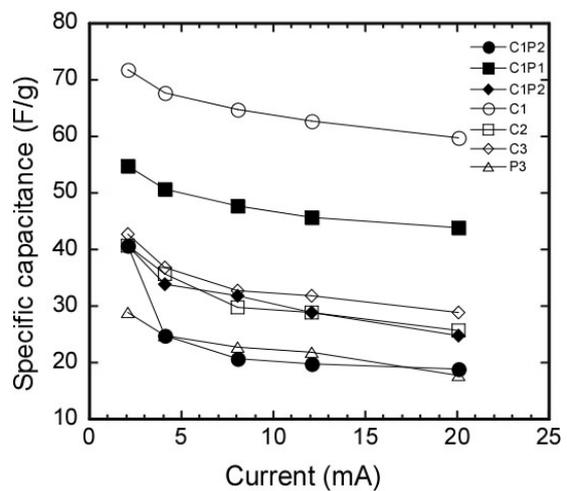


Fig. 2 Specific capacitances of carbon particle electrodes with different current in 1M H₂SO₄.