Development of Tin Oxide/Carbon Aerogel Composite Electrodes for Supercapacitor Applications

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Carbon aerogels which could be obtained via pyrolyzing RF(resorcinol-formaldehyde) organic aerogels have been considered as a promising material for various electrochemical applications. A high specific surface area in conjunction with a good electrical conductivity makes carbon aerogels optimal electrode materials for applications such as intercalation anodes of rechargeable lithium ion batteries, electrochemical double layer capacitors (EDLCs), fuel cells, and capacitive deionization process, and absorbents, etc. Tin oxide also has the advantages of the high conductivity (10^2 to 10^3 S/cm) and excellent pseudo-capacitive property for capacitor applications [1-5].

The objective of this research includes developing a cost-effective process for synthesizing RF aerogels via ambient drying instead of conventional supercritical drying and maximizing the specific capacitance of carbon aerogel electrodes. For these goals, tin oxide was selected as an additive material in carbon aerogels to combine the advantages of tin oxide and carbon aerogels for supercapacitor applications. The effect of tin oxide addition on the properties of RF aerogels and the physical/electrochemical properties of tin oxide/carbon aerogel composite electrodes has been experimentally elucidated.

RF wet gels were prepared with the aqueous polycondensation of resorcinol within formaldehyde using sodium carbonate as a base catalyst. Resorcinol and formaldehyde were mixed with the 1:2 molar ratio, and deionized water was used as a solvent to control the final concentration. The R/C (resorcinol/catalyst) molar ratio was fixed as 1000 and the solid concentration was controlled up to 40 wt %. RF wet gels were ambiently dried at R.T~50 ^{o}C after exchanging the solvents. Carbon aerogels were prepared by pyrolyzing RF aerogels. Pyrolysis of RF aerogels was carried out under nitrogen flow in a tube furnace. A typical galvanostatic charge/discharge method and the cyclic voltammetry (CV) were used to carry out the electrochemical characterization using an electrochemical analyzer (WBCS 3000) equipped with a cylinder-type capacitor cell.

Fig. 1 shows a galvanostatic charge/discharge curve of tin oxide/carbon aerogel composite electrodes. The charge and discharge rates were 10 mA and -10 mA, respectively. The specific capacitance of tin oxide/carbon aerogel composite electrodes increased up to 400 F/g (single electrode capacitance). Fig. 2 shows a cyclic voltammogram of composite electrodes. During 82 cycles with a scan rate of 10 mV/sec, the symmetric peaks originated from the surface faradaic reactions of carbon and tin oxide surfaces with electrolyte decreased gradually.

References

[1] E. Frackowiak and F. Béguin, Carbon, 39, 937 (2001).
[2] A. Mabuchi, K. Tokumitsu, H. Fujimoto, and T. Kasuh, J. Electrochem. Soc., 142, 1041 (1995).
[3] T. Zheng, H. Y. Liu, E. W. Fuller, S. Tseng, U. von Sacken, and J. R. Dahn, J. Electrochem. Soc., 142, 2581 (1995).
[4] Y. E. Eli, B. Markovsky, D. Aurnach, Y. Carmeli, H. Yamin, and S. Luski, Electrochemica Acta, 39, 2559 (1994).
[5] N. L. Wu, S.L. Kuo, and M. H. Lee, J. Power Sources, 104, 62 (2002).

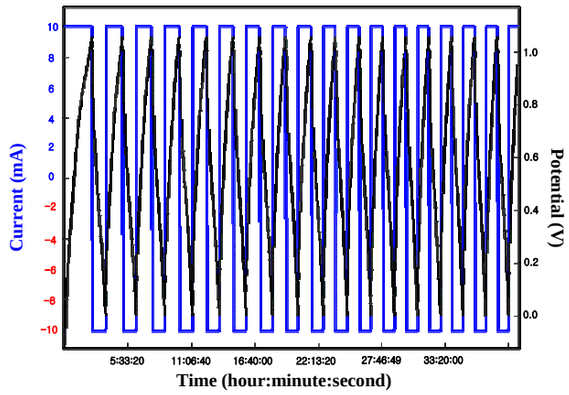

Fig. 1. Galvanostatic charge/discharge curve for tin oxide/carbon aerogel composite electrodes.

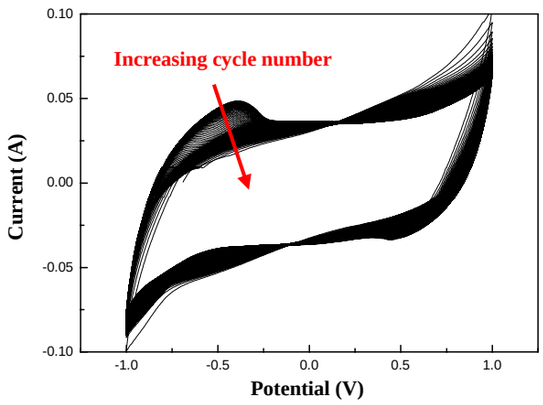

Fig. 2. Stability test of tin oxide/carbon aerogel composite electrodes up to 82 cycles (sweep rate = 10 mV/sec).