Capacitance Properties of C_{60}-loaded Activated Carbon Electrodes for High Power Electrochemical Supercapacitor

Keiichi Okajima, Atsushi Ikeda and Masao Sudoh

Department of Materials Science and Chemical Engineering, Shizuoka University
3-5-1 Johoku, Hamamatsu, Shizuoka 432-8561, Japan

Introduction

The representative material of the fullerene, C_{60}, has delocalized π-electrons due to its unique molecular structure. Two reduction waves corresponding to C_{60}^{-} and C_{60}^{2-} have been reported using cyclic voltammetry.[1)] Moreover, considering the threefold degenerate LUMOs, C_{60} is expected to accept six electrons. We picked C_{60} as a novel electrode material for the electric double-layer capacitor. In this study, fullerene-activated carbon composite electrodes were prepared and evaluated their properties for electrochemical supercapacitors.

Experimental

Activated carbon fiber (ACF) cloths (Toyobo, KF-1500M, 1500 m^2/g) were powdered and mixed with a carbon black and a PTFE binder. The C_{60} powder (MTR, Ltd., 99.5 %) was then added and kneaded. The C_{60} content was 1 - 30 % in comparison with the weight of the powdered ACF. The mixture was pressed to form a pellet, and then annealed in a vacuum. Two pieces of the pellet-formed electrodes sandwiching the separator were inserted into a two-electrode coin-type shaped cell. As the electrolyte solution, 0.5 mol/L H_2SO_4 was used for all the measurements. The galvanostatic charge/discharge measurements were carried out at room temperature using a battery test system (HIOKI, EDLC evaluation system). The investigated voltage range was 0 - 1 V at a constant current density of 2.5 - 100 mA/cm^2.

Results and Discussion

The charge/discharge characteristics of the C_{60}-loaded ACF electrodes showed a higher performance than those of an untreated conventional activated carbon electrode at high charge/discharge constant current densities above 50 mA/cm^2 (Fig. 1). The specific capacitances for the C_{60} content of 1 wt% increased 64 % and 79 % at 50 mA/cm^2 and 100 mA/cm^2, respectively. Figure 2 shows the discharge capacitance as a function of cycle number at current density of 50 mA/cm^2 on 1 wt% C_{60}-loaded ACF electrode. The discharge capacitance was kept 91 % after 1,000 charge/discharge cycles. under the depth of discharge (DOD) of 100 %. The AC impedance plots of C_{60}-loaded ACF electrodes are shown in Fig. 3. The effective concentration of hydrogen ion, $c_{H,eff}$, was evaluated using the Warbrug diffusive region on AC impedance measurements. The calculated $c_{H,eff}$ were almost equal. Thus, it was found that the increase in the capacitance at high discharge current densities was due to the C_{60} particles loaded on ACF surface.

Acknowledgment

This study was financially supported by Industrial Technology Research Grant Program from the New Energy and Industrial Technology Development Organization (NEDO) of Japan.

References

1) R. E. Haufler, J. Cocceicao, L. P. F. Chibante, Y. Chai, N. E. Byrne, S. Flanagan, M. M. Haley, S. C. O'Brien, C. Pan, Z. Xiao, W. E. Billups, M. A. Ciufolini, R. H. Hauge, J. L. Margrave, L. J. Wilson, R. F. Curl and R. E. Smalley, *J. Phys. Chem.*, **94**, 8634 (1990).

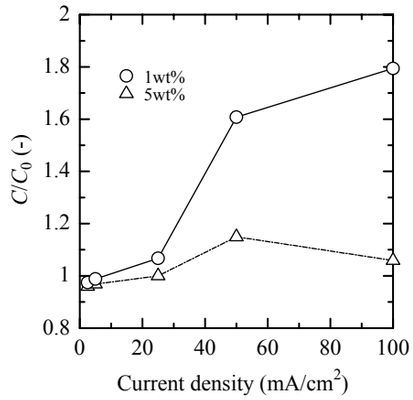

Fig. 1 Relationships between current density at discharge and increase ratio of capacitance, C/C_0, on C_{60}-loaded ACF electrodes.

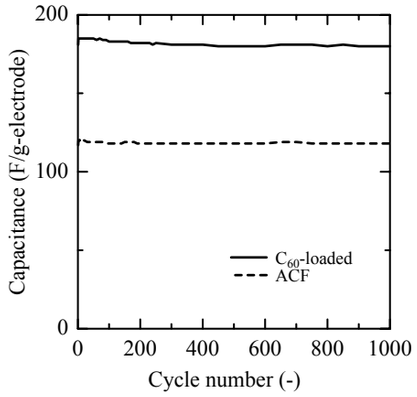

Fig. 2 Discharge capacitance as a function of cycle number at current density of 50 mA/cm^2 on 1wt% C_{60}-loaded ACF electrode.

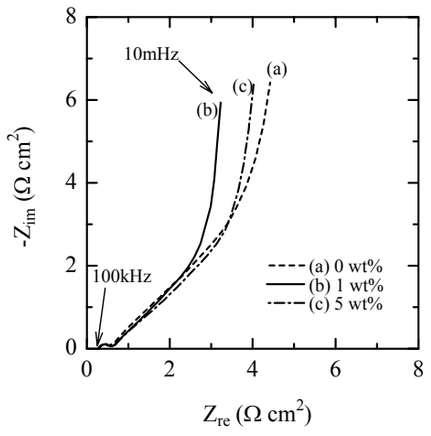

Fig. 3 AC impedance plots of C_{60}-loaded ACF electrodes.