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Fullerene C_{60}/Activated Carbon Composite Electrodes as Electrochemical Supercapacitors

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Introduction

Electric double-layer capacitors have recently become of major interest as energy storage systems for hybrid electric vehicle (HEV) because of their higher power density than those of dielectric capacitors, and have a longer cycle life than batteries. In this study, fullerene C_{60} was picked up as a novel electrode material for the electrochemical supercapacitor. The representative material of the fullerene, C_{60} has delocalized π-electrons due to its unique molecular structure and C_{60} is expected to accept six electrons. The objective of this work is to clarify the effect of ultrasonic on dispersion of fullerene and also the capacitance of composite electrode.

Experimental

An activated carbon fiber (ACF) cloth was used and powdered. Its specific surface area was 1500 m2/g (Toyobo, KF-1500M). To prepare the electrodes, ACF cloths were milled and powdered. Then, activated carbon powder was mixed with a carbon black and a PTFE binder. The C_{60} powder (MTR, Ltd., 99.5 %) was then added and kneaded. The mixture was pressed to form a pellet, and then annealed in a vacuum. A two-electrode coin-type shaped cell was used on electrochemical measurements. 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 - 50 mA/cm^2.

Results and Discussion

Figure 1 shows the relationship between the discharge current density and the capacitance of the C_{60}-loaded ACF electrodes. The capacitance of C_{60}-ACF electrodes became greater than that of the unloaded ACF at a higher charge/discharge current density. The specific capacitances of the C_{60}-loaded ACF electrodes at 50 mA/cm^2 were 109 F/g-electrode and 123 F/g-electrode for the C_{60} content of 1 wt% and 10 wt%, respectively. From the SEM observation, the size of the C_{60} agglomerate was 1 - 2 μm after kneading on the preparation of the electrode. In order to obtain a high-dispersed electrode, the carbon slurry on the electrode preparation was treated with an ultrasonic bath vibrator. Figure 2 shows the effect of ultrasonic treatment time on discharge capacitance at 50 mA/cm^2. The capacitance on 1wt% C_{60}-loaded ACF electrode increased with the ultrasonic treatment. Figure 3 shows the discharge capacitance at 50 mA/cm^2 on the C_{60}-loaded ACF electrodes prepared without ultrasonic treatment (a) and with ultrasonic treatment (b). The higher capacitance of 172 F/g was obtained on 1wt% C_{60}-loaded ACF electrode with ultrasonic treatment. From the SEM image of the ultrasonic treated C_{60}-ACF electrode, the size of the C_{60} agglomerate decreased to 0.1 μm or less.

Acknowledgment

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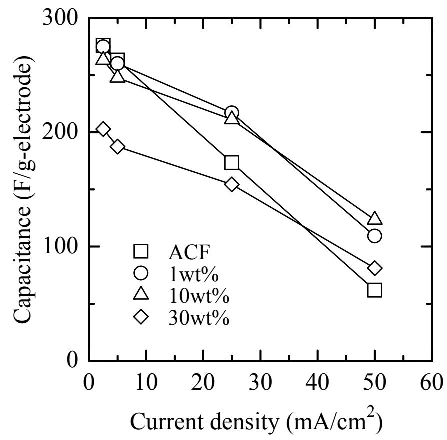

Fig. 1 Relationship between discharge current density and capacitance of C_{60}-activated carbon composite electrodes.

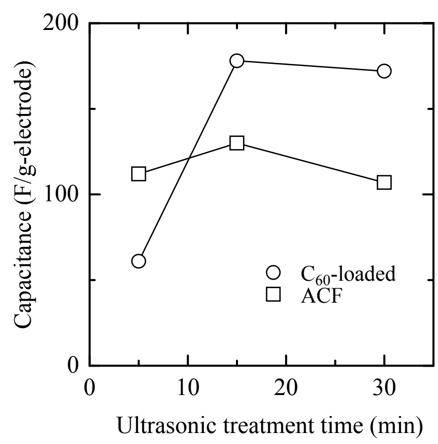

Fig. 2 Effect of ultrasonic treatment time on discharge capacitance at 50 mA/cm^2 on 1wt% C_{60}-loaded ACF electrode.

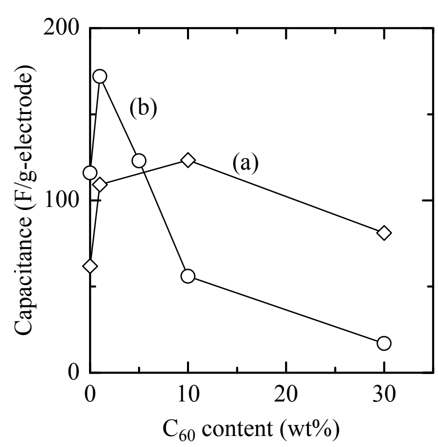

Fig. 3 Comparison with discharge capacitance at 50 mA/cm^2 on C_{60}-loaded ACF electrodes prepared, (a) without, (b) with ultrasonic treatment.