High Performance of Supercapacitors Using Carbon Nanotubes and Nanocomposite Electrodes

K. H. An, J. Y. Lee, C. Kim, S. C. Lim, D. J. Bae, and Y. H. Lee

BK21 Physics Division, Center for Nanotubes and Nanostructured Composites (CNNC), Sungkyunkwan University, Suwon, Kyunggi-do 440-746, Korea

In this study, we have investigated the key factors determining the performance of supercapacitors using singlewalled carbon nanotube (SWNT) electrodes. Several parameters of annealing temperature, charging time, and discharging current density are optimized for the best performance of the energy density and power density of supercapacitor [1]. We have also reported here the nanocomposite of SWNTs and polypyrrole (Ppy) for the supercapacitor with high capacitance. SWNT-Ppy nanocomposite electrodes are fabricated to improve the specific capacitance of the supercapacitor [2].

Figure 1 shows the specific capacitances of the heat-treated electrodes at various temperatures as a function of the charging time. Capacitances increase abruptly and reach about 80 % of the maximum capacitance during the initial 10 min. The capacitances increase gradually further and saturate to the maximum values at long charging time. The saturated capacitance increases with increasing heat-treatment temperatures and saturates to 180 F/g at 1000 ℃.

Figure 2 shows FE-SEM images of as-grown SWNTs, pure Ppy and SWNT-Ppy powder formed by *in-situ* chemical polymerization. From Figure 1(b), one can see that the pure Ppy synthesized without SWNT shows a typical granular morphology. The granule size of pure Ppy is about 2~3 μm. Figure 1(c) reveals the individual nanotube bundles to be uniformly coated with Ppy.

Figure 3 shows the specific capacitances of the as-grown SWNTs, pure Ppy, and SWNT-Ppy nanocomposite electrodes as a function of discharge current density. The SWNT-Ppy hybrid electrodes shows very high specific capacitance by 5 ~ 10 times. This very large specific capacitance seems to be caused by uniformly coated Ppy on the SWNTs, signifying that active sites on Ppy chains are increased.

The effects of conducting agent on the specific capacitance of the SWNT-Ppy hybrid electrode are shown in Fig. 4. The maximum specific capacitance appears at 15 wt% of conducting agent in electrode. The effect of the conducting agent is clearly seen particularly at high discharging current density. We obtain a maximum specific capacitance of 265 F/g from the SWNT-Ppy hybrid electrode containing 15wt% of the conducting agent.

We reveal that the very large specific capacitance of SWNT-Ppy nanocomposite electrode is caused by uniformly coated Ppy on the SWNTs, signifying that active sites on Ppy chains are increased. We emphasize that the pseudocapacitance by the redox reaction and the capacitance by electric double layer are simultaneously enhanced by the enlarged surface area of Ppy.

Reference

1. An, K.H., W. S. Kim, Y. S. Park, Y. C. Choi, S. M. Lee, S. C. Lim, D. J. Bae, and Y. H. Lee, *Advanced Materials*, 13, 497 (2001).
2. An, K. H., K. K. Jeon, J. K. Heo, S. C. Lim, D. J. Bae, and Y. H. Lee, *J. Elecrochem. Soc.* 149, A1058 (2002).

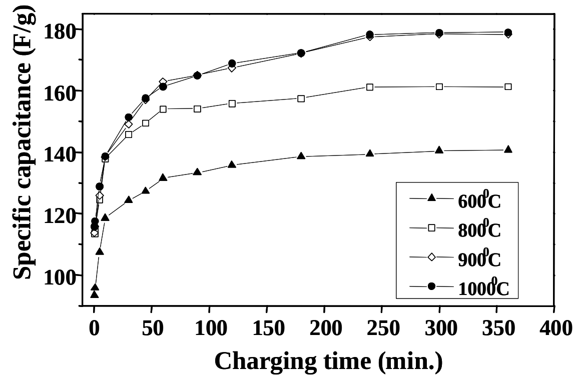
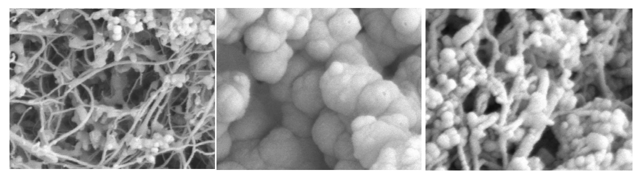


Fig. 1. The specific capacitances of the heat-treated electrodes at various temperatures as a function of the charging time at a charging voltage of 0.9 V.



(a) (b) (c)

Fig. 2. The FE-SEM images of as-grown SWNT (a), pure Ppy (b), and SWNT-Ppy powder (c).

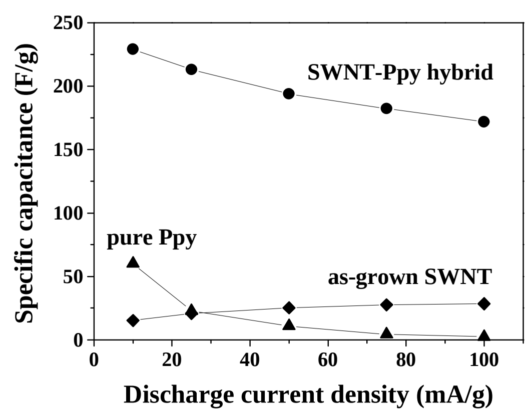


Fig. 3. The specific capacitances of the as-grown SWNTs, pure Ppy, and SWNT-Ppy hybrid electrodes as a function of discharge current density at a charging voltage of 0.9 V for 10 min.

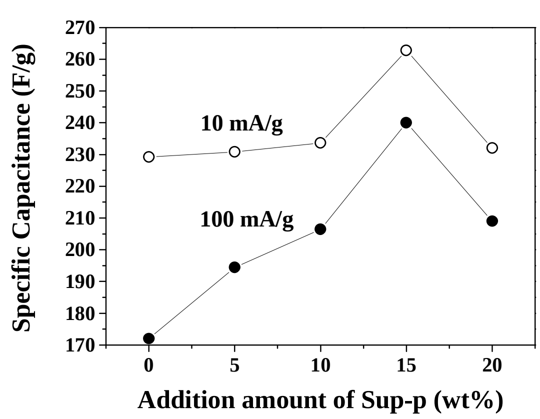


Fig. 4. The effects of conducting agent on the specific capacitance of the SWNT-Ppy hybrid electrode as a function of discharging current density at a charging voltage of 0.9 V for 10 min.