CHARACTERISTIC OF SUPERCAPACITORS FROM CARBON NANOTUBE COMPOSITE CARBON FIBERS BY ELECTROSPINNING

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Introduction

A supercapacitor has been considered as one of the most attractive rechargeable power devices because it offers high power density, high-rate charge/discharge ability, and long cycle life compared with a rechargeable battery. Electospinning process is a proper technology to produce carbon nano-fiber(CNF) composite carrying carbon nano-tube(CNT) with properties of superior electrical conductivity and flexibility for compressive process for the electrodes of the supercapacitor[1].

Experimental

10 wt.% of PAN was dissolved in *N,N*-dimethylformamide (DMF) and 1 wt. % of the mutlti-wall carbon nanotubes (MWCNTs) was evenly dispersed in the PAN solution by using ultrasonic mixer. The solutions were spun into fiber web by using an electrospinning apparatus consisting of a 25 kV DC power supply equipped with the positively-charged capillary from which the polymer solution was extruded and with a negatively-charged drum winder to collect the fibers as webs. The electrospun fiber web was stabilized at 280 °C for 1 h under air flow, and then activated at 900 °C for 60 minutes by supplying 30 vol.% of steam in the carrier gas of N_2. A sandwich type capacitor cell was fabricated with a pair of the activated webs separated by a separator (Selgard 3106) and current collectors made of Ni foil in a 30 wt.% KOH aqueous solution.

Results and Discussion

Fig. 1 shows SEM images of various nanocomposite activated carbon fibers. Not only CNF but also CNTs in the nanofibers (CNF/CNT) were partially aligned parallel to the winding direction and longitudinal direction of the component fibers. The average diameters of the CNF and CNF/CNT fibers were 300 nm and 400 nm, respectively.

The galvanostatic charge/discharge behaviors of the capacitor fabricated with the CNF and CNF/CNT nanocomposite electrodes were presented in Fig. 2(a). The capacitance gave rise by two times more from 82 F/g to 160 F/g by introduction of 1 wt.% CNT in the CNF at the current of 10 mA/g (Fig. 2(b)).

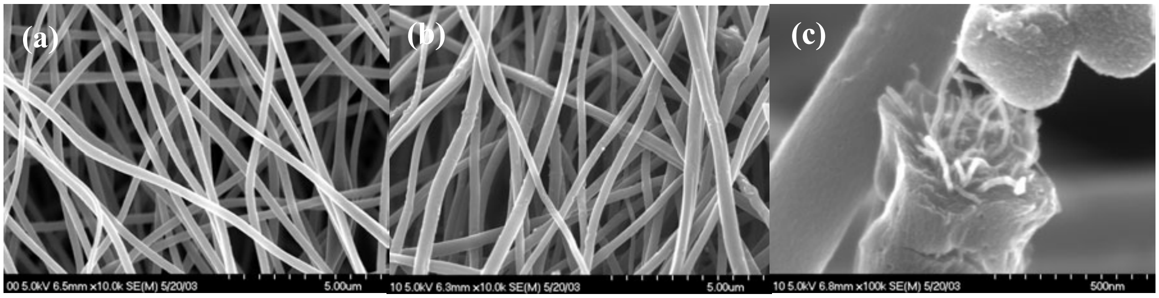

Fig. 1. SEM micrographs of activated carbon nanofibers. (a) PAN-based activated carbon nanofibers, (b) carbon nanocomposite fibers of 1 wt.% CNT in PAN-based nanofibers (c) higher magnification of (b).

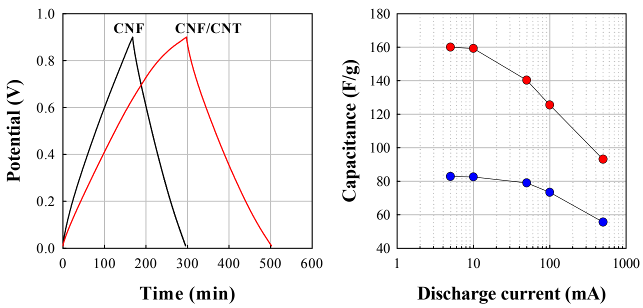

Fig. 2. (a) Charge/discharge curve of an electrochemical supercapacitor and (b) dependence of specific capacitances on the discharge current. Capacitance measurements were undertaken in a 30 wt.% KOH electrolyte aqueous solution.

The specific capacitance of the CNF and CNF/CNT electrode reduced by 33 % and 42 % with an increase in discharge current density from 5 mA to 500 mA, respectively. The larger reduction 42% of the CNF/CNT electrode would be resulted form the hindered accessibility of the ions in the micro pores in the CNF/CNT composite electrodes with more fraction of micro pores than in the CNF only. However, the specific capacitance of CNF/CNT capacitors was about 90 F/g at the current density of 500 mA/g. This value is even larger than the capacitance from the CNF electrode at the current density of 5 mA. The relatively high capacitance at the high current density is a practical importance for applications to supercapacitor in motor vehicle.

Conclusions

The 1 wt.% of MWCNT addition in 10wt.% PAN solution for composite carbon nano fibers led to not only increases in electrical conductivity but also specific surface area, which influence drastic increases in capacitance at high current density.

References

[1] Kim C, Yang KS. Electrochemical properties of carbon nanofiber web as an electrode for supercapacitor prepared by electrospinning. Applied Physics Letters 2003;83(6):1216-1218.