Activated Hybrid Composites for Energy Storages

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Abstract
Carbon based materials were investigated as potential supercapacitor electrode. The materials were prepared by casting polyacrylonitrile (PAN) on carbon cloth in-situ grown with CNTs, followed by carbonlization and activation. The activated carbon formed with the CNTs showed substantially higher contribution to specific capacitance compared with that formed in the absence of the CNTs.

Introduction:
Due to its large surface area and low cost, activated carbon (AC) is among the most developed materials for double layer supercapacitors, which store electrostatic charge at electrode materials/electrolyte interface that, in principle, possesses a value of long cycle life.
CNTs, in general, have higher electronic conductivity compared with AC. This, in addition to their excellent mechanical properties, fibrous structure, and good surface accessibility, leaves a possibility to improve supercapacitor properties by exploiting composite made using AC and CNT [1,2]. We applied PAN on carbon cloth in-situ grown with CNTs by solution casting followed by carbonlization and activation. The blinder-free active material was investigated for supercapacitor electrode.

Experimental:
Carbon clothes grown with CNTs by chemical vapor deposition using iron and nickel as the catalysts and hydrogen carbon gases as the carbon source were used as the substrates. PAN powder was dissolved in dimethylformamide, and drop casted on the substrates. To increase thickness of the coating, multiple steps of coating and drying were carried out. The coated pieces were treated in air at 230 ^oC for 20 hrs before being placed in a tube furnace and heated in N_2 gas to 850 ^oC at a rate of 10 ^oC/min. The materials were finally activated at the same temperature for 1 hr under a flow of carbon dioxide.
Supercapacitors were built by sandwiching a glass fiber separator with two identical pieces of the carbon cloth coated with AC/CNT. Electrochemical test was conducted in 1 M H_2SO_4 electrolyte using CHI 660C electrochemical working station. The electrode materials were also examined by scanning electron microscopy.

RUSLUTS AND DISSCUSSION
Figs.1a-c show the carbon cloth, AC coated, and AC coated with CNTs grown on the cloth, respectively. Fig.2 gives the typical cyclic voltammograms (CVs) of two samples: i) AC coated carbon cloth; ii) AC coated on the carbon cloth with CNTs grown on the cloth. The AC coatings of the two samples were prepared under the same conditions. Apparently, the AC formed on the CNTs gave considerably higher current compared with that without the CNTs. Determined from the CV at scan rate of 5 mV/s, the AC formed in the presence of the CNTs contributed to a value of 65 F/g of specific capacitance, being

much larger than that of the AC formed in the absence of the CNTs, which had a value of only 14 F/g. Although these values are not yet as high as expected and optimizing the process conditions is needed, it is clearly shown the in-situ grown CNTs promoted formation of more active carbon materials for the supercapacitors. In Fig. 2, AC with the CNTs shows also better rate ability than AC prepared in the absence of the CNTs, and we attribute this to the conductivity contribution from the CNTs.

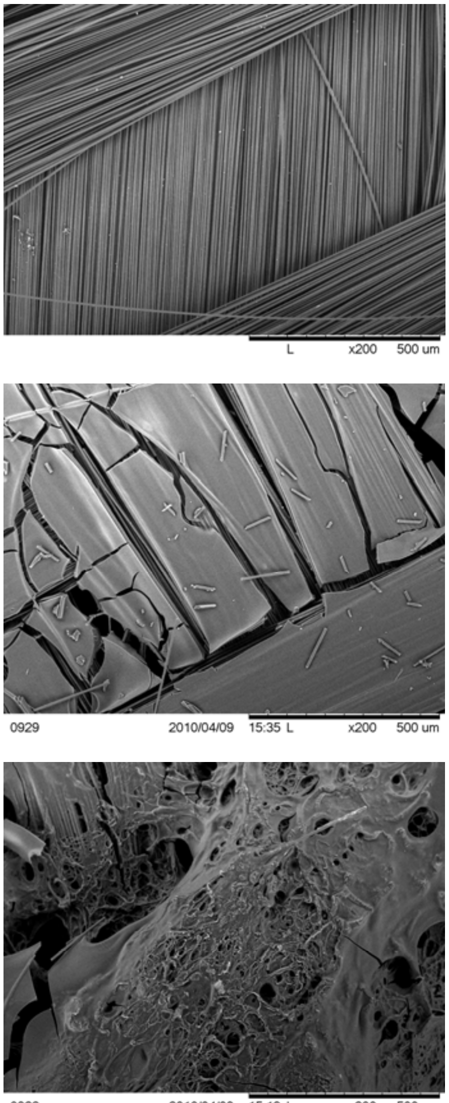

Fig.1 SEM images of a) carbon cloth; b) AC coated carbon cloth; c) AC coated carbon cloth grown with CNTs.

<u>CONCLUSIONS</u>

CNTs grown directly on carbon cloths provided a more favorable condition for casting PAN on the substrate. Carbonlization and activation of polymer in the presence of the CNTs resulted in more active material for supercapacitors by giving substantially higher specific capacitance compared with AC films prepared in the absence of the CNT.

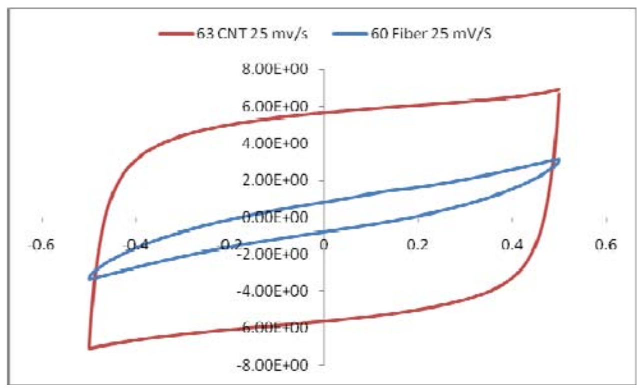

Figure 2. Cyclic voltammograms recorded at 25 mV/s for samples: i) AC formed the carbon cloth (blue drawing); ii) AC formed with CNTs grown on the carbon cloth (red drawing).

Reference

[1] B.E. Conway, Electrochemical supercapacitors, scientific fundamentals and technological applications, Kluwer Academic/Plenum Publishers, New York (1999).

[2] R. Kötz and M. Carlen, Principles and applications of electrochemical capacitors, *Electrochim Acta* **45** (15–16) (2000), pp. 2483–2498