Study of the MWCNTs/PEDOT-PSS and MWCNTs/PTFE composites as electrodes for supercapacitors

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Supercapacitors, acting as a promising renewable energy storage device, combine the advantages of batteries and conventional capacitors. Carbon nanotubes (CNTs) are widely used as an electrode material for supercapacitors due to their good chemical and mechanical stability, high conductivity and large surface areas. Normally, the specific capacitance of pristine CNTs ranges from 10 to 40 F/g, which depends on their porosity and purity, and the types of electrolytes. Recently, the use of conducting polymers as an electrode material for supercapacitors has been examined, it is found that the conducting polymers can increase the capacitance by contributing the pseudo-capacitance in addition to the double layer capacitance. But the conducting polymers show poor cyclability because of the chemical degradation of the polymers. In order to reap the benefits of both CNTs and conducting polymer, the composites of CNT binding with conducting polymers as an electrode material have been investigated.

Poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate (PEDOT-PSS), which is a conducting polymer, gains more attention due to its wider potential window and fast electrochemical kinetics. Besides, PEDOT-PSS can also act as a binder to fix electrode materials on the current collectors. The conductivity of PEDOT-PSS is superior to conventional binder polytetrafluoroethylene (PTFE), but the poorer chemical stability of PEDOT-PSS could result in rapid capacitive decline. So in this study, the electrodes made of multiwalled carbon nanotubes (MWCNTs) and PTFE were compared with the composites of MWCNTs and PEDOT-PSS.

In Figures 1 and 2a, the capacitance of the MWCNT/10wt% PTFE composite remained unchanged over 300 cyclic voltammetric cycles. However, the capacitance of the MWCNT/PEDOT-PSS composites decreased at the first 100 cycles and then reached stability (Figure 1), and the decrease in the capacitance is due to the gradual loss of the faradic current during cycling (Figure 2 b). The results also indicated that the capacitance of the MWCNT/10wt% PEDOT-PSS composite was 11.7 F/g, which was 1.22 times larger than that of the MWCNT composite composed of the same mass ratio of PTFE.

In conclusion, PEDOT-PSS is superior to the PTFE, although a capacitive decline at the beginning of charging/discharging process, the stable capacitance of the MWCNT/PEDOT-PSS composites still remains higher than that of MWCNT/PTFE composites.

Figure 1 Specific capacitance of composites vs. number of cycles

Figure 2 Cyclic voltammograms of composites of MWCNT combined with (a) 10wt% PTFE and (b) 10wt% PEDOT-PSS in 1 M Na$_2$SO$_4$ at 50 mV/s; vs. Ag/AgCl