An Asymmetrical Supercapacitor Based on $CNTs/SnO_2$ and $CNTs/MnO_2$ Nanocomposites Working at 1.7 V in Aqueous Electrolyte

Kok Chiang Ng, Shengwen Zhang, and George Z. Chen[z]

School of Chemical and Environmental Engineering,
University of Nottingham
University Park, Nottingham, NG7 2RD, UK

[z]george.chen@nottingham.ac.uk

In search for negative- and positive-electrode materials for supercapacitors, there has been growing interest in nanostructured materials based on carbon nanotubes (CNTs) that exhibit desirable properties such as high storage capacity and excellent cycling stability in charge discharge tests[1-5]. Particularly, recent research has been focused on composites of CNTs and transition metal oxides.[6-8]

One member of such transition metal oxides, SnO_2, combined with CNTs [6] has been found in this study to be a prospective negative electrode material in supercapacitors. The composite was prepared by a simple one step chemical-solution route with $SnCl_2$ as the precursor following the procedure described in literature[6].

As for the positive electrode, low cost MnO_2 is deposited onto CNTs to form the composite. We have previously reported this mechanism of the spontaneous redox deposition of MnO_2 on the CNTs in the $KMnO_4$ aqueous solution and have also found the composite to exhibit very high electrode specific capacitance ($\geq$ 5 Fcm^{-2}) in comparison to other reported materials[7-9].

Microstructures and surface morphologies of these $CNTs/SnO_2$ and $CNTs/MnO_2$ composites were examined by X-ray diffraction, scanning electron microscopy and transmission electron microscopy. The electrochemical and capacitive properties of the composites on the other hand, were investigated by cyclic voltammetry, galvanostatic charge/discharge and electrochemical impedance spectrometry. The electrochemical investigations of thin films of the composites revealed reasonably good mass-specific capacitance and high electrochemical stability/reversibility, making them promising affordable nanocomposites as electrode materials for high-performance supercapacitors.

As shown in Figure 1, the $CNTs/MnO_2$ composite can be polarised up to a potential of 0.9V in the positive range while under negative polarisation, pseudocapacitive behaviour of the $CNTs/SnO_2$ composite has been demonstrated to reach a negative potential of -0.8V with no evolution of hydrogen. Combining both $CNTs/SnO_2$ and $CNTs/MnO_2$ as the negative and positive electrode materials, respectively, an asymmetrical electrochemical capacitor was fabricated and could operate in a potential range as wide as 1.7 V without showing noticeable current resulting from water decomposition, see Figure 2. The rationale behind this unusual observation is discussed in terms of, for example, unfavourable over-potentials.

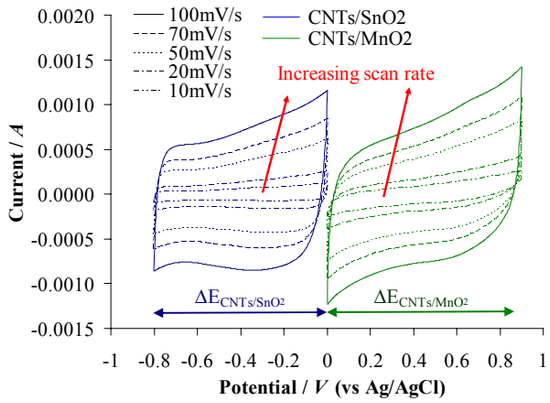

Fig. 1. Cyclic voltammograms in a three electrode cell with $CNTs/SnO_2$ or $CNTs/MnO_2$ composites as the working electrode, graphite rod as the auxiliary electrode and Ag/AgCl as the reference electrode in 2 mol L^{-1} KCl aqueous electrolyte.

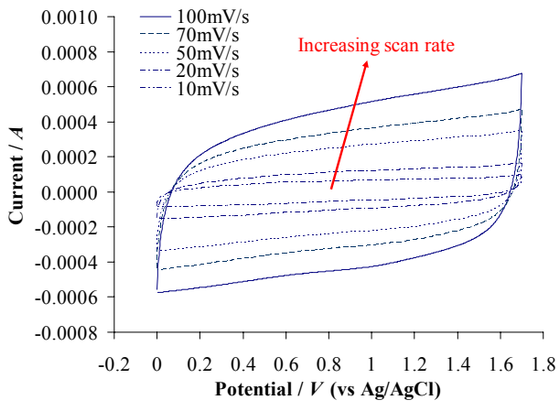

Fig. 2. Cyclic voltammograms of the asymmetric electrochemical capacitor with the $CNTs/SnO_2$ and $CNTs/MnO_2$ composites as the positive and negative electrodes, respectively, in 2 mol L^{-1} KCl aqueous electrolyte.

Reference

1. S.-W. Hwang and S.-H. Hyun, *Journal of Power Sources*, **172**, 451 (2007).
2. W. Yong-gang, Y. Le and X. Yong-yao, *Journal of The Electrochemical Society*, **153**, A743 (2006).
3. E. Raymundo-Pinero, V. Khomenko, E. Frackowiak and F. Beguin, *Journal of The Electrochemical Society*, **152**, A229 (2005).
4. K. Shin-Liang and W. Nae-Lih, *Electrochemical and Solid-State Letters*, **6**, A85 (2003).
5. C. Peng, S. Zhang, D. Jewell and G. Z. Chen, *Progress in Natural Science*, doi:10.1016/j.pnsc.2008.03.002.
6. W. Q. Han and A. Zettl, *Nano Lett.*, **3**, 681 (2003).
7. X. Jin, W. Zhou, S. Zhang and George Z. Chen, *Small*, **3**, 1513 (2007).
8. S.-B. Ma, K.-W. Nam, W.-S. Yoon, X.-Q. Yang, K.-Y. Ahn, K.-H. Oh, K.-B. Kim, *Journal of Power Sources*, **178**, 483 (2008).
9. M. Wu, G. A. Snook, G. Z. Chen and D. J. Fray, *Electrochemistry Communications*, **6**, 499 (2004).