Carbon Nanotube-Conducting Polymer Nanocomposites

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The electrochemical growth of carbon nanotube-conducting polymer composites offers the ability to produce three-dimensional nanostructured materials that combine the redox charge storage mechanism of conducting polymers with the high surface area and conductivity of carbon nanotubes.[1,2] This desirable merging of properties presents new opportunities to produce superior materials for applications such as supercapacitors, sensors and actuators. The work described here relates to electrochemically grown composite films of multiwalled carbon nanotubes and conducting polymers such as polypyrrole and poly(3-methylthiophene) and their energy storage capabilities for supercapacitor devices.

By manipulating such factors as the alignment, concentration, surface treatment, type and dispersion of nanotubes in these composites, it was found that the nanoporous composite structure and its electrochemical behaviour could be closely controlled and customised (Figure 1). When negatively charged functional groups were attached to the nanotube surface via an acid-treatment process, the nanotubes were able to partially dope the conducting polymer during film growth, creating a myriad of new electrochemical prospects for such nanocomposite films.

Using the factors described above, it was possible to minimise ionic diffusion distances within the nanoporous composite films, in addition to reducing their electrical and ionic resistance. Consequently, electrochemical capacitances per unit mass and geometric area in excess of $200\ F\ g^{-1}$ and $2.6\ F\ cm^{-2}$, respectively, were obtained for the composite films with rates of response that were more than an order of magnitude higher than those of similarly prepared pure conducting polymer films. These exceptionally high values of capacitance (more than double that of either component material) and rates of response illustrate the bulk property benefits to be gained from combining carbon nanotubes and conducting polymers on the nanoscale.

[1] Hughes, M., Chen, G.Z., Shaffer, M.S.P., Fray, D.J., and Windle, A.H., "Electrochemical capacitance of a nanoporous composite of carbon nanotubes and polypyrrole", *Chemistry of Materials*, 2002, Vol. 14(4), 1610.

[2] Hughes, M., Shaffer, M.S.P., Renouf, A.C., Singh, C., Chen, G.Z., Fray, J., and Windle, A.H., "Electrochemical capacitance of nanocomposite films formed by coating aligned arrays of carbon nanotubes with polypyrrole", *Advanced Materials*, 2002, Vol. 14(5), 382.

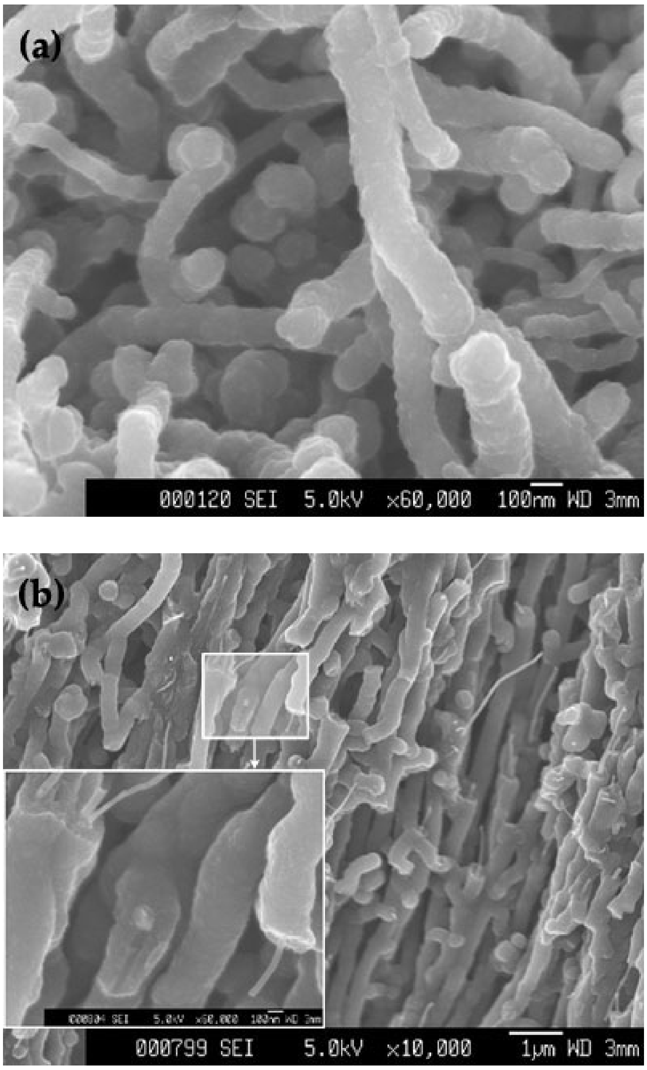

Figure 1: Scanning electron microscopy images of nanoporous composites of multiwalled carbon nanotubes and polypyrrole in which the nanotubes are (a) randomly oriented and (b) aligned.