Graphene Oxide and Activated Carbon Composites for High-Power Supercapacitors

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Abstract

Supercapacitors are gaining increasing attention for complementing or replacing batteries and they are highly desirable in applications where high power and long cycle life of energy storage devices are needed. Activated carbons (AC) are the most promising electrodes in the supercapacitor industry presenting the best performances/cost compromise. Recently, graphene, with a two dimensional carbon nanostructure, has emerged as a new class of promising electrode material in supercapacitors, due to its outstanding properties such as high electric conductivity, high surface area, good mechanical properties and chemical inertia. Among the various approaches to producing graphene materials, here we focus on reduced exfoliated graphene oxide (r-GO) derived from chemically synthesised graphene oxide (GO). However, the graphene materials prepared by either chemical or thermal reduction of the graphene oxide always exhibits a relatively low electrochemical performance due to the agglomeration of graphene sheets and does not reflect the intrinsic capacitance of an individual graphene nano-sheet. To exploit the potential electrochemical applications for graphene, a particularly attractive option is to design and develop composites of graphene with other materials. In this study, we present an approach to synthesize a composite of reduced graphene oxide (r-GO) with activated carbon and its use as an electrode material in supercapacitors. To the best of our knowledge, a few studies on the preparation of GO/AC composites have been reported so far. Graphene oxide was synthesised using vein graphite by a modified Hummers method and then mixed with activated carbon to prepare a homogeneous composite. The composite was thermally reduced to convert GO in to r-GO. The morphology and chemical structure of the materials were characterized by means of Electron microscopy, Raman spectroscopy, X-ray diffraction and Fourier Transform Infrared Spectroscopy. Thermal properties were investigated using Thermo Gravimetric Analysis. The electrochemical properties of as obtained composites with different mass ratios were investigated, together with their individual components (GO, r-GO and AC) for comparison. For electrochemical characterisation, two-electrode symmetrical supercapacitor cells were constructed and characterized by cyclic voltammetry and electrochemical impedance spectroscopy. Tetraethylammonium tetrafluoroborate (TEABF4) in Propylene Carbonate (PC) was used as the electrolyte. The CV curves were measured from 0 to 1 V with various scan rates ranging from 10 to 1000 mV s^{-1} and the CV data were used to calculate the specific capacitances of the electrodes. The results showed that the as-prepared composites exhibited an improved electrochemical performance as compared to pure r-GO or AC. This improvement can be attributed to the synergistic effect of AC and r-GO. The maximum specific capacitance observed for the r-GO/ AC composite was 115.6 F/g at a scan rate of 10 mV s^{-1}. The near-rectangular CV curves at ultrafast sweep rate of 1000 mV s^{-1} indicated very efficient charge transfer within the composite electrodes. The incorporation of r-GO into AC, not only provides the vacancies to accommodate ions, but also forms a promising network structure to conductively bridge the spaces between the AC particles, which can facilitate rapid transport

of the electrolyte ions within the electrode materials, leading to a high-rate performance of the supercapacitor. Within the composite, r-GO plays the role of both the binder and the conductive additive increasing the specific capacitance and the power density of the devices.

References

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Figures

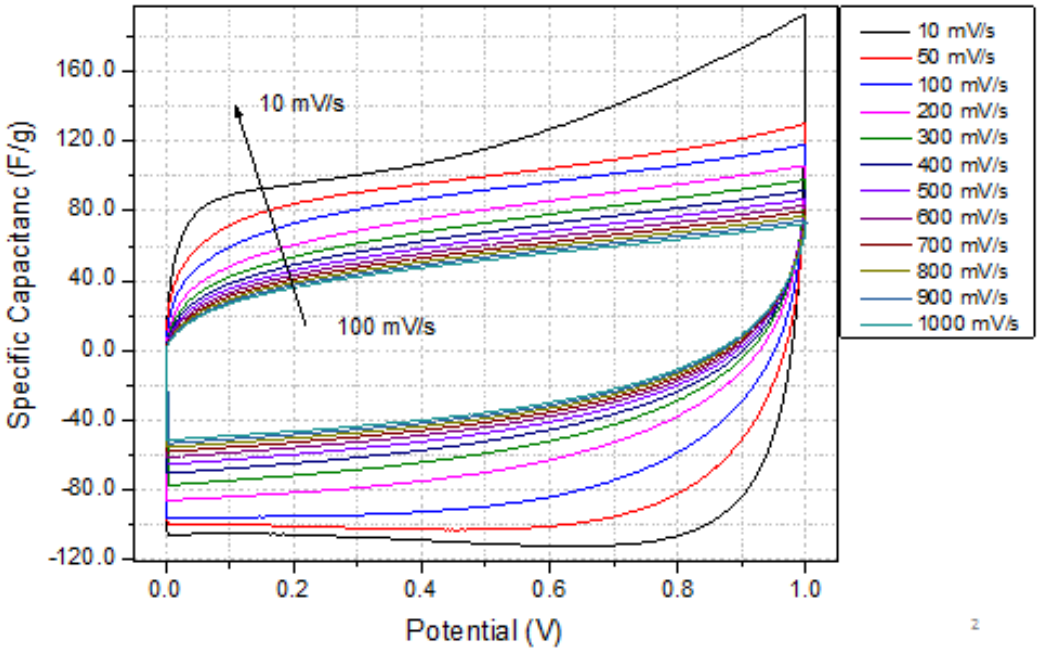

Figure 1. Electrochemical performance of r-GO/AC composite electrode in TEABF4 / AN solution -CV curves at various scan rates.