# Graphene Oxide Based Electrodes for Supercapacitors with Enhanced Cyclic Performance.

**D. Thanuja L. Galhena**, [†] Bernhard C. Bayer, [†] Stephan Hofmann[†] and Gehan A. J. Amaratunga[†]

[†] *Centre for Advanced Photonics and Electronics, Department of Engineering, University of Cambridge, 9 J. J. Thomson Ave., CB3 0FA, Cambridge, UK.*
*E-mail: dtlg2@cam.ac.uk*

Graphene and graphene-based materials have attracted significant recent attention because of their unique properties and have emerged as a new class of promising electrode material in supercapacitors. Among the various approaches, chemical exfoliation of graphite has provided an affordable route to the large scale processing of graphene-based materials. The most common chemical means of graphite exfoliation is the use of strong oxidizing agents to yield graphene oxide (GO). For GO, contiguous aromatic lattice of graphene is interrupted by epoxides, alcohols, ketone carbonyls and carboxylic groups. These surface oxides make GO electrically insulating but, hydrophilic and thus, allow intercalation of water and polar solvent molecules between the GO layers. Although GO is not a preferred electrode material for supercapacitors due to its electrically insulating nature, in this study we exploit the ability of GO to interact with organic solvents to enhance the cyclic performance of GO based supercapacitors. Deviating from the normal supercapacitor behaviour, for GO based supercapacitors, a gradual increase in specific capacitance was observed with the cycle number. Free standing, flexible GO paper was synthesised using graphite oxide derived from vein graphite following Hummer's method and used as the electrode material. The morphology and chemical structure of the material were characterized by means of scanning 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 GO paper were investigated, together with its thermally reduced component (r-GO) for comparison. For electrochemical characterisation, two-electrode symmetrical supercapacitor cells were constructed and characterized by cyclic voltammetry and electrochemical impedance spectroscopy. Tetraethylammonium tetrafluoroborate ($TEABF_4$) in Propylene Carbonate (PC) was used as the electrolyte. The results showed that for GO based supercapacitors, the specific capacitance increased by approximately six times (from 71 mF $g^{-1}$ to 422 mF $g^{-1}$) after 24,000 cycles. After 24,000 cycles, the specific capacitance decreased gradually, but even after 85,000 cycles the value did not drop below the initial specific capacitance (258 mF $g^{-1}$ after 85,400 cycles). However, for r-GO based supercapacitors, the specific capacitance decreased gradually with cycle number revealing the usual supercapacitor behaviour. This confirms that, the enhanced cyclic performance of GO based supercapacitors can be attributed to the presence of functional groups on GO. Their ability to interact with PC, allows PC molecules to intercalate between the graphene sheets, facilitating exfoliation of graphene sheets as confirmed by X-ray diffraction data. Subsequent increase in the electrochemically accessible surface area of the electrode material increases the specific capacitance of GO based supercapacitors. Although GO based supercapacitors exhibit relatively lower specific capacitance due to the electrically insulating nature of GO, when GO is mixed with a suitable conductive electrode material, the resulting composite may benefit from the presence of GO to enhance the cyclic performance.

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