Rev. Adv. Mater. Sci. 41 (2015) 35-43

# STRUCTURAL AND ELECTROCHEMICAL CHARACTERISTICS OF GRAPHENE NANOSHEETS AS SUPERCAPACITOR ELECTRODES

**Gomaa A.M. Ali[1,2], Salah A. Makhlouf[3,4], Mashitah M. Yusoff[1] and Kwok Feng Chong[1]**

[1]Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang, Gambang, 26300 Kuantan, Malaysia
[2]Chemistry Department, Faculty of Science, Al-Azhar University, Assiut, 71524, Egypt
[3]Physics Department, Faculty of Science, Assiut University, Assiut 71516, Egypt
[4]Deanship of Scientific Research, Al Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, 11463, Saudi Arabia

*Received: February 15, 2015*

**Abstract.** In this paper, graphene oxide (GO) was prepared by the Hummers' method and reduced using hydrazine to produce graphene nanosheets (GNS). Physicochemical characterizations of the prepared materials were performed using XRD, FTIR, TGA, DTA, BET, UV-vis, Raman, and FESEM techniques. The results elucidate the structure, morphology, mesoporousity and thermal stability of the prepared samples. Detailed electrochemical studies have been conducted on GNS by CV, galvanostatic and complex impedance measurements indicating some interesting features. GNS shows a specific capacitance of 140 F $g^{-1}$ at 0.05 A $g^{-1}$. GNS shows high cyclic stability of about 86% over 1100 cycles at a current density of 1 A $g^{-1}$. The large electrochemical active surface area suggests that most of the nanosheets are accessible to ions adsorption in the electrolyte system. Impedance spectra show low resistance of GNS, supporting its suitability for supercapacitor electrode applications.

## 1. INTRODUCTION

Supercapacitors, also known as ultracapacitors, are electrochemical energy storage devices with higher capacity than physical capacitors,furthermore their charging-discharging rate capability is higher than that of batteries. Two types of supercapacitors are known, namely electrochemical double layer capacitors (EDLCs) and pseudocapacitors. The former one stores energy non-faradically through the accumulation of charges at the electrode–electrolyte interface, whereas the latter stores energy faradically by the redox reaction [1-4]. EDLCs usually contain carbon based materials possessing high surface area as the electrode material, and the capacitance originates from the charge accumulation at the interface between electrode and electrolyte [5,6]. On the other hand, pseudocapacitors employ transition metal oxides [2,3,7-9] or conductive polymers [10,11] as the electrode material. Though the energy densities in pseudocapacitors are higher than that of EDLCs, the faradic reactions within pseudocapacitors could lead to phase changes and limit their life time [12].

Graphene is atomically thin two dimensional (2D) system of $sp^2$ carbon atoms organized in hexagonal lattice structure. Graphene has been found to be of both fundamental interest and suitable for a wide range of potential applications. The porous

Corresponding author: Gomaa A.M. Ali, e-mail: gomaasanad@gmail.com and gomaasanad@azhar.edu.eg