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Symmetric supercapacitor based on biosynthesized nanosheets of reduced graphene oxide (rGO): Characterization and electrochemical behavior

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Abstract

Reduced graphene oxide (rGO) nanosheets (NS) were synthesized via a simple, rapid, eco-friendly and cost effective biosynthesis approach using Lonar lake isolated bacterium strain *Bacillus cabrialesii RIRD-SK (MCC 4670)*. The biologically prepared rGO nanosheets were characterized via X-ray detection diffraction (XRD), Fourier transform infrared spectrum (FTIR), Raman spectroscopy, Field emission scanning electron microscopy (FE-SEM), Energy dispersive X-ray spectroscopy (EDX), and Brunauer-Emmett-Teller (BET) techniques, respectively. Electrochemical investigation was carried out using the cyclic voltammetry (CV), galvanostatic charge–discharge (GCD) and electrochemical impedance spectroscopy (EIS) tests. Most of the oxygen functional groups species in rGO were successfully eliminated resulting in little (0.39Ω) charge transfer resistance (R_{ct}). The rGO electrode exhibited 457 F/g specific capacitance at scan rate $5\,mVs^{-1}$ in 1 M Na_2SO_4 aqueous electrolyte within the potential window of −1 to 0V. It showed a superior electrochemical cycle stability of 96% after 10,000 cyclic voltammetry cycles. The aqueous symmetric supercapacitor device was prepared in the configuration of rGO/Na_2SO_4/rGO. Device exhibited 165 F/g specific capacitance at scan rate $5\,mVs^{-1}$ with cyclic retention of 94% for 10,000 cyclic voltammetry cycles.

Introduction

The ultracapacitor or supercapacitor is considered as a promising electrochemical energy storage device due to its numerous properties, such as ultrafast charging and discharging ability, environmental friendliness, long-term stability and high power density [1]. In general, ultracapacitors are classified into three categories based on their charge storage mechanism, and the electrode taxonomy is referred to as (i) pseudocapacitor, (ii) hybrid supercapacitor, and (iii) electric double layer capacitor (EDLC) [2], [3]. Supercapacitors have a longer cycle life compared to many other energy storage technologies, such as batteries and fuel cells [4]. However, the specific capacity of the EDLC is not significant since the electrolyte ions are stored by an adsorption/desorption reaction at the electrode/electrolyte interface or by a non-faradaic reaction [5]. To improve the performance of EDLC, several attempts have been made, including the new synthesis approach that uses liquid organic and aqueous electrolytes and manipulates the growth direction [6], [7]. However, the specific capacitance (Csp) obtained is still lower than that of the pseudocapacitors [8], [9]. Therefore, it is imperative to perform an alternative synthesis method to improve the Csp of carbon electrodes [10].