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Conducting polymer wrapped SnO_2/RGO nanocomposite: An efficient high-performance supercapacitor material

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ABSTRACT

This study describes a ternary poly (3,4-ethylenedioxythiophene)-poly-(styrenesulfonate) (PEDOT:PSS)-wrapped tin oxide/reduced graphene oxide (SnO_2/RGO/PEDOT: PSS) (SGP) nanocomposite electrode as a supercapacitor electrode. The properties of the SGP nanocomposites were studied using various characterization techniques such as X-ray Diffraction, scanning electron microscopy, energy-dispersive X-ray spectroscopy, transmission electron microscopy (TEM), Raman spectroscopy, and electrochemical impedance spectroscopy. The XRD results demonstrated the reduction of graphene oxide during the synthesis. TEM analysis confirmed the presence of PEDOT: PSS and graphene layers adorned with minuscule SnO_2 particles. Standard three-electrode geometry was used to investigate the electrochemical properties of the samples. For comparison, a two-electrode system was used to investigate the electrochemical properties. The as-prepared SGP nanocomposite electrode exhibited specific capacitance of 252.0 F/g and 124 F/g at a scan rate of 1 mV/s for the three-electrode and two-electrode systems, respectively. Furthermore, the electrode retained approximately 97.8 % of its capacitance even after 5000 cycles. However, the SGP electrode when operated to wide voltage window -0.6 V to +0.6 V exhibited the maximum specific capacitance of 285.0 F/g at scan rate 1 mV/sec and shows 114 % enhancement in the capacitance retention after the 5000 cycles at current density of 10 A/g which gives a protocol for future energy storage device application with high operating voltage. The SGP-based supercapacitor exhibited a high energy density (17.7 Wh kg $^{-1}$) and power density (1220 W kg $^{-1}$).

1. Introduction

Owing to the proliferation of science and technology, efforts have been devoted to flexible and wearable electronics that require high power densities and charge-transfer devices [1]. However, a single storage device cannot fulfill the above requirements, such as batteries, owing to their short cycle life and slow charging and discharging rates [2]. Therefore, high-performance energy storage devices have gained more of the consumer electronic device market, in which supercapacitors have attracted greater attention owing to their high-power capability, long cycle lifetime, and large specific capacitance [3]. Supercapacitive devices can also act as bridges between the batteries and capacitors. Conventionally, supercapacitors are categorized into two groups, depending on their charge storage mechanism: electrical double charge layer capacitance (EDLC) and pseudocapacitors [4]. The storage mechanism in EDLC is due to the charging of the electrical double layer at the electrolyte and electrode interface, while pseudocapacitance utilizes charge storage via a reversible faradic reaction [5]. Gel electrolytes are also of great importance in printed supercapacitors and can be used in sensor and actuator systems to provide temporary power backup [6]. Supercapacitors can be classified into four major groups: conducting polymers [7], carbon-based materials [8], metal oxides [9], and hydroxides [10]. Perovskite oxide materials also show good thermal and chemical stability; nevertheless, the method of preparation and calcination temperature result in a low surface area, which leads to a reduction in the specific capacitance [11]. Metal oxides such as NiO, RuO_2, MnO_2, and SnO_2 have been extensively studied owing to their large charge-transfer reaction capacitance and high energy density [12–15]. SnO_2 has attracted considerable attention owing to its economical production process, low toxicity, and high abundance;

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