



Preparation and characterization of a pseudocapacitor electrode by spraying a conducting polymer onto a flexible substrate

Shaker A. Ebrahim^a, Mohamed E. Harb^{b,*}, Moataz M. Soliman^a, Mazhar B. Tayel^b

^a Department of Materials Science, Institute of Graduate Studies and Research, Alexandria University, P.O. Box 832, Egypt

^b Department of Electrical Engineering, Faculty of Engineering, Alexandria University, P.O. Box 21544, Egypt

Received 31 March 2015; received in revised form 9 June 2015; accepted 9 July 2015

Available online 31 August 2015

Abstract

In this paper, polyaniline is deposited using a spraying technique onto a flexible current collector for pseudocapacitor applications. The polyaniline is characterized using Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and optical absorption studies. The energy density of a pseudocapacitor is higher than that of double-layer supercapacitors due to Faradaic reactions. A high specific capacitance of 594.92 F/g is obtained at a scan rate of 5 mV/s with a scanning potential window of (−0.8 to 0.8 V). The results show an increase in the energy density of 82.63 Wh/kg at a potential difference of 1 V using a 4 M potassium hydroxide aqueous electrolyte.

© 2015 The Authors. Production and hosting by Elsevier B.V. on behalf of Taibah University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Keywords: Conducting polymer; Polyaniline; Pseudocapacitors; Flexible electrode; Energy density

1. Introduction

Electronically conducting polymers (ECPs), such as polypyrrole (PPy), polyaniline (PANI), polythiophene (PTh) and poly[3,4-ethylenedioxythiophene] (PEDOT), can store and release charges through redox processes associated with π -conjugated polymer chains [1–5]. When oxidation occurs (also referred to as p-doping), ions from the electrolyte are transferred to the

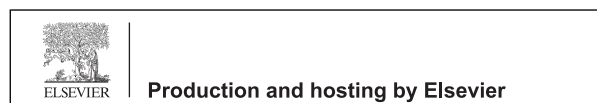
polymer backbone and, on reduction (“undoping”), they are released back into solution. Generally, p-dopable polymers are more stable than n-dopable polymers [5]. The doping/undoping process occurs throughout the bulk of the electrodes, offering the opportunity to achieve high values of specific capacitance. Among the conducting polymers, polyaniline (PANI) has attracted much attention because of its low cost, environmental stability, controllable electrical conductivity, and easy processability [5].

Electrochemical supercapacitors combine the advantages of dielectric capacitors, which can deliver high power within a very short time, and rechargeable batteries, which can store high amounts of energy. Supercapacitors have found an increasingly important role in power source applications, such as hybrid electric vehicles, short-term power sources for mobile electronic

* Corresponding author. Tel.: +20 1020982715.

E-mail address: moh.harb@yahoo.com (M.E. Harb).

Peer review under responsibility of Taibah University



devices, among others. The materials studied for supercapacitors are mainly of three types: carbon, metal oxide, and conducting polymer. Due to the Faradaic reaction, the energy density of a supercapacitor consisting of electro-active materials with several oxidation states or structures (e.g., transition metal oxides and conducting polymers) is expected to be higher than that of double-layer capacitors. Conducting polymers offer the advantages ease of synthesis and low cost. In this paper, PANI is prepared chemically for use as a pseudocapacitor electrode [6].

2. Experimental work

2.1. Materials

Aniline ($C_6H_5NH_2$, 99%) was purchased from CDH. Ammonium persulphate, $[(NH_4)_2S_2O_8]$, 98.5%] was purchased from WINLAB. Hydrochloric acid (HCl, 37%) and camphor sulphonic acid were purchased from Merck. These materials were used for the preparation of polyaniline. Potassium hydroxide (KOH) and sodium hydroxide (NaOH) were obtained from local agents.

2.2. Polyaniline preparation

Aniline (0.2 M) is added to 0.2 M HCl and then kept for 1 h at room temperature. Ammonium persulphate (APS) in 20 mL of distilled water is then slowly added to the suspension under stirring. The molar ratio of aniline, hydrochloric acid and APS is 1:1:1. The reaction is conducted by the in situ polymerization method in an ice bath for 1 h and then left at rest to polymerize for 24 h at room temperature. The prepared mixture is filtered and then rinsed with distilled water. PANI is simultaneously dedoped by 25 mL of 8 M sodium hydroxide at 90 °C for 5 h. The emeraldine salt is dried in air and then at 60 °C for 24 h. PANI is doped with camphor sulphonic acid (CSA) and then dissolved in chloroform [7–10].

2.3. Preparation of flexible PANI electrode

A flexible plastic sheet is coated with gold using a thermal vacuum evaporator. Camphor sulphonic acid doped PANI dissolved in chloroform is sprayed on the active area (1 cm × 1 cm) of the gold-coated plastic sheet using an air compressor and a spray gun. The samples are left in an oven at 70 °C to dry for 12 h prior to performing the electrochemical measurement. Electrochemical measurements are performed using two electrodes measurements in an electrochemical cell.

The used electrolyte is aqueous potassium hydroxide ($c = 4$ M) [11–15].

2.4. Electrochemical measurements

The electrochemical performance is analyzed for supercapacitor electrodes in a two-electrode system via cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) using a Potentiostat/Galvanostat/ZRE Gamry G750 instrument. The galvanostatic charge-discharge is performed using a Gamry Reference 3000 instrument. The cyclic voltammetry (CV) response of the electrodes is measured at different scan rates varying from 1 mV/s to 300 mV/s, and the electrolyte is 4 M potassium hydroxide. Impedance spectroscopy measurements are performed at a dc bias of 0.1 mA, with a sinusoidal signal of 1 mA over a frequency range of 1 MHz to 0.05 Hz.

2.5. Characterization

The UV-Visible Thermo (Evolution 600) spectrophotometer that covers the range of 190 to 900 nm is used to characterize the optical properties of PANI. A Fourier Transform Infrared PerkinElmer (Spectrum BX) Spectrophotometer is used to cover the spectral range from 400 to 4000 cm^{-1} . An XRD machine (X-Ray 7000 Shimadzu-Japan) equipped with a $Cu-K_{\alpha}$ radiation source ($\lambda = 0.15418$ nm) operating at 30 kV and 30 mA is operated at a scanning rate of 4° min^{-1} over 2θ values between 5° and 90° to characterize the structural properties. Scanning electron microscopy (SEM) is performed using a JEOL JSM 6360LA instrument operated at an acceleration voltage of 20 kV. A Raman Microscope Senterra Bruker, Germany, at a wavelength 532 nm is used to characterize the chemical bonding structure.

3. Results and discussion

Fig. 1 shows the UV–vis spectrum of PANI doped with CSA in chloroform. Two electronic transitions are observed at 357 nm and 787 nm. The characteristic band at 357 nm can be attributed to the $\pi-\pi^*$ transition on the polymer chain. The characteristic band at 787 nm is attributed to a polaron due to CSA doping and corresponds to localization of electrons [14,16].

Fig. 2 shows the FTIR spectrum of a chemically synthesized polyaniline in its undoped state. PANI shows vibration bands at 1588, 1495, 1322, 1164, 848 and 622 cm^{-1} . The 1588 cm^{-1} vibration band is due to the C=C double bond of the quinoid rings, whereas the 1495 cm^{-1} vibration band arises due to the vibration

Download English Version:

<https://daneshyari.com/en/article/1262982>

Download Persian Version:

<https://daneshyari.com/article/1262982>

[Daneshyari.com](https://daneshyari.com)