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Electrochemical Behavior Study of Copolymer (PANI/PEDOT: PSS) for Application in Supercapacitors

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ABSTRACT

The aims of this work is to study the electrochemical behavior of the copolymer PANI/PEDOT: PSS by electrochemical technics to apply in supercapacitors. Polyaniline (PANI) is a conductive polymer it was synthesized by electrochemical polymerization. It exhibits very stable properties in different environments. PEDOT: PSS is a conductive polymer based on poly(3,4-ethylenedioxythiophene) (PEDOT) and poly (styrene sulfonate) (PSS). It is commonly used with polyaniline to improve its electrical conductivity several physico-chemical and electrochemical technics were used for the characterization PANI/PEDOT: PSS: cyclic voltammetry (VC), electrochemical impedance spectroscopy (EIS), open circuit potential, SEM, Xray diffraction…etc. The results showed that the PANI/PEDOT: PSS composite is a promising material for supercapacitors due to its high electrical conductivity and high porosity. Electrochemical and physicochemical characterization tests have shown that the composite has high electrical and structural performances, making it a material of choice for high-performance energy storage applications.

Keywords: energy storage, supercapacitors, SIE, VC, PANI, poly(3,4-ethylenedioxythiophene) PEDOT) and poly (styrene sulfonate) (PSS).

1. Introduction

Supercapacitors constitute a new generation of electrochemical components intended for energy storage. These relatively new components occupy a truly intermediate position between electrolytic capacitors and electrochemical accumulators in terms of specific energy and power. Their interest lies in the significant energy, unlike capacitors, which they are able to store directly in its electrical form, thus maintaining the immediate availability of said energy. In capacitors, the energy storage is electrostatic, implementing only charge displacements. [1-4]. The poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT: PSS) has been considered as one of the most promising candidates as electrode materials, due to its solution processing advantages. aqueous, excellent stability and high transparency at 90% and high conductivity at 10^3 S/cm. The electrical conductivity of PEDOT: PSS strongly depends on the ratio of PEDOT and PSS, the PEDOT arrangement and the film morphology, which can be strongly modified via second doping or treatments on the film. It has been reported that the electrical conductivity of PEDOT: PSS can be improved by two or three orders of magnitude by doping with polar organic solvents such as dimethylformamide (DMF), dimethyl sulfoxide (DMSO), ethylene glycol (EG), glycerol and sorbitol. [5]. Surfactant is another effective dopant to increase both the electrical conductivity and wetting property of PEDOT: PSS films [6]. This large family of compounds combines both certain charge transport properties of conventional conductors and semiconductors and the advantages of polymers giving rise to numerous applications as electronic conductors or semiconductors. Among these mixtures we cite the PANI/PEDOT/PSS composite. This interest is mainly due to environmental, safety and process control considerations. A very vast field of knowledge and application opening new avenues in fundamental and applied research. The main objective of this research work being the study of the electrochemical behavior of PANI/PEDOT: PSS and their applications in supercapacitors.

2. Experimental

The conductivity of polymer films was investigated by electrochemical impedance spectroscopy (EIS). The

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DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)

potentiostat/galvanostat PGSTAT30-Autolab was used to record the EIS spectra of stainless-steel electrodes electrochemically coated with the PEDOT, PANI and PEDOT-PANI polymers. The solution of 0.5 M H_2SO_4 was used as an electrolyte in a three-electrode cell configuration. The counter electrode was a platinum plate of 1 cm^2 geometric area and a reference electrode was Ag/AgCl (3M KCl). An AC sinusoidal perturbation with amplitude of 10 mV was applied to record the electrochemical impedance spectra in a frequency range from 10^5 Hz to 1 mHz. The EIS data was fitted by using corresponding equivalent circuit by EIS NOVA 1.7 Analyser software.

3. Results and discussion

After cycling, the EIS diagrams (figures 1) of the various composites synthesized show perfect semi-circles or capacitive loops at high frequencies corresponding to charge transfer phenomena at the polymer/solution interface. At low frequencies, the systems tested exhibit a straight line that relates to diffusion phenomena in the pores of the polymers obtained. The equivalent circuit of the PANI/PEDOT: PSS systems proposed and shown in (figure2).

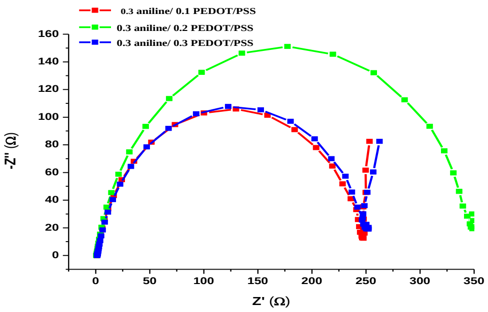

Figure 1: Nyquist diagrams of composite (PANI/PEDOT: PSS) formed at different volumes after cycling.

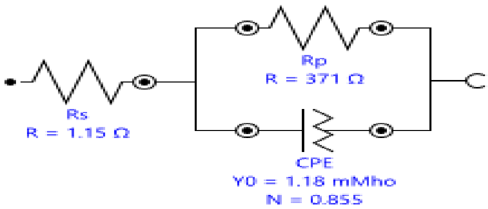

Figure 2: Equivalent electrical circuit of PANI/PEDOT: PSS systems for different volumes of PEDOT: PSS (0.1, 0.2 and 0.3 ml) in 0.5M H2SO4 before and after cycling.

4. Conclusion

The characterization of PANI powder and electrochemical PANI by SIE shows a capacitive behavior corresponding to the charge accumulated on the surface of the polymer and the diffusion process in the polymer. Before and after cycling, the SIE diagrams of the different synthesized composites present perfect semi-circles or capacitive loops at high frequency corresponding to the charge transfer phenomena at the polymer/solution interface linked to a law characterized diffusion in the materials polymers.

The scientific gains of this work are the obtaining of highly conductive deposits on very resistant supports used as electrodes in supercapacitors.

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ISBN: 978-81-970666-4-1

Series: AIJR Abstracts

DOI: 10.21467/abstracts.169