Fabrication of Polypyrrole Nanorod Arrays for Supercapacitor: Effect of Length of Nanorods on Capacitance

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Arrays of polypyrrole nanorods were fabricated using an anodized aluminum oxide (AAO) template for use as supercapacitors. Gold was deposited on one side of the AAO template by thermal evaporation for use as an electrode and pyrrole was electrochemically polymerized, causing it to grow from the gold electrode into the AAO template. The length of the PPy nanorods was controlled by adjusting the applied charge, and nanorods with three different lengths were prepared: 1.2 μm for 0.5 C cm⁻², 2.4 μm for 1.0 C cm⁻², and 4.6 μm for 2.0 C cm⁻². After the removal of the AAO template in alkali solution, a well-arranged polypyrrole (PPy) nanorod electrode structure having an extremely large surface area was produced. The morphology of the PPy nanorods was monitored by SEM. The capacitive performances of the PPy nanorod array electrodes were investigated by cyclic voltammetry (CV) as well as the galvanostatic charge/discharge test. Greatly enhanced capacity performance was observed in the nanorod electrodes. Also, a higher specific capacitance was observed in the longer nanorod electrode having a larger surface area.

Keywords: Nano-Array, Polypyrrole, Specific Capacitance, Supercapacitor, Templates.

1. INTRODUCTION

The growing demand for portable systems and electric vehicles which require high power in short term pulses has prompted a great deal of interest in electrochemical capacitors, which are also known as supercapacitors.1-4 Many attempts have been made to use electrically conducting polymers (ECPs) as electrode materials in electrochemical capacitors or supercapacitors with a high specific capacitance exhibiting a high specific energy and specific power.1,5 Among the extensively studied conducting polymers, polypyrrole (PPy) has drawn considerable attention due to its relatively high solid stability in ambient conditions and ease of synthesis.6 PPy is an important electrode material for redox supercapacitors and has the advantages of a porous morphology, good electrical conductivity, and a fast doping and dedoping process.1 It is well recognized that a thin and uniform coating of PPy is ideal for obtaining fast and effective ion diffusion in the polymer matrix, in order to improve the performance of a supercapacitor device.8

In general, electrochemical processes occur at the interface between an electrode and electrolyte; therefore, an electrode with a large surface area is necessary to enhance the ion mobility.8 Materials with a nanosized structure having a large surface area and high porosity give the best performances as the electrode materials for supercapacitors, because of their distinctive characteristics, which consist of conducting pathways, surface interactions, and nanoscale dimensions. Nanostructured electrodes demonstrate higher capacitance than traditional bulk materials.9-11

In previous studies, nanosized conducting polymers were prepared by various synthetic routes, such as the self-assembly method,12 emulsion polymerization technique13 and interfacial polymerization.14 However, none of the above-mentioned methods is suitable for preparing supercapacitors, because it is difficult to attach the nanosized conducting polymer onto the electrode substrate without there being a large contact resistance.15

Gomez-Romero et al. made a granular type of nanosized conducting polymer for supercapacitor applications using the chemical-electrochemical method. This type of nanosized conducting polymer improves the charge transfer at the interface of the conducting polymer with the...