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High performance supercapacitor using catalysis free porous carbon nanoparticles

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Abstract

Very high supercapacitance values are obtained using catalyst free porous carbon nanoparticles (PCNs). The obtained PCNs have a porous structure with fine particles 35 nm in size. The specific capacitance of PCNs is 343 F g^{-1} and 309 F g^{-1} at 5 mV s^{-1} and 0.06 A g^{-1}, respectively. PCNs shows a high cyclic stability of about 90% and high columbic efficiency of 95% over 2500 cycles at 1 A g^{-1}. Impedance spectra show low resistance of PCNs, supporting their suitability for supercapacitor electrode application.

Keywords: carbon nanoparticles, supercapacitor, porous, catalyst free

(Some figures may appear in colour only in the online journal)

1. Introduction

Carbon materials have been playing a significant role in the development of alternative clean and sustainable energy technologies. Energy density, power density, size, weight, initial cost and life are the most important requirements for energy storage devices. In terms of power and energy density, the supercapacitor fills up the gap between the battery and classical capacitor, allowing new applications. Many carbon-based materials are reported as energy storage supercapacitors due to their high power density, high energy density, low cost, short charging time and long cycle life. These materials include activated carbon, carbon nanotubes, carbon nanospheres and graphene [1–4]. The carbon-based electrical double layer capacitor (EDLC) utilizes the double layer formed at the interface between the nanoporous carbonaceous electrode and the electrolyte solution. The supercapacitance depends on pore size distribution of the carbon materials. The carbon materials with large pores are more suitable to high-power supercapacitor applications because the ions transport into the pores easily. Among all carbon materials, spherical carbon nanospheres are attractive candidates for functional materials due to high heat stability and excellent conductivity [2, 5]. Electrochemical supercapacitors have a wide range of applications in telecommunication devices, such as cell phones and pagers, stand-by power systems and electric hybrid vehicles [6, 7].

On the other hand, producing high quality porous carbon nanoparticles is a difficult challenge since they require lots of care and attention [8]. Additionally, PCNs are very attractive materials due to their wide variety of applications [8]. One of the prime interests that has recently arisen is to produce PCNs using biowaste materials which not only reduce the burden to the environment but can also be more effective as compared with available PCNs. Most of nanoparticle synthesis, including catalysis, is a necessary phenomena but an exception to this has been reported recently by our group where catalyst free PCNs were obtained using biowaste materials [9]. Excellent quality of the PCNs were characterized and the reported small particle sizes ranged from 30–50 nm.

To further extend this work, we here conduct detailed electrochemical studies on newly synthesized PCNs by cyclic

