Enhanced Capacitance of Microwave-assisted Functionalized Ordered Mesoporous Carbon for Supercapacitors

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Abstract: The electrochemical capacitance for a double layer of ordered mesoporous carbon (OMC) nanofibers functionalized under differing conditions is presented. OMC nanofibers were prepared using the molding method from SBA-15 and sucrose. Functionalisation was performed using varying HNO3 concentrations at 110°C and 120°C assisted by microwave radiation over 3 minutes. The transmission electron micrographs of the resulting fibers are reported. The capacitance, surface area and functional groups as functions of the acidity and heat treatment were analysed via cyclic voltammetry, nitrogen adsorption-desorption, and X-ray photoelectron spectroscopy, respectively. Ordered nanofibers treated with 7.7 M HNO3 at 110°C exhibited the highest capacitance.

Keywords: Ordered mesoporous carbon, functionalisation, capacitance, supercapacitors, EDLC

1. INTRODUCTION

Supercapacitors have been studied for use in energy storage applications for electric vehicles and any device requiring a high-pulse discharge profile [1-5]. Based on the principle of energy storage, supercapacitors can be classified into two groups, electric double-layer capacitors (EDLC) and pseudocapacitors [6]. EDLCs store electric charge in the double layer formed at the electrode/electrolyte interface, while pseudocapacitors utilize battery-like redox reactions to store energy.

In recent years, research on the development of mesoporous carbonaceous materials [7-12] for use as supercapacitors has intensified. For example, Jurewicz et al. prepared mesoporous carbon from different silica arrays (MCM-48 and SBA-15) via the molding method using propylene or sucrose as the carbon source. Their capacitance was tested in acid, alkaline and organic solutions, and the presence of interconnected mesopores, and secondary micropores was found to increase the active surface area available for the electric double layer over that in a strictly microporous material [13].

Liu et al. obtained mesoporous carbon using a resol phenol-formaldehyde resin as a carbon source and MCM-48 (mesoporous silica with pore connections and cubic pore geometry) as a template. The obtained capacitances oscillated between 250 and 150 mF; the materials were compared with microporous coal obtained from the same source, indicating that the mesoporous carbon tends to form a higher double-layer capacitance [14].

Fuertes et al. prepared mesoporous carbon using SBA-16 as a template synthesized at 100 and 150°C with polyfurfuryl alcohol as the carbon source and obtained average pore sizes of 3 and 8 nm. Electrochemical measurements on the two types of mesoporous carbons used as capacitor electrodes proved that smaller carbon pores provide better capacitor performance [15].

Xing et al. obtained three different types of carbon, two from mesoporous MCM-48 and SBA-15 with sucrose as the carbon source and one from SBA-15 with a Si/Al ratio of approximately 40 and polyfurfuryl alcohol as the carbon source. They found that ordered mesoporous carbons (OMCs) exhibit superior capacitive behavior, power output characteristics and high-frequency performance as evidenced by cyclic voltammetry studies and frequency response analysis. The cyclic voltammograms show superior capa-