VERSITA

Chemical Papers 67 (8) 1054–1065 (2013)
DOI: 10.2478/s11696-013-0348-2

ORIGINAL PAPER

Multi-wall carbon nanotubes with nitrogen-containing carbon coating

[a]Elena Tomšík*, [a]Zuzana Morávková, [a]Jaroslav Stejskal, [a]Miroslava Trchová, [a]Petr Šálek, [a]Jana Kovářová, [b]Josef Zemek, [c]Miroslav Cieslar, [c]Jan Prokeš

[a]*Institute of Macromolecular Chemistry, Academy of Sciences of the Czech Republic, 162 06 Prague 6, Czech Republic*

[b]*Institute of Physics, Academy of Sciences of the Czech Republic, 162 53 Prague 6, Czech Republic*

[c]*Charles University Prague, Faculty of Mathematics and Physics, 182 00 Prague 8, Czech Republic*

Received 23 July 2012; Revised 8 November 2012; Accepted 23 November 2012

Polyaniline coating was deposited on the surface of multi-wall carbon nanotubes of Russian and Taiwanese origin in situ during the polymerization of aniline. The deposited polyaniline film was subsequently carbonized under an inert atmosphere at various temperatures to produce coaxial coating of the carbon nanotubes with nitrogen-containing carbon. The new materials were investigated by infrared and Raman spectroscopies, which demonstrated the conversion of the polyaniline coating to a carbonized structure. X-ray photoelectron spectroscopy proved that the carbonized overlayer contains nitrogen atoms in various covalent bonding states. Transmission electron microscopy confirmed the coaxial structure of the composites. The Brunauer–Emmett–Teller method was used to estimate the specific surface area, the highest being 272 m^2 g^{-1}. The conductivity of 0.9–16 S cm^{-1} was measured by the four-point method, and it was only a little affected by the carbonization of the polyaniline coating.

Keywords: polyaniline coating, carbonization, multi-wall carbon nanotubes, supercapacitors

Introduction

Polyaniline (PANI) is one of the most studied conducting polymers due to its ability to respond to external stimuli by changes in conductivity, color, surface properties, and density, and by the variety of PANI produced nanostructures. These include especially nanotubes, nanofibers, nanorods, thin films, and colloidal particles (Chiou & Epstein, 2005; Sapurina & Stejskal, 2008; Laslau et al., 2009; Stejskal et al., 2010; Tran et al., 2011).

Multi-wall carbon nanotubes (MWCNT) have also become the subject of many research papers because of their structure, chemical stability, electrical conductivity, and high surface area. They have been used especially in the electrodes of fuel cells and in supercapacitors (Zhao et al., 2004; Ghosh & Raj, 2010; Zhang et al., 2010, 2011; Yan et al., 2011).

MWCNT immersed in the reaction mixture used for the oxidation of aniline become coaxially coated with a thin film of PANI (Konyushenko et al., 2006, 2008; Jiménez et al., 2010; Bavastrello et al., 2011). This is the result of the so-called surface polymerization of aniline (Stejskal et al., 1999, 2003; Bober et al., 2010; Liu et al., 2010) which produces a thin PANI film on macroscopic surfaces and coatings on microscopic ones. PANI–MWCNT composites find many applications (Gajendran & Saraswathi, 2008; Lu et al., 2011), e.g., in the design of sensors (Ding et al., 2011; Li & Kim, 2011; Liao et al., 2011; Lobotka et al., 2011) and electromagnetic radiation shielding (Im et al., 2010).

As a new approach in the preparation of nitrogen-containing CNT-like materials, PANI nanotubes have

*Corresponding author, e-mail: tomsik@imc.cas.cz