Accepted Manuscript

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PII: S0013-4686(18)30658-3

DOI: 10.1016/j.electacta.2018.03.143

Reference: EA 31509

To appear in: *Electrochimica Acta*

Received Date: 17 December 2017

Revised Date: 19 March 2018

Accepted Date: 22 March 2018

Please cite this article as: T.A. Babkova, H. Fei, N.E. Kazantseva, I.Y. Sapurina, P. Saha, Enhancing the supercapacitor performance of flexible MnO_XCarbon cloth electrodes by Pd-decoration, *Electrochimica Acta* (2018), doi: 10.1016/j.electacta.2018.03.143.

Enhancing the Supercapacitor Performance of Flexible MnO_xCarbon Cloth electrodes by Pd-decoration

T.A. Babkova*†, H. Fei, N.E. Kazantseva, I. Y. Sapurina, P. Saha

Centre of Polymer Systems, Tomas Bata University in Zlin, Tr. T. Bati 5678, Zlin, 760 01, Czech Republic

**†e-mail: tbabkova@cps.utb.cz*

ABSTRACT

Manganese oxide (MnO_x)-based hybrid electrode materials have been designed by electrochemical deposition on carbon cloth preliminary activated by palladium (Pd) nanoparticles. The synthesis conditions (current density, deposition time) were chosen in such a way as to achive a stable structure of MnO_x with a large surface area. The structural parameters and surface morphology of materials obtained are characterized by Scanning Electron and Transmission Electron Microscopy (SEM, TEM), Raman spectroscopy, X-ray Photoelectron Spectroscopy (XPS), etc. The electrochemical behavior was investigated by cyclic voltammetry, galvanostatic charge/discharge and impedance spectroscopy. The attained results indicate that MnO_x deposits reviled birnessite-type structural feature. Apart from that, the morphology of MnO_x transformed with increasing of current density from needlelike structure to loosely-packed thin sheets and then to closed-packed thicker sheets structures. Different morphology exhibits different specific surface area and electrochemical efficiency. Hence electrochemical analysis reviled the highest specific capacitance (186 F g^{-1}) and cyclic stability for MnO_xPdCC with obtained at current density of 1 mA·cm^{-2}. It can be explained by the formation of a less dense structure of MnOx (loosely-packed thin sheets) with large specific surface area and thus better permeability for Na^+ and SO_4^{-2} ions. As to the role of Pd, its nanoparticles deposited on CC can play a dual role, namely electron conducting passway between CC and MnO_x and structure–guiding agent of manganese oxides nucleation and grows.

Keywords: manganese oxide, palladium, carbon cloth, electrodeposition, nucleation and growth, supercapacitor

1.Introduction

In recent years, mixed-valent manganese oxides (MnO_x) nanostructures intensely investigated as a redox component of composite electrode materials with a view to improve specific characteristics of energy storage device such as alkaline rechargeable batteries, lithium ion batteries and supercapacitors (SCs) [1]. MnO_x attracts attention because of economic and environmental advantages, since they possesses set of properties: high theoretical capacity, relative low conversion potential within the window of water decomposition, rectangular cyclic voltammograms and narrow voltage hysteresis. Different allotropic forms of MnO_x show different charge–storage properties and stability during charge-discharge cycling [2-5]. It was established that MnO_x with spinel and birnessite crystal structure possesses the best capacitance and cyclic stability due to porous structure causing the large specific area [1, 6]. Moreover, it is of great importance that MnO_x in these forms have high ionic conductivity due to the redox reactions, i.e. transition between hydrous manganese oxides: Mn(III)/Mn(II), Mn(IV)/Mn(III) and Mn(VI)/Mn(IV) [1, 6]. However, MnO_x – based electrodes possess low