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Research Article

Manganese Dioxide Nanowires of Tunable Dimensions Synthesized via a Facile Hydrothermal Route

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Manganese dioxide (MnO_2) nanowires of tunable dimensions were successfully synthesized via the facile water-bathing hydrothermal route. Homogeneous solution mixtures of $KMnO_4$ and $MnSO_4$ of varying compositions were being aged in a thermostated water bath under controlled conditions. The dimensional aspect ratios of MnO_2 nanowires formed were readily modulated by varying synthesis parameters such as the initial concentration of chemical precursors, reaction temperature, and aging duration. At fixed initial precursor concentrations, the mean diameter of MnO_2 nanowires decreased slightly from 57 nm to 53 nm with increased reaction temperature from 60°C to 90°C. The mean diameter of MnO_2 nanowires decreased linearly within the range of 104 nm and 35 nm as the initial concentration of both precursors was increased in turn within the range of 10 mmol and 40 mmol at fixed aging temperature and duration. Upon aging for 2 to 24 hours at 80°C, the mean diameter and length of MnO_2 nanowires were observed to vary within the range of 33–55 nm and 0.69–2.68 μm, respectively, which corresponded to the dimensional aspect ratio range of 21 to 49. Henceforth, MnO_2 nanowires of tunable dimensions could be synthesized through optimally controlled synthesis parameters.

1. Introduction

Nanostructured manganese dioxide (MnO_2) has attracted increasing attention as a promising electrode material for the fabrication of electrochemical capacitor due to its abundance, environmentally friendly nature, and lower cost [1–3]. MnO_2 nanowires are expected to exhibit significantly different optical, electrical, and magnetic properties from their bulk 3D crystalline counterparts due to their small diameters, high specific surface area, and unique density of electronic states [4]. MnO_2 nanowires with mean diameter approximately 20 nm and BET specific surface area of 157 m^2/g [5] were synthesized by cathodic electrodeposition and postsynthesis heat treatment. MnO_2 nanowires prepared under hydrothermal condition in the presence of sodium carboxymethyl cellulose possessed mean diameter of 50–60 nm and mean length of around several micrometers [6]. MnO_2 thin films prepared from disordered nanowire networks using self-assembled method have been shown to exhibit substantially enhanced charge capacities [7]. Manganese dioxide nanowires with larger specific surface area were reported to exhibit high capacity and cycling stability as the electrode material of various electrochemical devices such as rechargeable lithium batteries and electrochemical capacitors [8, 9].

Herein, we have reported the facile synthesis of manganese dioxide nanowires with tunable dimensions via the water-bathing hydrothermal route. The effects of synthesis parameters such as reaction temperature, initial concentration of precursor chemicals, and aging duration on the formation, dimensions, and morphological characteristics of MnO_2 nanowires were investigated.

2. Experiment

2.1. Reagent and Apparatus. All chemicals used in this research were of analytical grade and were used as purchased without any further purification. Ultrapure water (~18.2 MΩ·cm, 25°C) was obtained from ELGA Ultrapure Water system (ELGA Ultra Genetic). Potassium permanganate ($KMnO_4$) and manganese sulfate monohydrate