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A hydrothermal-electrochemical synthesis of MnO_2 nanostructures for Zn-Air applications

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Abstract

In recent years, metal-air batteries that are receiving attention for both fundamental and industrial viewpoints, because they exhibit high specific energy density compared to other energy storage devices, in particular the Li-ion systems. Among metal–air batteries, the zinc–air batteries represents a safe, environmentally friendly and potentially cheap and simple way to store and deliver electrical energy for both portable and stationary devices as well as for electric vehicles [1]. In the development of zinc-air batteries, the high performance electrocatalysts for air cathode is an important issue [2]. MnO_2 has attracted great attention due to its favorable Oxygen Reduction Reaction activity, redox stability, low-cost and abundance [3].

In this work, manganese dioxide nanostructures were prepared by a hydrothermal-electrochemical method. The syntheses were performed in a closed, Teflon-lined stainless steel reaction vessel as a two-electrode system by constant current mode with a current density of 10 mA/cm^2 at 80 and 110 °C. Prepared samples have been characterized using X-ray diffraction (XRD), morphology of the samples has been characterized by field-emission scanning electron microscopy (FESEM). The pore structures of the prepared samples were tested by N_2 adsorption-desorption measurements. The electrochemical behaviors of prepared samples were investigated by electrochemical techniques including polarization curve and galvanostatic discharge.

The XRD patterns of the as-prepared samples indicating that purely crystalline γ-MnO_2 were successfully synthesized. The FESEM images showed that the nanoclusters of MnO_2 were composed. The size of nanoparticles were about 1–20 nm that reduced by increasing the synthesis temperature. The N_2 adsorption-desorption measurements results showed that isotherms of these samples were of typical IV classification and exhibited clear hysteresis loops which were characteristic of mesoporous materials. The results of electrochemical tests revealed that the peak power density of Zn-Air batteries were 80 mW/cm^2 which increased to 120 mW/cm^2 when temprature of MnO_2 synthesis was raised from 80 to 110°C. The cells galvanostatic discharge showed maximum discharge current density of 150 and 300 mA/cm^2 for cells, respectively.

Keywords: MnO_2 nanostructure, hydrothermal-electrochemical synthesis, Zinc-air battery.

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