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Microwave-assisted synthesis of graphene–SnO_2 nanocomposite for rechargeable lithium-ion batteries

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ABSTRACT

Graphene–SnO_2 nanocomposite was rapidly synthesized by a microwave-assisted method without using any additive. The as-prepared nanocomposite exhibits excellent electrochemical performance for lithium-ion batteries. Results show that the graphene–SnO_2 nanocomposite with 70 wt% SnO_2 content exhibits a stable capacity of about 890 mA h g^{-1} without noticeable fading for up to 80 cycles at a current density of 500 mA g^{-1}. Even when cycled at a high current density of 1000 mA g^{-1}, the specific capacity still remains approximately 790 mA h g^{-1}. The good electrochemical performance can be attributed to the porous structure of the nanocomposite and the restriction effect of graphene on the volume change of SnO_2 nanoparticles.

1. Introduction

SnO_2 is considered as one of the most promising lithium-ion battery anode materials and is attracting considerable attention because of its high theoretical capacity (782 mA h g^{-1}) [1–3]. However, the greatest drawback is its poor cycling performance, which is caused by serious volume changes (up to approximately 300%) during the cyclic charge–discharge process [4–6]. Among the most popular methods to overcome this drawback is dispersing the SnO_2 nanoparticles in a graphene nanosheet matrix to restrict its volume change [7–11]. However, most synthesis processes are complicated and time-consuming. Recently, some researchers have focused on the synthesis of graphene–SnO_2 nanocomposites using a microwave-assisted method [12–15], which has a short reaction time, convenient operation and high yield. Nevertheless, these works require additivies such as urea, NaOH, or HCl and tedious synthesis processes. In the present study, a microwave-assisted method was used to prepare graphene–SnO_2 nanocomposite without using any additive and with a short synthesis duration (2 min). The resulting nanocomposite is found to exhibit good electrochemical performance. This easy and rapid method is conducive to the mass production of graphene–SnO_2 anode materials.

2. Methods

Graphene oxide (GO) was synthesized from natural graphite powder by a modified Hummer's method [16]. The graphene–SnO_2 nanocomposite was synthesized by an easy microwave-assisted method. In a typical synthesis process, 100 mg of GO was dispersed in 50 mL of deionized water by ultrasonication for 10 min to form homogeneous solution A. At the same time, 300 mg of $SnCl_2 \cdot 2\,H_2O$ powder was added to 50 mL of deionized water to form solution B. Afterwards, solutions A and B were mixed together under vigorous stirring for 10 min. Then, the mixture was transferred to a Teflon vessel with a capacity of 150 mL, which was then placed in the microwave oven and heated for 2 min. Microwave-assisted reaction was conducted in an 800 W microwave oven, with a 2.45 GHz working frequency. After naturally cooling down to room temperature, the black suspension was washed by ethanol for several times and dried at 80 °C for 12 h. The obtained samples were investigated by X-ray diffraction (XRD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and N_2 adsorption–desorption analysis.

The electrodes were prepared by mixing 80 wt% graphene–SnO_2 nanocomposite, 10 wt% polyvinyldifluoride binder, and 10 wt% conducting carbon in N-methylpyrrolidone. The obtained slurry was coated onto a copper foil current collector and then dried in vacuum at 80 °C for 12 h. A 2032 coin-type cell was assembled in an argon-filled glove box with Li metal foil as counter electrode, Celgard 2250 as separator, and 1 M $LiPF_6$ in ethylene carbonate and diethyl carbonate (EC/DMC, 1:1, v/v) as electrolyte. Charge–discharge

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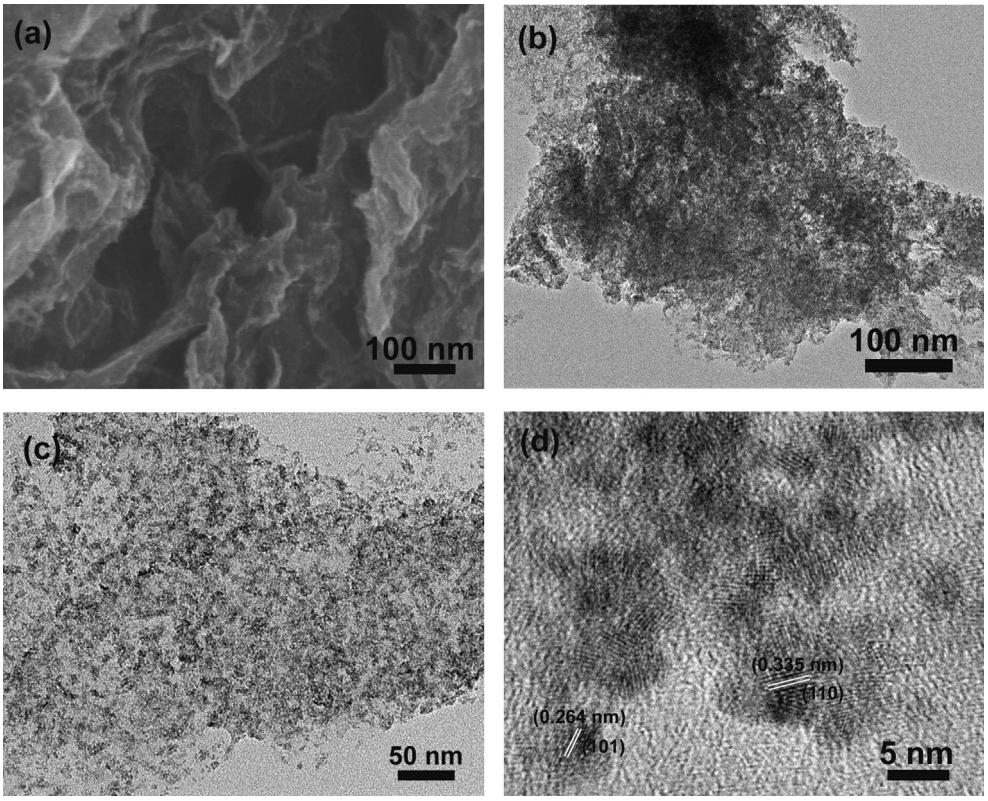

Fig. 1. SEM (a), TEM (b, c) and HRTEM (d) images of the graphene–SnO_2 nanocomposite.

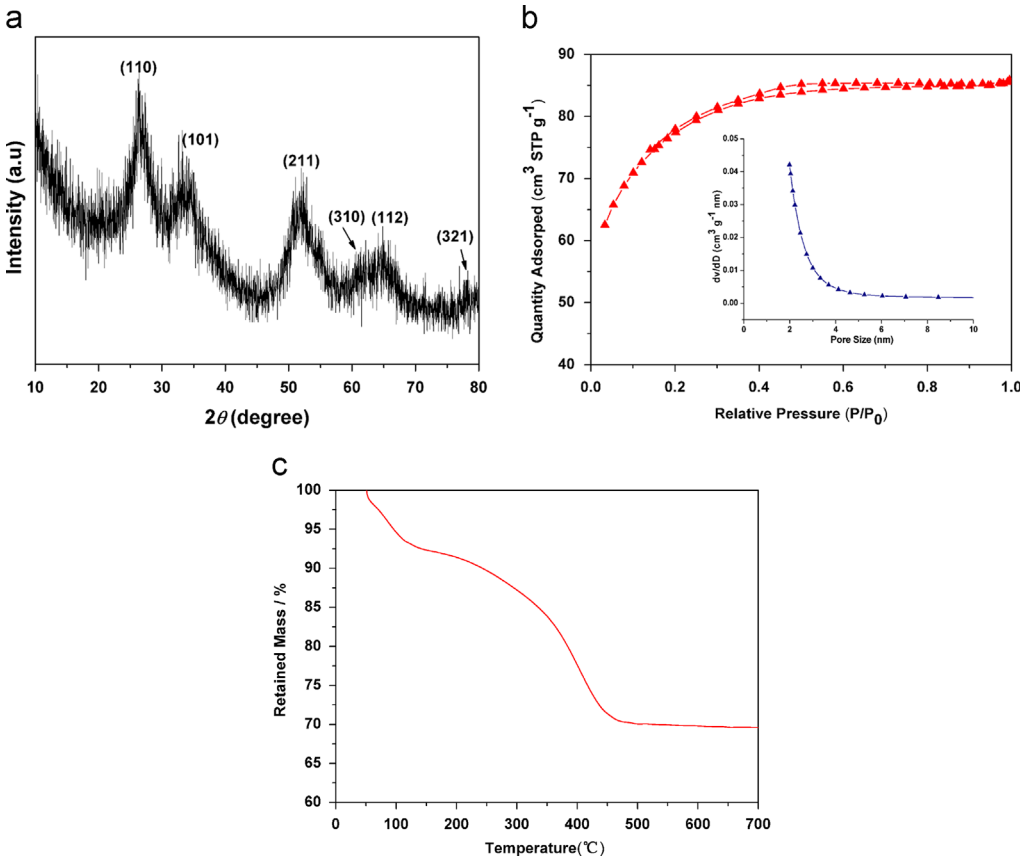

Fig. 2. (a) XRD pattern, (b) N_2 adsorption–desorption isotherms and pore size distribution, and (c) TGA curve of the graphene–SnO_2 nanocomposite.