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Study on Electrochemical Properties of MnO_2/MoS_2 composites

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1 Introduction

Supercapacitor also called electrochemical capacitor, has become one of the most promising energy storage devices due to its long service life, great power density, high energy density, green environmental protection (Simon et al, 2008; Ma et al, 2013). Based on the charge storage mechanisms, Supercapacitors can be divided into electrical double-layer capacitor (EDLC) and pseudo-capacitor according to the charge storage mechanism. The energy storage of EDLCs is the accumulation of ionic charges which occur at the interface between the electrode and electrolyte. For the pseudo-capacitor, it is produced by the fast reversible faradic transitions of active materials, e.g., transition metal oxides, conducting electric polymers (Lu et al, 2015; Huang et al, 2013). Among these active materials, manganese oxides (MnO_2) are the most potential one because of their low cost, natural abundance, high theoretical capacity (1370 F/g), nontoxicity and wide operating potential window in mild electrolyte. However, bulk MnO_2 suffers from low electronic conductivity (10^{-5}-10^{-6} S/cm), low ionic diffusion constant and structural susceptibility which limit their applications as active materials for supercapacitor (Zhang et al, 2014). Therefore, MnO_2 is usually mixed with other materials to prepare composite materials with better cycling, specific capacitance and mechanical stability.

As a graphene-like material, MoS_2 crystals are composed of the metal Mo layers sandwiched between two sulfur layers and stacked together by weak van der Waals interactions (He et al, 2016). Because of the intrinsic ionic conductivity higher than that of the metal oxide and the theoretical specific capacitance than graphite, the electrode material used as the capacitor has been deeply studied. However, there are still a lot of limitations when MoS_2 is used as electrode material alone (Ma et al, 2013; Huang et al, 2013; Firmiano et al, 2013).

This article is mainly study the electrochemical properties of MnO_2/MoS_2 composites.

2 Result and Discussion

2.1 X-ray diffraction

The X-ray powder diffraction (XRD, Rigaku D/max 2400, Cu K*a*) patterns of the MoS_2, pure MnO_2 and MnO_2/MoS_2 composites are shown in Fig. 1(a). It can be seen that diffraction of pure MnO_2 and MoS_2 shows a typical broad and weak reflection, which are the characteristic peak of amorphous or low-crystalline structures. The pure MoS_2 has the diffraction peaks at 33°, 44° and 59° can be assign to the (100), (103), and (110) planes of MoS_2 (JCPDS No.37-1492), respectively. The pure MnO_2 has the diffraction peaks at 12.5°, 25° and 37° can be assign to the (001), (002), and (100) planes of MnO_2 (JCPDS No.80-1098), respectively. For the MnO_2/ MoS_2 composites, in addition to the diffraction peaks of MoS_2, there exhibits another broad reflection. This is attributed to the diffraction patterns of MnO_2, and the results confirm that the MnO_2 was successfully attached into the MoS_2 nanosheets layer.

2.2 Cyclic voltammetry

The CV curves of the MnO_2/MoS_2 composites electrode in 1 M Na_2SO_4 aqueous electrolyte are shown in Fig. 1(b). The shape of the CV curves are basically rectangular with the increase of scanning speed, which indicates that the samples have typical double layer capacitance characteristics. However, when the scanning speed is increased to 50 mV /s, the curve is distorted to some extent. It can be seen from the curves that some weak redox peaks appear, indicating that MnO_2 provides a certain amount of pseudo capacitance.

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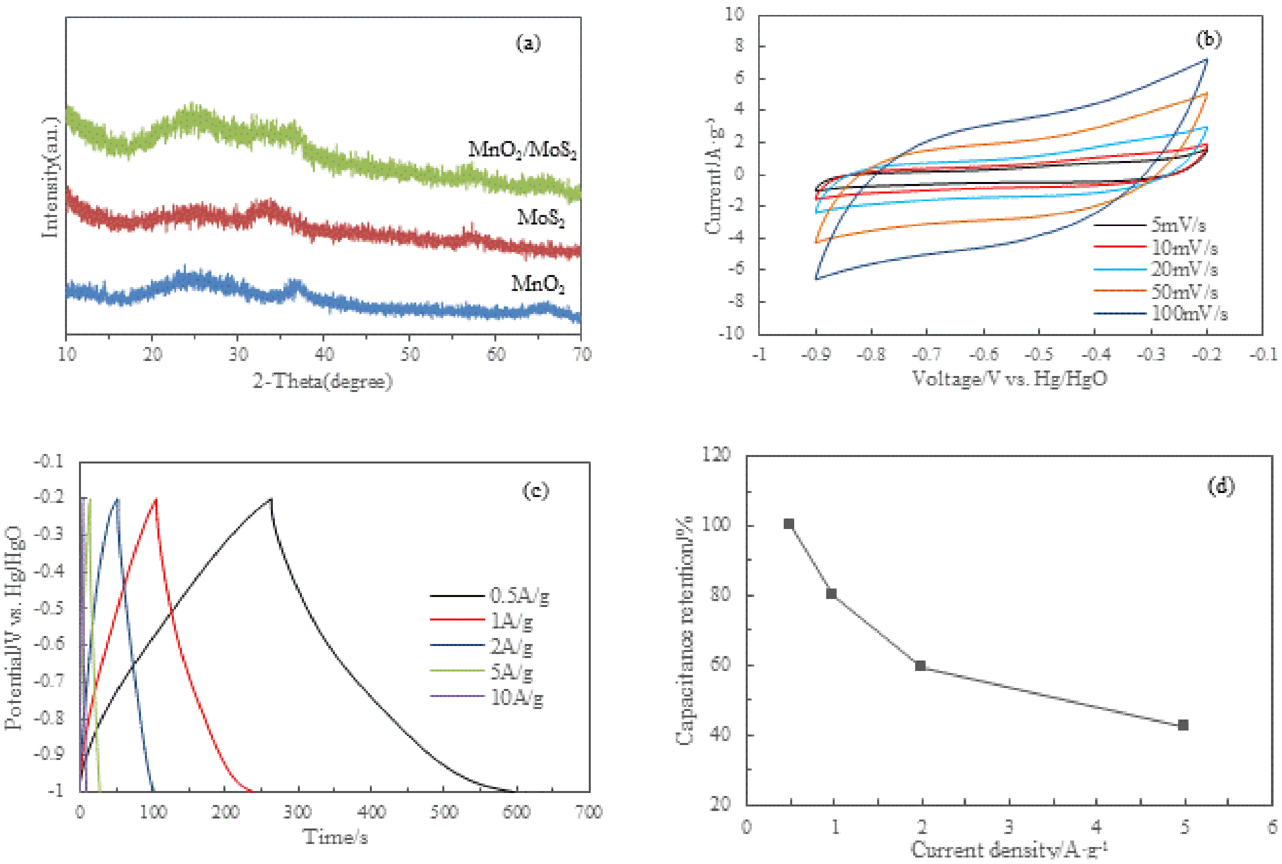

Fig. 1. XRD patterns, cyclic voltammograms and Galvanostatic charge/discharge properties of MnO_2/MoS_2 composites.
(a), XRD patterns of MoS2, pure MnO_2 and MnO_2/MoS_2 composites; (b), Cyclic voltammetry curves of MnO_2/MoS_2 composites in 1 M Na_2SO_4 aqueous electrolyte at various current densities in the potential window of -0.2 to -0.9 V; (c), Galvanostatic charge/discharge curves of MnO_2/MoS_2 composites in 1 M Na_2SO_4 aqueous electrolyte at various current densities in the potential window of -0.2 to -1 V; (d), capacitance retention of MnO_2/MoS_2 composites at different current density.

2.3 Galvanostatic charge/discharge

The galvanostatic charge-discharge curves are shown in Fig. 1(c). The charge curves are almost linear and somewhat mirror symmetrical to their discharge counterparts, suggestive of good electrochemical performance. According to the calculation formula of specific capacitance of electrode (Huang et al, 2013), the specific capacitances of the MnO_2/MoS_2 electrode at 0.5, 1, 2 and 5 A/g are 210, 167, 124 and 88 F/g, respectively. The variation of the specific capacitance with the current density is shown in Fig. 1(d). It shows that the capacitance is decreased with the increasing current density. The MnO_2/MoS_2 electrode displays a relatively good high rate behavior with 42% of its initial capacitance maintained when the current density increases to 5 A/g.

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