Electrochemical properties of tin oxide anodes for sodium-ion batteries

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Introduction

Recently, sodium-ion batteries have attracted great deal of attention as next generation low-cost and low environmental impact rechargeable power sources. Especially for large-scale battery, these batteries are considered as alternative to their lithium-ion counterparts. However, many of the anodes used in lithium-ion batteries such as graphite or silicon are electrochemically inactive towards sodium. Although Sn and the oxides are a few exceptions which are active towards both Li^+ and Na^+, there are few reports about the electrochemical performance of Sn-based anodes for sodium-ion batteries so far [1-3]. Here, we investigated the anode performances of tin oxides for sodium-ion batteries through the comparison of the electrochemical properties of SnO and SnO_2.

Experimental

SnO and SnO_2/C anode materials were prepared by hydrothermal method. $SnCl_2 \cdot 2H_2O$ or $SnCl_4 \cdot 5H_2O$ were dissolved in 0.25M citric acid and 0.1M sucrose solution. Aqueous ammonia was used to adjust pH and obtain SnO_x precursor solutions. Afterwards these tin precursor solutions were transferred to Teflon flasks and treated at 150°C for 1h by microwave-assisted heating. Thermal treatment yielded SnO and SnO_2/C powders which were washed with distilled water and ethanol several times and dried at 80°C overnight. Finally, SnO_2/C materials were carbonized at 500°C for 1h in Ar, and SnO_2 which without carbon were synthetized in the same procedure without sucrose.

Electrochemical measurements were carried out in two electrode coin cells. Working electrodes consisted of 70 wt% active material, 20 wt% acetylene black (AB) and 10 wt% poly acrylic acid (PAA). Sodium metal foils were used as counter electrodes and the electrolyte was 1M $NaClO_4$ dissolved in propylene carbonate (PC). Charge-discharge measurements were performed under constant current density 50 mA/g in the voltage range 5 mV-2.0 V.

Results and discussion

Figure 1 shows XRD patterns of SnO and SnO_2/C powders. It is clearly seen that our experimental procedure yielded pure SnO and SnO_2 phases shown in Fig.1. Voltage profiles and cycle performance of SnO, SnO_2/C electrodes are shown in Fig.2 and Fig.3. In Fig.3 both SnO and SnO_2/C shows higher capacity than SnO_2. The Reversible capacity of our SnO and SnO_2/C electrodes in the first cycle are 408, 294 mAh/g, respectively. The irreversible capacity in the first cycle of SnO and SnO_2/C are 31% and 55%. First cycle irreversible capacity is attributed to the formation of Na_2O matrix, which is similar to the formation of Li_2O when SnO_x is cycled vs. Li. These data show that tin oxides, especially SnO, can provide viable anodes with large capacity for sodium-ion batteries.

Acknowledgements

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References

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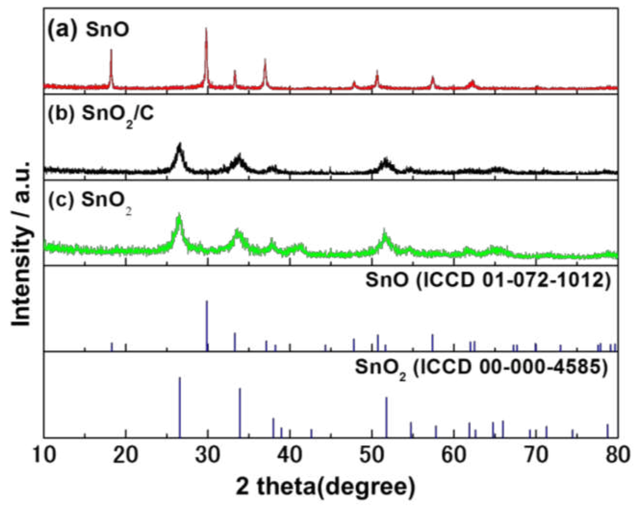

Fig. 1 XRD patterns of (a) SnO (b) SnO_2/C (c) SnO_2.

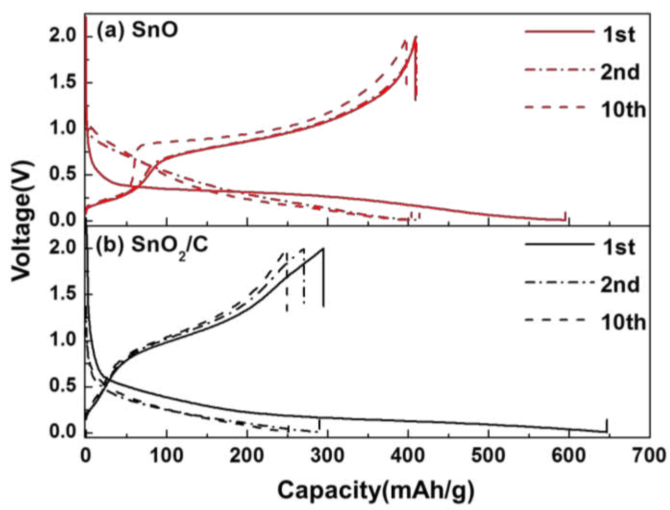

Fig. 2 Voltage profiles of (a) SnO (b) SnO_2/C vs. Na/Na^+.

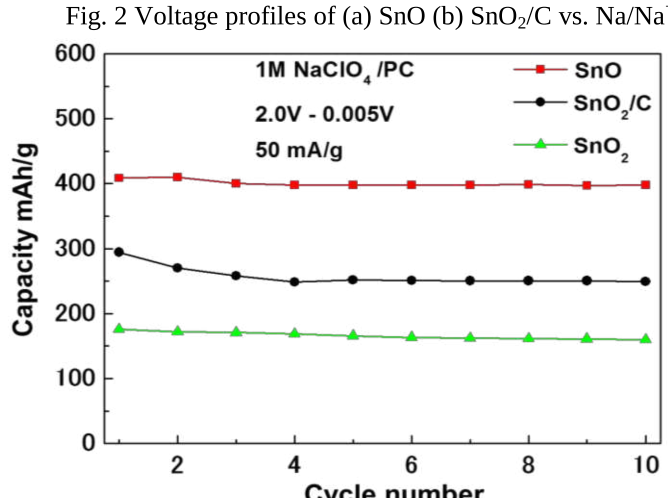

Fig. 3 Cycle performances of SnO, SnO_2/C and SnO_2 vs. Na/Na^+.