

## Supplementary Information

### Few-layers MoS<sub>2</sub> promote SnO<sub>2</sub>@C nano-composites for high performance sodium ion battery

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## Experimental

### 1.1 Synthesis of SnO<sub>2</sub>@C composite precursor

SnO<sub>2</sub>@C was synthesized by a simple hydrothermal method and carbonization under high-temperature conditions. Typically, 1.89 g SnCl<sub>4</sub>·5H<sub>2</sub>O and 11.89 g glucose are thoroughly dissolved in 60 ml deionized (DI) water while stirring uniformly. Then, 0.85 ml of 12 mol L<sup>-1</sup> HCl is added to the above aqueous solution under stirring. After being continuously stirred for 30 min, the obtained suspension is transferred into a 100 mL Teflonlined stainless steel autoclave, sealed and maintained at 180 °C for 12 h. The brown precipitates are centrifuged and washed with deionized water and ethanol several times, and then dried in vacuum at 60 °C overnight. The dried product was heated to 500°C at a 3 °C min<sup>-1</sup> rate in an Ar atmosphere and calcined at 500°C for 3 h to obtain SnO<sub>2</sub>@C (SC).

### 1.2 Synthesis of Few-layered MoS<sub>2</sub>@SnO<sub>2</sub>@C composites

0.1g SC was dispersed in 70 ml mixed aqueous solutions of 0.15 g (NH<sub>4</sub>)<sub>6</sub>Mo<sub>7</sub>O<sub>24</sub>·4H<sub>2</sub>O and 0.3g CH<sub>4</sub>N<sub>2</sub>S, which was then sonicated for optimal dispersion. The solution was then transferred to a 100 ml Teflonlined stainless steel autoclave and heated at 200 °C for 24 h to obtain a black precipitate. Few-layered MoS<sub>2</sub>@SnO<sub>2</sub>@C (FMSC) was obtained by washing with deionized (DI) water and drying at 80 °C for 24 h.

### 1.3 Material characterizations

The morphology of the synthesized products was examined using a field emission scanning electron microscope (FE-SEM, Hitachi SU8010) and a transmission electron

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microscope (TEM, FEI Talos F200S) equipped with an energy dispersive X-ray spectrometer (EDX) equipment. The phase and chemical states were analyzed using powder X-ray diffractometry (XRD, Bruker BRUKER D8 ADVANCE, Cu K $\alpha$ ,  $\lambda = 0.15406$  nm) and by X-ray photoelectron spectroscopy (XPS, Thermo Scientific K-Alpha). The weight ratio of carbon in the composites was estimated by thermogravimetric analysis (TG-DSC, Netzsch TG 209 F1) at a heating rate of 10 °C min<sup>-1</sup> in air. N<sub>2</sub> sorption measurements were performed on synthesized products using a Belsorp max instrument (Micromeritics ASAP 2460), and BET surface areas were calculated based on these measurements using the Brunauer-Emmer-Teller (BET) theory.

#### 1.4 Electrochemical measurements

Electrochemical measurements were performed using coin cells with CR2025. The working electrodes were prepared by mixing SC and FMSC active materials, black carbon and poly(vinylidene fluoride) (Aldrich) in a ratio of 80:10:10 in N-methyl pyrrolidone. The slurries were evenly spread on a 10 mm thick copper foil with a mass loading of 1-1.5 mg cm<sup>-2</sup>. The copper foil was then heated at 90 °C for 12 h in a vacuum oven. The electrodes were pressed and die-cut into round disks with a diameter of 12 mm. Coin-type cells were assembled in an Ar-filled glove box with sodium metal foil as the counter electrode and a glass microfiber (Whatman) as the separator. The electrolyte was 1 mol L<sup>-1</sup> NaClO<sub>4</sub> in ethylene carbonate/dimethyl carbonate (1:1 by volume) with 5 vol% fluoroethylene carbonate (FEC) addition. The multichannel battery test system (LAND CT3002A) is used to carry out galvanostatic charge/discharge measurements in the voltage range of 0.01-3.0 V. Cyclic

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voltammetry (CV) and electrochemical impedance spectral (EIS) measurements were conducted on the CHI604E electrochemical workstation. The CV measurements were carried out at a scan rate of  $0.1 \text{ mV s}^{-1}$ , ranging from 0.01 to 3.0 V. The EIS measurements were performed in a wide frequency range of 0.01 Hz  $\sim$  100 kHz.

#### 1.5 calculation method

The weight loss of  $\text{MoS}_2@\text{SnO}_2@\text{C}$  is attributed to the oxidation of  $\text{MoS}_2$  to  $\text{MoO}_3$  and carbon combustion, remaining  $\text{SnO}_2$  and  $\text{MoO}_3$ . Based on TGA data of SC, we can determine that the mass ratio of carbon to  $\text{SnO}_2$  in FMSC is 1.64:1. Let's assume that the mass of  $\text{SnO}_2$ ,  $\text{MoS}_2$  and carbon in FMSC are  $x$ ,  $y$  and  $z$  mg, respectively, with a total mass of  $n$  mg. So the equations are as follows:

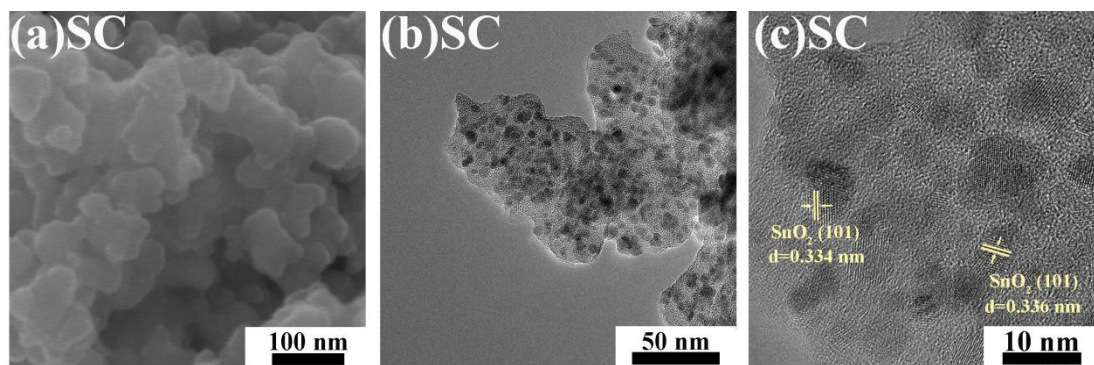
$$C=z=1.64x, \text{MoO}_3=\frac{y}{160*144}=0.9y$$

$$x+y+z=n$$

$$x+y+1.64x=100 \quad (1)$$

$$x+0.9y=47.1 \quad (2)$$

When we merge equations (1) and (2), we get: C=51.1%,  $\text{SnO}_2$ =31.2%, and  $\text{MoS}_2$ =17.7%



**Fig. S1** (a)SEM, (b)TEM and (c) HRTEM images of SC.

**Table S1** The element composition of FMSC is estimated based on Energy dispersive X-ray spectrometer (EDX).

Element	C	Sn	O	S	Mo
W (%)	52.50	15.43	16.11	8.07	7.89

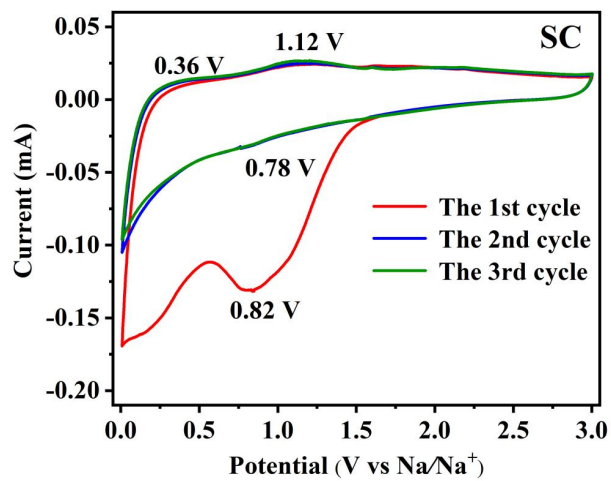
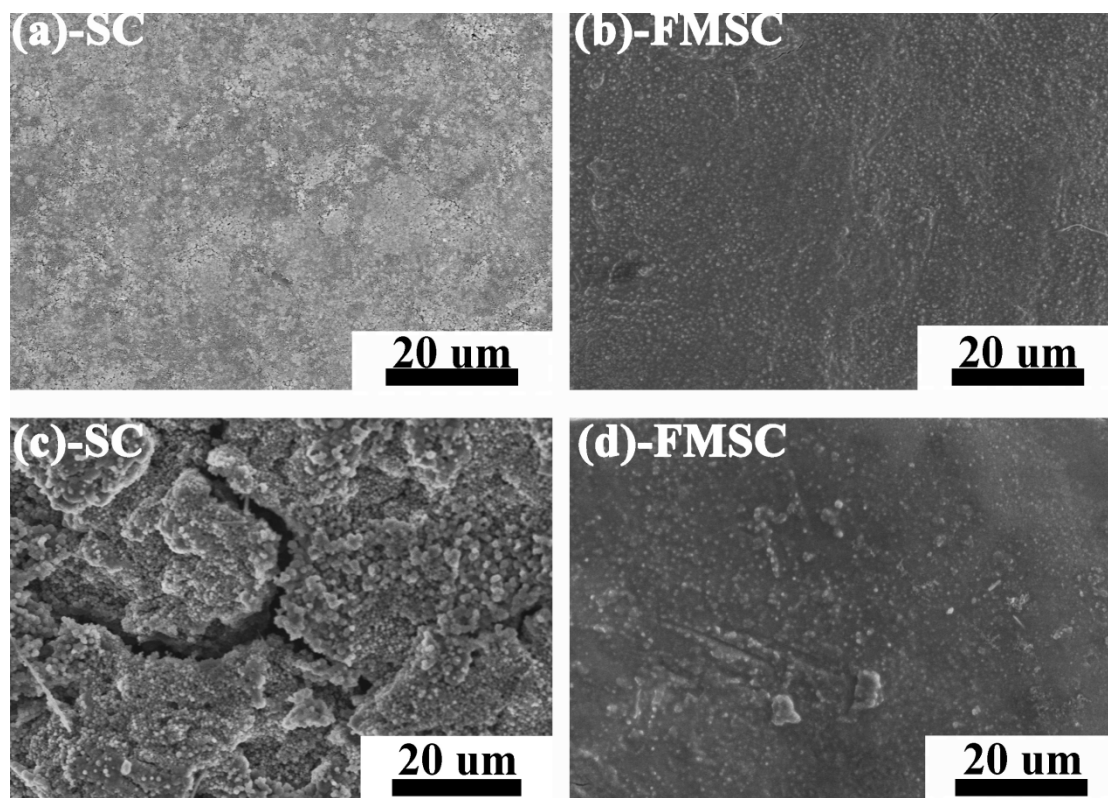


Fig. S2 CV curve of SC electrode.



**Fig. S3** The surface morphologies of (a,c) SC and (b,d) FMSC before and after 50 cycles at  $0.1 \text{ A g}^{-1}$

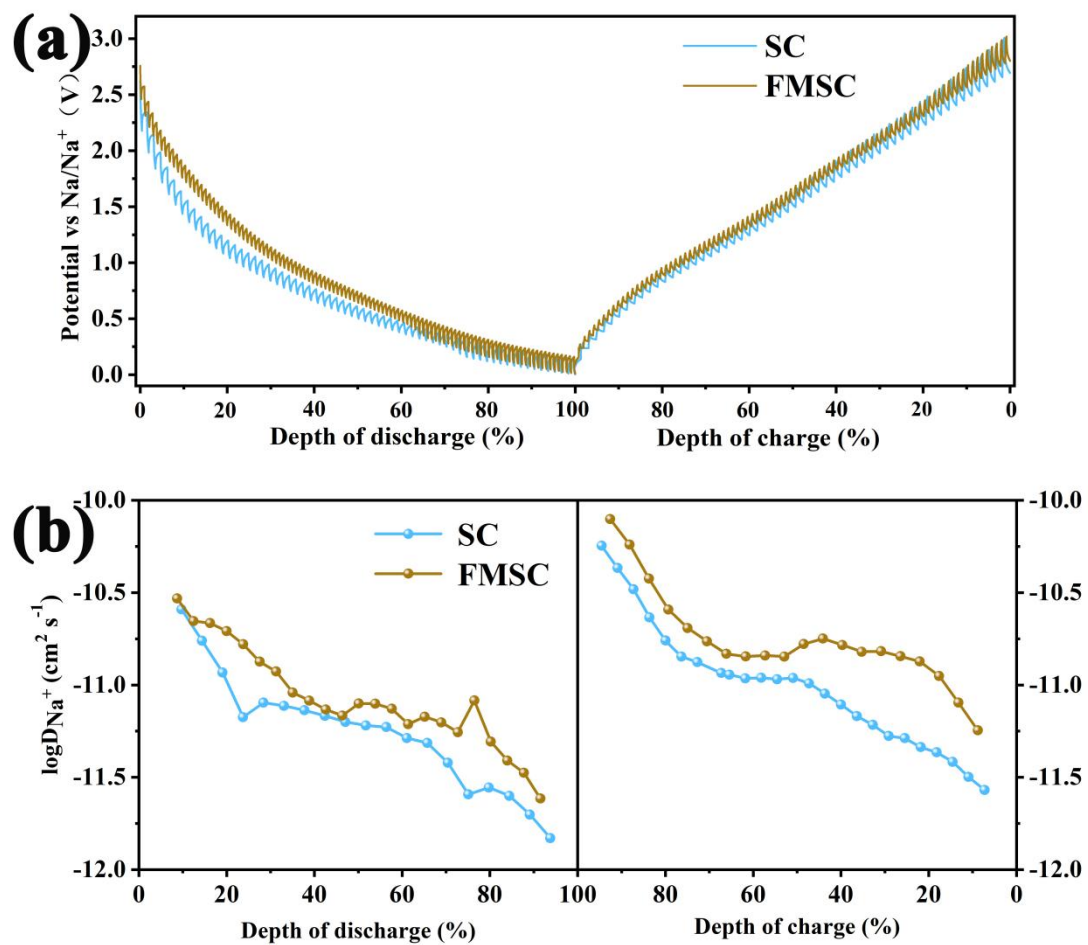


Fig. S4 (a) GITT curves for SC and FMSC electrodes, and (b) comparison of the corresponding  $\text{Na}^+$  diffusivity in SC and FMSC electrodes.