Electronic Supplementary Information

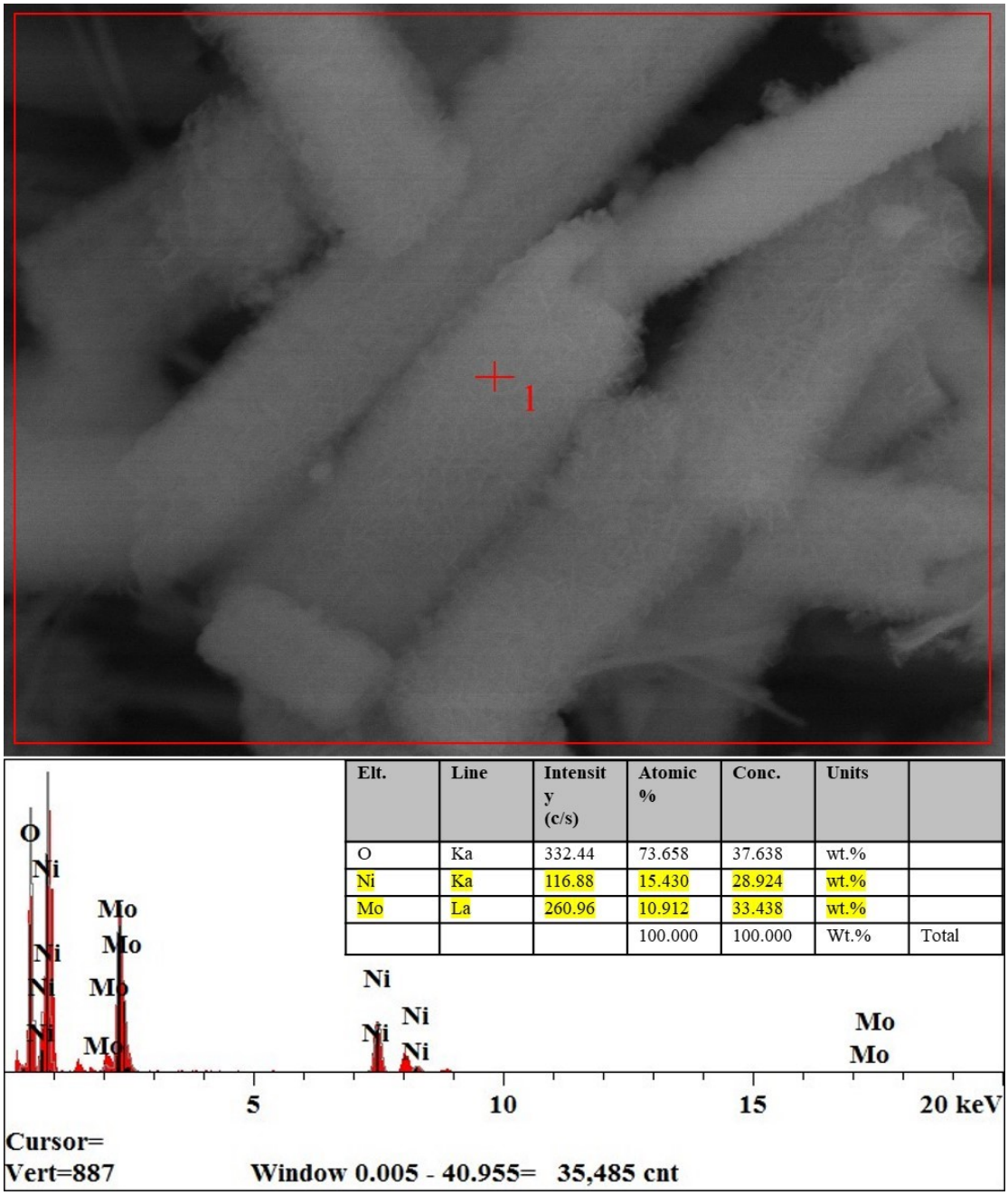
Hierarchical MoS_2-NiS nanosheet-based nanotubes@N-doped carbon coupled with Ether-based electrolytes towards high-performance Na-ion Batteries

Fan Yang[a], Shige Wang[a], Jieduo Guan[a], Lianyi Shao[a], Xiaoyan Shi[a], Junjie Cai[a,b]*, Zhipeng Sun[a] *

[a] School of Materials and Energy, Guangzhou 510006, Guangdong University of Technology, Guangzhou 510006, PR China

[b] Xi'an Jiaotong University Suzhou Institute, Suzhou, Suzhou 215123, PR China

Corresponding Author: caijunjie@gdut.edu.cn and zpsunxj@163.com



Elt.	Line	Intensity (c/s)	Atomic %	Conc.	Units	
O	Ka	332.44	73.658	37.638	wt.%	
Ni	Ka	116.88	15.430	28.924	wt.%	
Mo	La	260.96	10.912	33.438	wt.%	
			100.000	100.000	Wt.%	Total

Fig. S1 EDS analysis of Ni/Mo-Precursor.

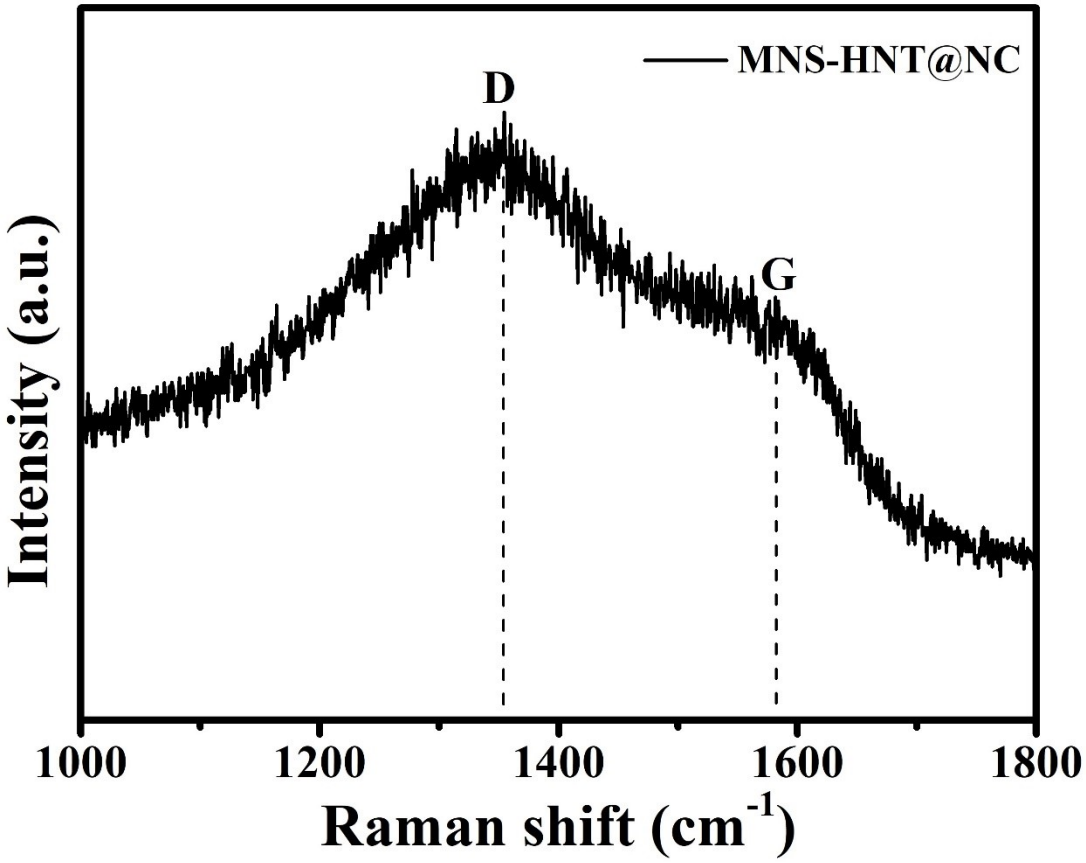


Fig. S2 Raman spectrum of MNS-HNT@NC

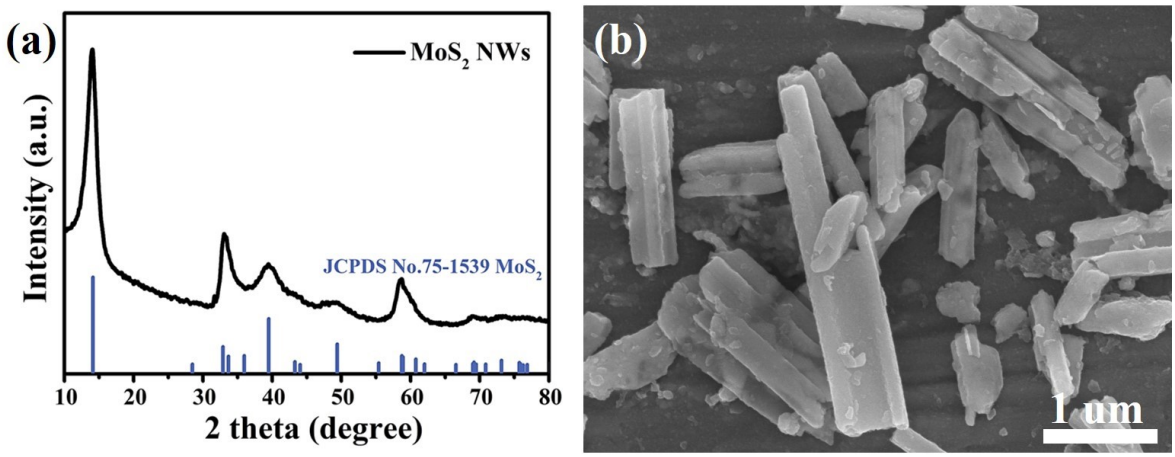


Fig. S3 (a) XRD pattern and (b) SEM image of MoS_2 NWs.

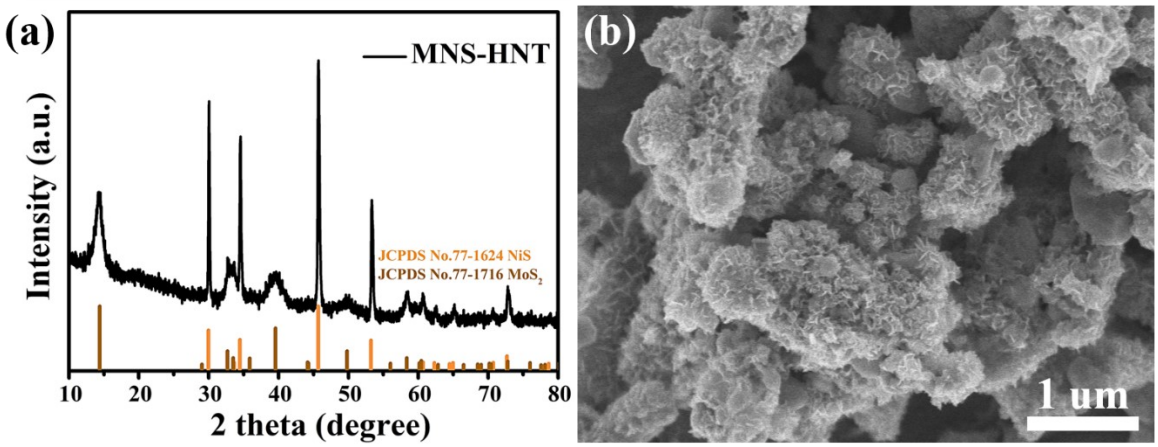


Fig. S4 (a) XRD pattern and (b) SEM image of MNS-HNT.

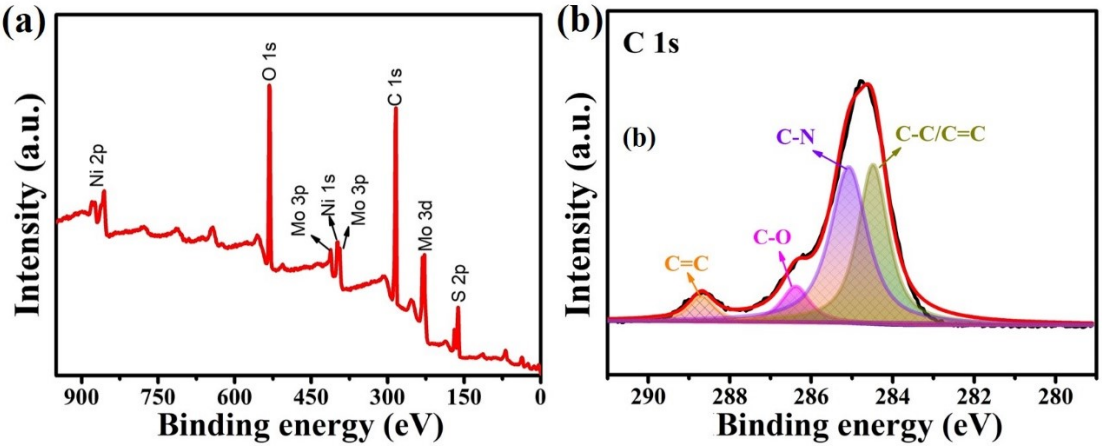


Fig. S5 (a) XPS survey spectrum, and (b) the corresponding C 1s of MNS-HNT@NC

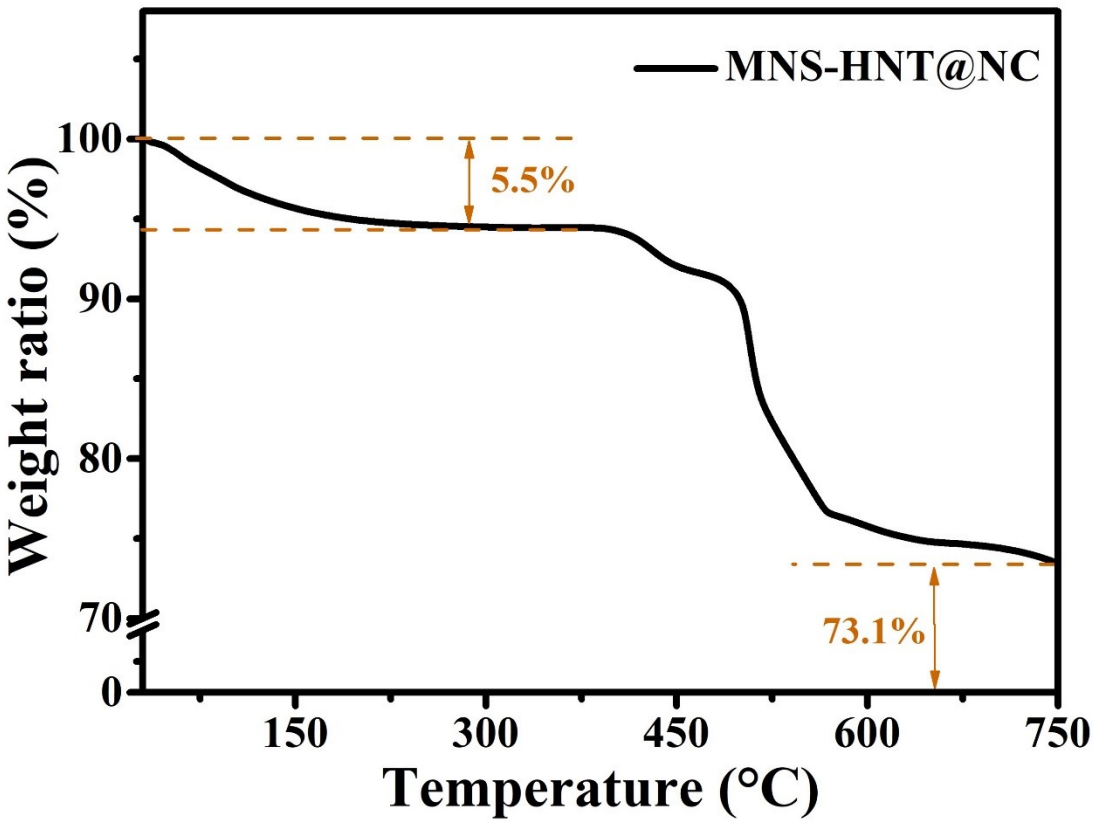


Fig. S6 TGA curve of MNS-HNT@NC tested under air flow.

Calculation method for determining the content in the MNS-HNT@NC:

TGA curves of MNS-HNT@NC from 30 °C to 800 °C. During the TGA test in airflow, NiS and MoS_2 can be converted to the corresponding high-temperature stable phase, NiO and MoO_3, respectively, on the chemical reactions of $NiS+O_2 \rightarrow NiO+SO_2$; $MoS_2+O_2 \rightarrow MoO_3+SO_2$. The EDS result (Fig. S1) shows that the atomic ratio of Ni to Mo atoms in the Ni/Mo-precursor was 15.43%:10.912%, and the NiS/MoS_2 and NiO/MoO_3 are derived from Ni/Mo-precursor. As a result, the mole ratio of Ni to Mo in the sample after the TGA test should be 1.414:1. Based on the molecule weight of NiS and MoS_2; NiO and MoO_3, the mass of each component can be calculated, respectively:

$$m_{NiO} = \frac{1.414 \times 74.1}{1.414 \times 74.1 + 144} \times 73.1\%m = 30.8\%m$$

$$m_{MoO_3} = \frac{144}{1.414 \times 74.1 + 144} \times 73.1\%m = 42.3\%m$$

$$m_{NiS} = \frac{90.7}{74.1} \times m_{NiO} = 37.7\%m$$

$$m_{MoS_2} = \frac{160}{144} \times m_{MoO_3} = 47.0\%m$$

$$m_{moisture} = 5.5\%m$$

$$m_C = m - m_{NiS} - m_{MoS_2} - m_{moisture} = 9.8\%m$$

After deducting the quality of water, the proportions of each component are as follows:

$$Ratio\ of\ NiS = \frac{m_{NiS}}{m - m_{moisture}} \times 100 = 39.9\%$$

$$Ratio\ of\ MoS_2 = \frac{m_{MoS_2}}{m - m_{moisture}} \times 100 = 49.7\%$$

$$Ratio\ of\ NC = \frac{m_C}{m - m_{moisture}} \times 100 = 10.4\%$$

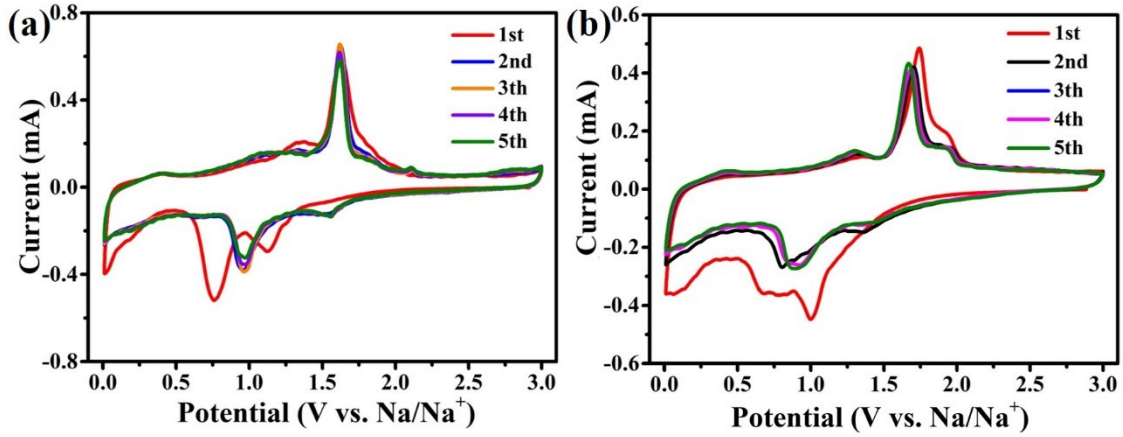


Fig. S7 CV curves of MNS-HNT@NC: (a) in Ether-based electrolyte; (b) in Ester-based electrolyte.

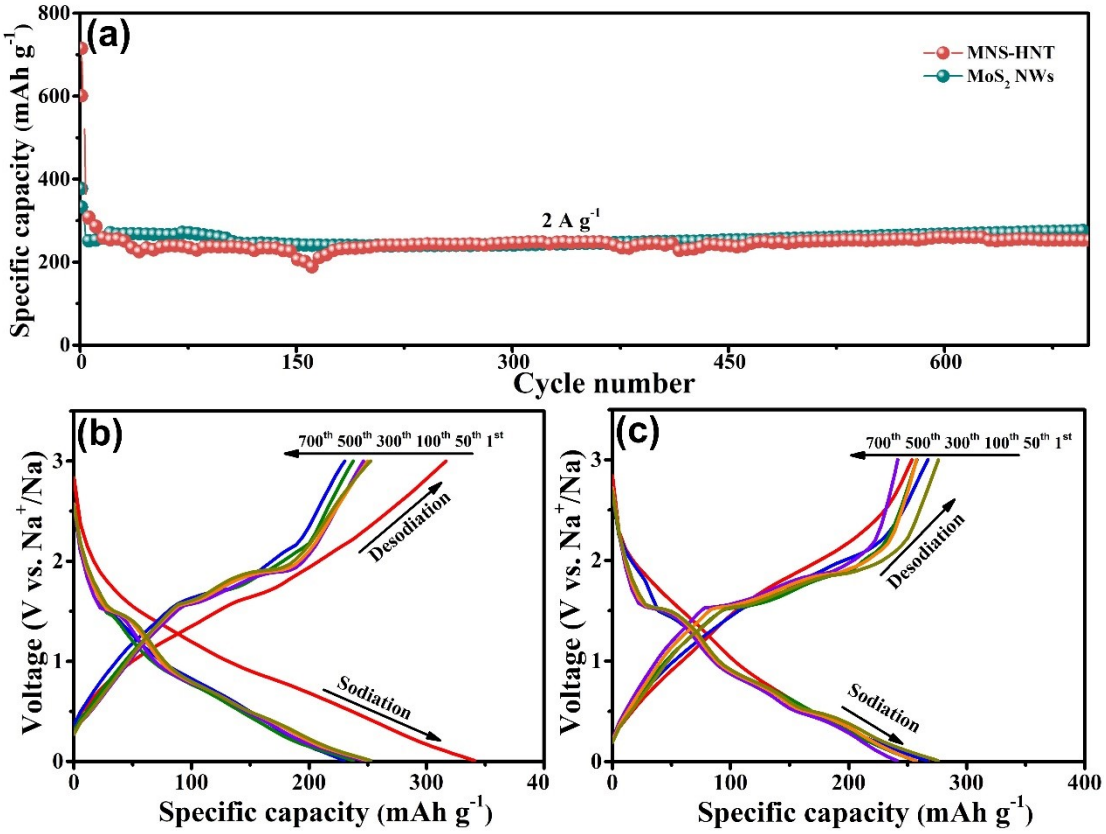


Fig. S8 (a) Long-term cycling performance of MNS-HNT and MoS_2 NWs at 2 A g^{-1}; the charge/discharge curves at of MNS-HNT (b) and MoS_2 NWs (c) different cycle.

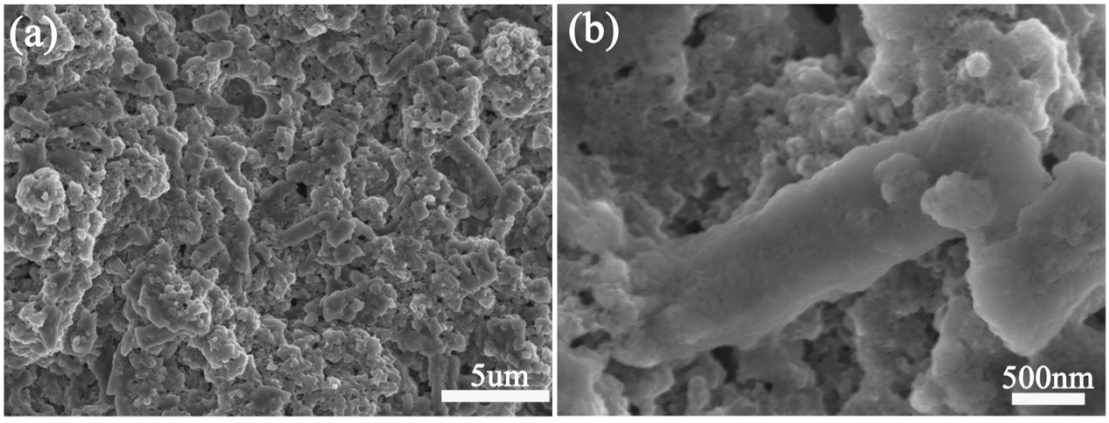


Fig. S9 SEM images of the MNS-HNT@NC anode after long-term cycling.

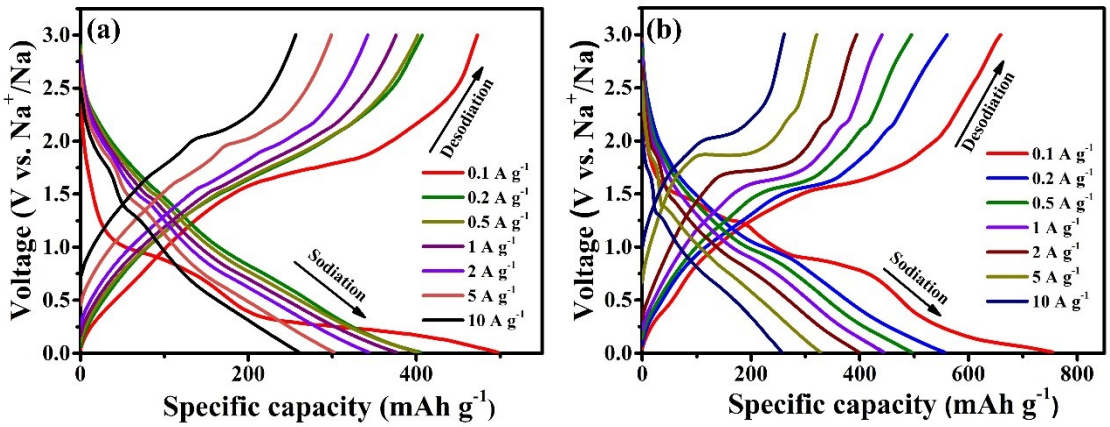


Fig. S10 The charge/discharge curves at different current densities of MoS_2 NWs (a), and MNS-HNT (b).

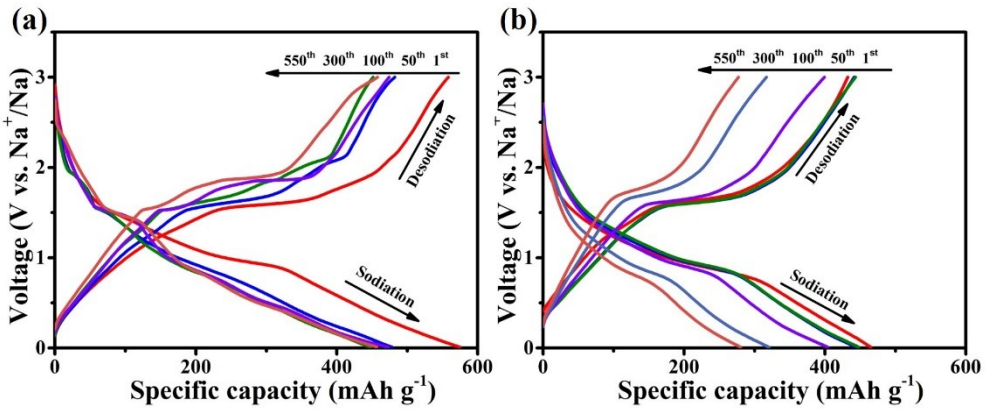


Fig. S11 Discharge/charge curves of MNS-HNT@NC at 1 A g^{-1}: (a) Ether-based electrolyte (b) Ester-based electrolyte.

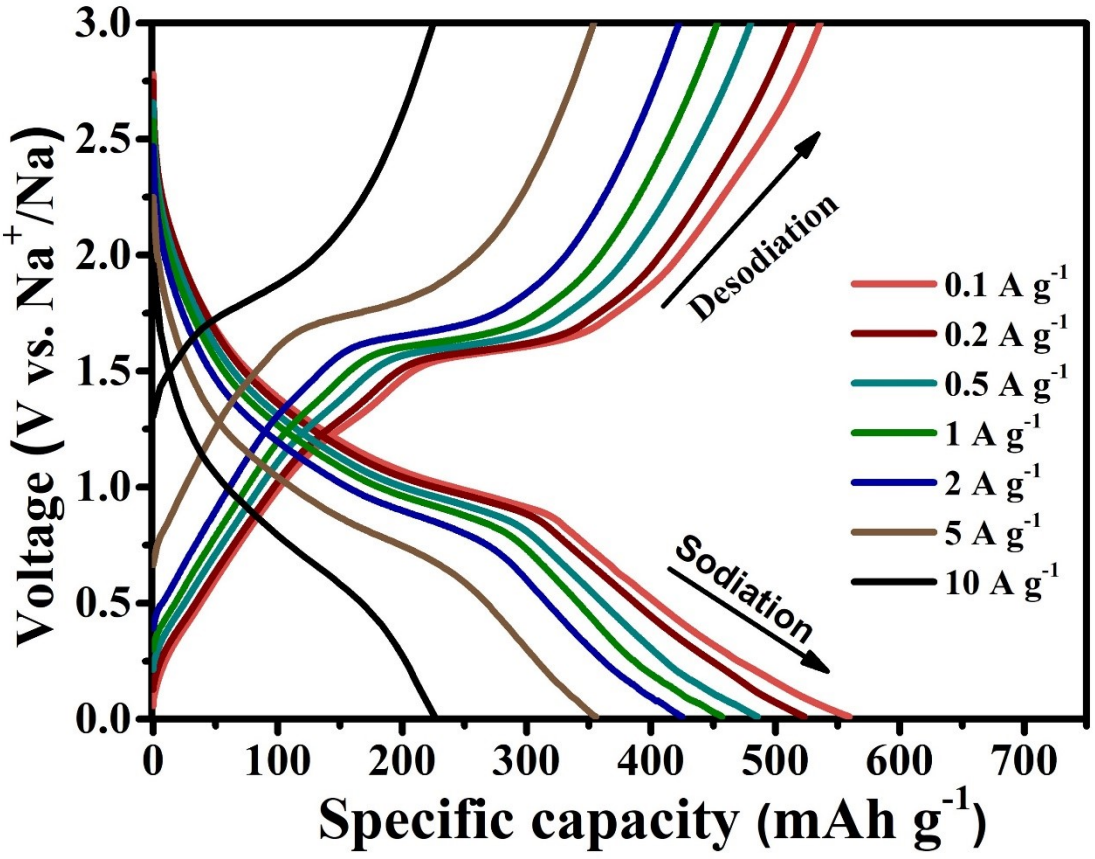


Fig. S12 The charge/discharge curves at different current densities of Ester-based electrolyte.

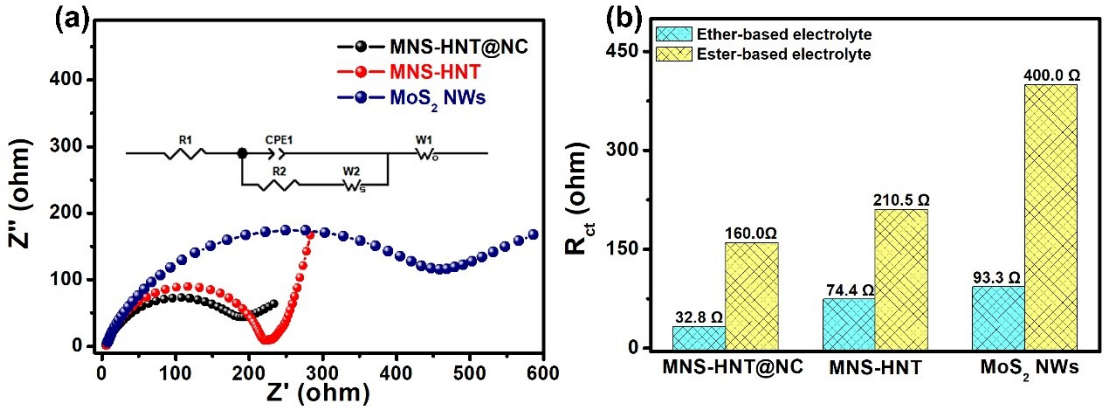


Fig. S13 (a) Nyquist plots from EIS of electrodes tested in Ester-based electrolyte, (b) the R_{ct} of each electrode in different electrolytes.

Table S1. Comparison of MoS_2-NiS@NC with some related works for SIBs.				
Materials	**Electrolyte**	**ICE**	**Capacity (mAh g^{-1})**	**References**
MNS-HNT@NC	**Ether-based**	**94%**	**391 mAh g^{-1} after 700 cycles at 2 A g^{-1}**	**This work**
$MoS_2/Ni_3S_2@MoS_2$	Ester-based	77%	462 mA g^{-1} after 400 cycles at 2 A g^{-1}	[40]
NiS@NCNT MSHMs	Ester-based	58.3%	289.8 mAh g^{-1} after 500 cycles at 1 A g^{-1}	[41]
NiS_2 NP/p-CNF	Ester-based	78%	140 mAh g^{-1} after 1000 cycles at 2 A g^{-1}	[42]
NiS/GNS	Ester-based	77.2%	483 mAh g^{-1} after 100 cycles at 0.2 A g^{-1}	[43]
NiS_2/NC	Ester-based	73.6%	356.2 mAh g^{-1} after 300 cycles at 0.5 A g^{-1}	[44]
MoS_2@C-700	Ester-based	79%	351.6 mAh g^{-1} after 200 cycles at 1 A g^{-1}	[45]
MoS_2/C-2.5	Ester-based	78.9%	400 mAh g^{-1} after 300 cycles at 0.5 A g^{-1}	[46]
MoS_2@C-CMC	Ester-based	79.4%	286 mAh g^{-1} after 100 cycles at 0.08 A g^{-1}	[47]
tulip-MoS_2/NG	Ester-based	55%	151 mAh g^{-1} after 1000 cycles at 5 A g^{-1}	[48]
NiS/MoS_2/C	Ester-based	80.2%	335 mAh g^{-1} after 200 cycles at 1 A g^{-1}	[49]