Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Hierarchical MoS_2-carbon porous nanorods towards atomic interfacial engineering for high-performance lithium storage

Zhenyou Li[1,2,7], Alexander Ottmann[1], Qing Sun[1,3], Anne K. Kast[6], Kai Wang[8], Ting Zhang[2], Hans-Peter Meyer[5], Claudia Backes[4], Christian Kübel[7,8,9], Rasmus R. Schröder[3,6], Junhui Xiang[2], Yana Vaynzof[1,3], Rüdiger Klingeler[1,3]*

[1]*Kirchhoff Institute of Physics, Heidelberg University, INF 227, 69120 Heidelberg, Germany*

[2]*College of Materials Science and Opto-Electronic Technology, University of Chinese Academy of Sciences, Yuquan Road 19A, Beijing, 100049 China.*

[3]*Centre for Advanced Materials (CAM), Heidelberg University, INF 225, 69120 Heidelberg, Germany*

[4]*Institute of Physical Chemistry, Heidelberg University, INF 253, 69120 Heidelberg, Germany*

[5]*Institute of Earth Sciences, Heidelberg University, INF 236, D-69120 Heidelberg, Germany*

[6]*BioQuant, Cryo Electron Microscopy, Heidelberg University, INF 267, 69120 Heidelberg, Germany*

[7]*Helmholtz Institute Ulm (HIU), Helmholtzstraße 11, D-89081 Ulm,Germany*

[8]*Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany*

[9]*Karlsruhe Nano Micro Facility (KNMF), Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany*

Author Information

Corresponding Authors

*Email: zhenyou.li@kit.edu

Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

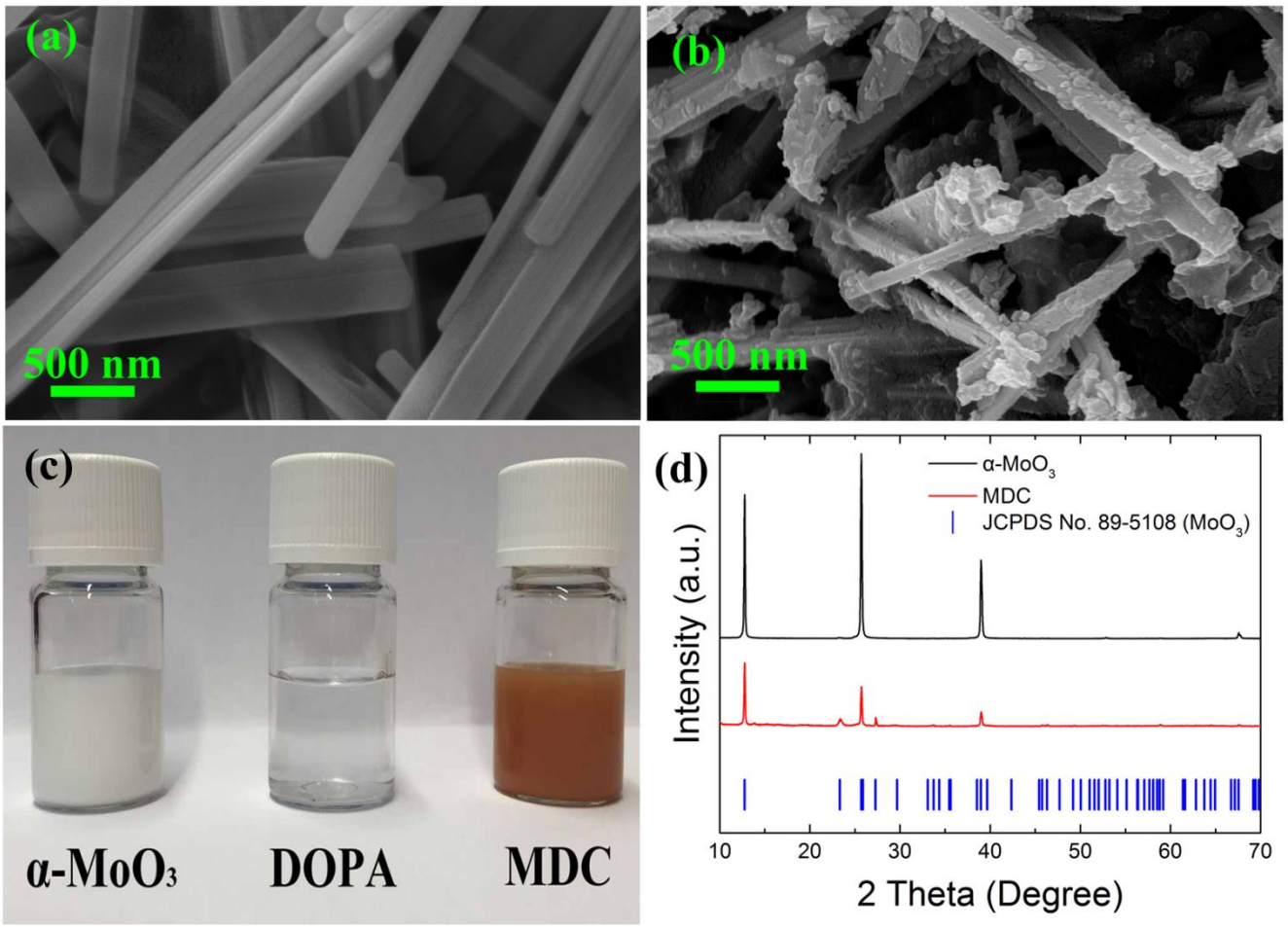


Fig. S1: SEM images of α-MoO_3 nanorods (a) and MDC (b); photo image of α-MoO_3 nanorods, DOPA and MDC water solution (c); and XRD pattern of synthesized α-MoO_3 nanorods, MDC, and standard pattern of α-MoO_3 according to JCPDS No. 89-5108 (d).

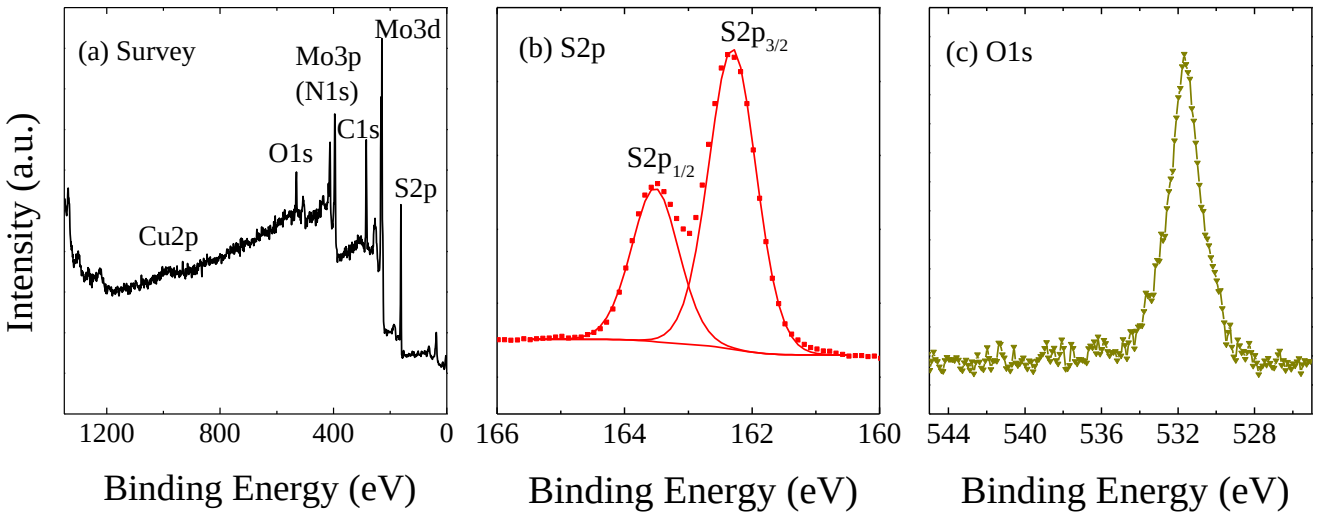


Fig. S2: XPS measurements of the MoS_2/NC-PNR superstructure: (a) survey scan, (b)~(c) high resolution scans of S2p and O1s.

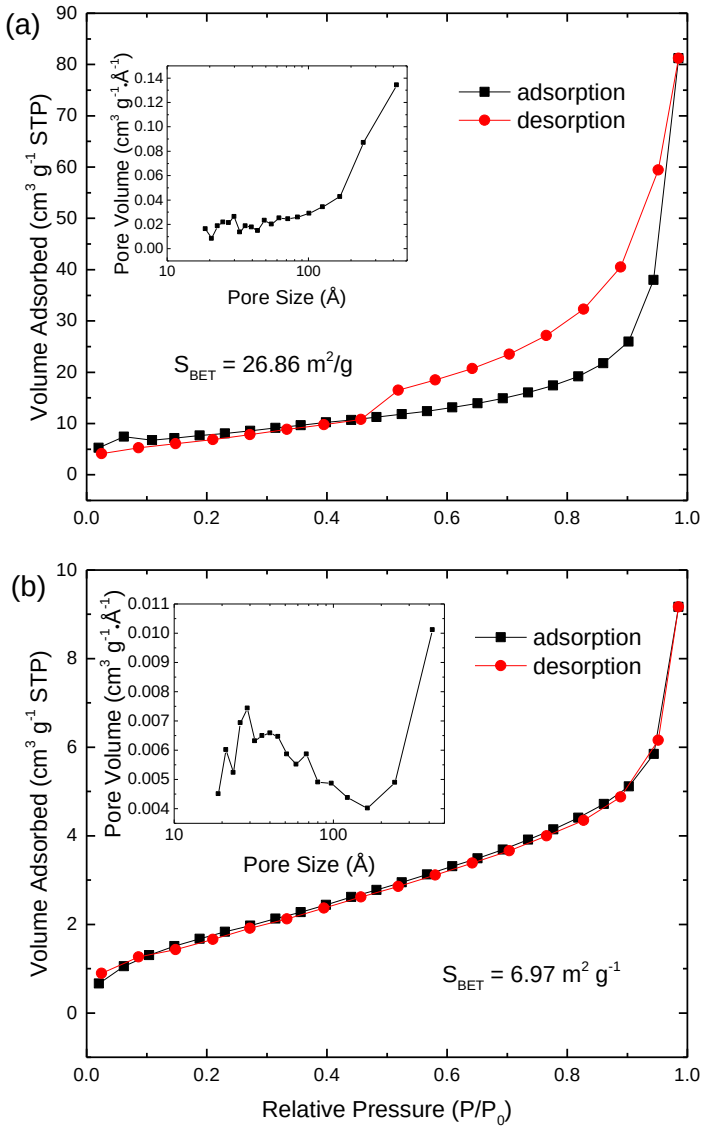


Fig. S3: N_2 adsorption-desorption isotherms of (a) MoS_2/NC-PNR and (b) S-MoS_2. Insets are the pore distribution.

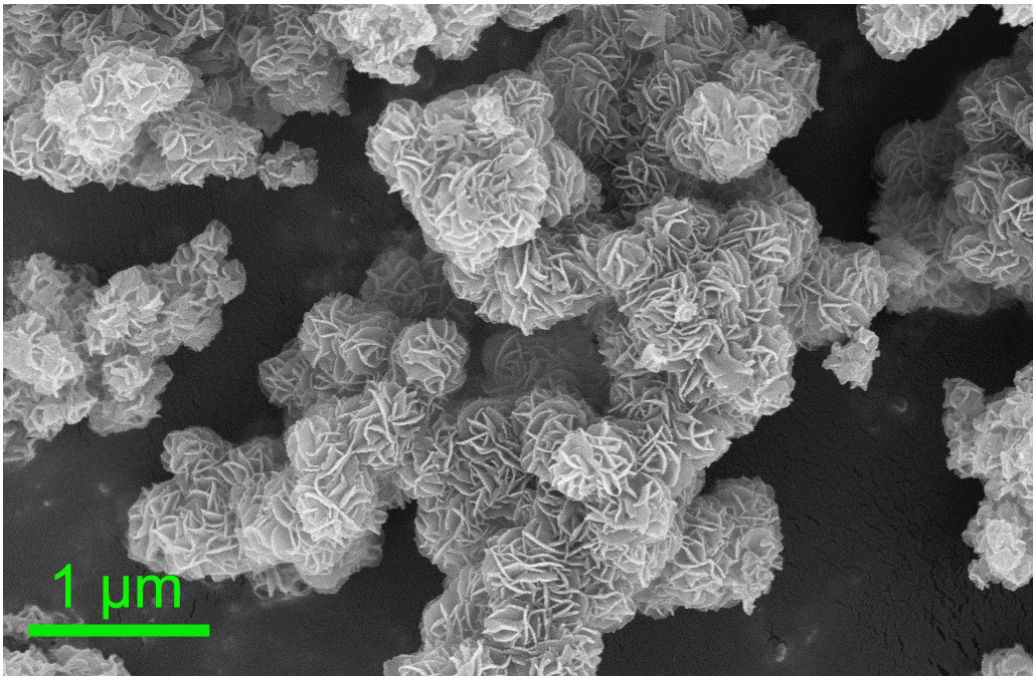


Fig. S4: Morphology of S-MoS_2 synthesized by the same procedure but without adding DOPA.

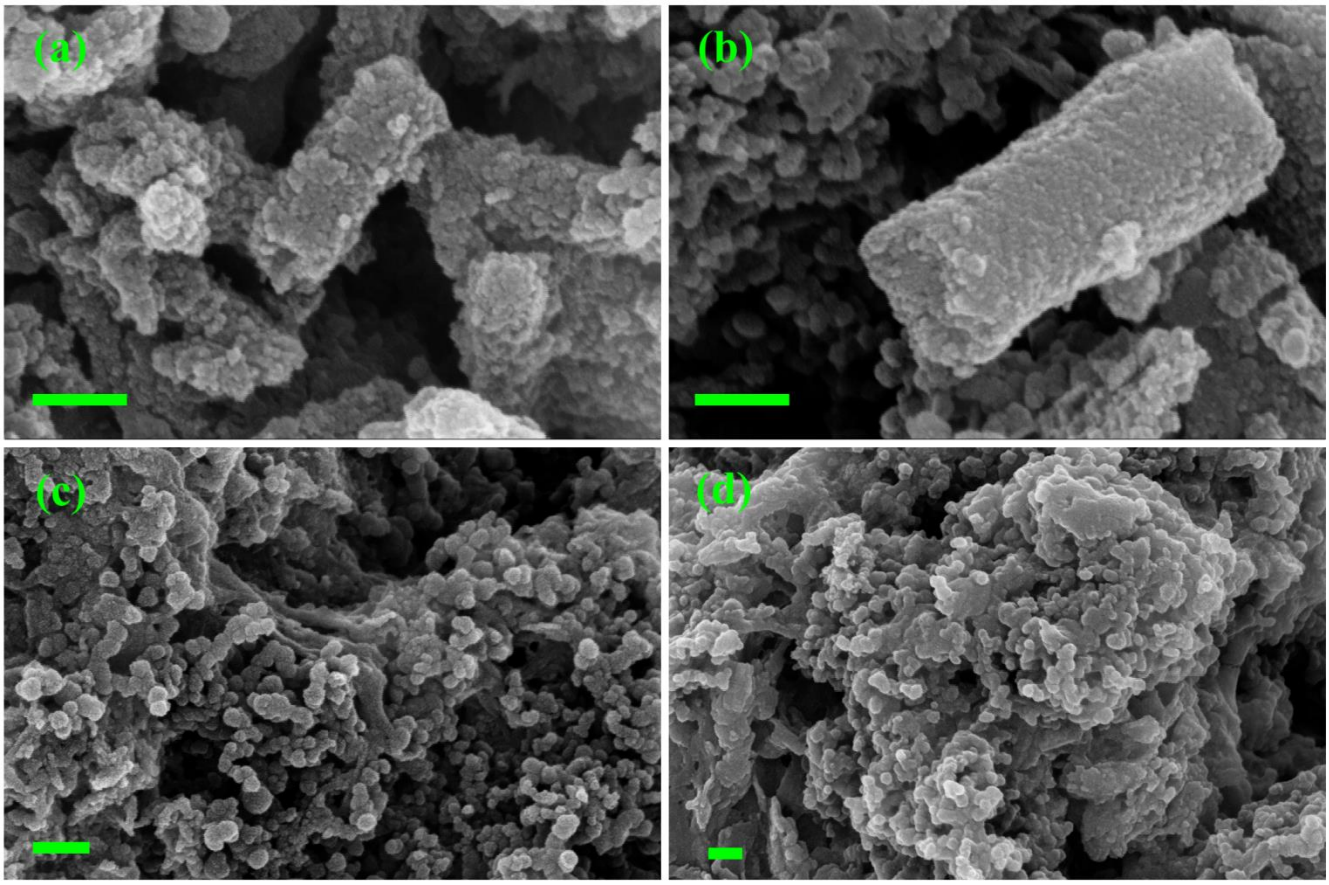


Fig. S5: SEM images of different samples after 150 cycles at 0.5 C: a~b for MoS_2/NC-PNR superstructure; c~d for S-MoS_2. The scale bar is 200 nm.

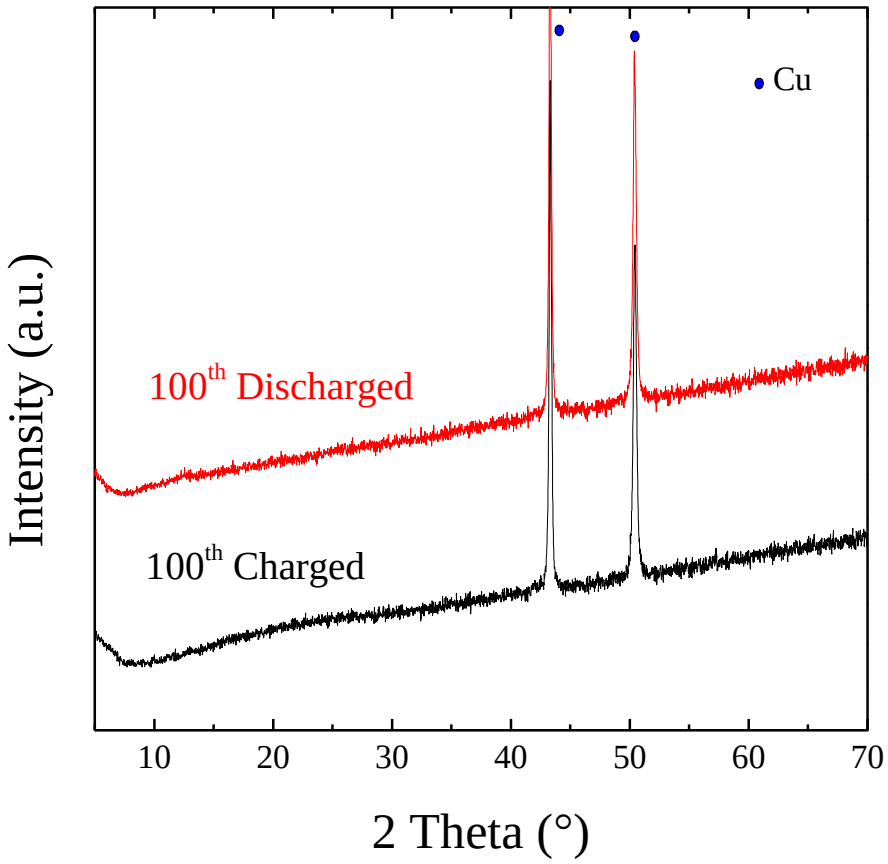


Fig. S6: XRD pattern of the MoS_2/NC-PNR electrode at the 100th discharged and 100th charged states, respectively.

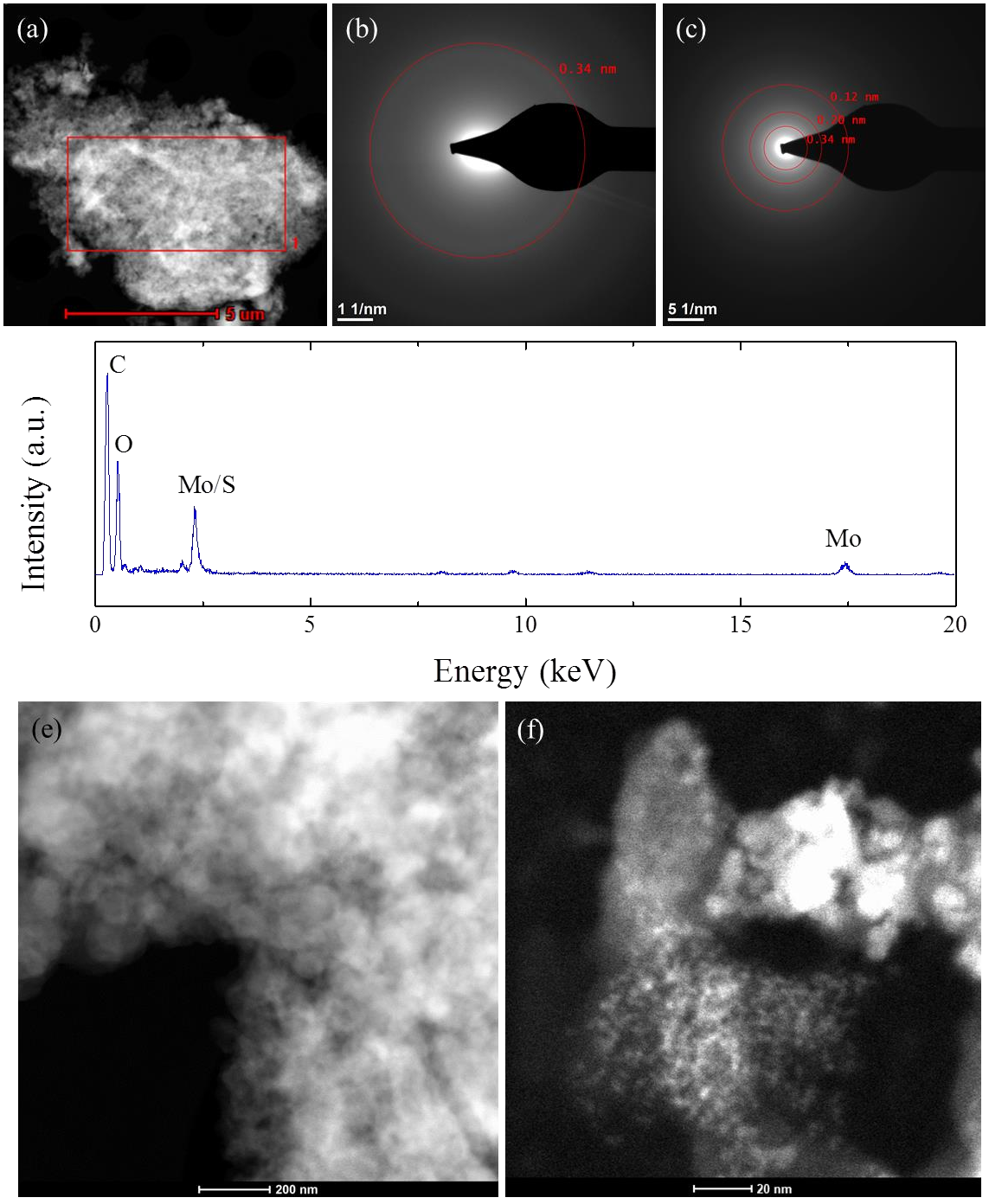


Fig. S7 S-/TEM study of the MoS_2/NC-PNR electrode at the 100th charged state: (a) HAADF-STEM image; (b)~(c): SAED patterns of (a) with different camera length, the red rings label the reflections of carbon; (d) EDX spectrum of the red square area in (a); (e)~(f) HAADF-STEM images with higher magnification.

TEM studies for the cycled electrode was performed using an aberration (image) corrected FEI Titan 80-300 microscope operated at 300 kV, equipped with a Gatan UltraScan CCD camera. The sample was prepared by dispersing the powder in dimethoxyethane, placing a drop on copper grids (Quantifoil Inc.) and taking of the residual suspension after natural drying in the glovebox.

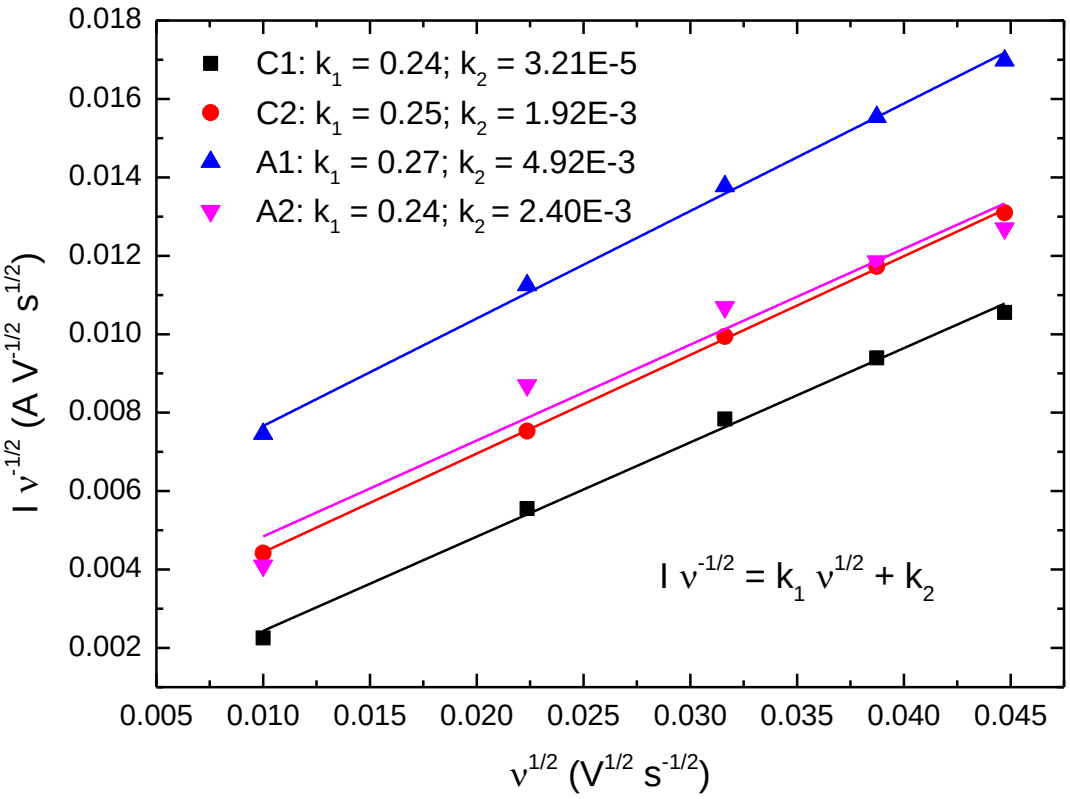


Fig. S8: I $\nu^{-1/2}$ verses $\nu^{1/2}$ plot of the MoS_2/NC-PNR electrode.

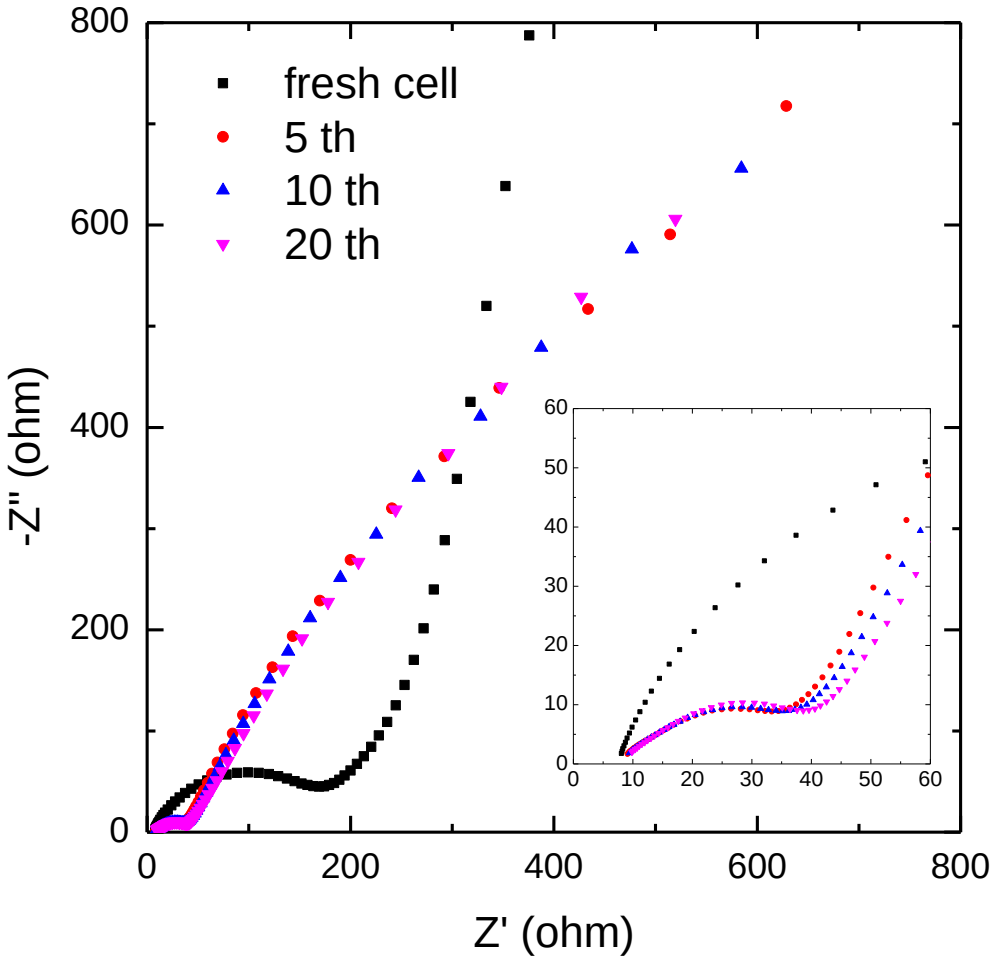
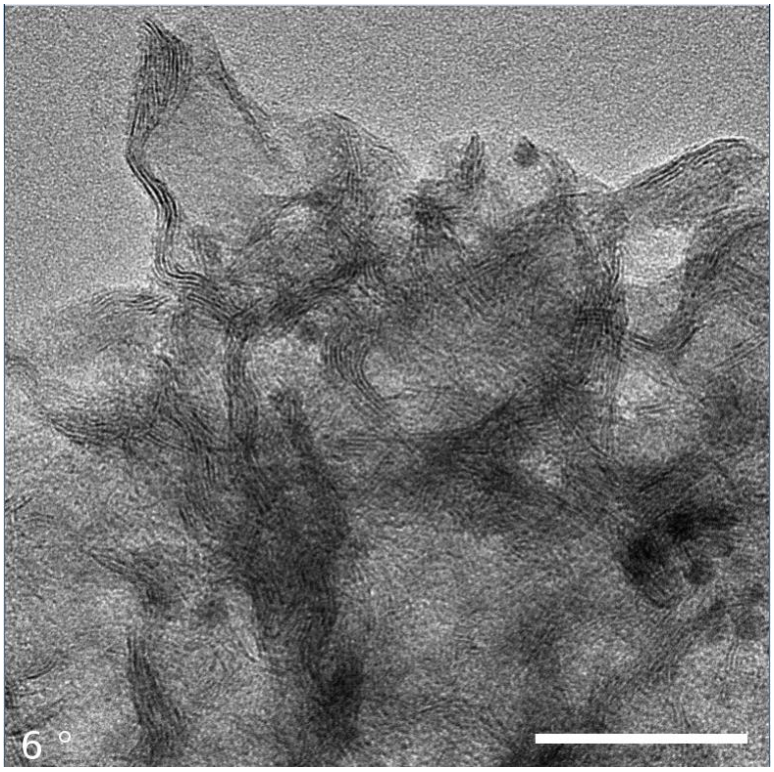


Fig. S9: Impedance measurements of the MoS_2/NC-PNR electrode before and after specific cycles at 0.5 C.



Movie S1: HR-TEM tilt-series movie of the MoS_2/NC-PNR superstructure in the range of -68° to + 64° with 1° steps. The scale bar is 50 nm.

MoS_2 hierarchical structure	MoS_2 content (%)	Cycling stability (cycles)	Rate capability		Ref.
			Specific capacity (mA h g^{-1})	Current density (A g^{-1})	
MoS_2/NC-PNR	74.2	700	925	0.067	Present work
			636	0.67	
			443	6.7	
MoS_2 HNS	-	100	944	0.1	[1]
			762	1	
			576	5	
CNTs@MoS_2@C	79.8	500	960	0.1	[2]
			820	1	
			758	2	
NDG/MoS_2/NDG	91.7	600	750	0.1	[3]
			589	1	
			416	4	
sS-MoS_2@C	87.2	100	980	0.1	[4]
			~830	1	
			805	5	
MHPC	62.3	300	948	0.1	[5]
			725	1	
			496	10	
HMCM	71	300	915	0.1	[6]
			648	1	
			481	4	
mesoporous-carbon/MoS_2	45	300	1400	0.1	[7]
			740	1	
			400	10	
MoS_2@C nanotubes	82	300	1327	0.067	[8]
			993	0.67	

			850	3.35	
MoS_2/CMK-3	70	150	893	0.1	[9]
			713	1	
			391	8	

Tab. S1: Battery performance comparison between this work and recently published MoS_2-based hierarchical structures.

Reference

1. Y. Wang, L. Yu and X. W. Lou, *Angew. Chem.-Int. Edit.*, 2016, **55**, 7423-7426.
2. Z. Zhang, H. Zhao, Y. Teng, X. Chang, Q. Xia, Z. Li, J. Fang, Z. Du and K. Świerczek, *Advanced Energy Materials*, 2018, **8**, 1700174.
3. B. Chen, Y. Meng, F. He, E. Liu, C. Shi, C. He, L. Ma, Q. Li, J. Li and N. Zhao, *Nano Energy*, 2017, **41**, 154-163.
4. B. Guo, K. Yu, H. Song, H. Li, Y. Tan, H. Fu, C. Li, X. Lei and Z. Zhu, *Nanoscale*, 2016, **8**, 420-430.
5. S.-K. Park, J. Lee, S. Bong, B. Jang, K.-d. Seong and Y. Piao, *ACS Appl. Mater. Interfaces*, 2016, **8**, 19456-19465.
6. Z. Bai, Y. Zhang, Y. Zhang, C. Guo and B. Tang, *Chemistry – A European Journal*, 2015, **21**, 18187-18191.
7. Y. Fang, Y. Lv, F. Gong, A. A. Elzatahry, G. Zheng and D. Zhao, *Adv. Mater.*, 2016, **28,** 9385-9390.
8. X. Zhang, X. Li, J. Liang, Y. Zhu and Y. Qian, *Small*, 2016, **12**, 2484-2491.
9. X. Xu, Z. Fan, X. Yu, S. Ding, D. Yu and X. W. D. Lou, *Advanced Energy Materials*, 2014, **4**, 1400902.