ADVANCED ENERGY MATERIALS

Supporting Information

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Flexible Nanowire Cathode Membrane with Gradient Interfaces and Rapid Electron/Ion Transport Channels for Solid-State Lithium Batteries

Yu Cheng, Jun Shu, Lin Xu, Yangyang Xia, Lulu Du, Gang Zhang, and Liqiang Mai**

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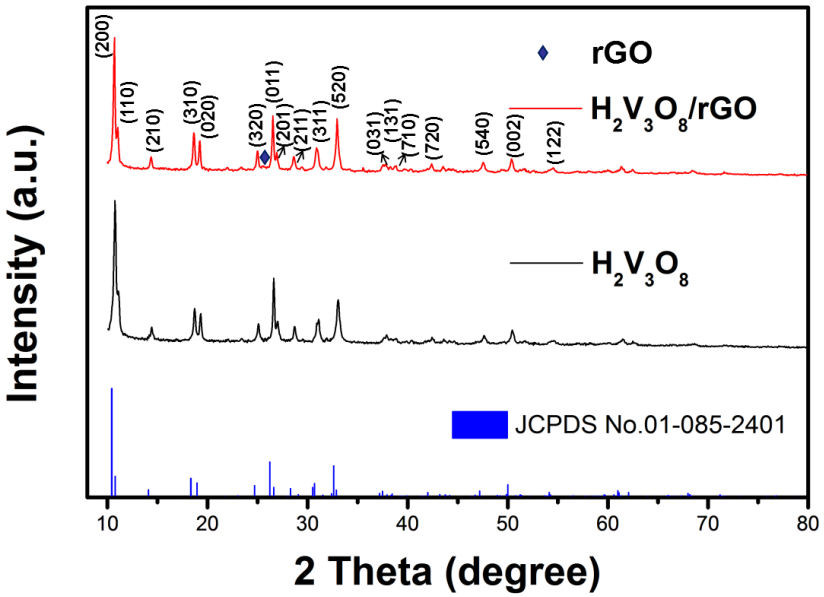

Figure S1. XRD pattern of $H_2V_3O_8$ nanowires/rGO composite and pure $H_2V_3O_8$ nanowires.

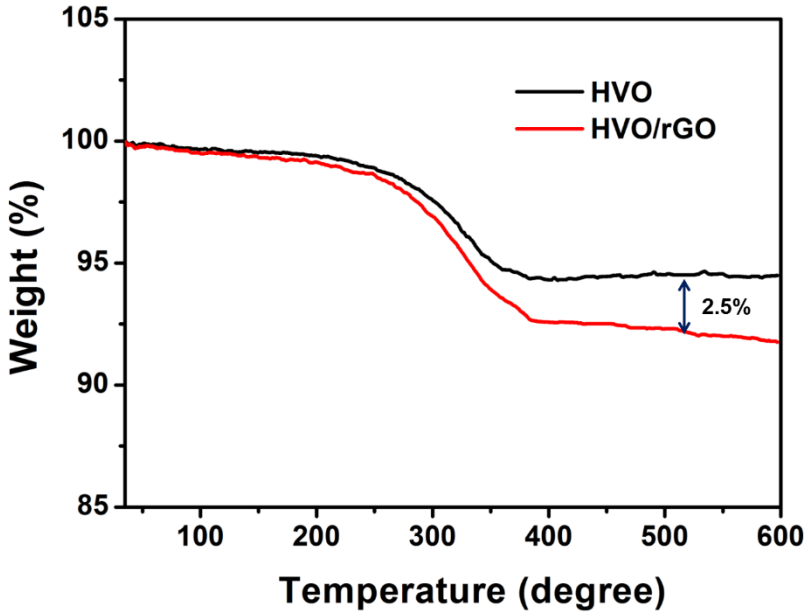

Figure S2. Thermogravimetric analysis of $H_2V_3O_8$ and $H_2V_3O_8$/rGO in Ar atomosphere.

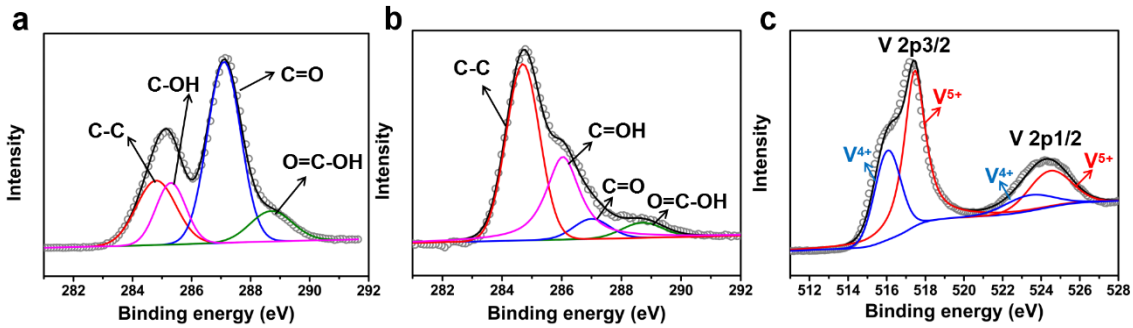

Figure S3. XPS spectra of carbon element. a) XPS of C 1s of the graphene oxide powder. b) XPS of C 1s of the $H_2V_3O_8$ NW/rGO composite. c) XPS spectra of V element.

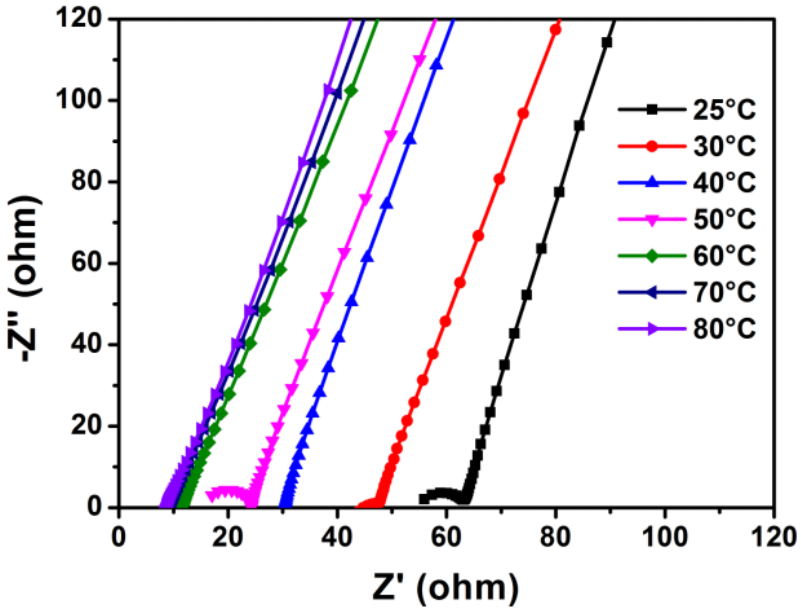

Figure S4. EIS curves of composite electrolyte from 25 to 80°C.

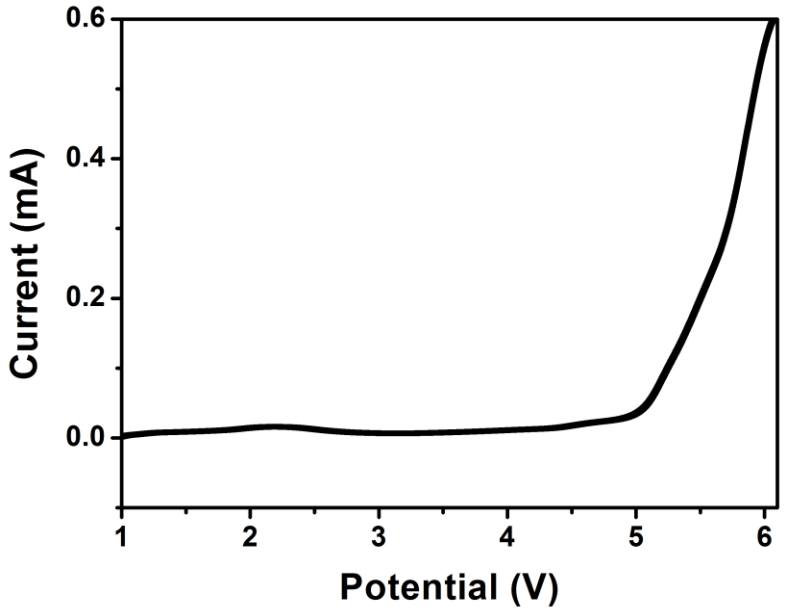

Figure S5. Electrochemical window of the composite electrolyte, LSV scans at a scanning rate of 0.5 mV s^{-1} at room temperature.

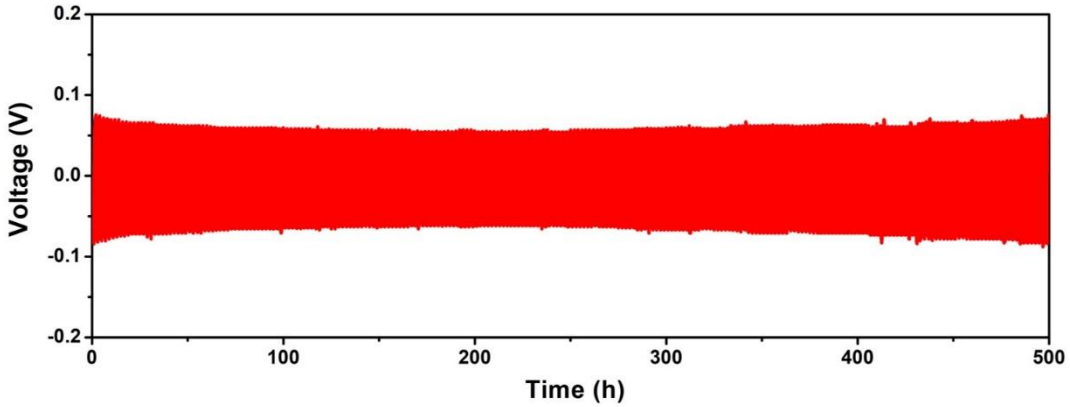

Figure S6. Plating/stripping test in Li|SSE|Li symmetric cell at 0.1 mA cm^{-2}.

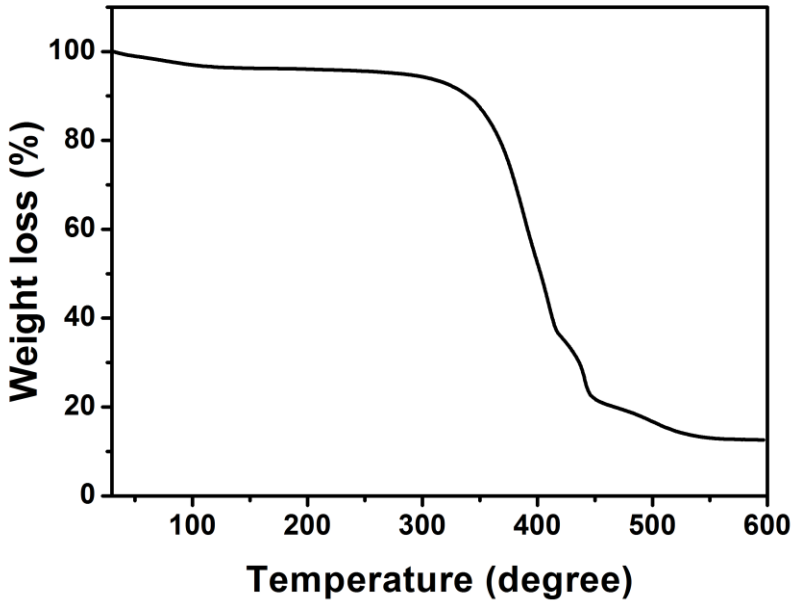

Figure S7. Thermogravimetric analysis of composite electrolyte in air.

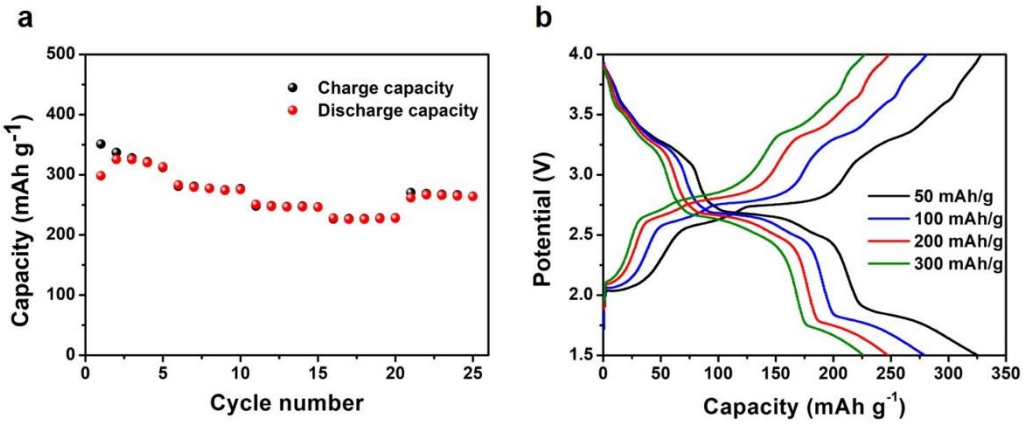

Figure S8. a) Rate performances of homogeneous nanowire cathode in liquid electrolyte. b) Typical charge-discharge curves of homogeneous nanowire cathode in liquid electrolyte. The cathode was prepared by tape casting method with 70 wt% $H_2V_3O_8$ active material, 20 wt% acetylene black and 10 wt% polyvinylidene difluoride binder, the liquid electrolyte is 1 M solution of $LiPF_6$ in EC: DMC: EMC 1:1:1.

Table S1. Electrochemical performance comparison of interfacial engineering in different solid-state battery systems.

Cathode/SSE	Cycling performance ($mAh\ g^{-1}$)	Rate performance ($mAh\ g^{-1}$)	Temperature (degree)	Ref.
Our work	200 (100^{th} cycle, 100 $mA\ g^{-1}$)	200 (300 $mA\ g^{-1}$)	Room temperature	
$LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$/ LATP+PAN+PEO	141 (100^{th} cycle, 0.5 C)	172.9 (0.1 C)	60 °C	[1]
$LiMn_2O_4$/ LAGP+SHE+IL	96 (100^{th} cycle, 0.1 C)	82.1 (0.5 C)	Room temperature	[2]
$LiFePO_4$/ LLZTO+PTFE+SN	158 (100^{th} cycle, 0.1 C)	130 (0.5 C)	Room temperature	[3]
$LiFePO_4$/ LAGP+IL	138 (100^{th} cycle, 0.3 C)	110 (2 C)	Room temperature	[4]
$LiCoO_2$/low graphitized carbon+LLZTO	122.3 (100^{th} cycle, 0.1 C) 106.1 (100^{th} cycle, 0.5 C)	70 (3 C)	/	[5]
$LiFePO_4$/ COF-modified LLZTO	146 (70^{th} cycle, 0.5 C)	97 (2 C)	Room temperature	[6]
$LiFePO_4$/ LLZT+LiF-LiC	164.2 (100^{th} cycle, 0.2 $mA\ cm^{-2}$)	114.3 (0.6 $mA\ cm^{-2}$)	Room temperature	[7]
$LiCoO_2$/ PVDF-PVAC+TMS	182 (100^{th} cycle, 0.5 C)	142 (4 C)	Room temperature	[8]

References:

[1] J.-Y. Liang, X.-X. Zeng, X.-D. Zhang, T.-T. Zuo, M. Yan, Y.-X. Yin, J.-L. Shi, X.-W. Wu, Y.-G. Guo, L.-J. Wan, *J Am Chem Soc* **2019**, 141, 9165.

[2] Q. Liu, D. Zhou, D. Shanmukaraj, P. Li, F. Kang, B. Li, M. Armand, G. Wang, *ACS Energy Lett.* **2020**, 5, 1456.

[3] T. Jiang, P. He, G. Wang, Y. Shen, C. W. Nan, L. Z. Fan, *Adv. Energy Mater.* **2020**, 10, 1903376.

[4] S. Xiong, Y. Liu, P. Jankowski, Q. Liu, F. Nitze, K. Xie, J. Song, A. Matic, *Adv Funct Mater* **2020**, 30, 2001444.

[5] W. Feng, X. Dong, X. Zhang, Z. Lai, P. Li, C. Wang, Y. Wang, Y. Xia, *Angew Chem Int Ed Engl* **2020**, 59, 5346.

[6] Z. Cheng, M. Xie, Y. Mao, J. Ou, S. Zhang, Z. Zhao, J. Li, F. Fu, J. Wu, Y. Shen, D. Lu, H. Chen, *Adv. Energy Mater.* **2020**, 10, 1904230.

[7] Y. Ruan, Y. Lu, Y. Li, C. Zheng, J. Su, J. Jin, T. Xiu, Z. Song, M. E. Badding, Z. Wen, *Adv Funct Mater* **2020**, 2007815. https://doi.org/10.1002/adfm.202007815.

[8] X. Yu, L. Wang, J. Ma, X. Sun, X. Zhou, G. Cui, *Adv. Energy Mater.* **2020**, 10, 1903939.