Supporting information

Vanadium based oxide-nitride heterostructure as a multifunctional sulfur host for advanced Li-S batteries

Menglong Zhao,[#a] Yang Lu,[*#a] Ya Yang,[a] Mengjie Zhang,[a] Zhenjie Yue,[a] Ning Zhang,[a] Tao Peng,[a] Xianming Liu,[b] and Yongsong Luo[*ac]

[a]*Henan Joint International Research Laboratory of New Energy Storage Technology, Key Laboratory of Microelectronics and Energy of Henan Province, School of Physics and Electronic Engineering, Xinyang Normal University, Xinyang 464000, P. R. China.*

[b]*College of Chemistry and Chemical Engineering, Luoyang Normal University, Luoyang 471934, P. R. China.*

[c]*College of Physics and Electronic Engineering, Nanyang Normal University, Nanyang 473061, P. R. China.*

[*]Corresponding author. Tel./fax: +86 376 6390801, E-mail: luyang.181@163.com (Y. Lu), ysluo@xynu.edu.cn (Y. S. Luo).
[#]Yang Lu and Menglong Zhao contributed equally to this work.

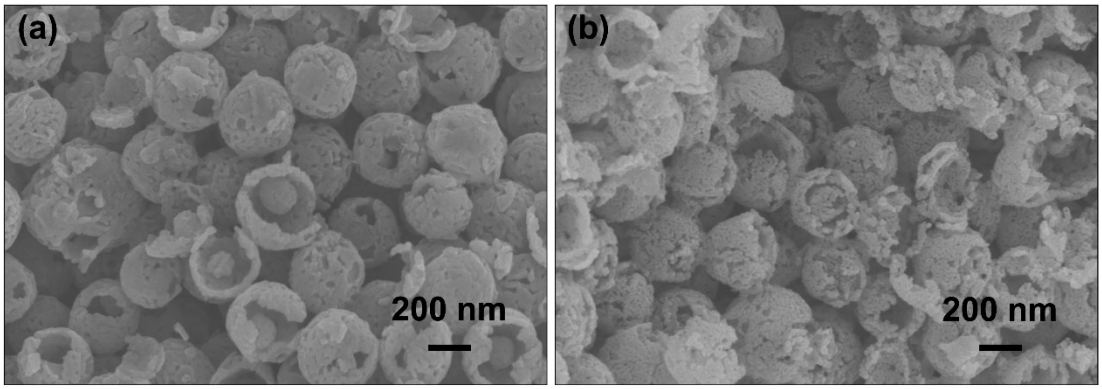

Figure S1. (a) SEM image of V_2O_3@C; (b) SEM image of VN@NC.

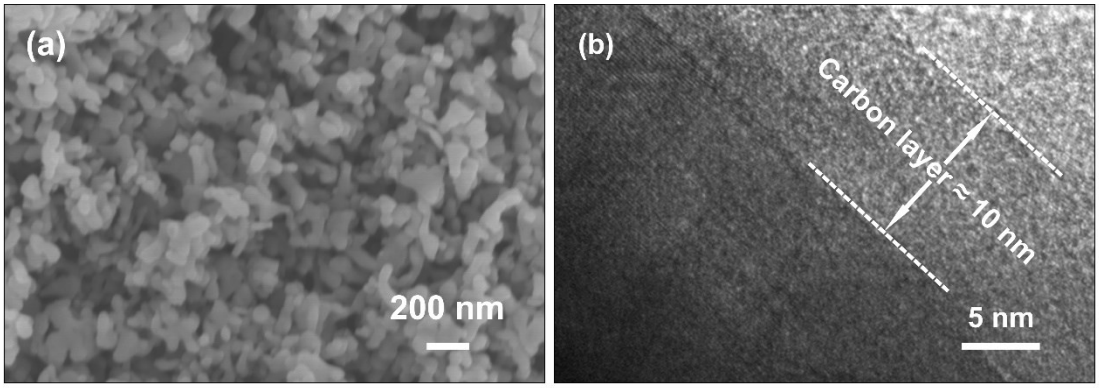

Figure S2. (a) SEM image of V_2O_3-VN without the outer glucose layer; (b) TEM image of the V_2O_3-VN@NC with the carbon layer.

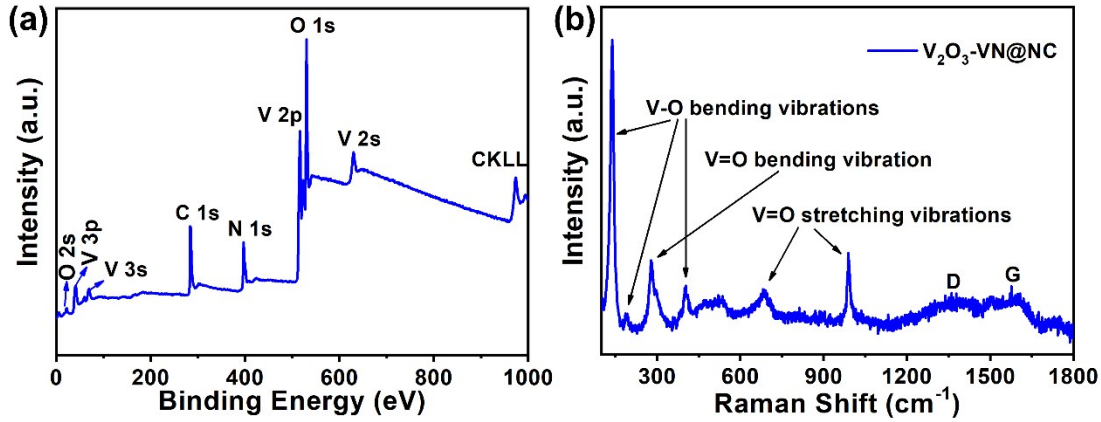

Figure S3. (a) XPS survey spectrum of V_2O_3-VN@NC; (b) Raman spectral of V_2O_3-VN@NC.

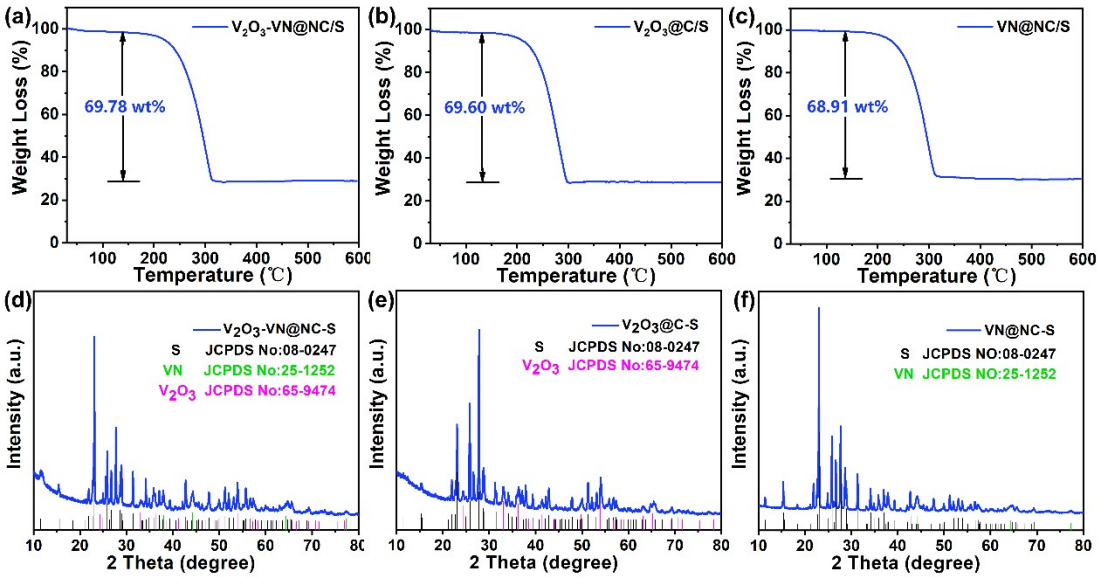

Figure S4. TG curves of the V_2O_3-VN@NC/S (a), V_2O_3@C/S (b) and VN@NC/S (c) composites; and corresponding XRD pattern of V_2O_3-VN@NC/S (d), V_2O_3@C/S (e) and VN@NC/S (f) composites.

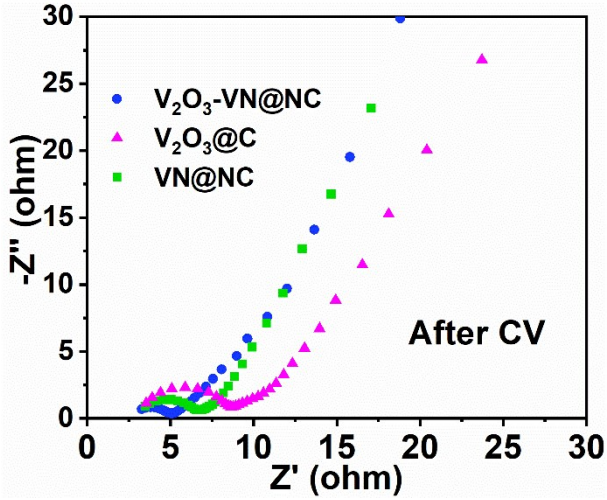

Figure S5. EIS curves of V_2O_3@C/S, VN@NC/S and V_2O_3-VN@NC/S electrodes after cycling.

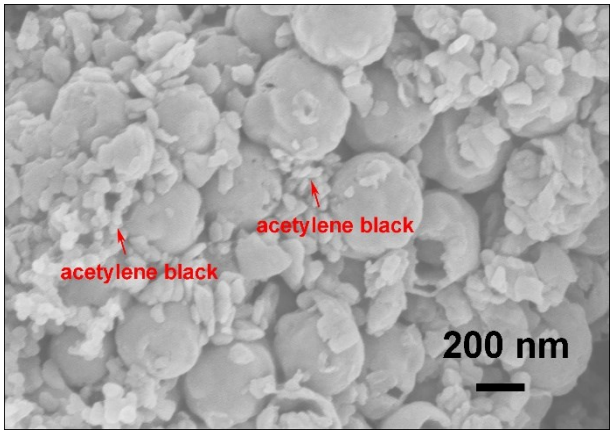

Figure S6. SEM image of V_2O_3-VN@NC/S electrodes after 800 cycles at 1C.

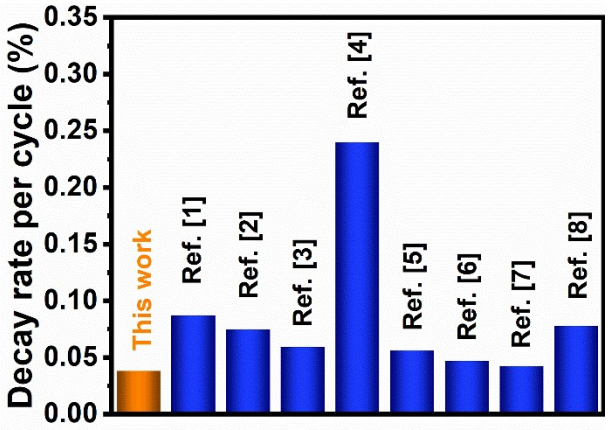

Figure S7. Comparison of decay rate per cycle for Li-S batteries between this work and other reported studies.

Supplementary References

1. Y. N. Fan, F. Ma, J. S. Liang, X. Chen, Z. P. Miao, S. Duan, L. Wang, T. Y. Wang, J. T. Han, R. G. Cao, S. H. Jiao and Q. Li, *Nanoscale*, 2020, **12**, 584-590.
2. S. D. Seo, D. Park, S. Park and D. W. Kim, *Adv. Funct. Mater.*, 2019, **29**, 1903712.
3. L. Y. Hu, C. L. Dai, H. Liu, Y. Li, B. L. Shen, Y. M. Chen, S. J. Bao and M. W. Xu, *Adv. Energy Mater.*, 2018, **8**, 1800709.
4. X. X. Li, K. Ding, B. Gao, Q. W. Li, Y. Y. Li, J. J. Fu, X. M. Zhang, P. K. Chu and K. F. Huo, *Nano Energy*, 2017, **40**, 655-662.
5. C. Ye, Y. Jiao, H. Y. Jin, A. D. Slattery, K. Davey, H. H. Wang and S. Z. Qiao, *Angew. Chem. Int. Ed.,* 2018, **57**, 16703-16707.
6. Z. G. Wang, K. Yu, S. J. Gong, E. Du and Z. Q. Zhu, *Nanoscale*, 2020, **12**, 18950-18964.
7. S. N. Gu, Z. W. Bai, S. Majumder, B. L. Huang and G. H. Chen, *Nanoscale*, 2019, **11**, 20579-20588.
8. L. B. Ma, H. N. Lin, W. J. Zhang, P. Y. Zhao, G. Y. Zhu, Y. Hu, R. P. Chen, Z. X. Tie, J. Liu, Z. Jin, *Nano Lett*., 2018, **18**, 7949-7954.

Table S1. Summary of D_{li}^{+} at peaks i, ii, iii for V_2O_3@C, VN@NC and V_2O_3-VN@NC cells.

CV Peak	V_2O_3@C	VN@NC	V_2O_3-VN@NC
Peak i	3.668×10^{-9} cm²/s	1.702×10^{-8} cm²/s	1.924×10^{-8} cm²/s
Peak ii	5.672×10^{-9} cm²/s	1.391×10^{-8} cm²/s	1.706×10^{-8} cm²/s
Peak iii	1.232×10^{-8} cm²/s	8.633×10^{-8} cm²/s	9.823×10^{-8} cm²/s