Supporting Information

Green Synthesis of Vanadate Nanobelts at Room Temperature for Superior Aqueous Rechargeable Zinc-Ion Batteries

Zhiqiang Xie[a,1], Jianwei Lai[a,1], Xiuping Zhu[b,2], Ying Wang[a,*]

[a] Department of Mechanical & Industrial Engineering, Louisiana State University, Baton Rouge, LA 70803, USA.

[b] Department of Civil and Environmental Engineering, Louisiana State University, Baton Rouge, LA 70803, USA.

* Corresponding author: Prof. Ying Wang, E-mail: ywang@lsu.edu.

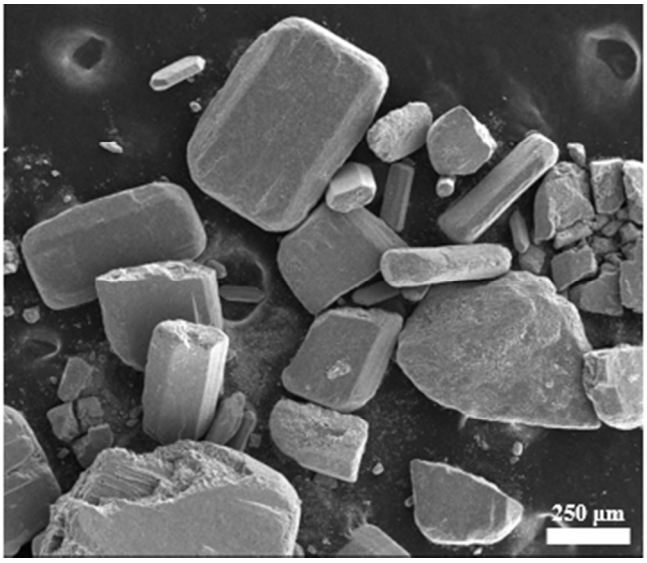

Figure S1. The SEM image of commercial V_2O_5 powder.

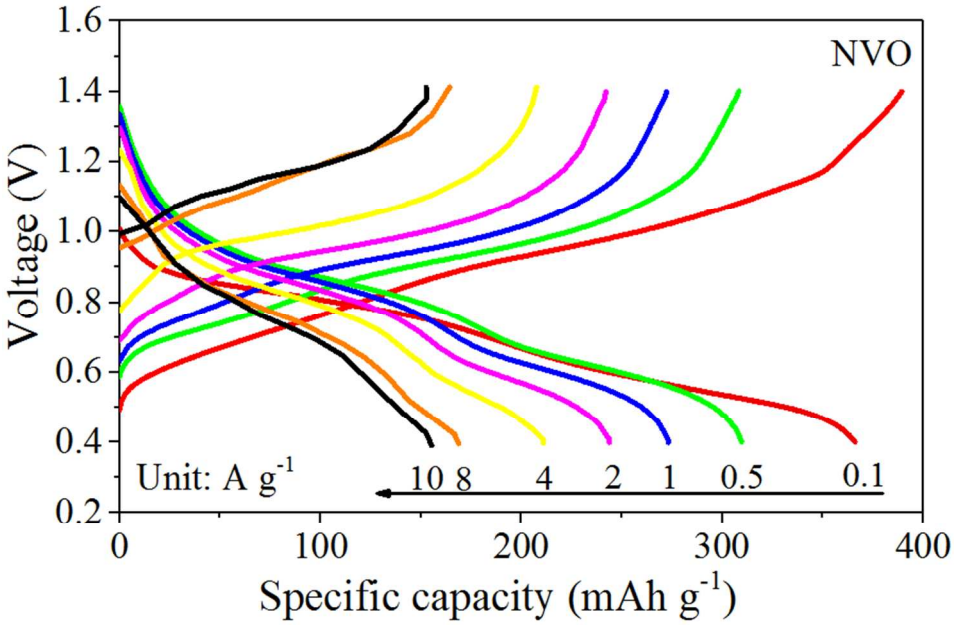

Figure S2. Charge-discharge curves of the NVO at different current densities ranging from 0.1 to 10 A g^{-1}.

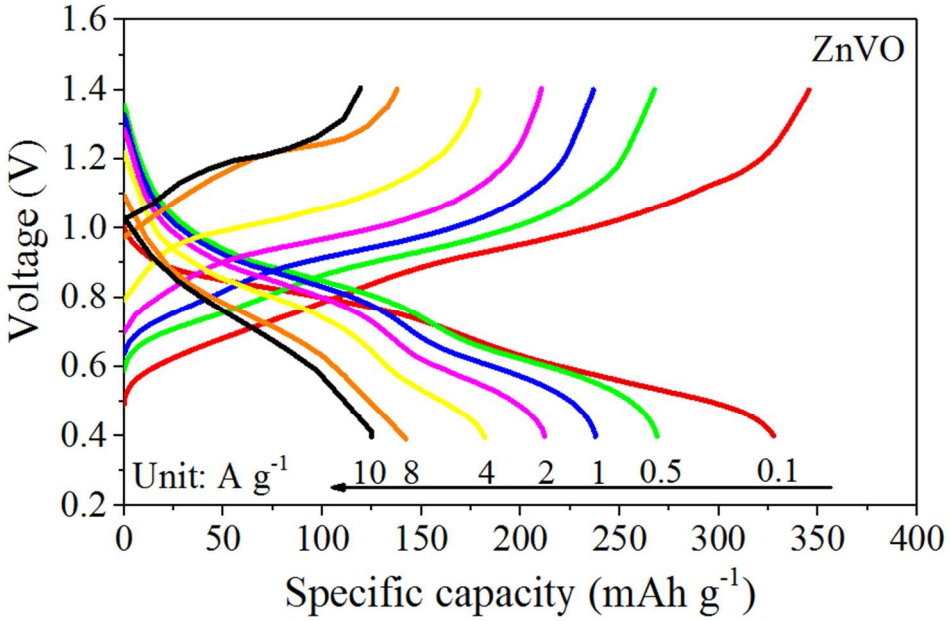

Figure S3. Charge-discharge curves of the ZnVO at different current densities ranging from 0.1 to 10 A g^{-1}.

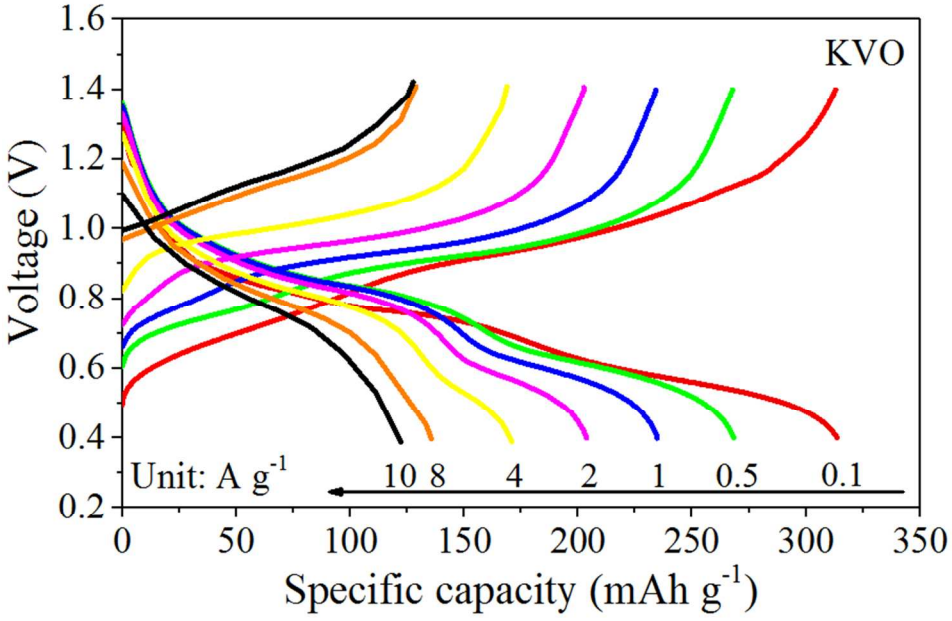

Figure S4. Charge-discharge curves of the KVO at different current densities ranging from 0.1 to 10 A g^{-1}.

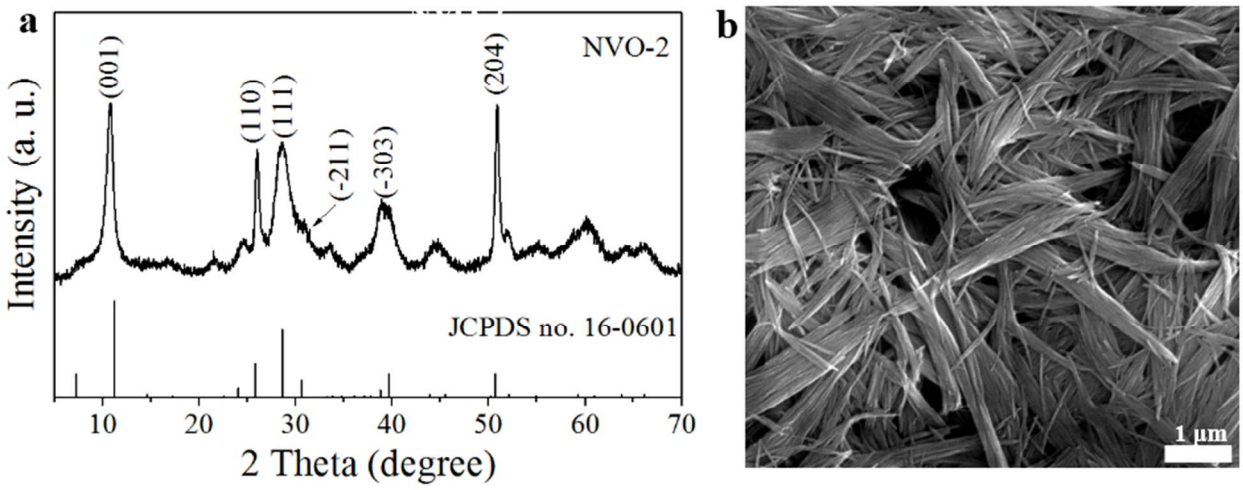

Figure S5. (a) X-ray diffraction pattern of the NVO-2 nanobelts, (b) corresponding SEM image.

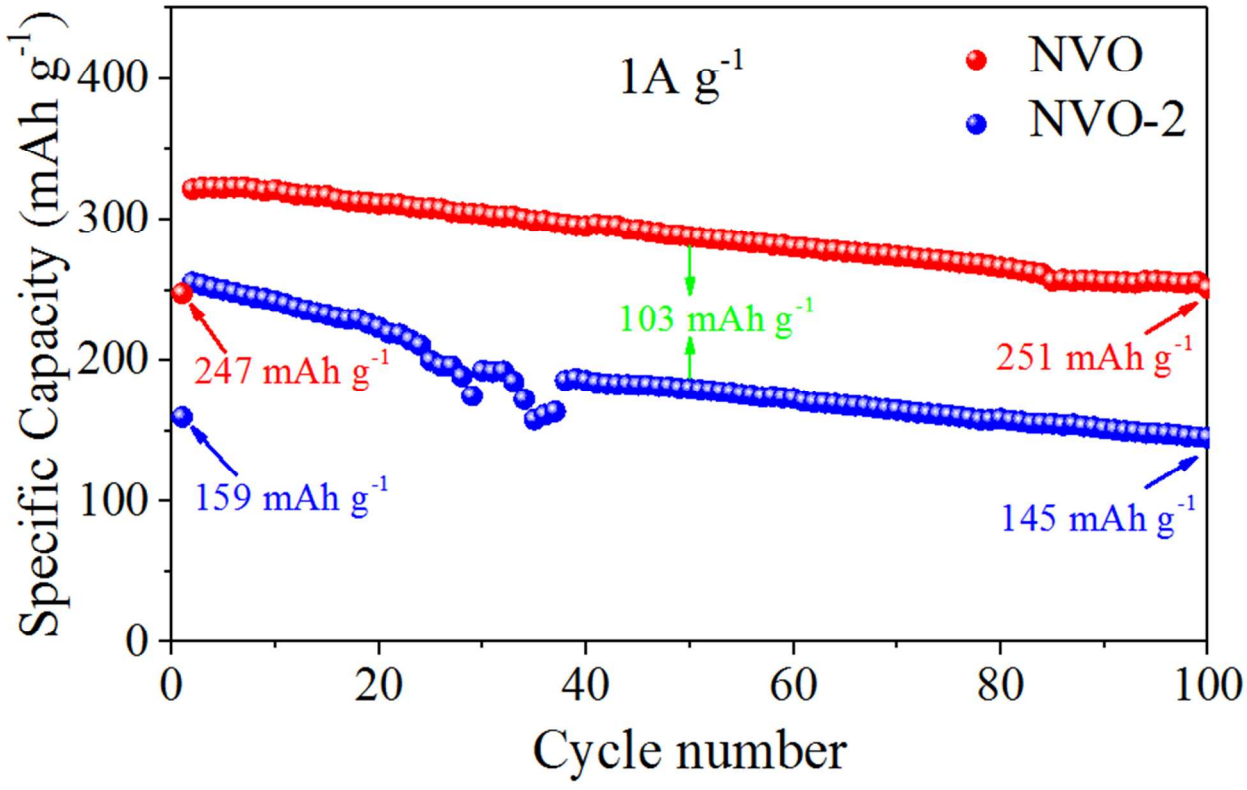

Figure S6. Cycling performances of NVO and NVO-2 at 1 A g^{-1}.

Table S1. Comparison of our work with recently reported vanadium-based cathode materials on the synthesis technique and electrochemical performances for zinc-ion battery.

Materials	**Synthesis technique**	**Precursors**	**Electrolyte**	**Specific capacity ($mAh\ g^{-1}$)/ current density ($mA\ g^{-1}$)**	**Ref.**
$NaV_3O_8{\cdot}1.35H_2O$	Room-temperature stirring for 72 h	V_2O_5, NaCl	1 M $ZnSO_4$	366/ 100	**Present work**
$Zn_3V_2O_8{\cdot}1.85H_2O$	Room-temperature stirring for 144 h	V_2O_5, $ZnSO_4{\cdot}7H_2O$	1 M $ZnSO_4$	328/ 100	**Present work**
$KV_3O_8{\cdot}0.51H_2O$	Room-temperature stirring for 72 h	V_2O_5, KCl	1 M $ZnSO_4$	316/ 100	**Present work**
$Zn_{0.25}V_2O_5{\cdot}nH_2O$	Microwave method at 180 °C for 90 min	V_2O_5, acetone, zinc acetate	1 M $ZnSO_4$	300/ 50	1
$Zn_2V_2O_7$	Hydrothermal method at 210 °C for 48 h	$Zn(NO_3)_2{\cdot}6H_2O$, NH_4VO_3	1 M $ZnSO_4$	250/ 50	2
$Zn_3V_2O_7(OH)_2{\cdot}2H_2O$	Microwave method at 180 °C for 6 h	$Zn(NO_3)_2{\cdot}2H_2O$, NH_4VO_3	1 M $ZnSO_4$	200/ 50	3
$K_2V_8O_{21}$	Hydrothermal method at 180 °C for 48 h	V_2O_5, PEG, KOH	2 M $ZnSO_4$	247/300	4
$VO_{1.52}(OH)_{0.77}$	Hydrothermal method at 150 °C for 24 h	VOCl, benzyl alcohol	1 M $ZnSO_4$	140/ 15	5
LiV_3O_8	Anneal method at 400 °C for 12 h	V_2O_5, $LiCO_3$	1 M $ZnSO_4$	280/ 16	6
VS_2	Hydrothermal method at 180 °C for 20 h	NH_4VO_3, $NH_3.H_2O$, thioacetamide	1 M $ZnSO_4$	190/ 50	7
$NaV_3O_8{\cdot}1.5H_2O$	Stirring at 30 °C for 96 h	V_2O_5, NaCl	1M $ZnSO_4$ / 1M Na_2SO_4	380/ 100	8
$Na_3V_2(PO_4)_3$	Hydrothermal method at 180 °C for 48 h with post anneal method	V_2O_5, $NH_4H_2PO_4$, Na_2CO_3, citric acid, PEG	0.5 M $Zn(CH_3COO)_2$	97/ 50	9
$Na_2V_6O_{16}{\cdot}\ 1.63\ H_2O$	hydrothermal method at 180 °C for 24 h	V_2O_5, NaOH	3M $Zn(CF_3SO_3)_2$	353/ 50	10

References

(1) Kundu, D.; Adams, b.; Duffort, v.; Vajargah, S.; Nazar, L. A High-Capacity and Long-Life Aqueous Rechargeable Zinc Battery using a Metal Oxide Intercalation Cathode. *Nature Energy*. **2016**, 1, 16119.

(2) Sambandam, B.; Soundharrajan, V.; Kim, S.; Alfaruqi, M.; Jo, J.; Kim, S.; Mathew, V.; Sun, Y.; Kim, J. Aqueous Rechargeable Zn-Ion Batteries: an Imperishable and High-Energy $Zn_2V_2O_7$ Nanowire Cathode through Intercalation Regulation. *J. Mater. Chem. A*. **2018**, 3850-3856.

(3) Xia, C.; Guo, J.; Lei, Y.; Liang, H.; Zhao, C.; Alshareef, H. Rechargeable Aqueous Zinc-Ion Battery Based on Porous Framework Zinc Pyrovanadate Intercalation Cathode. *Adv. Mater*. **2018**, 30, 1705580.

(4) Tang, B.; Fang, G.; Zhou, J.; Wang, L.; Lei, Y.; Wang, C.; Lin, T.; Tang, Y.; Liang, S. Potassium Vanadates with Stable Structure and Fast Ion Diffusion Channel as Cathode for Rechargeable Aqueous Zinc-Ion Batteries. *Nano Energy*. **2018**, 51, 579-587.

(5) Jo, J.; Sun, Y.; Myung, S. Hollandite-type Al-doped $VO_{1.52}(OH)_{0.77}$ as a Zinc Ion Insertion Host Material. *J. Mater. Chem. A*. **2017**, 5, 8367-8375.

(6) Alfaruqi, M.; Mathew, V.; Song, J.; Kim, S.; Islam, S.; Pham, D.; Jo, J.; Kim, S.; Baboo, J.; Xu, Z.; Lee, K.; Sun, Y.; Kim, J. Electrochemical Zinc Intercalation in Lithium Vanadium Oxide: A High-Capacity Zinc-Ion Battery Cathode. *Chem. Mater*. **2017**, 29, 1684-1694.

(7) He, P.; Yan, M.; Zhang, G.; Sun, R.; Chen, L.; An, Q.; Mai, L. Layered VS_2 Nanosheet-Based Aqueous Zn Ion Battery Cathode. *Adv. Energy Mater*. **2017**, 7, 1601920.

(8) Wan, F.; Zhang, L.; Dai, X.; Wang, X.; Niu, Z.; Chen, J. Aqueous Rechargeable Zinc/Sodium Vanadate Batteries with Enhanced Performance from Simultaneous Insertion of Dual Carriers. *Nat. Commun.* **2018**, 9, 1656.

(9) Li, G.; Yang, Z.; Jiang, Y.; Jin, C.; Huang, W.; Ding, X.; Huang, Y. Towards Polyvalent Ion Batteries: A Zinc-Ion Battery based on NASICON Structured $Na_3V_2(PO_4)_3$. *Nano Energy*. **2016**, 25, 211-217.

(10) Hu, P.; Zhu, T.; Wang, X.; Wei, X.; Yan, M.; Li, J.; Luo, W.; Yang, W.; Zhang, W.; Zhou, L.; Zhou, Z.; Mai, L. Highly Durable $Na_2V_6O_{16}\cdot$ 1.63 H_2O Nanowire Cathode for Aqueous Zinc-Ion Battery. *Nano letters.* **2018**, 18, 1758-1763.