Supporting information

Expansion counteraction effect assisted vanadate with rich oxygen vacancies as a high cycling stability cathode for aqueous zinc-ion batteries

Contents

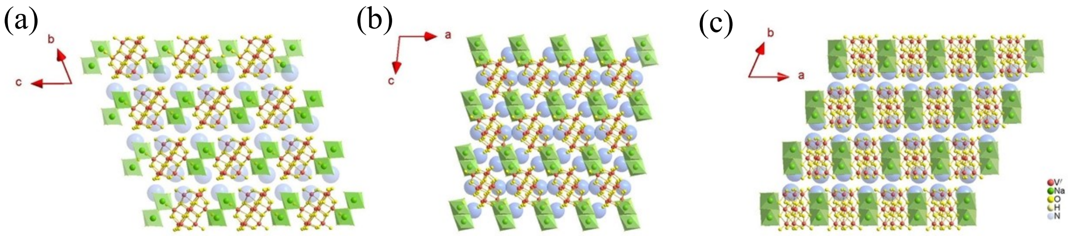

Fig. S1 Crystal structures of **NaNVO** (a) along *a*-axis, (b) along *b*-axis and (c) along *c*-axis.

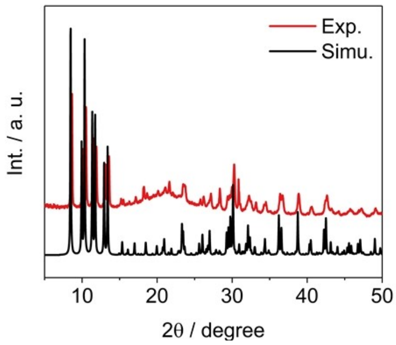

Fig. S2 XRD pattern of **NaNVO**.

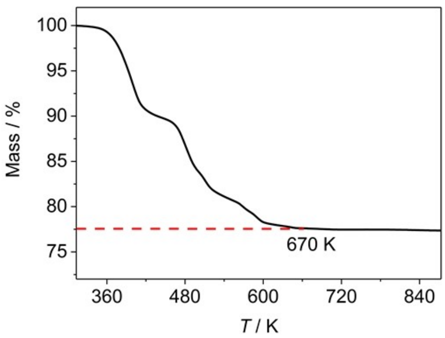

Fig. S3 TG curve of **NaNVO**.

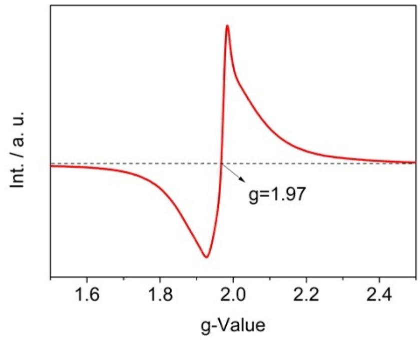

Fig. S4 EPR spectroscopy of **NaVO**.

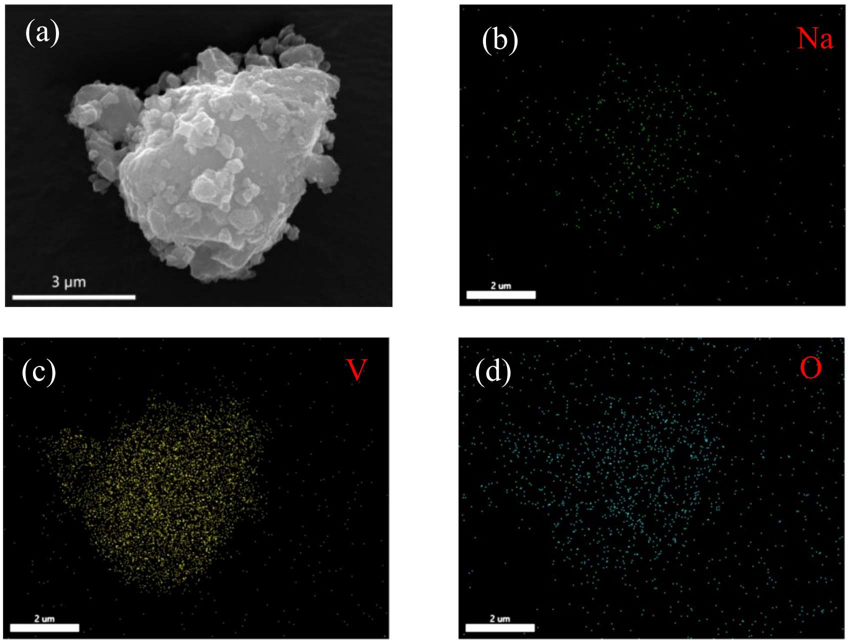

Fig. S5 (a) SEM image, (b) Na, (c) V and (d) O elemental mapping images of **NaVO**.

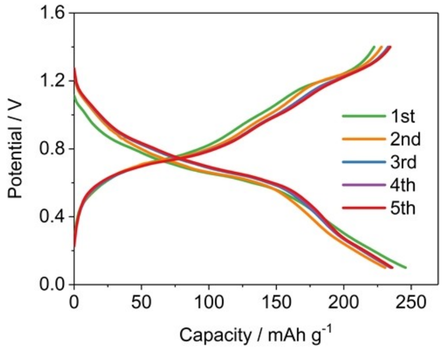

Fig. S6 Charging-discharging curves at 0.1 A g^{-1} during the initial five cycles of the **NaVO** cathode.

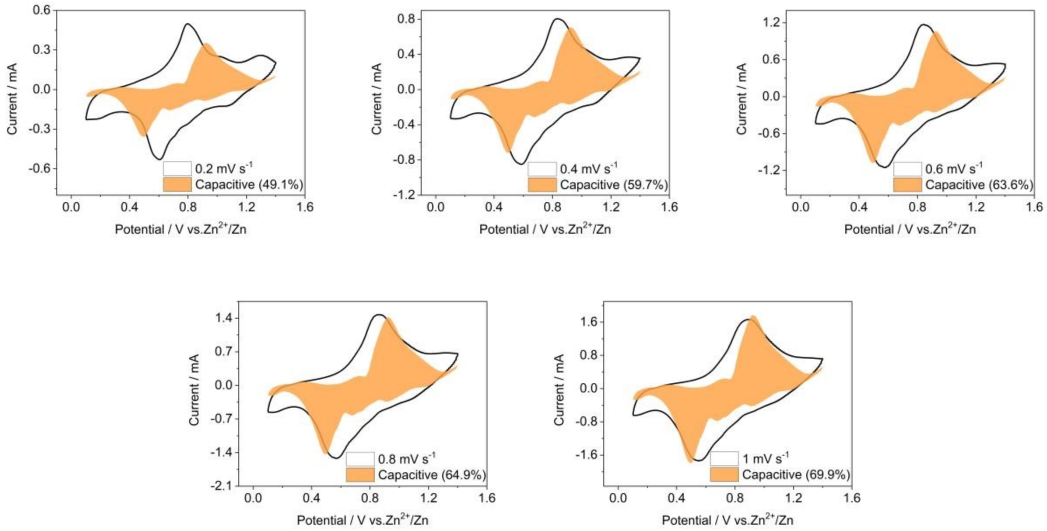

Fig. S7 Capacitive contributions to total storage for the Zn//**NaVO** battery at different scan rates.

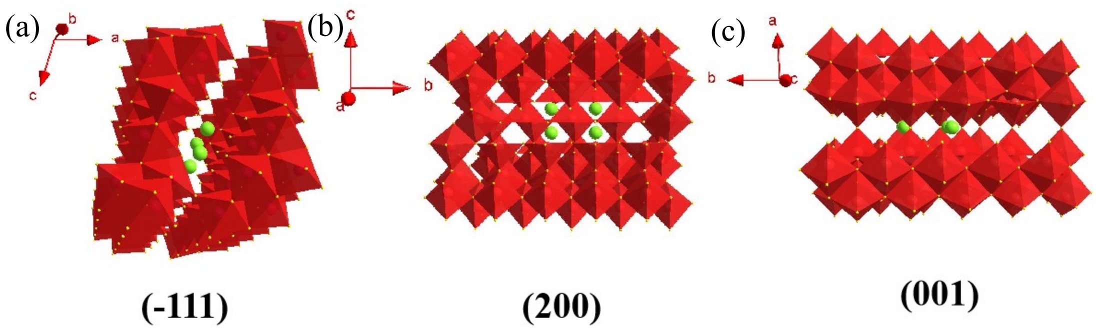

Fig. S8 The tunnel of **NaVO** viewed along the (a) (001), (b) (200) and (c) (–111) plane.

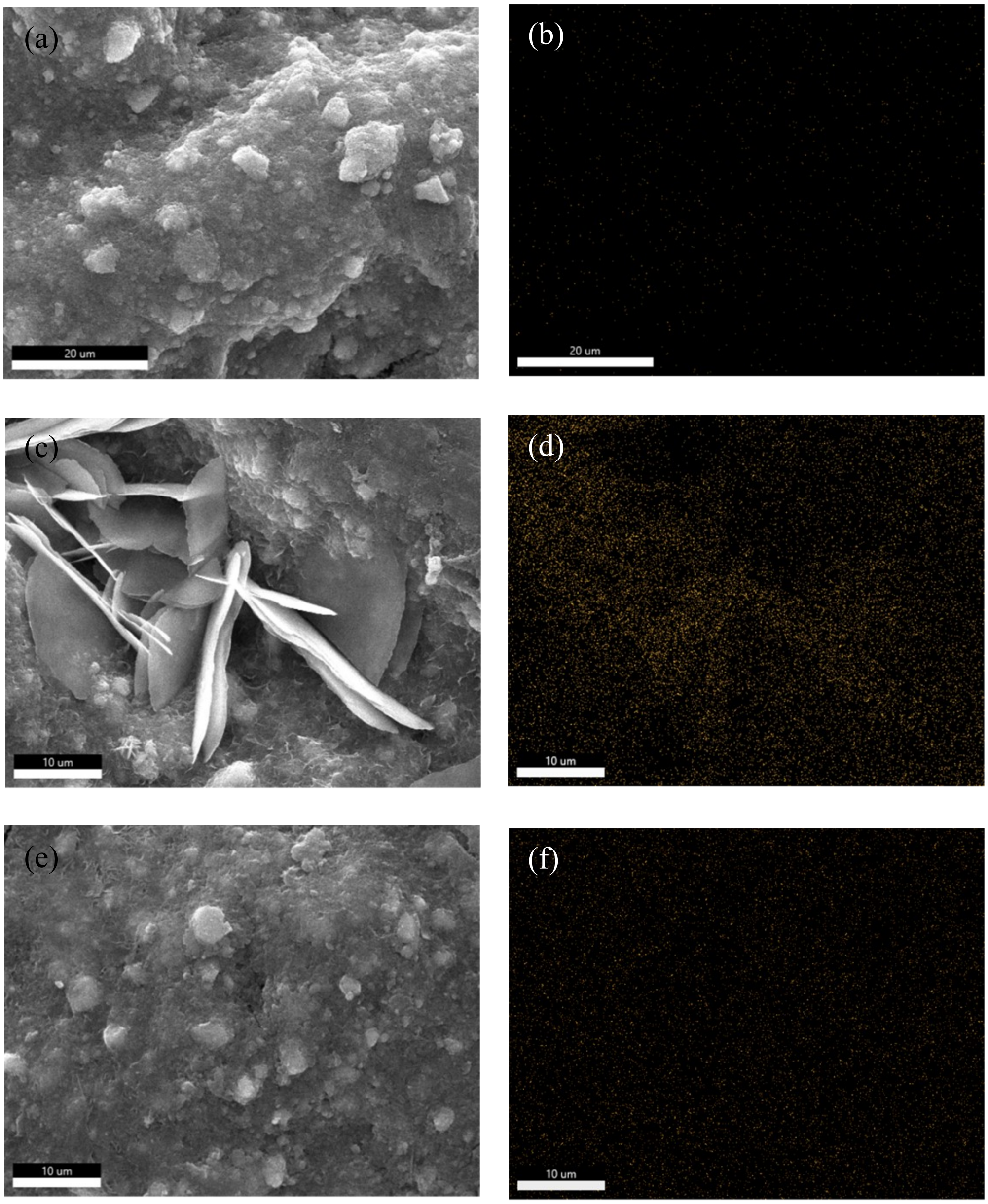

Fig. S9 Zn elemental mapping images of the **NaVO** electrode (a, b) at pristine, (c, d) discharge to 0.1V and (e, f) charge to 1.4 V at first cycle.

Table S1 Rietveld refinement data of **NaVO**.

Rwp = 12.00%	Chi^2: 1.38			
Space group: *C 1 2/m 1*		a = 15.45, b = 3.61, c = 10.08 (Å)		
		$\alpha = \gamma$ = 90.00, β = 109.56 (°)		
Atom	X	Y	Z	Occupancy
Na1	-0.00610	0.00000	0.40400	0.34875
V1	0.33652	0.00000	0.10323	0.50000
V2	0.11433	0.00000	0.12256	0.50000
V3	0.28382	0.00000	0.40964	0.50000
O1	0.00000	0.00000	0.00000	0.25000
O2	0.17105	0.00000	-0.03689	0.50000
O3	0.37743	0.00000	-0.08674	0.50000
O4	0.44334	0.00000	0.22874	0.50000
O5	0.25996	0.00000	0.22855	0.50000
O6	0.10292	0.00000	0.27693	0.50000
O7	0.24313	0.00000	0.57003	0.50000
O8	0.39445	0.00000	0.47032	0.50000

Table S2 ICP analysis for **NaVO** with the atomic ratio for Na and V.

Sample	The atomic ratio of Na:V
NaVO	1:4.3

Table S3 Comparison of the electrochemical performance of **NaVO** and vanadium-based cathode materials for AZIBs.

Cathode	Operating conditions (V)	Current density (A g^{-1})	Highest capacity (mAh g^{-1})	Capacity retention (loss / cycle)	Ref.
$Zn_3V_4(PO_4)_6$	0.3–1.9	0.11	~104.0	0% / 250	1
$NH_4V_4O_{10}$	0.4–1.4	0.3	~380.0	26.0% / 50	2
$Ni_{0.24}V_{5.76}O_{13}$	0.2–1.4	1.0	~300.0	8.6% / 100	3
$Ni_{0.26}V_2O_5\cdot1.11H_2O$	0.3–1.4	0.2	280.7	0% / 40	4
CuVO	0.3–1.4	1.0	359.0	26.5% / 50	5
$Na_{0.56}V_2O_5$	0.4–1.5	0.5	196.0	16.0% / 200	6
$Na_{0.33}V_2O_5$	0.2–1.6	0.2	276.6	8.7% / 100	7
$Na_6[V_{10}O_{28}]\cdot nH_2O$	0.2–1.5	0.3	~150.0	14.4% / 50	8
PPy-$Na_{1.1}V_3O_{7.9}$	0.4–1.4	1.0	396.0	0% / 45	9
$K_{0.52}V_2O_5\cdot0.29H_2O$	0.4–1.4	0.1	300.0	12.0% / 100	10
LiV_3O_8	0.6–1.2	0.13	~205.0	24.9% / 65	11
LiV_3O_8@NaV_3O_8	0.3–1.6	0.2	395.5	11.0% / 100	12
$Zn_3V_3O_8/VO_2$	0.3–1.5	0.3	385.2	7.8% / 200	13
$Zn_{0.125}V_2O_5\cdot0.95H_2O$	0.2–1.6	0.2	375.0	~12.0% / 50	14
NaVO	0.1–1.4	0.1	254.7	9.8% / 150 11.2% / 300 12.7% / 350	This work

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