Supporting information for

Hybrid ternary co-intercalation in interlayer of vanadium oxide cathode enables high-capacity and stable zinc ion batteries

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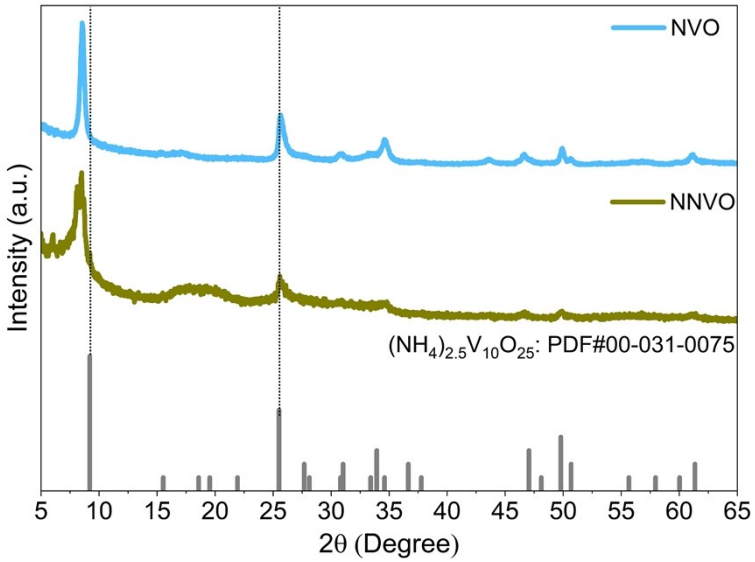

Figure S1. The XRD pattern of NVO, NNVO, and $(NH_4)_{2.5}V_{10}O_{25}$ standard card for comparison.

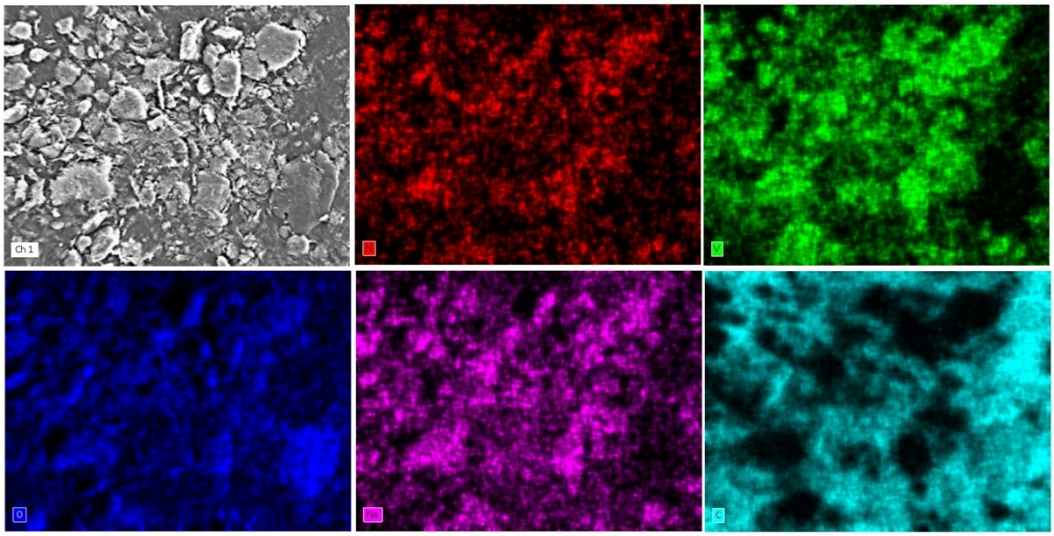

Figure S2. The elements distribution (N, V, O, Na, C) of NNVO tested by EDS-mapping.

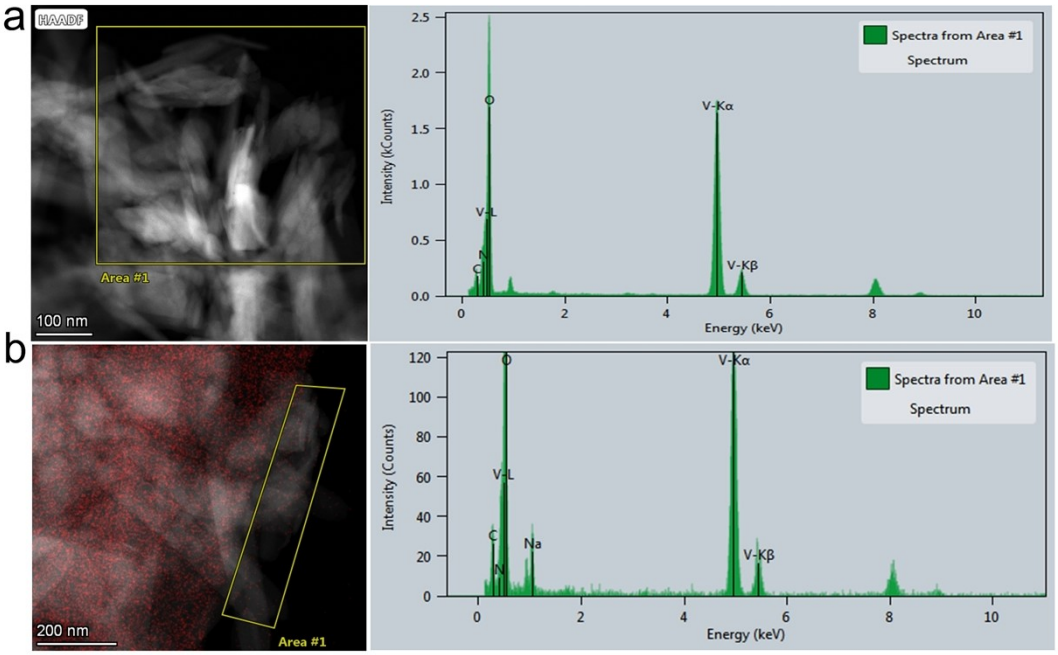

Figure S3. The TEM-EDS results of (a)NVO, and (b) NNVO.

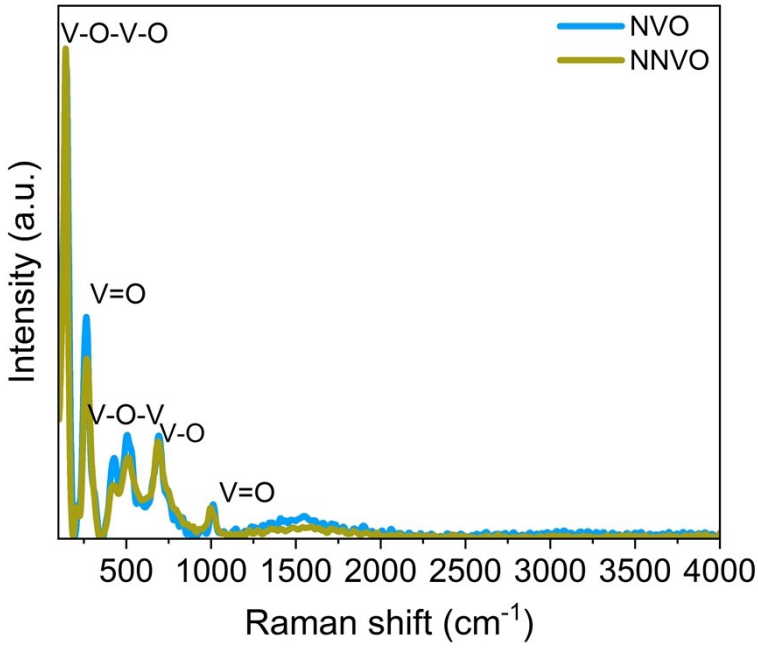

Figure S4. The full Raman spectrum of NVO and NNVO.

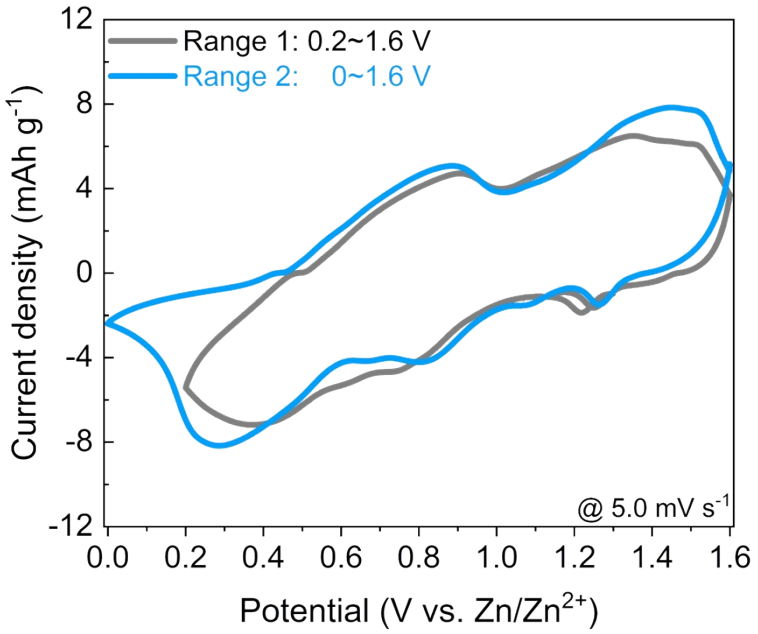

Figure S5. The CV curves of NVO in different potential windows.

Table S1. Rate performance of this work compared to similar reports.

Cathode materials	**Capacity/mAh g^{-1} @Current density/A g^{-1}**	**Ref.**
δ-$Ni_{0.25}V_2O_5 \cdot nH_2O$	400@0.2; 350@0.5; 290@1.0; 235@2.0; 199@3.0; 145@5.0	*Adv. Energy Mater.* ***2020****, 10, 2000058*
$Mg_{0.9}Mn_3O_7 \cdot 2.7H_2O$	400@0.2; 350@0.5; 290@1.0; 235@2.0; 199@3.0; 145@5.0	*Adv. Energy Mater.* ***2022****, 12, 2201840*
$(NH_4)_2V_{10}O_{25} \cdot 8H_2O$ (NVO nanowires)	450@0.1; 415@0.2; 385@0.4; 360@0.6; 355@0.8; 325@1.0; 305@2.0; 245@5.0	*Mater. Today Chem.* ***2023****,33, 101686*
δ-$K_{0.49}V_2O_5$	350@0.2; 335@0.3; 315@0.5; 290@1.0; 245@2.0; 200@3.0; 150@5.0	*Chem. Eng. J.* ***2023****,454,140260*
$Na_{0.3}(NH_4)_{0.6}V_4O_{10} \cdot 0.4H_2O$(NVO-Na)	380@0.1; 350@0.5; 335@1.0; 320@2.0; 305@3.0; 280@5.0	*Chem. Eng. J.* ***2022****,446,137090*
Tunnel-Oriented VO_2 (B)	400@0.1; 390@0.2; 380@0.5; 370@1.0; 360@2.0; 350@5.0	*Adv. Mater.* ***2024****, 36, 2400888*
CaV_3O_7/V_2O_5	400@0.25; 390@0.5; 375@0.75; 350@1.0; 325@1.5; 315@2.0; 305@2.5; 295@3.0; 280@4.0; 270@5.0	*ACS Sustainable Chem. Eng.* ***2023****, 11, 12571*
$NH_4V_4O_{10}$ (Mg^{2+} substituting NH_4^+)	405@0.1; 360@0.5; 325@1.0; 300@2.0; 248@5.0	*Adv. Funct. Mater.* ***2023****, 33, 2306205*
$V_2O_5 \cdot nH_2O$	355@0.2; 345@0.5; 325@1.0; 305@2.0; 275@5.0	*Nano Energy* ***2024****,120,109152*
PEO-LiV_3O_8	448@0.1; 405@0.2; 385@0.5; 350@1.0; 305@2.0; 240@5.0	*Adv. Mater.* ***2024****, 36, 2310434*
$Na_x(NH_4)_{2-x}V_{10}O_{25} \cdot 8H_2O$ (NNVO)	481@0.1; 434@0.2; 397@0.4; 376@0.5; 350@1.0; 307@2.0; 237@5.0	**This work**
$(NH_4)_2V_{10}O_{25} \cdot 8H_2O$ (NVO)	487@0.1; 337@0.2; 283@0.4; 263@0.5; 227@1.0; 189@2.0; 117@5.0	

a

$$D_{GITT} = \frac{4}{\pi\tau}\left(\frac{m_B V_m}{M_B S}\right)^2 \left(\frac{\Delta E_S}{\frac{dE_\tau}{d\sqrt{\tau}}}\right)^2 \approx \frac{4}{\pi\tau}\left(\frac{m_B V_m}{M_B S}\right)^2 \left(\frac{\Delta E_S}{\Delta E_\tau}\right)^2$$

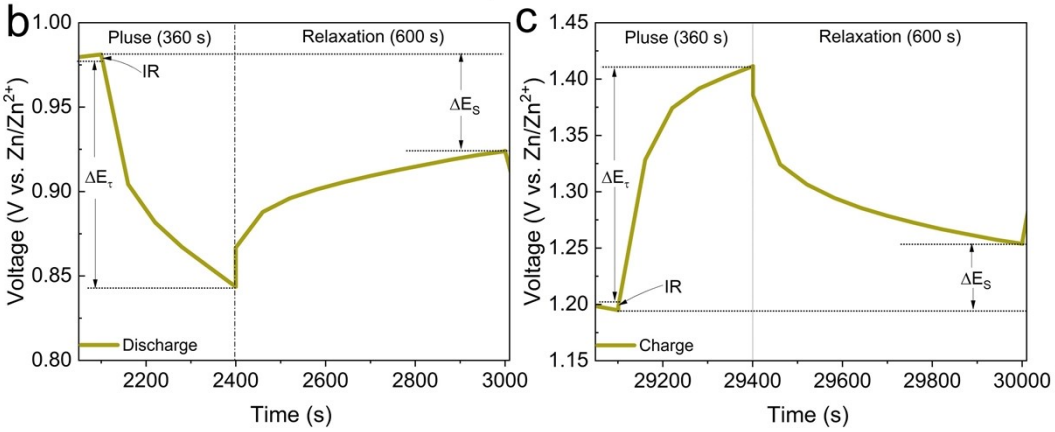

Figure S6. The calculation method for GITT.

Table S2. The parameters for the D_{GITT} calculated based on GITT test.

Materials	**m_B/ g**	**V_m/ cm^3 mol^{-1}**	**M_m/ g mol^{-1}**	**S/ cm^2**	**τ/ s**
NVO	0.0013	260.72	1089.6	1.0	600
NNVO	0.0011	273.75	1095.6	1.0	600

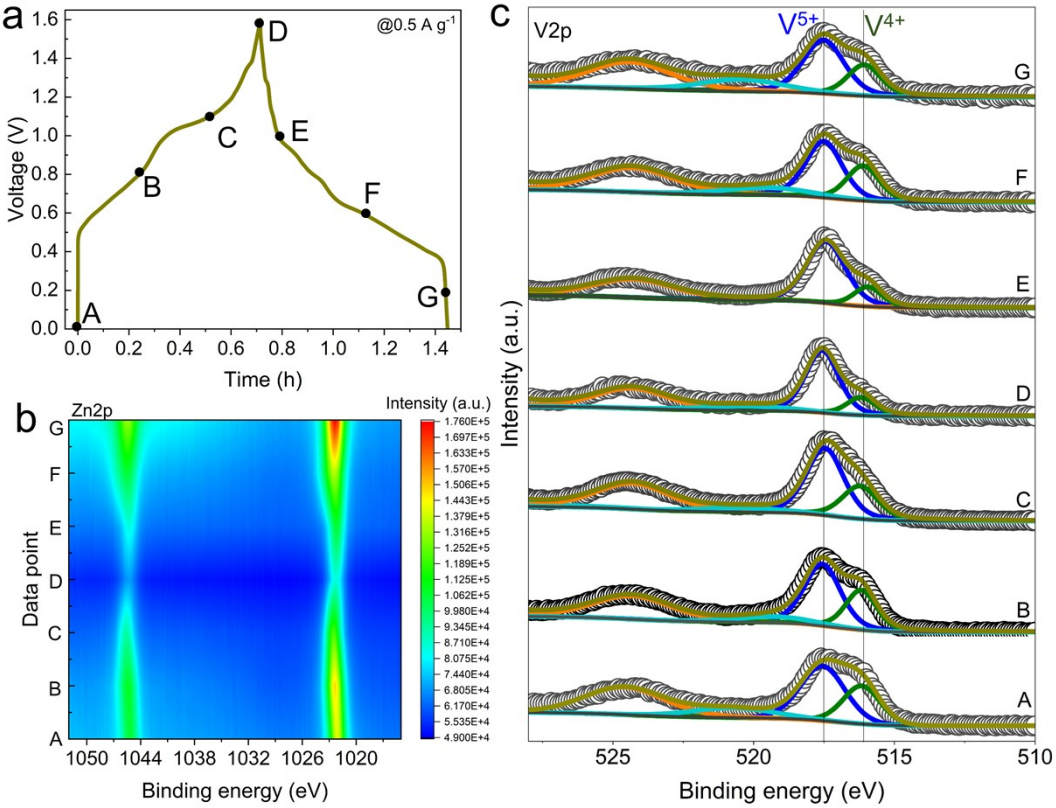

Figure S7. The ex-situ XPS of NNVO electrodes at different states. (a) Data point from GCD curves. (b) Zn2p. (c) V2p

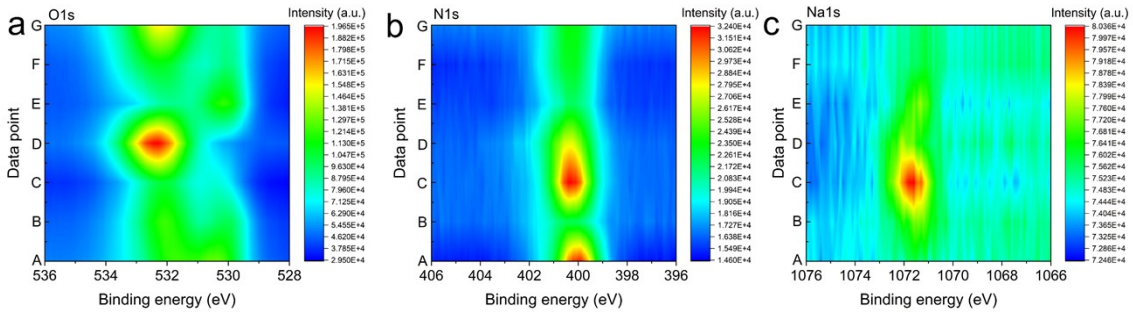

Figure S8. The ex-situ XPS of NNVO electrodes at different states. (a) O1s. (b) N1s. (c) Na1s.

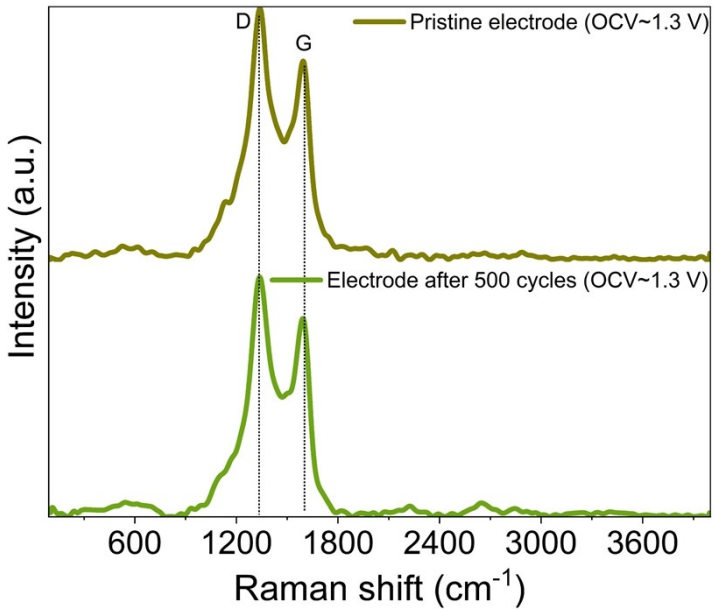

Figure S9. The full Raman spectrums of NNVO electrodes at different states.

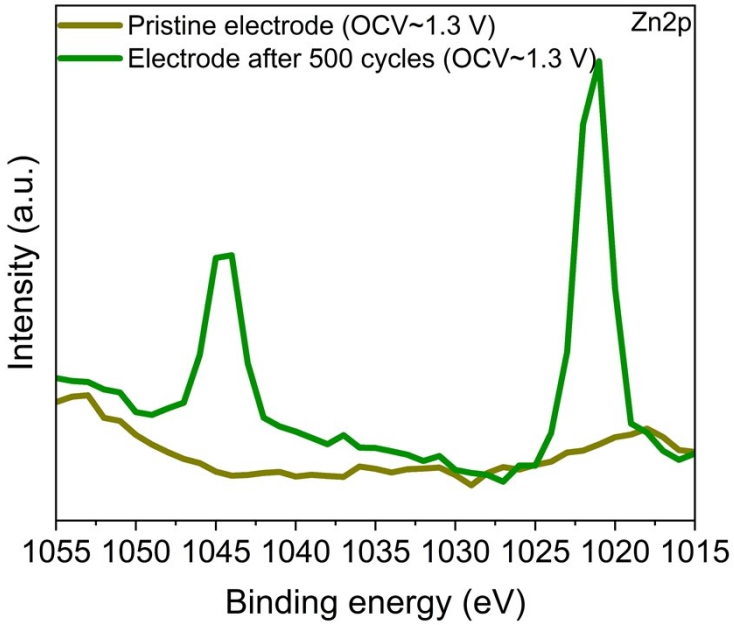

Figure S10. The Zn2p XPS spectrum of NNVO electrodes at different states.