Electronic Supplementary Information

# Layered $VSe_2$: A promising host for fast zinc storage and its working mechanism

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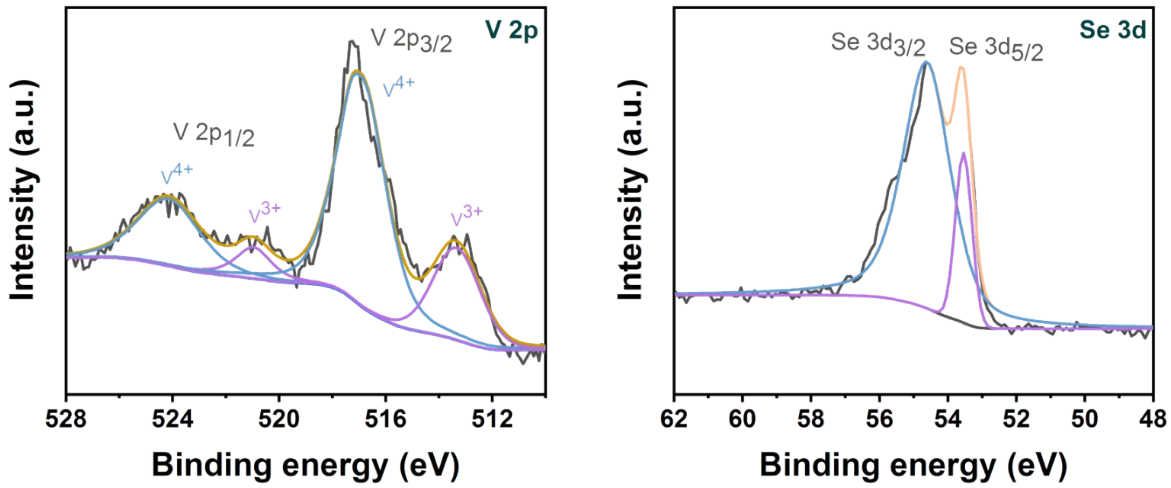


**Figure S1.** (a) High-resolution V 2p and (b) Se 3d XPS spectrum of $VSe_2$.

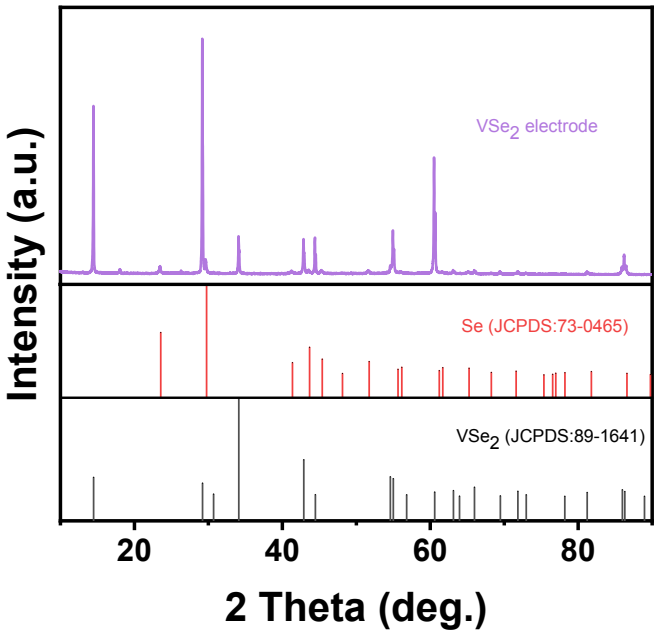


**Figure S2.** The XRD pattern of $VSe_2$ electrode after electrode fabrication.

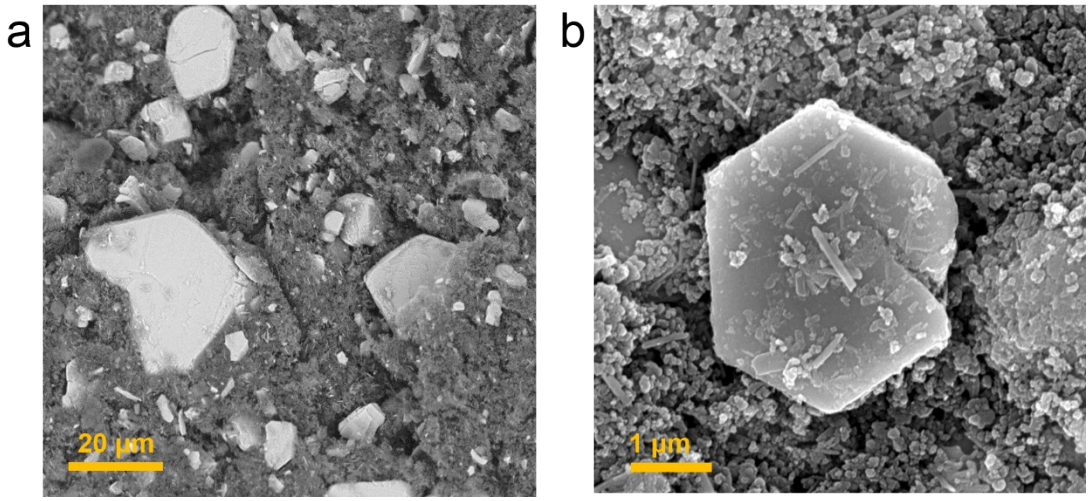


**Figure S3.** The SEM images of $VSe_2$ electrode material after electrode fabrication.

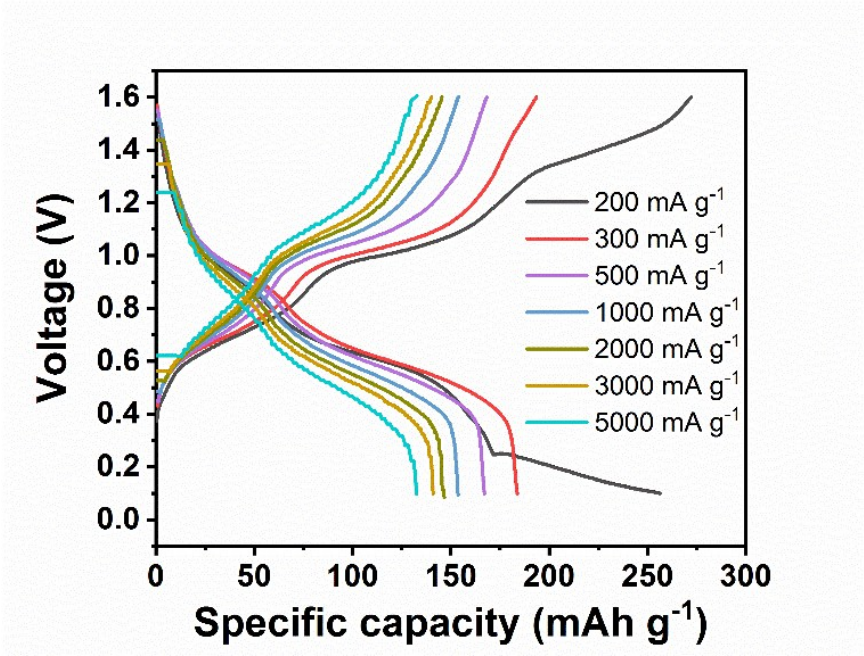


**Figure S4.** The charge/discharge profiles of Zn/$VSe_2$ battery at different current densities.

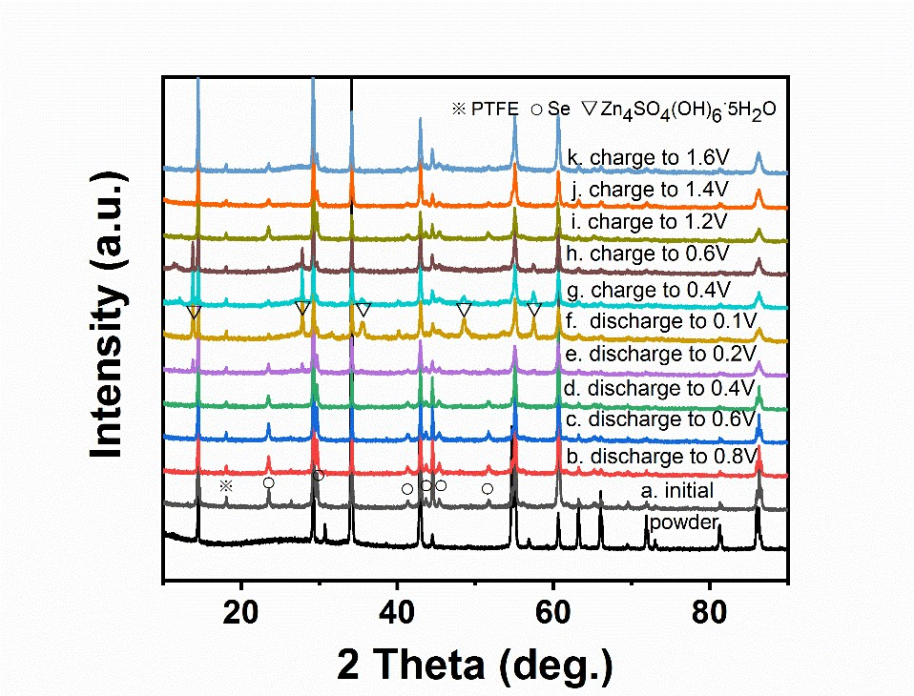


**Figure S5.** Ex situ XRD patterns at different charge/discharge states, in which the diffraction peaks of Se and $Zn_4SO_4(OH)_6•5H_2O$ can be clearly observed.

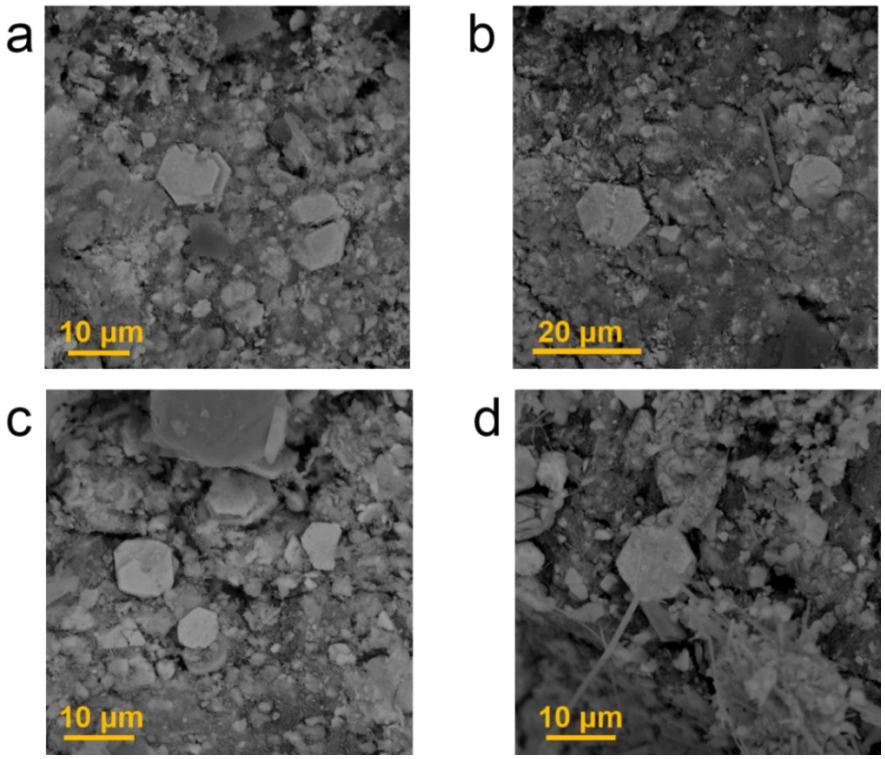


**Figure S6.** The SEM images of $VSe_2$ electrodes (a-b) after 20 cycles (c-d) and 50 cycles.

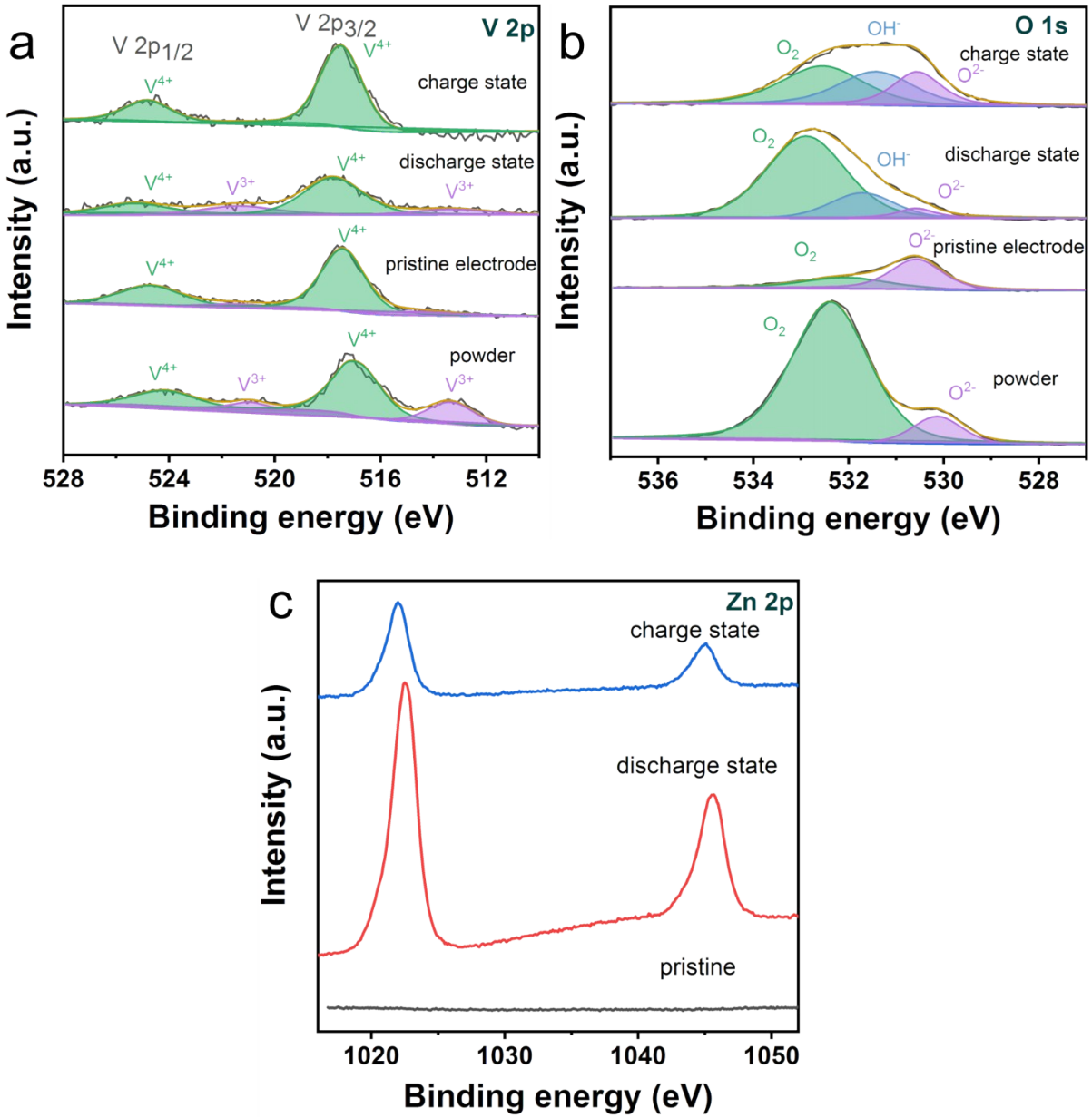


**Figure S7.** (a) V 2p, (b) O 1s and (c) Zn 2p XPS spectra in different states of $VSe_2$.

**Table S1.** Comparison of the Zn ion storage performance of $VSe_2$ and other recently reported Zn-ion battery cathodes.

| Samples | Voltage Window (V) | Electrolyte | Specific capacity | | Cycling performnace | | | Rate performance | | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Current (mA $g^{-1}$) | Capacity (mAh $g^{-1}$) | Current (mA $g^{-1}$) | Cycle number | Capacity retention | Current (mA $g^{-1}$) | Capacity (mAh $g^{-1}$) | |
| BL-$V_2O_5$ | 0.3-1.5 | 0.5M AN-$Zn(TFI)_2$ | 14.4 | 196 | 14.4 | 120 | 87% | 288 | 130 | [1] |
| $V_2O_5$ | 0.4-1.4 | 3M $ZnSO_4$ | 100 | 224 | 2000 | 400 | / | 2000 | 113 | [2] |
| $V_2O_5$ | 0.5-1.5 | 3M $Zn(CF_3SO_3)_2$ | 20 | 319 | 588 | 500 | 81% | 2940 | 104 | [3] |
| $Mg_{0.34}V_2O_5 \cdot nH_2O$ | 0.1-1.8 | 3M $Zn(CF_3SO_3)_2$ | 50 | 353 | 5000 | 2000 | 97% | 5000 | 81 | [4] |
| $VS_2$ | 0.4-1.0 | 1M $ZnSO_4$ | 50 | 190.3 | 500 | 200 | 98% | 2000 | 115.5 | [5] |
| $MoS_2$ | 0.3-1.5 | 2M $ZnSO_4$ | 100 | 202.6 | 1000 | 600 | 98.6 | 4000 | 104.5 | [6] |
| $MoS_2$-O | 0.2-1.4 | 3M $Zn(CF_3SO_3)_2$ | 100 | 232 | 1000 | 2000 | 68% | 1000 | 98 | [7] |
| $MoS_{2-x}$ | 0.25-1.25 | 3M $Zn(CF_3SO_3)_2$ | 100 | 135 | 1000 | 1000 | 87.8% | 2000 | 80.8 | [8] |
| α-$MnO_2$ | 1.0-1.8 | 1M $ZnSO_4$ | 83 | 233 | 83 | 50 | 63% | 1666 | 226 | [9] |
| δ-$MnO_2$ | 1.0-1.8 | 1M $ZnSO_4$ | 83 | 250 | 83 | 100 | 44% | 1666 | 7 | [10] |
| Todorokite-type $MnO_2$ | 0.7-2.0 | 1M $ZnSO_4$ | 50 | 108 | 50 | 50 | 50% | 1000 | 39.6 | [11] |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $MnO_2$@C | 1.0-1.8 | 1M $ZnSO_4$ | 66 | 272 | 66 | 50 | 69% | / | / | [12] |
| $ZnMn_2O_4$ | 0.8-1.9 | 3M $Zn(CF_3SO_3)_2$ | 50 | 150 | 500 | 500 | 94% | / | / | [13] |
| $Zn_3V_2O_7(OH)\cdot 2H_2O$ | 0.2-1.8 | 1M $ZnSO_4$ | 50 | 213 | 200 | 300 | 68% | 3000 | 54 | [14] |
| $Na_3V_2(PO_4)_3$ | 0.8-1.7 | 0.5M $CH_3COONa$ +$Zn(CH_3COO)_2$ | 50 | 93 | 50 | 200 | 77% | 2000 | 60 | [15] |
| This work | 0.1-1.6 | 2M $ZnSO_4$ | 200 | 250.6 | 2000 | 800 | 83% | 5000 | 132.6 | / |

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