Electronic Supplementary Information

Synthesis of cobalt-doped V_2O_3 with hierarchical yolk-shell structure for high-performance lithium-ion batteries

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Characterization materials

The crystal phase of Co-V_2O_3-24 and pure V_2O_3 were investigated by powder X-ray diffraction (PXRD, Bruker D8 advance diffractometer, Cu Kα radiation, λ=0.15405 nm) in the 2θ range of 10~80°. Microscopic morphologies and structure were characterized by field-emission scanning electron microscopy (FESEM, Hitachi S-4800), low-magnification transmission electron microscope (TEM, Hitachi H-600), and high-resolution TEM (HRTEM, JEOL, JEM-2100). The elemental mapping and chemical composition were performed on energy-dispersive X-ray spectroscope (EDX) attached to the FESEM. The elemental valence was detected by X-ray photoelectron spectroscopy (XPS, ESCALAB 250 Xi) from Thermo Fisher Scientific.

Electrochemical measurements

All CR2032 type coin cells were assembled in a glove box filled with argon and containing less than 1 ppm of water and oxygen. The lithium foil was regarded as counter and reference electrode, Celgard 2300 as the separator and 1 M $LiPF_6$ in ethylene carbonate (EC)/ethyl methyl carbonate (EMC)/dimethyl carbonate (DMC) (1:1:1, v:v:v). The working electrode was prepared by full mixing active materials (60 wt %), carbon black (30 wt %) and polyvinylidene fluoride (PVDF, 10 wt %) in N-methyl pyrrolidone (NMP). The homogeneous slurry was coated onto Copper foil and then dried at 80 ^oC in vacuum oven for 12 h. Cyclic voltammetry (CV) curves were tested through electrochemical workstation (CHI660D, Chenhua, China) within the potential range of 0.01~3 V. Galvanostatic charge-discharge cycles were conducted by testing system (Land CT2001A, Wuhan, China) in the voltage range of 0.01~3 V at the room temperature. Electrochemical impedance spectroscopy (EIS) were carried out by using Zahner Elektrik electrochemical workstation within the frequency range of 100 kHz to 0.01 Hz under open circuit voltage.

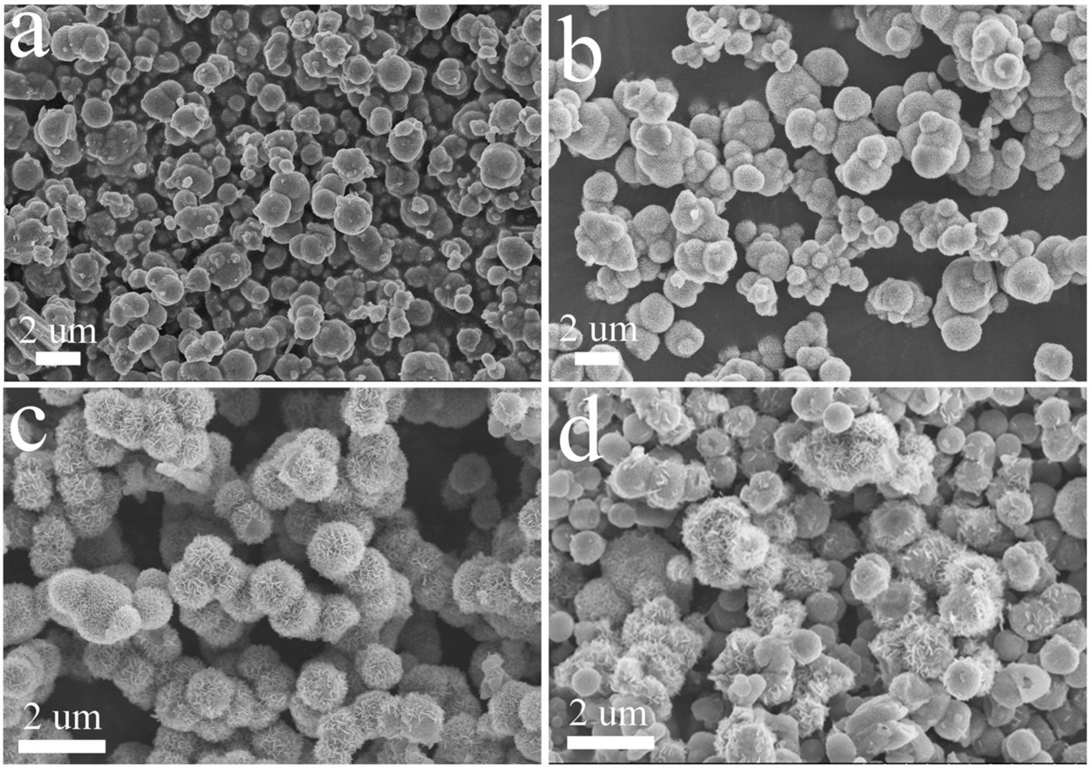


Figure S1. FESEM images with the different doping content of $Co(NO)_3{\cdot}6H_2O$: 0 mmol (a), 0.05 mmol (b), 0.1 mmol (c), 0.15 mmol (d).

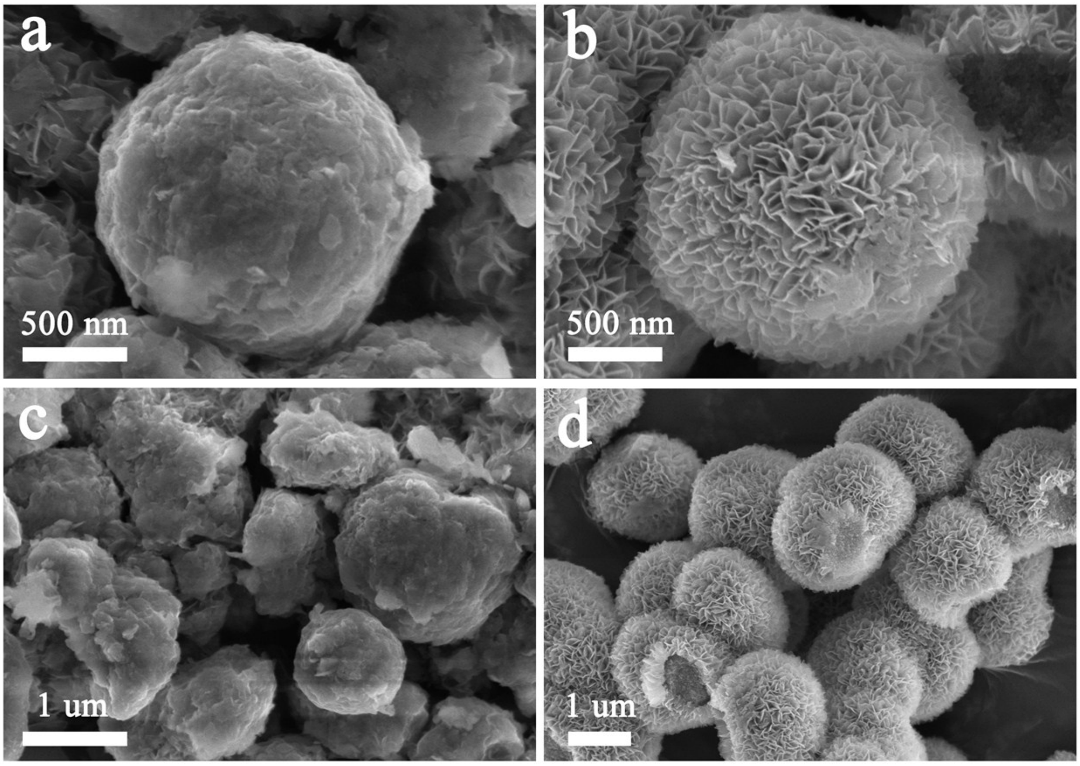


Figure S2. The effects of different metal salts on the morphology of products. (a, c) 0.1 mmol $Co(CH_3COO)_2{\cdot}4H_2O$; (b, d) 0.1 mmol $Ni(NO_3)_2{\cdot}6H_2O$.

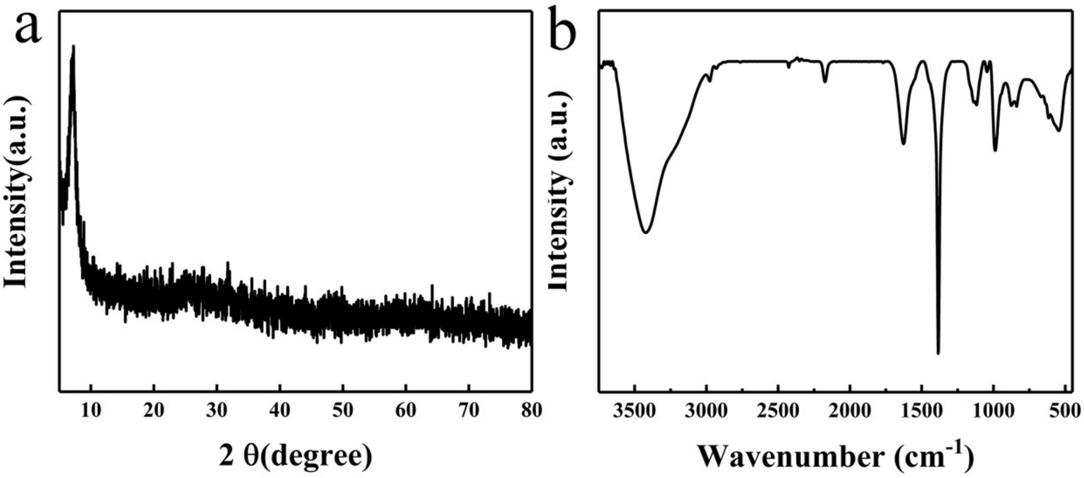
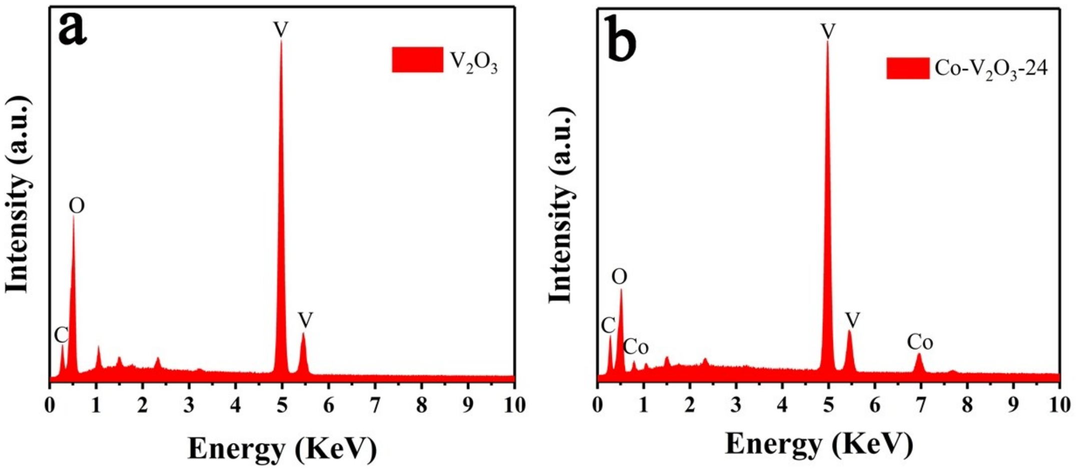


Figure S3. The XRD pattern (a) and FTIR (b) of Co-doped vanadium alkoxide precursors after solvothermal for 24 h.



c *Element*	*At% (V_2O_3)*	*At% (Co-V_2O_3-24)*
CK	09.03	10.91
OK	68.95	59.03
VK	22.02	26.85
CoK	0	03.28

Figure S4. EDS spectra of V_2O_3 (a) and Co-V_2O_3-24 (b), atomic percentage of V_2O_3 and Co-V_2O_3-24 (c).

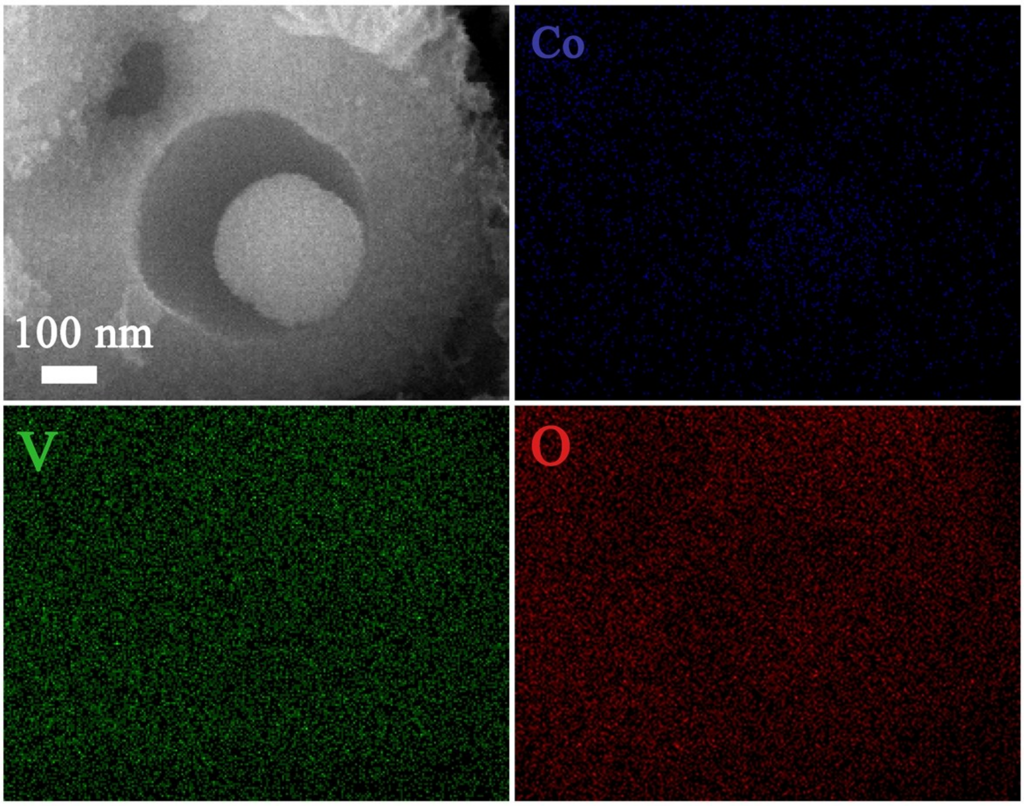


Figure S5. EDX mapping images of broken Co-V2O3-24

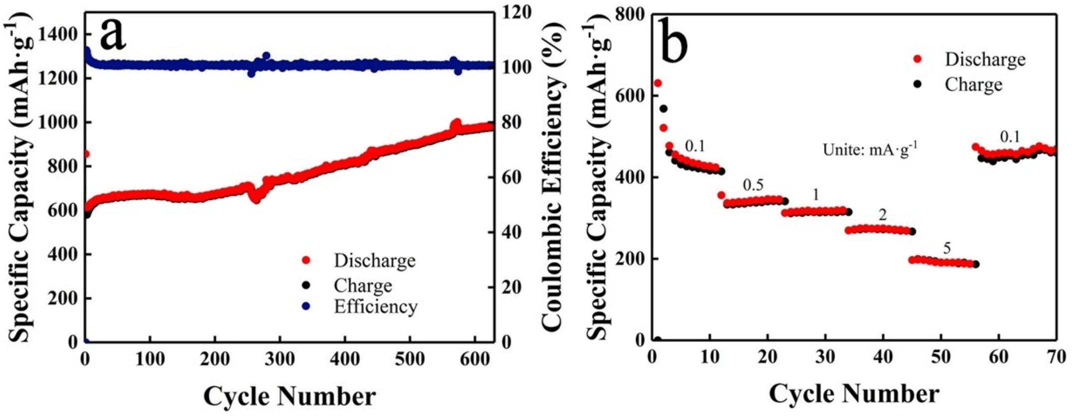


Figure S6. (a) The cycling performance and coulombic efficiency of Co-V_2O_3-24 at 0.5 A·g^{-1}. (b) Rate performance of pure V_2O_3.

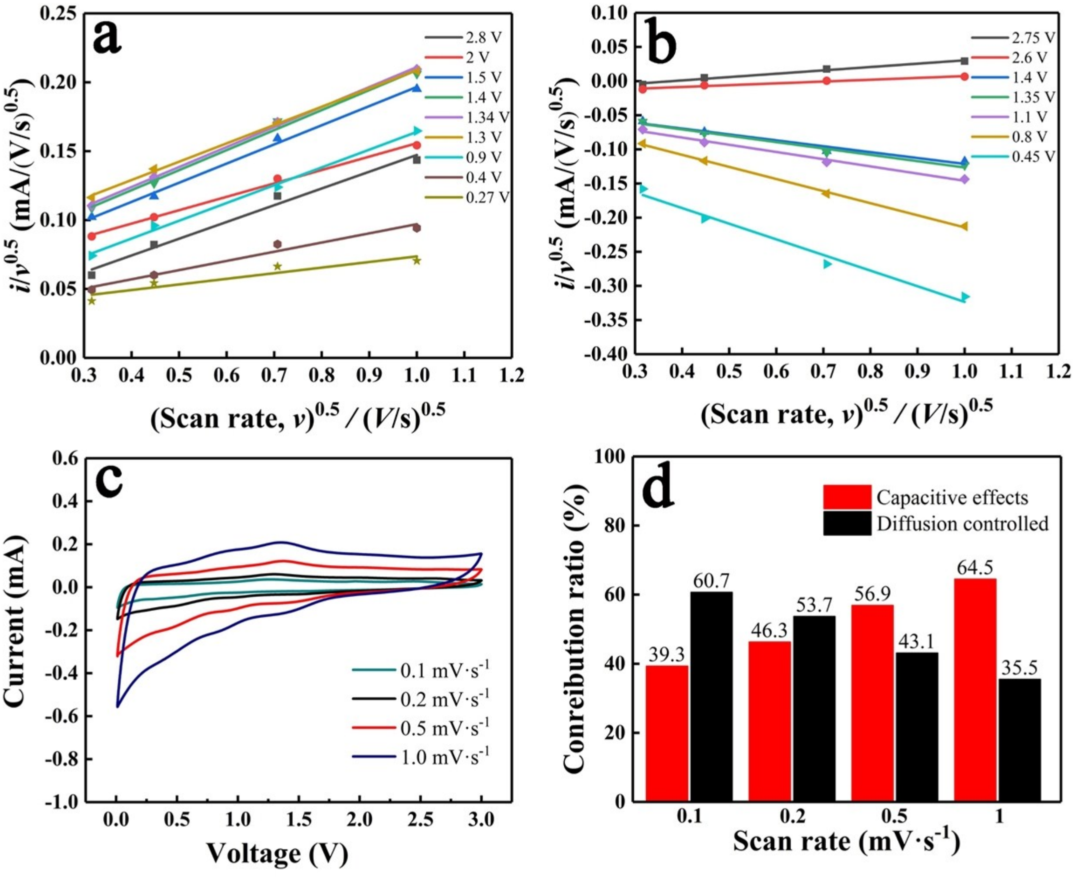


Figure S7. The lines of $i/v^{0.5}$ vs. $v^{0.5}$ used to evaluate k_1 and k_2 at various potentials (a, b). CV cures of Co-V_2O_3-24 at various scan rate (c). Contribution ratio of the capacitive effect and diffusion-controlled at different scan rates (d).

Table S1. The value of R_S and R_{ct} after fitting with equivalent circuit

Electrode	**$R_s(\Omega)$**	**$R_{ct}(\Omega)$**
Pure V_2O_3 before cycling	1.7	324.4
Co-V_2O_3-24 before cycling	2.5	263.3
Co-V_2O_3-24 after 200 cycles	1.9	198.5
Co-V_2O_3-24 after 2200 cycles	10.13	252.1

Table S2. Comparison between other reports and our work of vanadium oxide as anode materials for LIBs

Vanadium oxide anode	Current density ($A\cdot g^{-1}$)	Discharge capacity ($mAh\cdot g^{-1}$)	Reference
Porous vanadium oxides@C heterostructure	0.1	569 (after 105 cycles)	1
Peapod-like CNT@V_2O_3	0.5	652.4 (after 200 cycles)	2
Carbon-Coated Yolk−Shell V_2O_3 Microspheres	0.1	437.5 (after 100 cycles)	3
Carbon-supported and nanosheet-assembled vanadium oxide microspheres	2	260 (after 7000 cycles)	4
pea-pod structured V_2O_3 yolk-shell microspheres @N, S co-doped carbon fiber	0.1	793.7 (after 100 cycles)	5
Porous V_2O_3@C hollow spheres	2	583 (after 800 cycles)	6
Hierarchical porous intercalation-type V_2O_3	0.1	732 (after 136 cycles)	7
Carbon-confined V_2O_3 hollow spheres	2	472 (after 700 cycles)	8
V_2O_3/porous N-doped carbon	0.5	436 (after 200 cycles)	9
3D hierarchical yolk-shell structure Co-V_2O_3-24	0.5	986.2 (after 630 cycles)	This work

Notes and references

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