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Supporting Information

Design and Fabricate Co₃V₂O₈ Nanotubes by Electrospinning as

High-Performance Anode for Lithium-Ion Batteries

Zhongzheng Qin, Jian Pei, * Gang Chen, * Dahong Chen, Yongyuan Hu, Chade Lv, Changfeng Bie

MIIT Key Laboratory of Critical Materials Technology for New Energy Conversion and Storage,
School of Chemistry and Chemical Engineering, Harbin Institute of Technology,
Harbin, 150001, P. R. China.
E-mail: peijian008@163.com; gchen@hit.edu.cn; Fax: +86-0451-86403117;
Tel: + 86-0451-86403117



Fig. S1 FESEM images of the PVP-M fibers (a). FESEM images (b, c), TEM images (d, e), and XRD pattern (f) of the CVO-NWs by sintering the PVP-M fibers at 500 °C.



Fig. S2 FESEM images of the PAN-M fibers (a), and the CVO-NWs (b) by sintering the PAN-M fibers at 500 $^{\circ}$ C.



Fig. S3 FTIR spectrum of the PAN/PVP-M fibers after sintered in different temperature.

The absorption peak observed at 1660 cm⁻¹ is assigned to the stretching vibration of C=N from the decomposed product of PAN sintered at 400 °C. When the temperature increases to 450 °C, the absorption peak at 2925 cm⁻¹ still appears, which suggests the product contains organic components. When the temperature increases to 500 °C, no noticeable absorption peak of organics, such as C-N, C=N, and C-H, can be found in the FTIR spectrum, Indicating the complete decomposition of organics.

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Fig. S4 TGA curve of the PAN/PVP-M fibers in air between 25 and 700 °C with a heating rate of 10 °C min⁻¹.

The TGA curve can be divided into five steps. The 3.3% weight loss at initial step (25-120 °C) is attributed to the evaporation of absorbed water and remaining solvent (DMF).¹ The 21.4% weight loss at the 2nd step (120-260 °C) corresponds to the decomposition of inorganic salts and initiatory degradation of PVP and PAN.² By further increasing temperature to 425 °C (3rd step), the weight loss increases to 64.5%, in which PVP can completely be degraded and $Co_3V_2O_8$ is formed.³ However, PAN still can not complete decomposition at this temperature, which corresponds to the result of FTIR spectrum in ESI (Fig. S3). The TGA curve suggests that PAN decomposes thoroughly at the 4th step (425-489.81 °C) and the weight loss keeps stability after 489.81 °C. Thus, it is capable of obtaining high pure $Co_3V_2O_8$ by calcinating PAN/PVP-M fibers at 500 °C in air.



Fig. S5 FESEM images of the PAN/PVP-M fibers after sintered in different temperature with a heating rate of 1 °C min⁻¹: (a) 400 °C, (b) 450 °C, (c) 550 °C, (d) 600 °C.



Fig. S6 FESEM images of the PAN/PVP-M fibers after sintered in 500 °C with different heating rates: (a, b) 2 °C min⁻¹, (c, d) 3 °C min⁻¹, (e, f) 5 °C min⁻¹.

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Fig. S7 Energy-dispersive X-ray spectroscopy (EDX) pattern of the CVO-NTs.



Fig. S8 XRD pattern of CVO-MPs by sintering the PAN/PVP-M fibers at 600 °C.



Fig. S9 N_2 adsorption and desorption isotherms of CVO-NTs. Insets are the corresponding pore size distributions.



Fig. S10 Electrochemical performances of the CVO-NWs electrodes: (a) Cyclic voltammetry curves of the initial 4 cycles scanned at the rate of 0.2 mV s⁻¹, (b) the discharge-charge curves for the 1st, 2nd, 30th, 50th and 100th cycles at a current density of 100 mA g^{-1} from 0.02 to 3 V.

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Fig. S11 Electrochemical performances of the CVO-MPs electrodes: (a) Cyclic voltammetry curves of the initial 4 cycles scanned at the rate of 0.2 mV s⁻¹, (b) the discharge-charge curves at different cycles, (c) rate performances at the current densities from 100 to 5000 mA g⁻¹, (d, e) longlife cycling performances at different current density.

Cobalt-vanadium material	Current density [mA g ⁻¹]	Cyclability [mAh g ⁻¹]
morphologies		
$Co_3V_2O_8$ nanotubes (this work)	5,000	630 after 1100 cycles
$Co_3V_2O_8$ interconnected hollow	5,000	~600 after 300 cycles
microsphere ⁴	10,000	424 after 300 cycles
Co ₃ V ₂ O ₈ multilayered nanosheets ⁵	5,000	470 after 500 cycles
$Co_3V_2O_8$ · nH ₂ O hollow hexagonal	2,000	502 at 270th cycle after
hrismatic hencils ⁶		the rate rest
porous $Co_3V_2O_8$ microspheres ⁷	5,000	650 after 400 cycles
$Co_2V_2O_7$ hierarchical nanosheets ⁸	5,000	441 after 900 cycles
$Co_2V_2O_7$ hexagonal microplatelets ⁹	2,000	520 after 580 cycles

Table	S1 .	Comparison	of	cyclability	performance	at	high	current	density	of	various
cobalt	vana	dium based a	node	e for LIBs.							

 Table S2. The simulated results from EIS of the CVO-NTs, CVO-NWs and CVO-MPs electrodes.

Fresh cell	Re (Ω)	R _{ct} (Ω)
CVO-NTs	1.29	115.8
CVO-NWs	1.54	214.9
CVO-MPs	2.79	423.7



Fig. S12 Ex situ SEM images of the CVO-NTs electrode after different cycles at the current density of 1000 mA g^{-1} .(a, b) 50 cycles, (c, d) 200 cycles.

Notes and references

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