Electronic Supplementary Information

Synthesis of One-dimensional NiFe₂O₄ Nanostructures: Tunable Morphology and High-Performance Anode Materials for Li Ion Batteries

Jianan Wang, Guorui Yang *, Ling Wang, Wei Yan *

Department of Environmental Science and Engineering, State Key Laboratory of Multiphase Flow in

Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China

* Corresponding authors:

E-mail: <u>yanwei@mail.xjtu.edu.cn</u> (W. Yan); <u>yangguorui@mail.xjtu.edu.cn</u> (G. Yang)

Fax: +86-29-82664731.



Fig. S1. EDS spectrums of sample (a) NP, (b) NYS and (c) NT.



Fig. S2. FT-IR spectra of various samples: PVP, as-spun fibers, NYS and NT.

Fig. S2 shows the Fourier transform infrared spectra (FTIR) of PVP, as-spun fibers, NYS and NT. The peaks at 1662, 1497, 1291, 1169, 1024 and 849 cm⁻¹ corresponded well to PVP molecules.^{1,2} For the as-spun precursor fibers, although most of the PVP characteristic peak were weakened greatly, there were two obvious peaks located at 1386 and 1662 cm⁻¹, which were assigned to the N–O stretching vibration from the Fe(NO₃)₃³ and C=O stretching vibration from PVP¹, respectively. After calcination at 550 °C for 2h, both the two peaks diminished but still existed, certifying the existence of residual organic species and metallic precursor salts in NYS nanofibers. Through the further hydraulic agitation, these small peaks standing for the residual matters disappeared with the removal of the amorphous core in NT.



Fig. S3. Thermogravimetric analysis (TGA) of NiFe₂O₄ precursor fibers from 30 °C to 700 °C.

(I). 30 °C \sim 270 °C: Evaporation of moistures and the organic solvent in the metallic precursor including crystal water, acetic acid and methyl alcohol.

(II). 270 °C ~ 330 °C: The main decomposition of PVP chains.⁴

(III). 330 °C \sim 550 °C: The oxidation decomposition of residual partial organic materials in the core of fibers.

(IV).550 °C \sim 700 °C: the resulting products residues.



Fig. S4. X-ray diffraction patterns of (a) $CoFe_2O_4$, (b) $ZnFe_2O_4$, (c) $CdFe_2O_4$ and (d) α -Fe₂O₃ onedimensional hollow nanostructures synthesized by electrospinning-hydraulic agitation method.



Fig. S5. Electrochemical impedance spectra (Nyquist plots) of NT products at open circuit voltage and discharged state after various discharge–charge cycles; the inset in the upper left is the equivalent electrical circuit model

The resistances of NT products after various discharge–charge cycles (fresh cell, 30^{th} cycle and 80^{th} cycle) were analyzed by electrochemical impedance spectroscopy (EIS) in Fig S5. The Nyquist plots of all the products exhibited similar shapes with a semicircle at high frequency and an inclined line at low frequency. According to the EIS results, the equivalent electrical circuit model was made in the upper left Fig S5, similar to the previos reports.^{5, 6} The components of the equivalent circuit include: *Rs* is the combination of electrolyte resistance and ohmic resistances of cell components; *Rf* is represented for the film resistance; *Rct* is represented for charge-transfer resistance. The lower *Rct*, the faster kinetic of the faradic reactions; *QPE1*, *QPE2*, and *Zw* are the capacitance of the interface layers formed on the electrode surfaces, double layer capacitance, and the Warburg impedance, respectively. Among them, the *Rf* of fresh cell, 30^{th} cycle and 80^{th} cycle were calculated to be 585.6, 335.8 and 167.0 ohm, respectively. The gradual drop of the film resistance suggested that the formed SEI layers have tended to be stable with increased cycle times. Furthermore, the transfer resistances (*Rct*) of fresh cell, 30^{th} cycle and 80^{th} cycle ohm, respectively, which is in good agreement with the cycling performance of NT that the capacity faded first and recovered after few cycles.



Fig. S6. SEM images of NT electrode before cycling at (a) lower magnification and (b) higher magnification; SEM images of cycled NT electrode (after 80 charge–discharge cycles) at (c) lower magnification and (d) higher magnification (inset shows the cycled single nanotube in enlarged scale).

Sample	Elements (Atomic %)			
	Fe	Ni	О	С
NP	14.88	6.90	47.31	30.91
NYS	15.37	6.33	45.40	32.90
NT	16.28	8.17	46.18	29.36

Table S1. Chemical composition of the samples calculated from high resolution XPS spectra

Table S2. Metal ions compositions of the samples from ICP-AES data

Sampla	Elements (mg/L)		
Sample	Ni	Fe	
NYS	10.6	19.0	
NT	10.8	19.2	
Mixing solution	0. 198	0.118	
Ultrapure water	-	-	

*The concentration of every sample for ICP-AES measurement is 50 mg/L.

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