Supporting Information
Fabrication and pseudocapacity behavior of elm flower branch-like nickel@graphene fibers

Borong Yu\(^1\), Hui He\(^2\), Yongxing Lin\(^2\)*, Xin Ding\(^2\), Xingyou Tian\(^2\)*, Xianglan Liu\(^2\)

\(^1\) School of physics and Material Sciences, Anhui University, Hefei 230601, P. R. China.
\(^2\) Key Laboratory of Materials Physics, Anhui Key Laboratory of Nanomaterials and Nanotechnology, Institute of Solid State Physics, Chinese Academy of Sciences, Hefei 230031, P. R. China

* Corresponding authors. Tel.: +86 551 65592752; fax: +86 551 65591434. E-mail addresses: yxlin@issp.ac.cn (YX Lin), xytian@issp.ac.cn (XY Tian).
\(^\ddagger\) The authors contribute equally to this work

Part I: Experimental Section

1.1 Preparation of PAN nanofibers by electrospinning

10 wt.% PAN solution was prepared by mixing with polyacrylonitrile (PAN) in N,N-dimethylformamide (DMF, CP). A variable high-voltage power supply was used to provide high voltage of approximately 17 kV for electrospinning. The positive electrode of the high-voltage power supply was connected to the needle tip with 1 mm in diameter. The flow rate and tip-collector distance was 160 µL/h and 20 cm, respectively. The grounded electrode was connected to a metallic collector wrapped with aluminum foil.

1.2 Preparation of Elm flower branch-like nickel@graphene fiber

Elm flower branch-like nickel@graphene fiber (ENGF) was synthesized via solvothermal reaction followed by annealing. The precursor solution was prepared by mixing 0.7 g of Ni(NO\(_3\))\(_2\)·6H\(_2\)O and 0.2 g of urea with 40 mL of ethanol. Electrospinning PAN
nanofibers (~30 mg) were then placed in the preceding solution, and the mixture was transferred into a Teflon-lined autoclave with a capacity of 100 mL. The solvothermal reaction time and reaction temperature were set for 15 h and at 170 °C, respectively.

After the solvothermal reaction, the fiber-like product was rinsed with deionized water and dried at 60 °C for 12 h. The dried nanofibers were completely immersed into 1 wt.% PMMA solution (DMF) for 2 h, picked out, and dried at 70 °C for 24 h. Thenthe fibers coated with PMMA were annealed at 900 °C in Ar (5% H2) atmosphere for 3 min. Nickel@graphene structural fiber was thus obtained.

1.3 Characterization

The samples were characterized by field-emission scanning electron microscopy (FESEM; Sirion 200), TEM (EM-200CX), and X-ray diffraction (XRD; Philips X’Pert) using Cu-Kα radiation. Raman spectra were performed with an Intelligent Fourier transform infrared–Raman spectroscopy (NEXUS). The specific surface area was examined by N2 adsorption–desorption (Quantachrome Autosorb 3B).

The electrochemical measurements were carried out in a three-electrode system with 1 M KOH solution as the electrolyte at room temperature on an electrochemical working station (IM6 & Zennium, Zahner, Germany). A working electrode was constructed by pressing the prepared electrode materials onto nickel foam (0.5 cm × 1.0 cm) under 10 MPa. The electrode materials containing poly(vinylidene fluoride) (PVDF) as a binder, and the mass ratio of the prepared composites to PVDF was 8:1. Typical weight of the active materials of each sample was controlled within 2.0 ± 0.2 mg. A Pt foil and an Ag/AgCl electrode served as counter and reference electrodes, respectively. Cyclic voltammetry (CV) and galvanostatic charge–
discharge were performed to evaluate the electrochemical behavior of the mesoporous
graphitic carbon/nickel nanoparticle composites.

Fig. S1 SEM images of the first group of as-prepared products after PAN nanofibers were dealt with solvothermal reaction at 100 °C for 15 h (A) and 130 °C for 15 h (B).

Fig. S2 FESEM images of the second group of as-prepared products after PAN nanofibers were dealt with solvothermal reaction at 170 °C for 3 h (A), 170 °C for 7 h (B), and 170 °C for 12 h (C).
Fig. S3 CV curves of nickel foam at a scan rate of 5 mV/s within a potential window of 0.0 V to 0.6 V vs. SCE in 1.0 M KOH aqueous solution.

Fig. S4 Discharge curves of nickel@graphene structural fibers at different current densities (A) and the specific capacitance as a function of the current densities (B).
Part III: Calculations

The mass-specific capacitance was calculated from the galvanostatic discharge curves using an equation as below:

\[
C = \frac{I \times \Delta t}{\Delta V \times m}
\]  

where \( I \) was the discharge current (A), \( \Delta t \) was the time spent in discharge (s), \( \Delta V \) was the potential drop during discharge (V), and \( m \) was the mass of active electrode materials (g).

The specific capacitance of the electrodes could also be calculated from the CV curves according to the following equation:

\[
C = \frac{Q}{m \Delta V}
\]  

where \( Q \) (C) was the average charge during the charging and discharging processes, \( m \) (g) was the mass of the active materials in the electrodes, and \( \Delta V \) (V) was the potential window.
Notes and references

1 The analysis of XRD pattern is based on JCPDS card: 10-2279 and the results of the following literature:


2 The preparation of A-ENGF: A certain amount (20 mg) of ENGF was put into 50 ml nitric acid (Vacid:Vwat=1:4) in 100ml Teflon-lined autoclave. The solvothermal reaction time and reaction temperature were set for 10 h and at 60 °C, respectively. After the solvothermal reaction, the product was washed with deionized water until neutral, and dried.
