Supporting Information

Hierarchical mesoporous NiFe$_2$O$_4$ nanocone forest directly growing on carbon textile for high performance flexible supercapacitors

Muhammad Sufyan Javed$^{1,2}$, Cuilin Zhang$^1$, Lin Chen$^1$, Yi Xi$^1$, Chengu Hu$^1$*

$^1$Department of Applied Physics, Chongqing University, Chongqing 400044, P. R. China

$^2$Department of Physics, COMSATS Institute of Information Technology Lahore 54000, Pakistan

*Corresponding author. Tel: +86 23 65670880; Fax: +86 23 65678362

E-mail address hucg@cqu.edu.cn (CG Hu)
1. **Figure S1.** Optical photographs of carbon textile and supercapacitors. (A) Pristine carbon textile, (B) NFO assembled carbon textile after annealing at 350 °C for 2h, (C) As-prepared single electrode and (D) As-fabricated solid state supercapacitors.

2. **Figure S2.** SEM images of NFO precursor and after annealing process at different magnifications. (A) NFO nanocone forest precursor, (B) SEM image of NFO after heat treatment, (C) Selected part from Figure B, (D) high resolution SEM of image of NFO nanocone forest.

3. **Figure S3.** (A) N₂ adsorption–desorption isotherm, (B) BJH adsorption pore size distribution of NiFe₂O₄ nanocone forest.

4. **Figure S4.** Electrochemical performances of the NiFe₂O₄ nanoforest single electrode in 6 M of LiCl aqueous electrolyte. (A) CV curves at different scan rates ranging from 5 to 100 mVs⁻¹ in potential window of -0.2 to 0.7 V, (B) Specific capacitance as a function of scan rate.

5. **Figure S5.** XRD pattern of the electrode before and after 50 cycles at charging state at room temperature. The peaks for the electrode after 50 cycles are in agreement with standard values of Carbon textile (CT), Li₂O, Ni and Fe from JCPDS cards (Graphite: 752078; Li₂O: 772144; Ni: 882326; Fe: 870722).

6. **Figure S6.** Electrochemical performances of the NiFe₂O₄ nanoforest single electrode in 6 M of LiCl aqueous electrolyte. (A) Charging-discharging curves taken at different current densities ranging from 1 to 6 A/g in potential window of 0 to 0.45 V, (B) Nyquist plot of impedance from 0.01 to 100 kHz at open circuit potential.

7. **Figure S7.** The comparison of CV curves of bare CT based supercapacitor and NiFe₂O₄ assembled CT based supercapacitor at scan rate of 50 mV s⁻¹.

8. **Figure S8.** (A) Low resolution SEM image of the NiFe₂O₄ nanocone forest after 10,000 cycles (inset arrow shows the layer of gel electrolyte), (B) high resolution SEM image.

9. **Calculation details**
Figure S1. Optical photographs of carbon textile and supercapacitors. (A) Pristine carbon textile, (B) NiFe$_2$O$_4$ assembled carbon textile after annealing at 350 °C for 2h, (C) As-prepared single electrode, (D) Optical photographs of as-fabricated solid state supercapacitors.
2. Figure S2

Figure S2. SEM images of NFO precursor and after annealing process at different magnifications. (A) NFO nanocone forest precursor, (B) SEM image of NFO after heat treatment, (C) Selected part from Figure B, (D) high resolution SEM of image of NFO nanocone forest.
Figure S3: (A) N2 adsorption–desorption isotherm, (B) BJH adsorption pore size distribution of NiFe$_2$O$_4$ nanocone forest.
Figure S4. Electrochemical performances of the NiFe$_2$O$_4$ nanoforest single electrode in 6 M of LiCl aqueous electrolyte. (A) CV curves at different scan rates ranging from 5 to 100 mVs$^{-1}$ in potential window of -0.2 to 0.7 V, (B) Specific capacitance as a function of scan rate.
Figure S5. XRD pattern of the electrode before and after 50 cycles at charging state at room temperature. The peaks for the electrode after 50 cycles are in agreement with standard values of Carbon textile (CT), Li$_2$O, Ni and Fe from JCPDS cards (Graphite: 752078; Li$_2$O: 772144; Ni: 882326; Fe: 870722). In the same time, we also found the shift of the peaks of NiFe$_2$O$_4$, which means the deformation of the crystal structure of the NiFe$_2$O$_4$. The further investigation will be also very interesting and we are planning to carry out in the recent future.
Figure S6. Electrochemical performances of the NiFe$_2$O$_4$ nanoforest single electrode in 6 M of LiCl aqueous electrolyte. (A) Charging-discharging curves taken at different current densities ranging from 1 to 6 A/g in potential window of 0 to 0.45 V, (B) Nyquist plot of impedance from 0.01 to 100 kHz at open circuit potential.
Figure S7: The comparison of CV curves of bare CT based supercapacitor and NiFe$_2$O$_4$ assembled CT based supercapacitor at scan rate of 50 mV s$^{-1}$. 
Figure S8. (A) Low resolution SEM image of the NiFe$_2$O$_4$ nanocone forest after 10,000 cycles (the arrow shows the layer of gel electrolyte), (B) high resolution SEM image.
9. Calculation details

The specific capacitance \( C_{sp} \), energy density (ED) and power density (PD) of single electrode and solid state supercapacitor were calculated according to the following equations.\(^{1-4}\)

\[
C_{sp} = \frac{\int I(A)dV}{M \nu (V_f - V_i)}
\]  
(1)

\[
E = CV^2 \times \left( \frac{5}{36} \right)
\]  
(2)

\[
P = \frac{E}{t_d} = \frac{1}{2M} \times 1000 \Delta V
\]  
(3)

Where \( C_{sp} \) (F g\(^{-1}\)) is the specific capacitance; \( \int I(A)dV \) is the area of CV curve; \( A \) is the active area of supercapacitor; \( M \) (g) is the mass of active material on one electrode; \( \Delta V = V_f - V_i \) is the potential window; \( \nu \) (Vs\(^{-1}\)) is the scan rate; \( I \) (A) is the applied current; \( P \) (W kg\(^{-1}\)) is the power density; \( E \) (Wh kg\(^{-1}\)) is the energy density; \( t_d \) is charging time (s), respectively.