Supporting Information

Enhanced cycling stability of hierarchical NiCo$_2$S$_4$@Ni(OH)$_2$@PPy core-cell nanotube arrays for aqueous asymmetric supercapacitors

Miaomiao Liang, a Mingshu Zhao*, Haiyang Wang, Junfang Shen and Xiaoping Song*

*aSchool of science, MOE Key Laboratory for Non-Equilibrium Synthesis and Modulation of Condensed Matter, Key Laboratory of Shaanxi for Advanced Functional Materials and Mesoscopic Physics, State Key Laboratory for Mechanical Behavior of Materials, Xi'an Jiaotong University, Xi'an 710049, PR China.

* Corresponding author: E-Mail: zhaomshu@xjtu.edu.cn;

Tel: +86-13186193932.
Fig. S1 XRD patterns for NiCo$_2$S$_4$ and NiCo$_2$S$_4$@Ni(OH)$_2$@PPy powders that are scraped from nickel foam, respectively.
Fig. S2 SEM images of Ni-Co precursor with different magnifications.

Fig. S3 The cross-sectional SEM image of NiCo$_2$S$_4$@Ni(OH)$_2$@PPy
Fig. S4 CV and GCD curves of (a), (b) NiCo$_2$S$_4$, (c), (d) NiCo$_2$S$_4$@Ni(OH)$_2$ and (e), (f) NiCo$_2$S$_4$@PPy electrodes at varied scanning rates and current densities respectively.
Fig. S5 Cycling properties of NiCo$_2$S$_4$, NiCo$_2$S$_4$@Ni(OH)$_2$, NiCo$_2$S$_4$@PPy and NiCo$_2$S$_4$@Ni(OH)$_2$@PPy electrodes at current density of 60 mA cm$^{-2}$ for 3000 cycles; the inset figures show the GCD curves of the last 10 cycles of the electrodes.
Fig. S6 XRD pattern of cycled NiCo$_2$S$_4$@Ni(OH)$_2$@PPy electrode.
Fig. S7 The SEM images of (a) NiCo$_2$S$_4$, (b) NiCo$_2$S$_4$@Ni(OH)$_2$, (c) NiCo$_2$S$_4$@PPy and (d) NiCo$_2$S$_4$@Ni(OH)$_2$@PPy electrode respectively after cycling for 3000 cycles.
Fig. S8 Plots of log(peak current) versus log(sweep rate) at E=0.3V

Fig. S9 (a) CV curves of active carbon at varied scan rates from 2-50 mV s\(^{-1}\), (b) GCD plots at various current densities.
Fig. S10 (a) CV curves at different potential windows, (b) CV curves at different scan rates and (c) GCD curves at varied current densities for NiCo$_2$S$_4$/AC asymmetric supercapacitors; (d) CV curves at different potential windows, (e) CV curves at different scan rates and (f) GCD curves at varied current densities for NiCo$_2$S$_4$@Ni(OH)$_2$/AC asymmetric supercapacitors; (g) CV curves at different potential windows, (h) CV curves at different scan rates and (i) GCD curves at varied current densities for NiCo$_2$S$_4$@PPy //AC asymmetric supercapacitors.
Fig. S11 (a) The cycling performance of the devices. The corresponding last 10 cycles of charge/discharge curves for (b) NiCo$_2$S$_4$/AC, (c) NiCo$_2$S$_4$@Ni(OH)$_2$/AC and (d) NiCo$_2$S$_4$@PPy//AC at current densities of 60 mA cm$^{-2}$, 60 mA cm$^{-2}$ and 30 mA cm$^{-2}$, respectively.