

Supplementary Information

Successive cation and anion exchange strategy towards hierarchical Ni-Co sulfide arrays for high-performance hybrid supercapacitors

Experimental

Materials characterization

The crystal structures of materials were recorded by the X-ray diffractometer (XRD). The morphology of the samples was characterized by scanning electron microscopy (SEM). The elemental mapping was tested by the energy-dispersive X-ray spectroscope (EDS) equipped on SEM.

Electrochemical measurements

The Ni foam supported electroactive materials was directly used as work electrode for performance evaluation. The electrode was cut into a size of 1 cm × 1 cm with a mass loadings of electroactive materials around 4.8 mg cm⁻². The performance were measured using 6 M KOH electrolyte in a classical three-electrode configuration with Hg/HgO reference electrode and Pt foil counter electrode. The cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS) were tested using a CHI 660E electrochemical workstation. The EIS spectra were tested at the open circuit potential with an ac perturbation of 5 mV. The specific capacity values were calculated from the GCD curves using:

$$C=I\Delta t/m \quad (1)$$

where C (C g⁻¹) is the specific capacity, I (A g⁻¹) is the discharge current, Δt (s) is the discharge time and m (g) is the mass loading of the electroactive material.

The HSCs were assembled using Ni-Co-S-30 sulfides as the positive electrode and reduced graphene oxidized (RGO) as the negative electrode. The mass loadings of the two electrodes were calculated by this equation: $m_+/m_-=C_-/C_+$, where C was calculated from the CV curves at 5 mV s⁻¹, and m is the mass loading of the two electrodes. The specific energy and specific power of the HSC device were calculated from the GCD curves using the following equations:

$$E = \frac{1}{3.6} I_s \int_0^{V_{max}} V dt \quad (2)$$

$$P = \frac{3.6E}{\Delta t} \quad (3)$$

where E (W h kg^{-1}) is the specific energy, P (kW kg^{-1}) is the specific power, and V (in V) is the voltage of the HSC device.

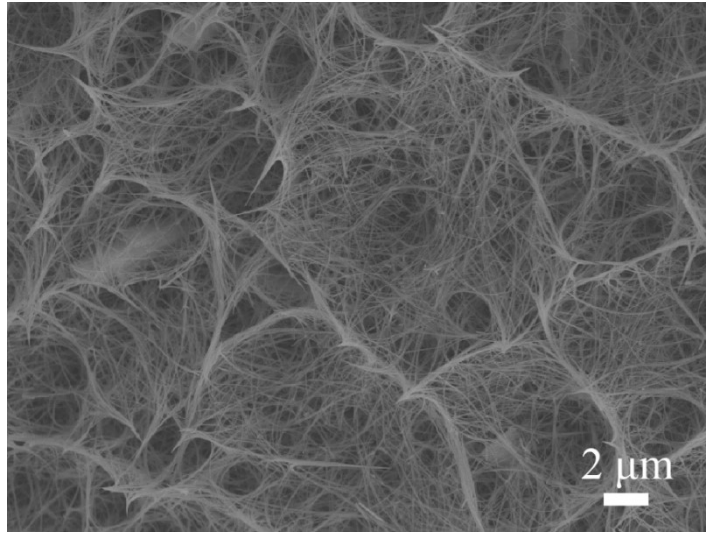


Fig. S1 SEM image of $\text{Co}(\text{CO}_3)_{0.5}\text{OH}$ sample.

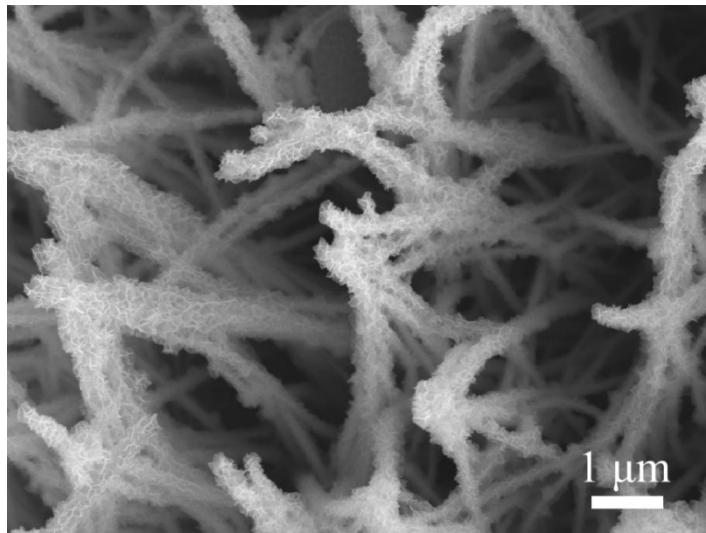


Fig. S2 SEM image of NiCo-15 sulfide sample.

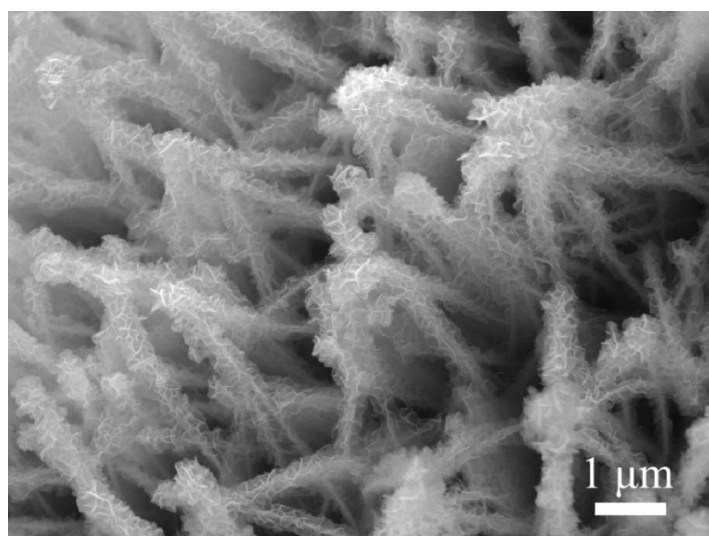


Fig. S3 SEM image of NiCo-45 sulfide sample.

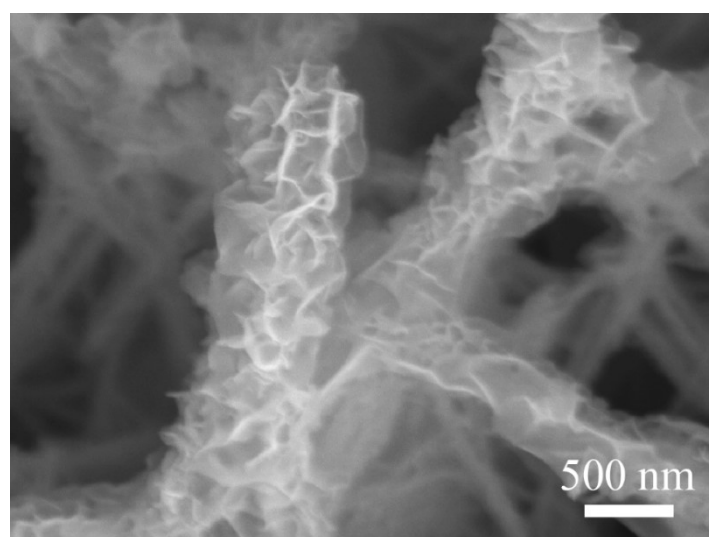


Fig. S4 SEM image of NiCo-60 sulfide sample.

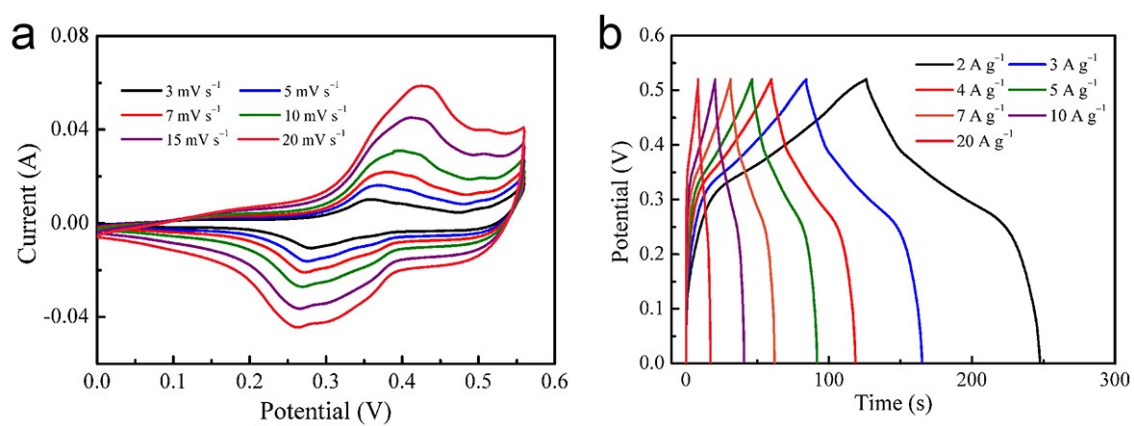


Fig. S5 (a) CV curves at various scan rates and (b) GCD curves at different specific currents of Co sulfide.

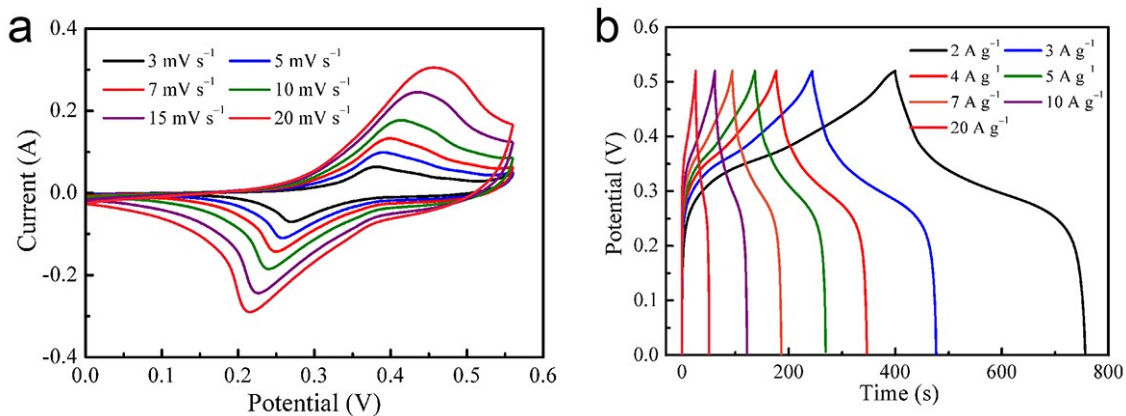


Fig. S6 (a) CV curves at various scan rates and (b) GCD curves at different specific currents of NiCo-15.

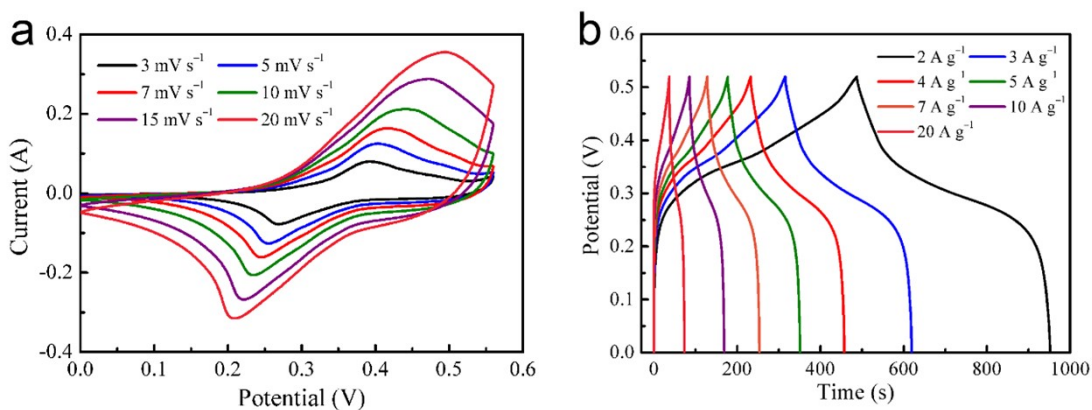


Fig. S7 (a) CV curves at various scan rates and (b) GCD curves at different specific currents of NiCo-30.

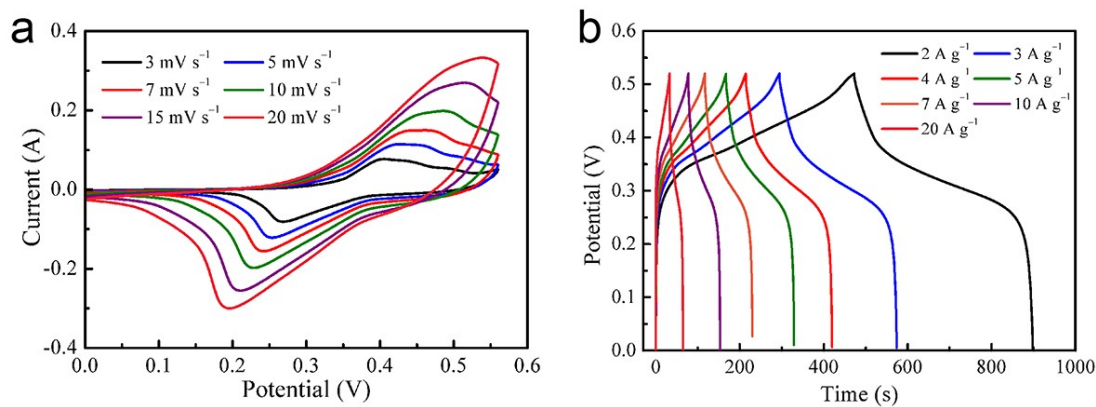


Fig. S8 (a) CV curves at various scan rates and (b) GCD curves at different specific currents of NiCo-45.

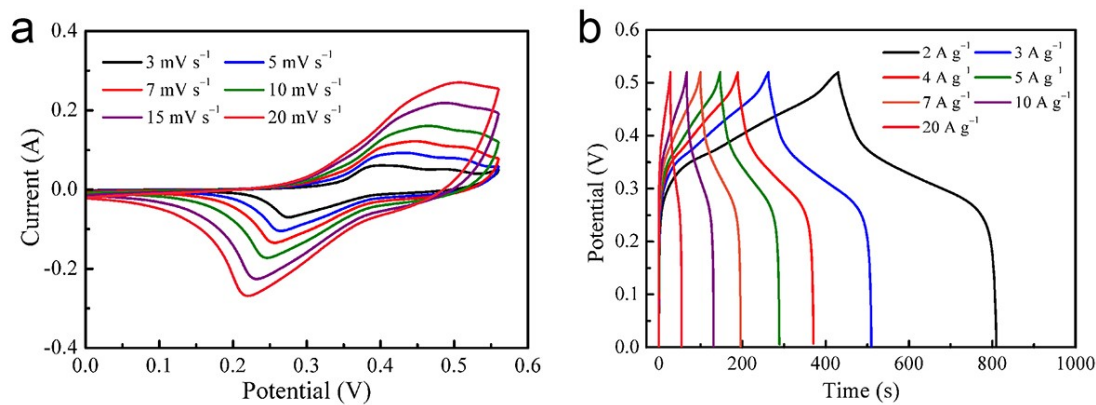


Fig. S9 (a) CV curves at various scan rates and (b) GCD curves at different specific currents of NiCo-60.

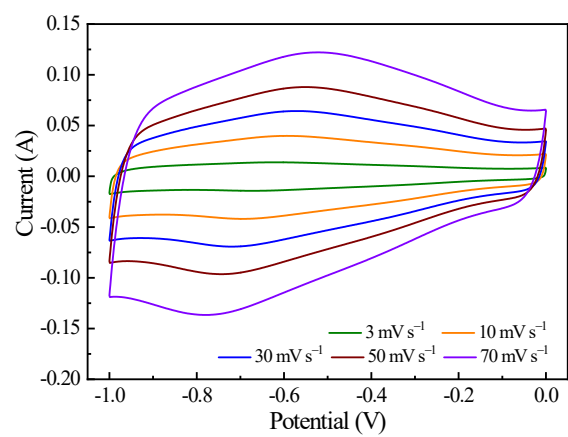


Fig. S10 CV curves at various scan rates of the RGO electrode.