Unusual CoS$_2$ Ellipsoids with Anisotropic Tube-like Cavities and Their Application in Supercapacitors

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Experimental Section

*Materials Synthesis.* In a typical synthesis, 0.25 g of cobalt acetate tetrahydrate (Co(Ac)$_2$; Co(CH$_3$COO)$_2$·4H$_2$O, Aldrich) and 0.5 g of polyvinyl-pyrrolidone (PVP; MW=58000, Reagent Chemicals) were first dissolved in 20 mL of polyethylene glycol (PEG; MW=400, Aldrich) at room temperature, followed by the addition of 0.25 g of urea (CO(NH$_2$)$_2$, Aldrich) under vigorous stirring. After stirring for 15 min, the mixture was transferred into a 60 ml Teflon-lined stainless steel autoclave and placed in an electric oven at 220 °C for 18 h. After that, the product was harvested, and washed with de-ionized water and ethanol several times by a centrifugation-redispersion process. Then the final product was dried in an oven at 60 °C for 24 h. To convert the carbonate into CoS$_2$, the as-synthesized CoCO$_3$ was heated to 350 °C with a temperate ramp of 2 °C min$^{-1}$ and kept at the same temperature for 6 h in a gas flow of 10% H$_2$S + 90% N$_2$.

*Materials Characterization.* X-ray diffraction (XRD) patterns were collected on a Bruker D8 Advanced X-Ray Diffractometer with Ni filtered Cu Kα radiation ($\lambda$=1.5406 Å) at a voltage of 40 kV and a current of 40 mA. Field-emission scanning electron microscopy (FESEM) images were acquired on a JEOL JSM 6700F microscope operated at 5 kV. Transmission electron microscopy (TEM) images were taken on JEOL 2010 and JEOL 2100F microscopes. Thermogravimetric analysis (TGA) was carried out under nitrogen flow with a temperature ramp of 10 °C min$^{-1}$. Nitrogen sorption measurement was performed on Autosorb 6B at liquid N$_2$ temperature.

*Electrochemical Measurements.* The working electrode was prepared by mixing 70 wt% of electroactive material (CoS$_2$), 20 wt% of carbon black (super-P), and 10 wt% of polyvinylidene difluoride (PVDF, Aldrich). This mixture was then pressed onto the Ni foam electrode and dried at 80 °C. The electrolyte used was a 2M KOH aqueous solution. The capacitive performance of the
samples was evaluated on a CHI 660C electrochemical workstation using cyclic voltammetry and chronopotentiometry tests with a three-electrode cell where Pt foil serves as the counter electrode and a standard calomel electrode (SCE) as the reference electrode.
Figure S1. XRD pattern of CoCO$_3$ ellipsoids.

Figure S2. (a, b) FESEM and (c, d) TEM images of CoCO$_3$ ellipsoids.
Figure S3. TGA curve of the CoCO$_3$ ellipsoids in N$_2$ with a temperature ramp of 10 °C min$^{-1}$.

Figure S4. N$_2$ adsorption-desorption isotherms of CoS$_2$ ellipsoids with anisotropic tube-like cavities.
**Figure S5.** The cyclic voltammograms of Ni foam with and without loading of CoS$_2$ ellipsoids at a scan rate of 5 mV s$^{-1}$.

**Figure S6.** Specific capacitance and Coulombic efficiency of CoS$_2$ ellipsoids with anisotropic tube-like cavities in an aqueous KOH (2 M) electrolyte as a function of cycle number at current density of 2.5 A g$^{-1}$.  

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