Supplementary information

Integration of adsorption and catalysis active sites in cobalt iron oxide nanorods for excellent performance Li-S Battery with a wide temperature range

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Experimental Section

Synthesis

Synthesis of CoFe$_2$O$_4$ nanorods. All chemicals were analytical grade and used without further purification. 1 mmol Fe(acac)$_3$ and 0.5 mmol Co(acac)$_2$ was dissolved into 50 mL ethylene glycol. After stirred for 3 h, the mixture was then transferred into a round-bottom flask and refluxed at 160°C for 3 h. Then the reactant was cooled to room temperature. The precipitate was collected by centrifugation, then washed with ethanol and distilled water several times. Subsequently dried at 50 °C, then calcined at 700 °C in a temperature-programmed muffle furnace for 3 h in air to get the CoFe$_2$O$_4$ nanorod.

Synthesis of Co$_3$O$_4$. The method was the same as the preparation of CoFe$_2$O$_4$ Nanorod, but 1mmol Co(acac)$_3$ was used to replace Fe(acac)$_3$.

Preparation of the Sulphur composites. The CoFe$_2$O$_4$/S composite was prepared via the classical melt-diffusion method. First, the required amount of elemental sulfur and CoFe$_2$O$_4$ nanorod (3:1 by mass) were mixed thoroughly by grinding. Then the mixture was heated at 155 °C for 6 h and cooled to room temperature. The Co$_3$O$_4$/S, Sup P/S composite was prepared by the same method as CoFe$_2$O$_4$/S one.

Polysulphide adsorption sample preparation. The 10 mM Li$_2$S$_6$ solutions were prepared by dissolving appropriate amounts Li$_2$S$_6$ into 5 ml DOL/DME solvent in five vials with same volume. 10 mg Sup P, CoFe$_2$O$_4$ nanorod and Co$_3$O$_4$ were then added to three different vials, respectively. All procedures were completed in an Ar-filled glovebox.

Characterization of the materials

X-ray diffraction (XRD) patterns of the samples were recorded on a Philips analytical X-pert diffractometer with Cu Ka radiation (λ = 0.1548 nm) at 40 kV and 30 mA and a step of 0.02. Data were recorded ranging from 20 to 80 degree. Scanning electron microscopy (SEM) was performed on a Hitachi S-

4800 scanning electron microscope at an accelerating voltage of 15 kV. Transmission electron microscopy (TEM) observations were carried out FEI Tecnai F30 microscopes at 300 kV. Thermogravimetric (TG) analysis was carried out on a Perkin Elmer instrument. Nitrogen adsorption and desorption isotherms at 77 K were characterized by a Micromeritics Tristar 3020 analyzer surface area and pore-size analyzer.

Electrochemical measurements

To evaluate the electrochemical properties of the $CoFe_2O_4/S$ composite as a cathode material, its electrochemical testing was constructed. The cathode electrode consists of 70 wt% active material (sulfur composites), 20 wt% super P, and 10 wt% binder (LA) (the actual ration of sulfur in the cathode is about 51.8%). All test cells were assembled in an Ar-filled glove box. Celgard 2400 as the separator, Li foils were used as the counter electrode, and the electrolyte was 0.5 M $LiCF_3SO_3$ & 0.5 M $LiNO_3$ (dissolved in 1,2-dimethoxyethane and dioxolane with a 1:1 volume ratio). The areal mass loading of sulfur in electrode is about 2 mg cm^{-2}, the electrode area of cathode is 2 cm^2 and electrode area of anode is 1.91 cm^2, area of separator is about 3.08 cm^2, the E/S ratio in each cell 8 μL/mg. These cells were cycled on a NEWARE BTS-5 V/20 mA type battery chargers (Shenzhen, China) testing system at room temperature, and the galvanostatic charge-discharge cycling with a voltage window of 1.7–2.7 V. The cell without any activation when current densities blew 1 C. And the cell wll be an activation at a 0.1 C rate for 3 cycles when the current densities were 1 C, 2 C and 5 C.
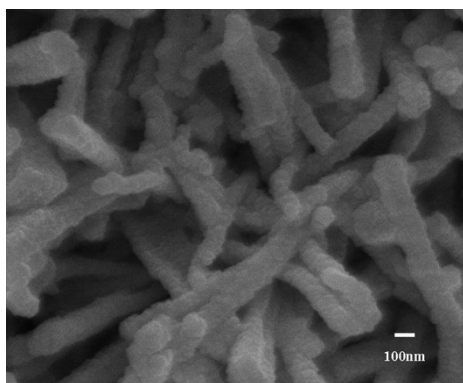
Fig. S1 SEM image of the CoFe$_2$O$_4$ nanorod.
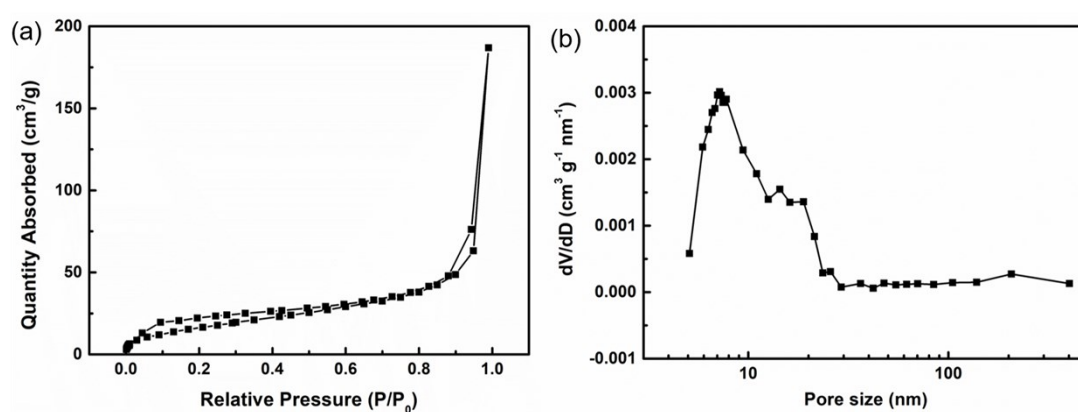
Fig. S2 Nitrogen adsorption–desorption isotherms and BJH pore size distribution of CoFe$_2$O$_4$ nanorods. The specific surface area of CoFe$_2$O$_4$ nanorods. is 63.45 m^2 g^{-1}, and the high pore volume is 0.289 cm^3 g^{-1}.
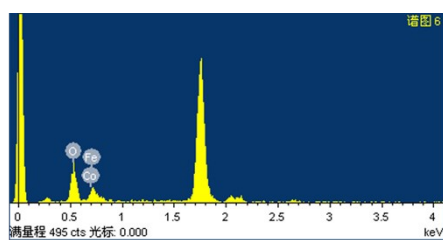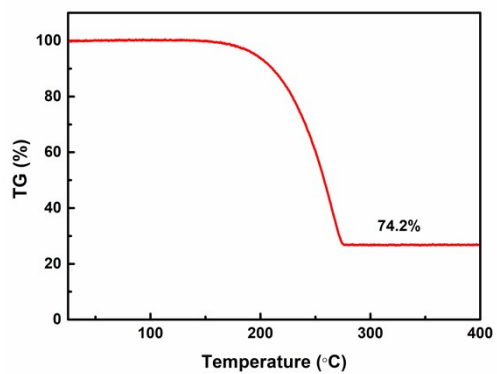

谱图处理 :
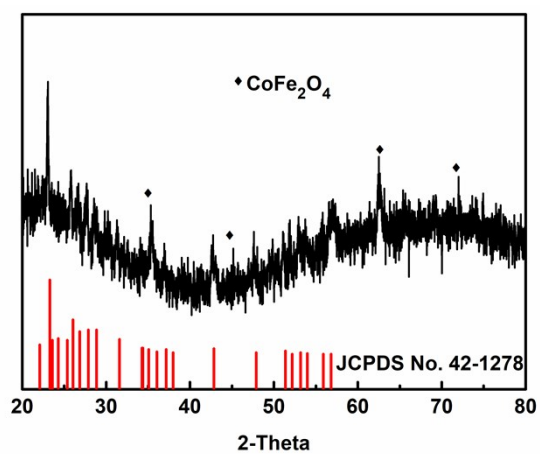可能被忽略的峰 : 0.275, 1.743, 2.030, 2.650 keV

处理选项 : 所有经过分析的元素 (已归一化)
重复次数 = 3

标准样品 :
O   SiO2   1-Jun-1999 12:00 AM
Fe   Fe   1-Jun-1999 12:00 AM
Co   Co   1-Jun-1999 12:00 AM

元素	重量百分比	原子百分比
O K	49.80	77.91
Fe K	32.49	14.56
Co K	17.72	7.53
总量	100.00	

Fig. S3   EDS of the CoFe$_2$O$_4$ nanorods. The atomic ratio of Co and Fe in the sample is about 1:2.
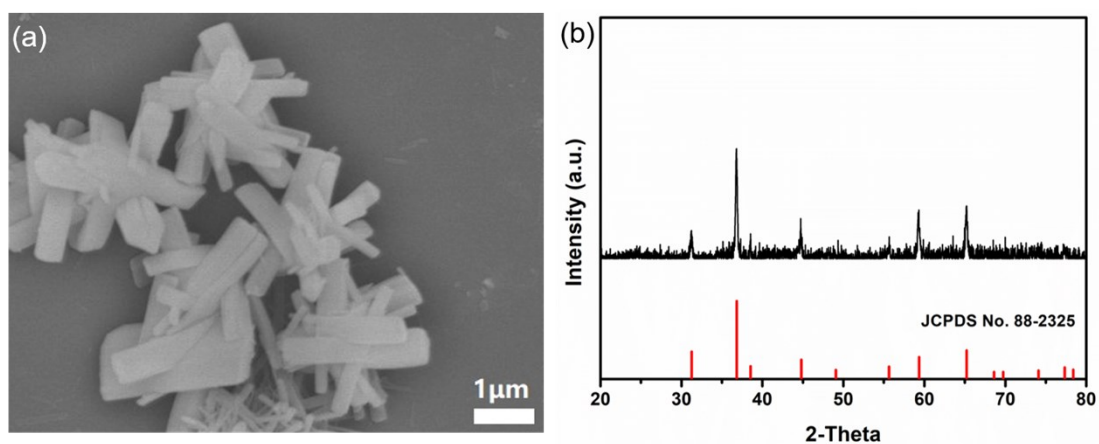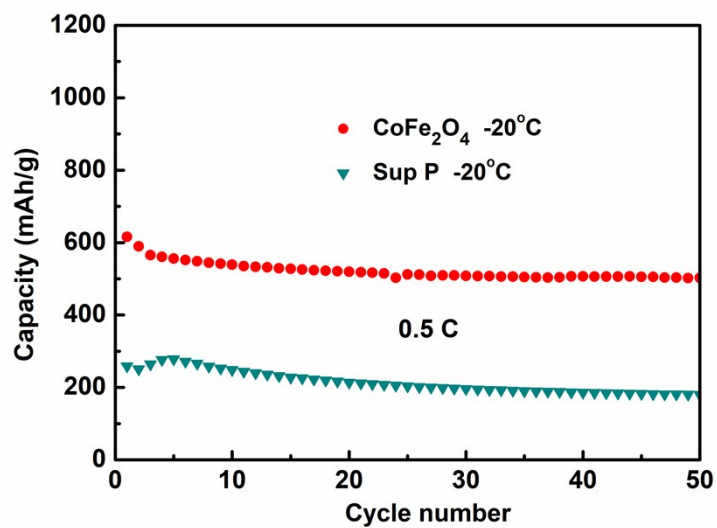
Fig. S4 TG curve of CoFe$_2$O$_4$/S sample.

Fig. S5 XRD of CoFe$_2$O$_4$/S sample.

Fig. S6 The characterization of the CoFe$_2$O$_4$/S sample.

Fig. S7 (a)The SEM of the Co₃O₄ sample (b) the XRD of the Co₃O₄ sample.

Fig. S8. Discharge capacity of CoFe₂O₄/S and Sup P/S versus cycle number at a current density of 0.5 C under -20℃.