Electronic Supporting Information for

Synergistic design of core-shell V_3S_4@C host and homogeneous catalysts promoting polysulfides chemisorption and conversion for Li-S batteries

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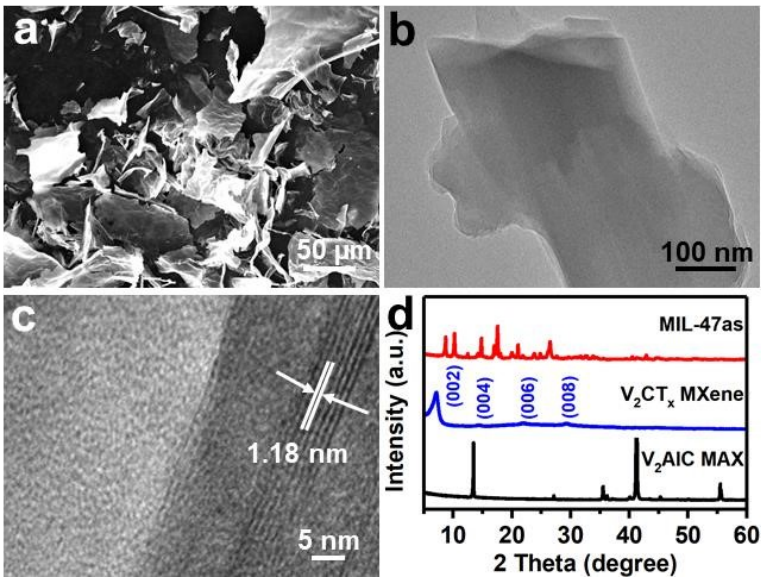

Fig. S1. (a) FESEM image, (b) TEM image and (c) HR-TEM image of the V_2CT_x; (d) XRD patterns of V_2AlC MAX, V_2CT_x and MIL-47as.

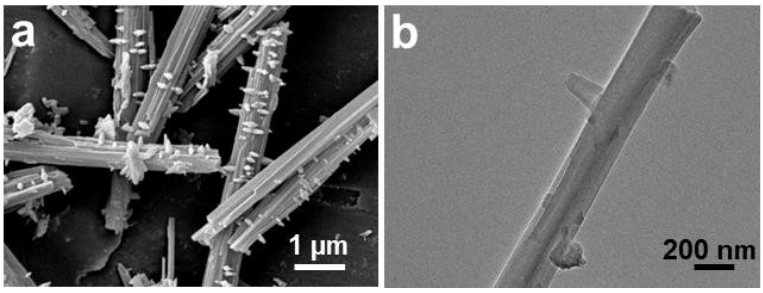

Fig. S2. (a) FESEM image and (b) TEM image of the MIL-47as.

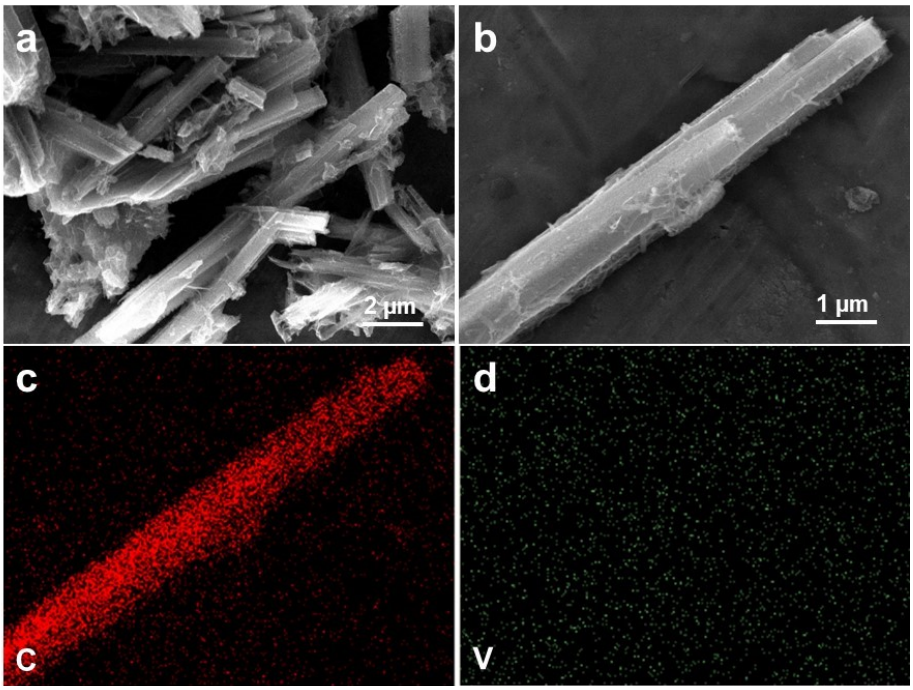

Fig. S3. (a, b) FESEM images and (c, d) corresponding elemental mapping images of the V_3S_4@C after being etched by HCl solution.

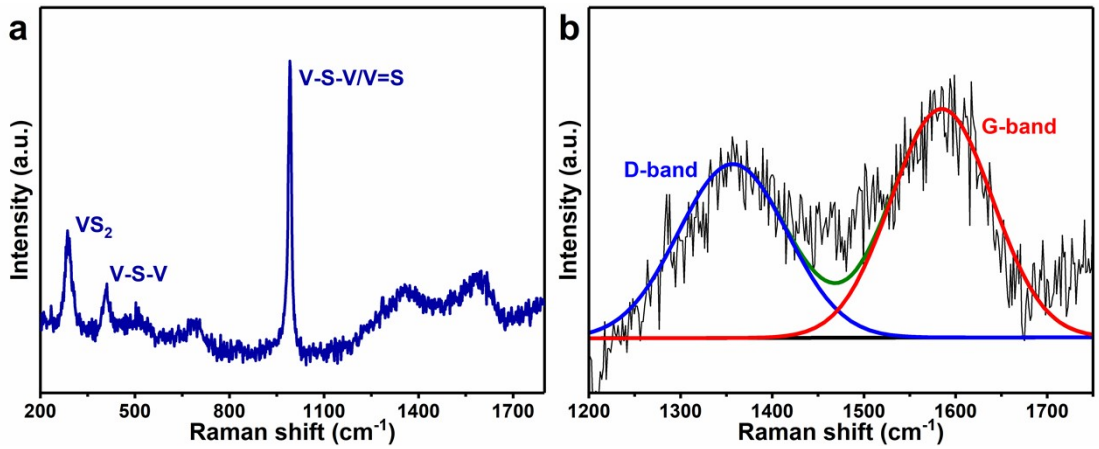

Fig. S4. (a) Raman spectrum of V_3S_4@C; (b) Enlarged region from 1200 to 1750 cm^{-1} and corresponding fitting curves of V_3S_4@C.

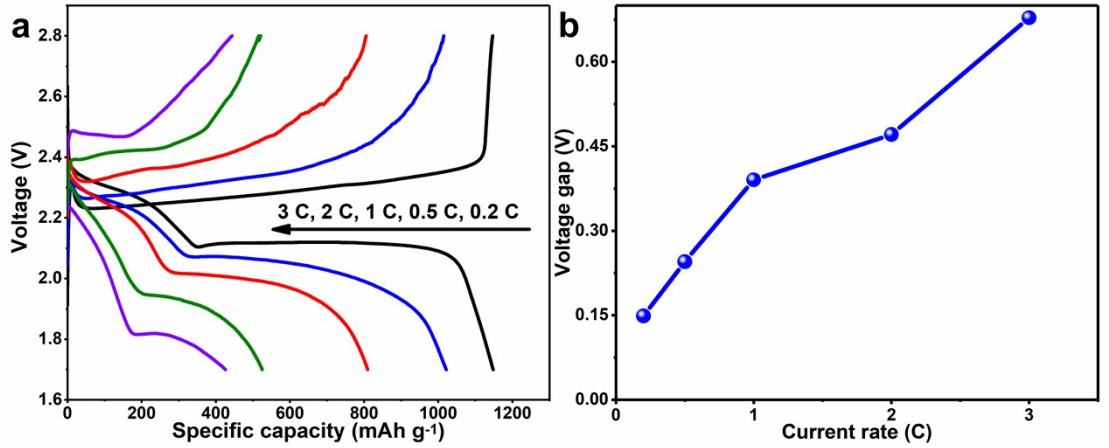

Fig. S5. (a) Galvanostatic charge-discharge plots and (b) voltage gaps of different rates for the S/V_3S_4@C cathode.

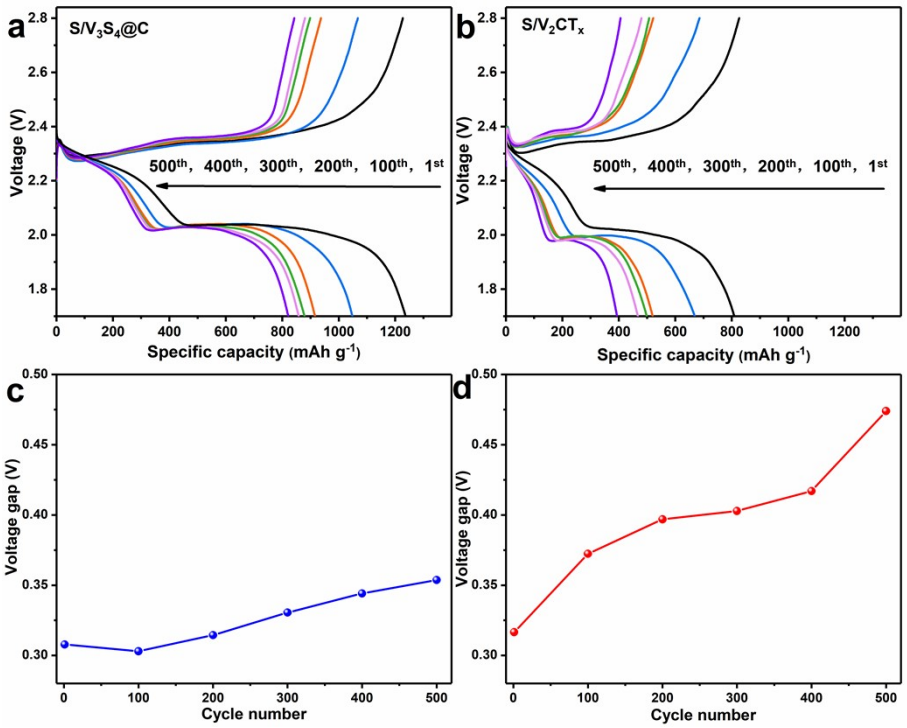

Fig. S6. The selected galvanostatic charge-discharge profiles of (a) $S/V_3S_4@C$ and (b) S/V_2CT_x cathodes, and corresponding voltage gaps of (c) $S/V_3S_4@C$ and (d) S/V_2CT_x cathodes.

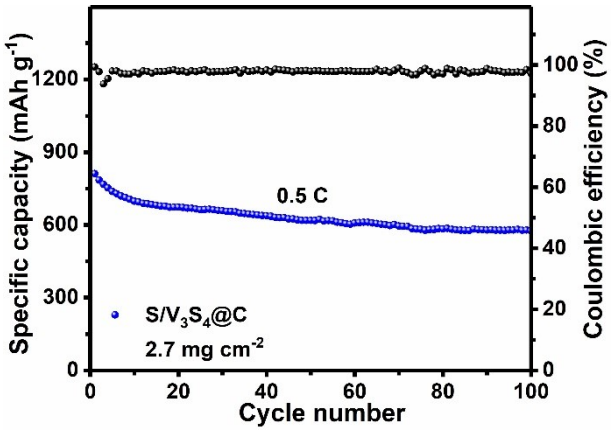

Fig. S7. Cycling performance of S/V_3S_4@C (S areal loading: 2.7 mg cm^{-2}) at 0.5 C.

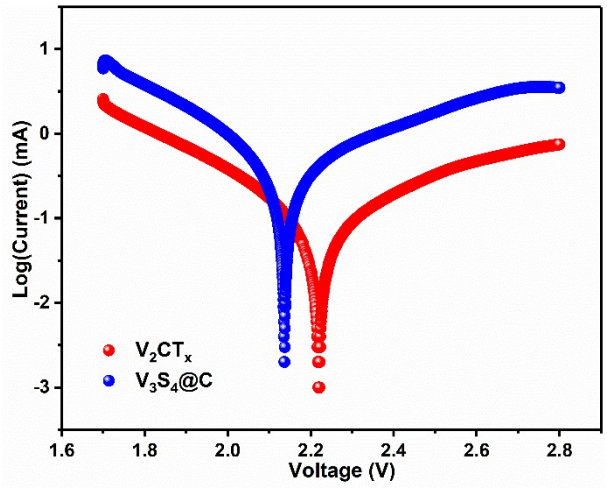

Fig. S8. Tafel plots of V_3S_4@C and V_2CT_x as indicated.

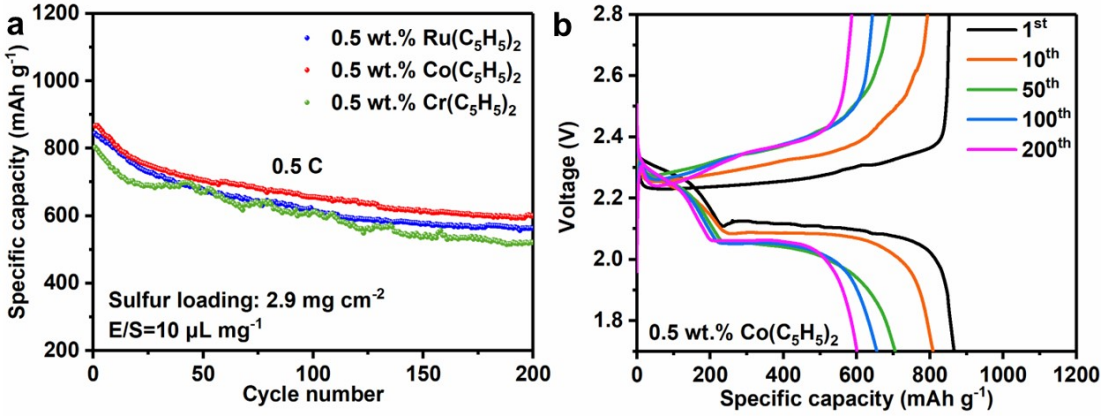

Fig. S9. (a) Cycling performance (0.5 C) of the S/V_3S_4@C cathode with high S loading (2.9 mg cm^{-2}) and a E/S ratio (~10 μL mg^{-1}) in elecctrolytes with different HCs as indicated, and (b) selected charge-discharge profiles of the S/V_3S_4@C cathode with 0.5 wt.% Co-electrolyte.

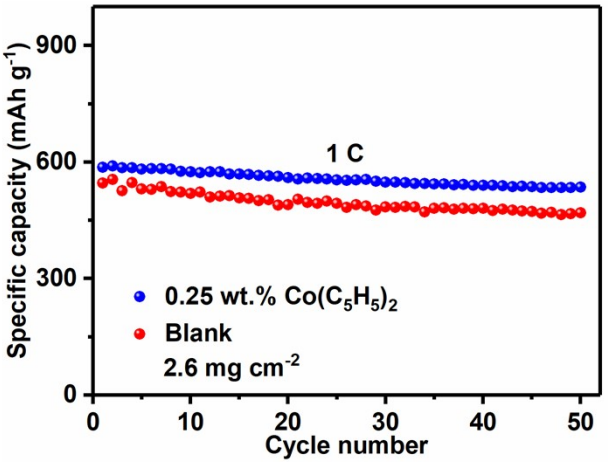

Fig. S10. Cycling performance (1 C) of the $S/V_3S_4@C$ cathode with high S loading (2.6 mg cm^{-2}) and low E/S ratio (~10 μL mg^{-1}) with/without 0.25 wt.% Co-electrolyte.

Table S1 Comparison in electrochemical performance of $S/V_3S_4@C$ with/without 0.5 wt.% $Co(C_5H_5)_2$ in electrolytes and other similar cathodes.

Electrodes	Areal sulfur loading (mg cm^{-1})	E/S ratio (μL mg^{-1})	Performance (mAh g^{-1})	Cycle number	Reference
$S/V_3S_4@C$	2.1	10	~675.5 at 1 C	300	This work
$S/V_3S_4@C$, with 0.25 wt.% $Co(C_5H_5)_2$	4.6	8	~421.2 at 1 C	100	This work
$VS_2@S$	1.5	20	~413.0 at 1 C	200	1
$S@VS_4@RGO$	5	10	~853 at 0.2 C	100	2
SnS@C/S	1.5	10	~513 at 0.5 C	600	3
TiO_2-Ni_3S_2	3.9	9	~504 at 0.3 C	500	4
$MoSe_2$@rGO/S	1.22 1.16	16	~823 at 1 C ~672 at 2 C	270 500	5
$S/V_3S_4@C$-7	2.3 4.2	16 – 25	~611.4 at 1 C ~389.3 at 1 C	500 500	6
MoS_2-MoN/S	1.2	/	~520 at 1 C	1000	7
Li_2S_6/ZnS_{1-x}-CC	1.7	15	~524 at 1 C	500	8
$Co_{0.85}Se$/NC-S	1	26	~799 at 1 C	400	9

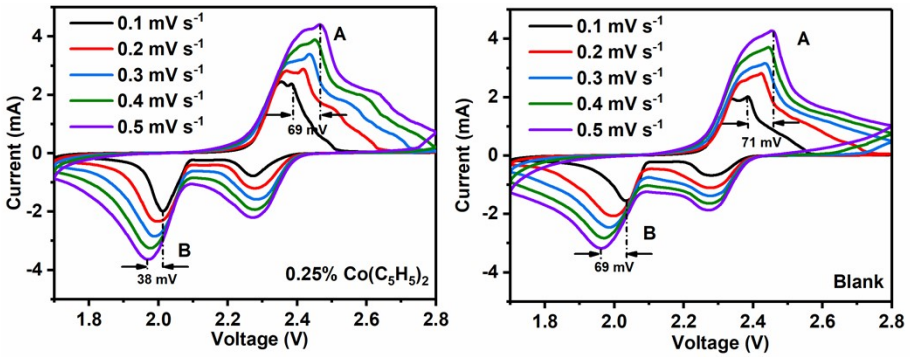

Fig. S11. CV curves of the S/V_3S_4@C cathode (a) with or (b) without 0.25 wt.% Co-electrolyte at different scanning rates.

According to the Randles-Sevcik formula:

$$I_p = (2.65 \times 10^5) n^{1.5} S D_{Li^+}^{0.5} \Delta C_{Li^+} v^{0.5}$$

therein, I_p is the peak current, n is the number of participating electrons in the reaction (n=2), S is the electrode area (S=1.13 cm^2), ΔC_{Li^+} is the Li^+ ion concentration in the electrolyte and v is the scanning rate.[10] The diffusion coefficient of the Li^+ ion (D_{Li^+}) is calculated by the linear fitting of I_p versus $v^{0.5}$, as shown in **Fig.911**. The D_{Li^+} value for peak A is 3.729×10^{-8} (Co-electrolyte) and 3.408×10^{-8} cm^2 s^{-1}(blank), and for peak B is 2.521×10^{-8} (Co-electrolyte) and 1.948×10^{-8} cm^2 s^{-1}(blank).

Reference

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