## Supporting Information

Promoting polysulfide conversion by catalytic ternary Fe<sub>3</sub>O<sub>4</sub>/carbon/graphene composites with ordered microchannels for ultrahigh-rate lithium-sulfur batteries

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Figure S1. SEM images of (a) Fe-MOF, (b) Fe-MOF/GO composite, and (c-d) rGO aerogels.

Figure S2. EDX mapping of C, O, Fe for Fe<sub>3</sub>O<sub>4</sub>/NC/G aerogel.



Figure S3. XRD patterns of Fe-MOF.





**Figure S4.** Nitrogen sorption isotherm of Fe<sub>3</sub>O<sub>4</sub>/NC.







**Figure S6.** Nyquist plots of Fe<sub>3</sub>O<sub>4</sub>/NC/G and rGO before and after cycling.

**Figure S7.** (a) Comparison of CV curves between  $Fe_3O_4/NC/G$  and rGO at a scan rate of 0.1 mV s<sup>-1</sup>; (b) CV curves of  $Fe_3O_4/NC/G$  cathode at different scan rates.





**Figure S8.** Discharge-charge profiles of  $Fe_3O_4/NC/G$  at different rates from 0.1 C to 3 C.







**Figure S10.** The first and second discharge-charge profiles of Li-S battery with  $Fe_3O_4/NC/G$  host at 0.1 C.

**Figure S11**. (a) The first and second discharge-charge curves of Li-S batteries with rGO at 0.1 C and the corresponding *in situ* XRD patterns in a contour plot. (b) The evolution of  $\beta$ -S<sub>8</sub> and Li<sub>2</sub>S during the second discharge-charge cycle at 0.1 C based on the integrated areas of (311) and (111) planes, respectively.



Figure S12. Comparison of adsorption binding energies for polysulfides and  $S_8$  on Fe<sub>3</sub>O<sub>4</sub> and carbon.





Figure S13. XRD pattern of the powder yield after 1000 °C TGA test in air.