Supplementary Information

MOF-derived NiO-NiCo$_2$O$_4$@PPy hollow polyhedron as a sulfur immobilizer for lithium-sulfur batteries

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Figure S1. FESEM image of ZIF-67.
Figure S2. FESEM image of NiO-NiCo$_2$O$_4$ polyhedron.
Figure S3. FESEM image of NiO-NiCo$_2$O$_4$@PPy.
Figure S4. XRD pattern of the as-synthesized ZIF-67.
Figure S5. XRD patterns of (a) S and (b) NiO-NiCo$_2$O$_4$. 

(a)  

(b)
Figure S6. (a) C 1s, (b) O 1s, (c) Co 2p and (d) Ni 2p spectra of S/NiO-NiCo$_2$O$_4$@PPy.
Figure S7. (a) Nitrogen adsorption-desorption isotherms and (b) pore size distribution curve of NiO-NiCo$_2$O$_4$@PPy composite.
Figure S8. CV curves of (a) S and (b) S/NiO-NiCo$_2$O$_4$. 
Figure S9. Cycling performance of NiO-NiCo$_2$O$_4$@PPy at 335 mA g$^{-1}$. 
**Figure S10.** Charge-discharge profiles of (a) S and (b) S/NiO-NiCo$_2$O$_4$ at 0.2 C. Charge-discharge profiles of (c) S and (d) S/NiO-NiCo$_2$O$_4$ at various current densities from 0.1 to 2 C in the voltage range of 1.7-2.8 V.
Figure S11. UV-Vis spectra of Li$_2$S$_6$ in DME/DOL, PPy+Li$_2$S$_6$ in DME/DOL, NiO-NiCo$_2$O$_4$+Li$_2$S$_6$ in DME/DOL, and NiO-NiCo$_2$O$_4$@PPy+Li$_2$S$_6$ in DME/DOL. Inset: photographs of sealed vials of Li$_2$S$_6$ in DOL/DME and Li$_2$S$_6$ in DOL/DME after being in contact with PPy, NiO-NiCo$_2$O$_4$, and NiO-NiCo$_2$O$_4$@PPy for 5 h.
Figure S12. Photographs of separators of batteries with pure sulfur and S/NiO-NiCo$_2$O$_4$@PPy after cycling, compared to photograph of separator before cycling (blank).
Figure S13. SEM images of S/NiO-NiCo$_2$O$_4$ cathode (a) before cycle and (b) after 100 cycles at 0.2 C. SEM images of S cathode (c) before cycle and (d) after 100 cycles at 0.2 C.
<table>
<thead>
<tr>
<th>Materials</th>
<th>Capacity (mAh g$^{-1}$)</th>
<th>Current density</th>
<th>Sulfur content</th>
<th>Areal loading (mg cm$^{-2}$)</th>
<th>Cycle</th>
<th>Ref.</th>
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<tbody>
<tr>
<td>S-PPy-based sandwich electrode</td>
<td>383</td>
<td>0.1 C</td>
<td>—</td>
<td>—</td>
<td>500</td>
<td>[1]</td>
</tr>
<tr>
<td>S/PPy</td>
<td>613</td>
<td>0.1 C</td>
<td>—</td>
<td>—</td>
<td>50</td>
<td>[2]</td>
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<tr>
<td></td>
<td>475</td>
<td>1 C</td>
<td>—</td>
<td>—</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>NiCo$_2$O$_4$/S</td>
<td>601</td>
<td>0.5 C</td>
<td>27%</td>
<td>—</td>
<td>200</td>
<td>[3]</td>
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<tr>
<td>S-Co$_3$O$_4$ nanotubes</td>
<td>538</td>
<td>0.2 C</td>
<td>78%</td>
<td>—</td>
<td>100</td>
<td>[4]</td>
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<tr>
<td>Co$_3$O$_4$/S/ACNTs</td>
<td>496</td>
<td>0.5 C</td>
<td>58.73%</td>
<td>1.5</td>
<td>550</td>
<td>[5]</td>
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<tr>
<td>S/NiO-NiCo$_2$O$_4$@PPy</td>
<td>641</td>
<td>0.2 C</td>
<td>61.5%</td>
<td>2</td>
<td>100</td>
<td>This work</td>
</tr>
<tr>
<td></td>
<td>411</td>
<td>1 C</td>
<td>—</td>
<td>—</td>
<td>200</td>
<td></td>
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References