Supporting Information

Multi-Shelled CoP Nanospheres Modified Separator for Highly Efficient Li-S Batteries

Xiaoxia Chen, a Xuyang Ding, a Chunsheng Wang, a Zhenyu Feng, a Liqiang Xu, a, * Xue Gao, a Yanzun Zhai, b

Debao Wang c

a Key Laboratory of Colloid & Interface Chemistry (Shandong University), Ministry of Education and School of Chemistry and Chemical Engineering, Shandong University, Jinan 250100, China. E-mail: xulq@sdu.edu.cn.

b School of Chemistry and Chemical Engineering, Liaocheng University, Liaocheng, P.R. China

c College of Chemistry and Molecular Engineering, Qingdao University of Science & Technology, Qingdao 266042, P. R. China

E-mail: xulq@sdu.edu.cn.
Supplementary Figures and Table:

**Fig. S1** The XRD patterns of (a) Co$_3$O$_4$, (b) CoP.
Fig. S2 (a) The SEM and (b)TEM image of rGO. (c) the XRD patterns of sulfur, rGO and rGO@S. (d) the TGA of rGO@S cathode.
Fig. S3 (a) N$_2$ adsorption-desorption isotherm curves and (b) the pore size distributions of hollow structured CoP.
**Fig. S4** The electrolyte contact angle of (a) CoP/KB coated separator and (b) Commercial separator.
Fig. S5 Elemental mapping of O, Co and P.
Fig. S6 High-resolution XPS spectrum of (a) O 1s (b) S 2p (c) Li 1s after CoP interacting with Li$_2$S.
Fig. S7 The first five CV curves of the cell with functional separator at a scan rate of 0.1 mV s$^{-1}$. 
Fig. S8 Rate performance of the battery with CoP (a) and KB coated separators (b) at different current densities. Discharge capacities of the cells with CoP (c) and KB coated separator at 0.5 C.
Fig. S9 The discharge capacities of the cells with only functional separator as a cathode at 0.5 C.
Fig. S10 Discharge capacities of the cells use functional separator at 0.2 C with the high sulfur loading of 3.24 mg cm$^{-2}$. 
Fig. S11 Nyquist plots of electrodes with commercial and CoP/KB coated separator before cycling.
Fig. S12 EDX spectra of CoP/KB coated separator surface (a) toward the cathode and (b) toward the anode, on routine separator surface (c) toward the cathode and (d) toward anode after several cycles.
**Table S1** Comparison of the capacity maintained at various high current density in this work with the recently reported Li-S batteries.

<table>
<thead>
<tr>
<th></th>
<th>Coated mass (mg. cm(^{-2}))</th>
<th>C rate (C)</th>
<th>No. of cycles</th>
<th>Fading rate (% per cycle)</th>
<th>Maximum discharge capacity / mA h g(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>rGO@MoS(_2) ([1])</td>
<td>0.24</td>
<td>1</td>
<td>500</td>
<td>0.116</td>
<td>615 (2C)</td>
</tr>
<tr>
<td>CoS(_2)/KB ([2])</td>
<td>0.5-0.7</td>
<td>2</td>
<td>450</td>
<td>0.09</td>
<td>475 (5 C)</td>
</tr>
<tr>
<td>PVDF-HFP/CNT ([3])</td>
<td>1.55</td>
<td>0.5</td>
<td>500</td>
<td>0.092</td>
<td>500 (2 C)</td>
</tr>
<tr>
<td>PANI-GO ([4])</td>
<td>2.48</td>
<td>1</td>
<td>300</td>
<td>0.13</td>
<td>1048 (1 C)</td>
</tr>
<tr>
<td>CNTOH ([5])</td>
<td>0.14</td>
<td>0.5</td>
<td>400</td>
<td>0.11</td>
<td>~1000 (2 C)</td>
</tr>
<tr>
<td>TiO(_2)/C ([6])</td>
<td>0.35</td>
<td>0.5</td>
<td>300</td>
<td>0.228</td>
<td>820 (2 C)</td>
</tr>
<tr>
<td>EUV-CNT ([7])</td>
<td>1.53</td>
<td>0.2</td>
<td>200</td>
<td>0.16</td>
<td>618 (3 C)</td>
</tr>
<tr>
<td>N-doped carbon ([8])</td>
<td>0.28</td>
<td>1</td>
<td>500</td>
<td>0.11</td>
<td>750 (5 C)</td>
</tr>
<tr>
<td><strong>This work</strong></td>
<td>0.2</td>
<td>1</td>
<td>500</td>
<td>0.078</td>
<td>725 (5 C)</td>
</tr>
</tbody>
</table>


