Electronic Supplementary Information (ESI)

Fabrication of sandwich structural electrode for high-performance lithium-sulfur battery

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Fig. S1 (a, b) SEM images and (c, d) TEM images of Graphene/S composite.
Fig. S2 STEM image of Graphene/TiO$_2$/S nanocomposite.

Fig. S3 TG curves of Graphene/TiO$_2$/S nanocomposite.
**Fig. S4** CV curves of Graphene/S electrode at a scaning rate of 0.2 mV s\(^{-1}\).

**Fig. S5** Electrochemical behaviors of Graphene/TiO\(_2\) electrode: (a) Galvanostatic charge-discharge profiles at a current rate of 0.5 C (1C=170 mA g\(^{-1}\)). (b) Cycling performance at different current densities. (All measurements were conducted in the same potential window and electrolyte with that of Graphene/TiO\(_2\)/S electrode.)

As an electrochemically active host, the cycling stability and rapid ionic/electronic transport of Graphene/TiO\(_2\) electrode is critical to the electrochemical performances of Graphene/TiO\(_2\)/S. As shown in Fig. S4, the Graphene/TiO\(_2\) electrode exhibits...
typical electrochemical behaviors of anatase TiO$_2$. Fig. S3a shows the galvanostatic charge/discharge profiles at a current rate of 0.5 C. The two voltage plateaus appear at approximately 1.7 and 1.9 V are related to the phase transition between the tetragonal and orthorhombic phases with Li insertion into anatase TiO$_2$. The Graphene/TiO$_2$ electrode shows a first discharge capacity of 209 mAh g$^{-1}$ and a subsequent charge capacity of 114 mAh g$^{-1}$. The high irreversible capacity loss could be contributed to the formation of an inactive solid/electrolyte interphase (SEI) on the surface of the TiO$_2$ nanocrystal. In the 5th cycle, the discharge capacity decreased to 95 mAh g$^{-1}$ with a corresponding charge capacity of 89 mA h g$^{-1}$, leading to a much higher Coulombic efficiency of 94%. Compared with previous reports, the Graphene/TiO$_2$ electrode shows lower specific capacities. This may due to two reasons: (1) as shown in the TGA curve (Fig. S1), the content of active TiO$_2$ in the Graphene/TiO$_2$ (62.5 wt%) is relatively lower. (2) The potential window (1.5–3 V) is much narrower than that in previous reports. However, as depicted in Fig. S4b, the Graphene/TiO$_2$ electrode exhibits excellent cycling stability and rate performance. For the Graphene/TiO$_2$ electrode, the mesoporous and sandwich nanostructure could favor rapid diffusion of the electrolyte and lead to shortened diffusion path. Meanwhile, the highly conductive graphene layer act as a continuous conductor to facilitate easier electron transport.
**Table S1** Comparison of electrochemical performances of sandwich structural Graphene/TiO$_2$/S electrode with the results of similar reports

<table>
<thead>
<tr>
<th>Graphene-based hosts</th>
<th>Cycling Performance</th>
<th>Reference</th>
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<tbody>
<tr>
<td>GO with epoxy and hydroxyl groups</td>
<td>954 mA h g$^{-1}$/0.1 C/50th cycle</td>
<td>S8</td>
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<tr>
<td>Sulfur assisted exfoliated graphene</td>
<td>615 mA h g$^{-1}$/1 C/100th cycle</td>
<td>S9</td>
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<tr>
<td>PEG modified GO-carbon</td>
<td>520 mA h g$^{-1}$/0.2 C/100th cycle</td>
<td>S10</td>
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<tr>
<td>Graphene reduced by hydrazine</td>
<td>819 mA h g$^{-1}$/0.05 C/100th cycle</td>
<td>S11</td>
</tr>
<tr>
<td>Nafion coated Graphene</td>
<td>662 mAg$^{-1}$/1 C/100th cycle</td>
<td>S12</td>
</tr>
<tr>
<td>Hydrofluoric acid treated graphene</td>
<td>800 mA h g$^{-1}$/0.1 C/50th cycle</td>
<td>S13</td>
</tr>
<tr>
<td>KOH activated graphene</td>
<td>829 mA h g$^{-1}$/0.1 C/50 cycle</td>
<td>S13</td>
</tr>
<tr>
<td>Sandwich structural Graphene/TiO$_2$</td>
<td>765 mA h g$^{-1}$/0.5 C/100th cycle</td>
<td>S14</td>
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<td></td>
<td>737 mAh g$^{-1}$/0.5 C/ 100th cycle</td>
<td>this work</td>
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References: