Electronic supplementary information

Ionic Conductivity Promotion of Polymer Electrolyte with Ionic Liquid Grafted Oxides for All-Solid-State Lithium-Sulfur Batteries

Ouwei Sheng,‡ Chengbin Jin,‡ Jianmin Luo,‡ Huadong Yuan,‡ Cong Fang,‡ Hui Huang,‡ Yongping Gan,‡ Jun Zhang,‡ Yang Xia,‡ Chu Liang,‡ Wenkui Zhang,‡ and Xinyong Tao,‡,*

Fig. S1 Schematic illustration of the fabrication process of IL@NPs based on ion exchange method.

Fig. S2 SEM morphology of (a) IL@SiO₂, (b) IL@TiO₂, (c) IL@ZrO₂.
**Fig. S3** Flammability tests of (a-c) 1 M LiTFSI and 0.1M LiNO$_3$ dissolved in a mixture of 1,3-dioxolane (DOL) and dimethoxymethane (DME) (v/v=1:1) and (d-f) PEO-Li-Zr electrolytes using a burning torch.

**Fig. S4** XPS of (a) C1s and (b) O1s respectively.

**Fig. S5** EDX full elements analysis of N-CNs.
**Fig. S6** TG curves of N-CN/S materials.

**Fig. S7** The discharge/charge curves of the first three cycles for the battery based on PEO-Li, PEO-Li-Si, PEO-Li-Ti, PEO-Li-Zr electrolytes at 50 °C.
Fig. S8 Discharge capacity and Coulombic efficiencies of PEO-Li, PEO-Li-Si, PEO-Li-Ti battery at 50 °C.

Fig. S9 Electrochemical impedance spectroscopy (EIS) of PEO-Li-Si, PEO-Li-Ti battery at 50 °C.
**Fig. S10** The discharge/charge curves of the first three cycles for the battery based on PEO-Li, PEO-Li-Si, PEO-Li-Ti, PEO-Li-Zr electrolytes at 37 °C.

**Fig. S11** Discharge capacity and Coulombic efficiencies of PEO-Li, PEO-Li-Si, PEO-Li-Ti battery at 37 °C.
**Fig. S12** Electrochemical impedance spectroscopy (EIS) of PEO-Li-Si, PEO-Li-Ti battery at 37 °C.
Fig. S13 Typical discharge/charge curves of Carbon black/S cathode and N-CNs/S cathode using PEO-Li-Zr electrolyte at 50 °C. b) Discharge/charge capacity and Coulombic efficiencies of the battery with Carbon black/S cathode or N-CNs/S cathode at 50 °C. c) Typical discharge/charge curves of Carbon black/S cathode and N-CNs/S cathode using PEO-Li-Zr electrolyte at 37 °C. d) Discharge/charge capacity and coulombic efficiencies of the battery with Carbon black/S cathode or N-CNs/S cathode at 37 °C.
### Table S1. Comparison of the electrochemical performance of different all-solid-state batteries

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Cathode/Anode</th>
<th>Working Voltage (V)</th>
<th>Working Temp (°C)</th>
<th>Capacity (mAh g⁻¹)</th>
<th>Year</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEO-LiTFSI -Pyr_{14}TFSI</td>
<td>LiFePO_{4}/Li</td>
<td>3.0-4.0</td>
<td>40</td>
<td>160 (After 100cycles)</td>
<td>2014</td>
<td>[1]</td>
</tr>
<tr>
<td>PEO-LiTFSI -HMOP</td>
<td>LiFePO_{4}/Li</td>
<td>2.9-3.8</td>
<td>65</td>
<td>120 (After 100cycles)</td>
<td>2016</td>
<td>[2]</td>
</tr>
<tr>
<td>PEO-LiClO_{4} -SiO_{2}</td>
<td>LiFePO_{4}/Li</td>
<td>2.5-4.1</td>
<td>90</td>
<td>105 (After 80cycles)</td>
<td>2016</td>
<td>[3]</td>
</tr>
<tr>
<td>PEO-LiClO_{4} -LLZTO</td>
<td>LiFePO_{4}/Li</td>
<td>2.6-3.8</td>
<td>60</td>
<td>105 (After 200cycles)</td>
<td>2016</td>
<td>[4]</td>
</tr>
<tr>
<td>PEO-LiCF_{3}SO_{3} -Li_{2}S-ZrO_{2}</td>
<td>Li_{2}S-C /Li</td>
<td>1.5-3.2</td>
<td>70</td>
<td>600 (After 50cycles)</td>
<td>2010</td>
<td>[5]</td>
</tr>
<tr>
<td>PEO-LiTFSI -MIL-53(Al)</td>
<td>PANI@C/S-280/Li</td>
<td>1.0-3.0</td>
<td>80</td>
<td>876 (After 60cycles)</td>
<td>2015</td>
<td>[6]</td>
</tr>
<tr>
<td>PEO-LiTFSI -IL@ZrO_{2}</td>
<td>CMK-3/S /Li</td>
<td>1.5-3.0</td>
<td>60</td>
<td>450 (After 200cycles)</td>
<td>2016</td>
<td>[7]</td>
</tr>
<tr>
<td>PEO-LiTFSI -IL@ZrO_{2}</td>
<td>N-CN/S/Li</td>
<td>1.8-2.6</td>
<td>37</td>
<td>600 (After 80cycles)</td>
<td>Our</td>
<td></td>
</tr>
</tbody>
</table>

**References**