Improved lithium-sulfur batteries with a conductive coating on the separator to prevent the accumulation of inactive S-related species at the cathode-separator interface

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Fig.S1 (a) photograph of the cross section of Li-S battery fabricated in a quartz cell. (b) photographs of In situ scanning Raman setup.

Calculation of the amount of polysulfides accommodated in the separator. The thickness of the separator is 25 µm. The porosity of the separator is 50%. Thus, the empty space in one piece of the 1 cm² separator is: $25 \mu m \times 1 cm^2 \times 0.5 = 1.25 \mu l$.

The highest dissolution concentration of Li$_2$S$_8$ in electrolyte (1:1, DOL:DME) is ~8 M (the molar concentration was calculated based on sulfur). If the polysulfide (Li$_2$S$_8$) diffused into the electrolyte during discharging is 5 M, then the amount of polysulfide
accommodated in the separator is: \(1.25 \mu l \times 5 \text{ mol/L} \times 32 \text{ g/mol} = 0.2 \text{ mg.}\)

Fig.S2 Electrochemical impedance spectroscopy plots of Li–S cells with pristine separator (50 wt.% cathode) and super P coated separator (60 wt.% cathode), respectively.

Fig.S3 Rate capability of Li-S cells with pristine separator (50 wt.% cathode) and super P modified separator (60 wt.% cathode), respectively.
Fig. S4 (a) cycling performance of 70 wt.% sulfur cathode with super P carbon coating on the separator and the cathode, respectively. C/10. (b) SEM image of the surface of super P carbon coating on the cathode at the discharge status (1.7V) after 50 cycles.

Fig. S5 (a-d) SEM images of ketjen black carbon coated separator, multi wall carbon nanotube coated separator, TiO$_2$ nanoparticles-super P coated separator, and Al$_2$O$_3$ nanoparticles-super P coated separator, respectively. Insets are corresponding photos, respectively.

Table S1. The summary of sheet resistance of different coating layers on the surface of the separator.

<table>
<thead>
<tr>
<th>Coating materials</th>
<th>Multi-wall CNTs</th>
<th>Ketjenblack carbon</th>
<th>Super P carbon</th>
<th>Al$_2$O$_3$ NPs Super P</th>
<th>TiO$_2$ NPs Super P</th>
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</thead>
<tbody>
<tr>
<td>Sheet resistance ($\Omega/\square$)</td>
<td>472±86</td>
<td>514±92</td>
<td>1065±104</td>
<td>2780±157</td>
<td>2375±143</td>
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