Rechargeable Li-CO$_2$ batteries with carbon nanotubes as air cathodes

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Experimental Section

Material Characterization: CNTs were purchased from J&K. Field emission SEM (FESEM) images were obtained on a JEOL-JSM 7500 microscope. HRTEM and EELS were conducted on a FEI Tecnai G2F20 field emission TEM. FTIR spectroscopy was collected with a Nicolet MAGNA-560 spectrometer. XRD was performed to characterize the discharge and charge products on a D/MAX III diffractometer with Cu Kα radiation.

Cell Assembles and Electrochemical Tests: The cathodes were prepared as follows. A slurry containing 90 wt. % CNTs and 10 wt.% PVDF was mixed and then uniformly spread on the carbon paper. The electrochemical performances were evaluated in Swagelok-type cells. The cells were assembled in a glove box filled with high-purity argon (O$_2$ and H$_2$O < 1 ppm). The cells composed of lithium metal anodes,
ploytetrafluoroethylene (PTFE) separators, and CNTs cathodes. The electrolyte composed of 1 mol L\(^{-1}\) LiTFSI dissolved in TEGDEM. Electrochemical measurements were performed on the LAND-CT2001A tester at room temperature. EIS was also performed for the assembled Li-CO\(_2\) cells at different discharge-charge stages under an electrochemical workstation (Zahner Elektrik IM6e) in a frequency window between 100 kHz and 10 mHz.

**Fig. S1** Discharge-charge curves of Li-CO\(_2\) batteries with Ar as the working gas.
Fig. S2 FTIR spectra of (a) PVDF, (b) LiTFSI/TEGDME and (c) Li$_2$CO$_3$.

Fig. S3 (a) TEM and (b) EELS of discharge product of Li/CO$_2$ batteries with platinum net cathodes in the first discharge state.
**Table S1** Summary of electrochemical performance of Li-CO$_2$ batteries with different cathodes at room temperature.

<table>
<thead>
<tr>
<th>Cathode</th>
<th>Maximum capacity</th>
<th>Cyclability</th>
<th>Ref</th>
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<tbody>
<tr>
<td>Super P</td>
<td>~0 mAh g$^{-1}$</td>
<td>/</td>
<td>[16]</td>
</tr>
<tr>
<td>High surface area carbon</td>
<td>~750 mAh g$^{-1}$</td>
<td>/</td>
<td>[16]</td>
</tr>
<tr>
<td>KB</td>
<td>1032 mAh g$^{-1}$</td>
<td>7 cycles at 30 mA g$^{-1}$</td>
<td>[17]</td>
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<tr>
<td>Graphene</td>
<td>14772 mAh g$^{-1}$</td>
<td>20 cycles at 50 mA g$^{-1}$</td>
<td>[22]</td>
</tr>
<tr>
<td>Carbon nanotubes</td>
<td>8379 mAh g$^{-1}$</td>
<td>29 cycles at 50 mA g$^{-1}$</td>
<td>This work</td>
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