Electronic Supplementary Information

Direct grown carbon nanotube based hybrid electrodes with enhanced thermo-cell performances
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SI-1 The Cup-shaped TEC device

![Schematic picture of the Cup-shaped TEC device](image)

**Fig. S1** Schematic picture of the Cup-shaped TEC device

SI-2 XPS data on the elemental contents of the Ag-CNTs hybrid electrodes

**Table S1** Comparison of the atomic concentrations of CNTs-based hybrids

<table>
<thead>
<tr>
<th>Sample</th>
<th>C (%)</th>
<th>O (%)</th>
<th>Fe (%)</th>
<th>Cr (%)</th>
<th>Ag (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag-CNTs-5</td>
<td>90.22</td>
<td>4.53</td>
<td>1.23</td>
<td>3.21</td>
<td>0.81</td>
</tr>
<tr>
<td>Ag-CNTs-10</td>
<td>89.19</td>
<td>3.63</td>
<td>1.15</td>
<td>3.43</td>
<td>2.6</td>
</tr>
<tr>
<td>Ag-CNTs-20</td>
<td>87.57</td>
<td>3.49</td>
<td>1.24</td>
<td>3.11</td>
<td>4.59</td>
</tr>
<tr>
<td>Ag-CNTs-30</td>
<td>86.15</td>
<td>3.89</td>
<td>1.31</td>
<td>3.02</td>
<td>5.63</td>
</tr>
</tbody>
</table>

SI-3 XPS peak analyses of the Fe2p and Cr2p

![XPS spectra of Ag-CNTs sample. (a) Fe2p; (b) Cr2p.](image)

**Fig. S2** XPS spectra of Ag-CNTs sample. (a) Fe2p; (b) Cr2p.
As shown in Fig. S2a, XPS spectrum showed two peaks at 710.6 eV (Fe2p$_{3/2}$) and 723.5 eV (Fe2p$_{1/2}$), corresponding to the Fe-O bonds. As for the Cr2p (Fig. S2b), two peaks from O-Cr bonds appeared at 576.5 eV (Cr2p$_{3/2}$) and 586.7 eV (Cr2p$_{1/2}$).

SI-4 Comparison of conductivity and thermal conductivity of the pristine CNTs and CNTs-based hybrids

Table S2 Comparison of conductivity and thermal conductivity of the pristine CNTs and CNTs-based hybrids

<table>
<thead>
<tr>
<th>Sample</th>
<th>Conductivity (Ω)</th>
<th>Thermal conductivity (W.m$^{-1}$.K$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNTs</td>
<td>11.92</td>
<td>0.1023</td>
</tr>
<tr>
<td>Ag-CNTs-5</td>
<td>9.12</td>
<td>0.3368</td>
</tr>
<tr>
<td>Ag-CNTs-10</td>
<td>5.65</td>
<td>0.9344</td>
</tr>
<tr>
<td>Ag-CNTs-20</td>
<td>4.01</td>
<td>1.0002</td>
</tr>
<tr>
<td>Ag-CNTs-30</td>
<td>2.80</td>
<td>1.1096</td>
</tr>
</tbody>
</table>

Fig. S3 Four-probe current–voltage measurements of the pristine CNTs and the Ag-CNTs hybrids

SI-5 Internal resistance of the TEC with a variation of the temperature difference

Fig. S4 The relation between the internal resistance and the temperature difference
With the increasing temperature difference, the internal resistance of the cell decrease from 68.2 Ω for ΔT =6.1°C to 46.1 Ω for ΔT =30.1°C, which might be due to an increase of the ion conductivity of the electrolyte, similar case could be found in the porous nanocarbon electrodes.3

SI-6 Effect of temperature difference on maximum specific output power

![Graph showing specific output power vs temperature difference for the Ag-CNT electrode.]

**Fig. S5** Specific output power vs temperature difference for the Ag-CNT electrode.

With the increasing temperature difference, the maximum specific output power ($P_{MAX}$) increase from 11.5 to 304.2 mW.m$^{-2}$. By fitting data, the $P_{MAX}$ increase quadratically with the temperature difference.

SI-7 Internal resistance of the TEC with a variation of the operation temperature

![Graph showing internal resistance vs operating temperature for the Ag-CNTs electrode.]

**Fig. S6** Internal resistance vs operating temperature for the Ag-CNTs electrode.
Under the same temperature difference (13.2°C), the internal resistance of the cell decrease by 24.5 % (from 57.5 to 43.4Ω) with the increasing operating temperature.

SI-8 Two identical cells connected in series

References