Supporting Information

Bio-Ingredients Assisted Formation of Porous TiO$_2$ for Li-Ion Battery Electrodes

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Figure S1. SEM image of the reference sample.

Figure S2. EDX result from the rectangular area in the TEM image of C-PT. The same image is displayed in Figure 4a in the main article also.

Figure S3. Raman spectrum of C-PT.

Figure S4. SEM image of C-PT.

Figure S5. XRD pattern of C-PT.

Figure S6. N$_2$ adsorption-desorption isotherms of sample C-PT. Inset: pore size distributions of the material.

Figure S7. Four continuous scans of cyclic voltammograms of (a) PT and (b) the reference sample.

Figure S8. Discharge/charge curves of anodes composed of (a) C-PT, (b) C-PT-2, (c) PT, and (d) the reference sample at 3 - 1 V versus Li$^+$/Li.

Figure S9. Rate capacities of C-PT at 5 C (1 C = 334 mAh/g) for 100 cycles.

Figure S10. (a) Impedance plots of the samples before cycling. (b) Plots of impedance as a function of the inversed square root of angular frequency in the Warburg region.

Figure S11. (a) Impedance plots of C-PT before and after discharge-charge cyclings. (b) Plots of impedance as a function of the inversed square root of angular frequency in the Warburg region.

Table S1. Summary of electrochemical properties of the anatase TiO$_2$ anode materials for Li-ion batteries. All cathodes are Li metal foils.

Table S2. Warburg factors ($\sigma$) and diffusion coefficients (D) (estimated from the equations S1 and S2 below) of Li ions in different anode samples.
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<table>
<thead>
<tr>
<th>TiO$_2$ Anode Materials</th>
<th>Morphology</th>
<th>Surface area (m$^2$/g)</th>
<th>Performance</th>
<th>References</th>
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<tbody>
<tr>
<td></td>
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<td>Working Potential (V)</td>
<td>Cycling Rate (mA/g)</td>
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<tr>
<td>Anatase</td>
<td>Nanotube</td>
<td>400</td>
<td>1.2 - 3</td>
<td>4000</td>
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<td>Anatase</td>
<td>Nanosheet</td>
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<td>1 - 3</td>
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<td>3400</td>
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<tr>
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<td>Hollow sphere</td>
<td>135</td>
<td>1 - 3</td>
<td>1700</td>
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<td>Anatase</td>
<td>Spindle-shaped</td>
<td>16</td>
<td>1 - 3</td>
<td>170</td>
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<td>Anatase</td>
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<td>1 - 3</td>
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<td>1 - 3</td>
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<td>Anatase</td>
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<td>1 - 3</td>
<td>680</td>
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<td>1700</td>
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<td>3400</td>
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<tr>
<td>Anatase/Rutile$^1$</td>
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<td>C/Anatase$^2$</td>
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<td>1 - 3</td>
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<td>1650</td>
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<tr>
<td>C/Anatase$^2$</td>
<td>Porous</td>
<td>53</td>
<td>1 - 3</td>
<td>1670</td>
</tr>
</tbody>
</table>
1. Mixed phases.
2. C-coated anatase.
3. N-doped C coated anatase.


Table S2. Warburg factors ($\sigma$) and diffusion coefficients ($D$) (estimated from the equations S1 and S2 below) of Li ions in different anode samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>$\sigma$ (ohm cm$^2$/s$^{0.5}$)</th>
<th>$D$ (cm$^2$/s)</th>
</tr>
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<tbody>
<tr>
<td>PT</td>
<td>125.9</td>
<td>2.27*10$^{-13}$</td>
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<tr>
<td>C-PT</td>
<td>75.233</td>
<td>6.36*10$^{-13}$</td>
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<tr>
<td>Reference</td>
<td>508.82</td>
<td>1.39*10$^{-13}$</td>
</tr>
</tbody>
</table>

**Derivation of Warburg factor**

$$Z_{\text{real}} = R_e + R_{ct} + \sigma \omega^{-0.5} \quad (S1)$$

$Z_{\text{real}}$: Real resistance of the impedance response of the system

$R_e$: Resistance between the electrolyte and the electrode

$R_{ct}$: Charge transfer resistance

$\sigma$: Warburg factor in ohm cm$^2$/s$^{0.5}$

$\omega$: Angle frequency

**Warburg diffusion equation**

$$D = 0.5 \left( \frac{RT}{AF^2 \sigma C} \right)^2 \quad (S2)$$

$D$: Diffusion coefficient of Li$^+$ ions in the electrode

$R$: Gas constant, 8.314 J/mol K

$T$: Room temperature, 298 K

$A$: Surface area of the electrode

$F$: Faraday constant, 96486 C/mole

$C$: Molarity of Li$^+$ ions

$\sigma$: Warburg factor in ohm cm$^2$/s$^{0.5}$