Supporting information

Synthesis of LiMnPO₄/C with superior performance as Li-ion battery cathode by a two-stage microwave solvothermal process

Jian-Nan Zhu, Wen-Cui Li, Fei Cheng and An-Hui Lu *

State Key Laboratory of Fine Chemicals, School of Chemical Engineering, Dalian University of Technology, Dalian 116024, P. R. China

E-mail: anhuilu@dlut.edu.cn, Fax: (+86)-411-84986112

Table S1. Synthesized samples used in this study.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Synthesis temp. / °C</th>
<th>Synthesis time / min</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW-160-03</td>
<td>160</td>
<td>3</td>
</tr>
<tr>
<td>MW-160-10</td>
<td>160</td>
<td>10</td>
</tr>
<tr>
<td>MW-160-30</td>
<td>160</td>
<td>30</td>
</tr>
<tr>
<td>MW-180-10</td>
<td>180</td>
<td>10</td>
</tr>
<tr>
<td>MW-200-10</td>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td>LMP/NC</td>
<td>C-coated MW-160-10 using dopamine as carbon source</td>
<td></td>
</tr>
<tr>
<td>LMP/C</td>
<td>C-coated MW-160-10 using glucose as carbon source</td>
<td></td>
</tr>
<tr>
<td>Pure-LMP</td>
<td>Pure MW-160-10 without a carbon coating</td>
<td></td>
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</tbody>
</table>

Table S2. Elemental analysis results.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Element content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (wt%)</td>
</tr>
<tr>
<td>LMP/C</td>
<td>0.05</td>
</tr>
<tr>
<td>LMP/NC</td>
<td>1.18</td>
</tr>
<tr>
<td>MW-160-03/C</td>
<td>1.12</td>
</tr>
<tr>
<td>MW-160-30/C</td>
<td>1.07</td>
</tr>
<tr>
<td>MW-180-10/C</td>
<td>1.10</td>
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<tr>
<td>MW-200-10/C</td>
<td>1.08</td>
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</tbody>
</table>
**Fig. S1.** Powder X-ray diffraction patterns of the carbon-coated LiMnPO$_4$ obtained under different conditions.

**Fig. S2** The impedance spectra for samples under different condition assembled in coin cell.

**Fig. S3** (a-c) the TEM and FFT of sample MW-160-03/C, (d-e) the TEM and FFT of sample MW-160-30/C.
Fig. S4. The TG analysis results.

Calculation of the carbon content

For the sample of LMP/NC, there is 91.8 wt% of residue after pyrolysis at 800 °C in air, and for the pure LMP, it is 97 wt%.

By assuming that the carbon content is x.

\[(1-x) \times 0.97 + x \times 0 = 0.918\]

Thus, \[x = 5.4\%\].

So the carbon content of the three samples are separately 5.4 wt% (LMP/NC), 7.1 wt% (LMP/C), and 3 wt% (Pure-LMP).

Lithium ion diffusion coefficient:

\[D_{Li^+} = \frac{R^2T^2}{2A^2n^4F^4C^2\sigma^2}\]  \hspace{1cm} (Eq. S1)

The lithium ion diffusion coefficient \([D_{Li^+}]\) has been calculated for all samples using the Eq. S1, where \(R\) is the gas constant, \(T\) is the absolute temperature, \(A\) is the contact area of the electrode \((2.01\; \text{cm}^2)\), \(n\) is the number of electrons per molecule, \(F\) is the Faraday constant, \(C\) is the concentration of \(Li^+\) ions \((6.38 \times 10^{-3} \; \text{mol cm}^{-3})\), ratio between the tap density of the prepared material and molecular weight) and \(\sigma\) is the Warburg coefficient associated with the slope of the linear fits between \(Z_{re}\) and the reciprocal square root of the angular frequency in the low frequency region.
<table>
<thead>
<tr>
<th>Synthesis process</th>
<th>Cycle performance</th>
<th>Rate performance</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Solvothermal method</td>
<td>Charge 0.5 C</td>
<td>Charge 10 C</td>
<td>Journal of Materials Chemistry A [16]</td>
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<td>Discharge 0.5 C</td>
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<tr>
<td></td>
<td>134 mA h g⁻¹ after 100 cycles</td>
<td>108 mA h g⁻¹</td>
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<tr>
<td>Solid state reaction</td>
<td>Charge 0.02 C</td>
<td>Charge 0.02 C</td>
<td>Nano Letters [33]</td>
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<td></td>
<td>Discharge 0.2 C</td>
<td>Discharge 10 C</td>
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<td></td>
<td>130 mA h g⁻¹ after 50 cycles</td>
<td>35 mA h g⁻¹</td>
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<td>Charge 0.1 C</td>
<td>Charge 0.1 C</td>
<td>Advanced Energy Material [40]</td>
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<tr>
<td></td>
<td>Discharge 1 C</td>
<td>Discharge 10 C</td>
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<tr>
<td></td>
<td>155 mA h g⁻¹ after 50 cycles</td>
<td>110 mA h g⁻¹</td>
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<td>Ultrasonic spray pyrolysis</td>
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<td>Charge 0.1 C</td>
<td>Advanced Functional Material [41]</td>
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<td>Discharge 0.5 C</td>
<td>Discharge 10 C</td>
<td></td>
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<tr>
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<td>130 mA h g⁻¹ after 50 cycles</td>
<td>58 mA h g⁻¹</td>
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<td>Charge 10 C</td>
<td>This work</td>
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<td></td>
<td>Discharge 0.5 C</td>
<td>Discharge 10 C</td>
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<tr>
<td></td>
<td>154 mA h g⁻¹ after 100 cycles</td>
<td>118 mA h g⁻¹</td>
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**References:**