Supporting Information

Inverse-spinel $\text{Mg}_2\text{MnO}_4$ cathode for high-performance and flexible aqueous zinc-ion battery

Xuming Yuan $^\dagger$, Tianjiang Sun $^\dagger$, Shibing Zheng $^a$, Junquan Bao $^a$, Jing Liang $^a$, Zhanliang Tao $^a$

$^a$Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education), College of Chemistry, Nankai University, Tianjin 300071, P. R. China.

$^\dagger$These authors contributed equally to this work.

$^*$Corresponding author
Zhanliang Tao
E-mail: taozl@nankai.edu.cn
Figure S1. The SEM-EDS of as-synthesized Mg$_2$MnO$_4$ sample.

Figure S2. HRTEM image of the as-obtained Mg$_2$MnO$_4$ sample.

Figure S3. XRD pattern of the as-obtained MgMn$_2$O$_4$ sample.
Figure S4. SEM images of the as-obtained MgMn$_2$O$_4$.

Figure S5. A comparison of average discharge potential, specific capacity and energy density between this work and reported materials.
Figure S6. a) The charge-discharge curves of Zn//MgMn$_2$O$_4$ battery. b) Rate capacity of Zn//MgMn$_2$O$_4$ battery. c) Cycling stability of Zn//MgMn$_2$O$_4$ battery.

Figure S7. Electrochemical stability of the full battery surveyed by self-discharge experiments. Specifically, the full battery was fully charged to 1.9 V, then fully discharged to 0.4 V after rest for 24 h.

Figure S8. a~b) The ex-situ SEM patterns of Mg$_2$MnO$_4$ electrodes. a) Discharge to 0.4 V; b) Charge to 1.9 V.
Figure S9. Typical Nyquist plots for Zn//Mg₃MnO₄ battery at different state.

Figure S10. a~b) The ex-situ SEM patterns of Zn anode. a) Discharge to 0.4 V; b) Charge to 1.9 V.

Figure S11. a~b) The ex-situ XRD patterns of Zn anode. a) Discharge to 0.4 V; b) Charge to 1.9 V.
Figure S12. The structural formula for the polymerization.

Figure S13. The ATR-FTIR spectra of AM, AMPS, and P-APSA sample.

Figure S14. The stretching test of P-APSA sample.
**Figure S15.** Reversible Zn$^{2+}$ plating/stripping behaviour on SS

**Figure S16.** Cycling stability of Zn//P-APSA//Zn symmetric cell.
Figure S17. The CV curves of Zn//P-APSA//Mg$_2$MnO$_4$ battery.

Figure S18. The charge-discharge curves of Zn//P-APSA//Mg$_2$MnO$_4$ battery.
Figure S19. Typical Nyquist plots for Zn//P-APSA//Mg$_2$MnO$_4$ battery.

Figure S20. Typical Nyquist plots for Zn//P-APSA//Mg$_2$MnO$_4$ battery after five cycles.
**Figure S21.** The charge-discharge curve of two batteries connected in series.

**Figure S22.** The discharge curves of single battery and two batteries connected in parallel.
Table S1 The SEM-EDS of as-synthesis Mg$_2$MnO$_4$ sample.

<table>
<thead>
<tr>
<th>Technology</th>
<th>SEM-EDS</th>
<th>ICP-OES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element</td>
<td>wt%</td>
<td>wt% sigma</td>
</tr>
<tr>
<td>O</td>
<td>36.77</td>
<td>0.29</td>
</tr>
<tr>
<td>Mg</td>
<td>31.62</td>
<td>0.25</td>
</tr>
<tr>
<td>Mn</td>
<td>31.61</td>
<td>0.27</td>
</tr>
<tr>
<td>Mole ration of Mn:Mg</td>
<td>0.442:1</td>
<td>0.445:1</td>
</tr>
</tbody>
</table>

Table S2 A comparison of electrochemical performance between this work and reported materials.

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Electrolyte</th>
<th>Specific capacity</th>
<th>Cycling stability</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZnMn$_2$O$_4$@C</td>
<td>3 M Zn(CF$_3$SO$_3$)$_2$</td>
<td>150 mAh g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>94% after 500 cycles mA g$^{-1}$</td>
<td>1</td>
</tr>
<tr>
<td>ZnMn$_2$O$_4$@N-GO</td>
<td>1 M ZnSO$_4$+ 0.05M MnSO$_4$</td>
<td>221 mAh g$^{-1}$ at 100 mA g$^{-1}$</td>
<td>97.4% after 2500 cycles at 1000 mA g$^{-1}$</td>
<td>2</td>
</tr>
<tr>
<td>Mn$_2$O$_4$</td>
<td>2 M ZnSO$_4$</td>
<td>239.2 mAh g$^{-1}$ at 100 mA g$^{-1}$</td>
<td>72.2% after 300 cycles at 500 mA g$^{-1}$</td>
<td>3</td>
</tr>
<tr>
<td>SSWM@Mn$_2$O$_4$</td>
<td>2 M ZnSO$_4$+ 0.1 M MnSO$_4$</td>
<td>296 mAh g$^{-1}$ at 100 mA g$^{-1}$</td>
<td>60% after 500 cycles at 500 mA g$^{-1}$</td>
<td>4</td>
</tr>
<tr>
<td>MgV$_2$O$_4$</td>
<td>2 M Zn(TFSI)$_2$</td>
<td>272 mAh g$^{-1}$ at 200 mA g$^{-1}$</td>
<td>74% after 500 cycles at 4000 mA g$^{-1}$</td>
<td>5</td>
</tr>
<tr>
<td>ZnV$_2$O$_4$</td>
<td>2 M Zn(ClO$_4$)$_2$</td>
<td>312 mAh g$^{-1}$ at 0.5 C</td>
<td>82% after 1000 cycles at 10C</td>
<td>6</td>
</tr>
<tr>
<td>rGO@HM-ZnMn$_2$O$_4$</td>
<td>1 M ZnSO$_4$+ 0.05M MnSO$_4$</td>
<td>146.9 mAh g$^{-1}$ at 300 mA g$^{-1}$</td>
<td>88% after 650 cycles at 1000 mA g$^{-1}$</td>
<td>7</td>
</tr>
<tr>
<td>ZnNi$_2$Co$<em>x$Mn$</em>{2-x}$O$_4$@N-rGO</td>
<td>2 M ZnSO$_4$+ 0.2M MnSO$_4$</td>
<td>200.5 mAh g$^{-1}$ at 10 mA g$^{-1}$</td>
<td>79% after 900 cycles at 1000 mA g$^{-1}$</td>
<td>8</td>
</tr>
<tr>
<td>MgMn$_2$O$_4$</td>
<td>1 M MnSO$_4$ + 1M MgSO$_4$</td>
<td>247 mAh g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>80% after 500 cycles at 500 mA g$^{-1}$</td>
<td>9</td>
</tr>
<tr>
<td>Mg$_2$MnO$_4$</td>
<td>2 M ZnSO$_4$+ 0.1M MnSO$_4$</td>
<td>371.7 mAh g$^{-1}$ at 150 mA g$^{-1}$</td>
<td>85% after 2000 cycles at 3000 mA g$^{-1}$ (compared to the discharge capacity after activation)</td>
<td>This work</td>
</tr>
</tbody>
</table>

Reference:


