Supporting Information

Manganese ion pre-intercalated hydrated vanadium oxide as a high-performance cathode for magnesium ion batteries

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Fig. S1 The XRD patterns of MnVO, MnVO-400 and HVO respectively.

Fig. S2 (a) Survey XPS spectrum and (b) high-resolution XPS spectrum of V 2p peak of the MnVO.
Fig. S3 (a, c) SEM images of Mn$_{0.04}$V$_2$O$_5$. (b, d) SEM images of V$_2$O$_5$·nH$_2$O.
Fig. S4 (a, b) TEM image of HVO and MnVO-400. (c, d) SAED pattern of HVO and MnVO-400.
**Fig. S5** Energy dispersive X-ray (EDX) spectrum of the MnVO.

**Fig. S6** (a) CV curve of Mg|Mg(TFSI)$_2$/AN|Mo cell at 50 mV s$^{-1}$ in −1.0-3.0 V. (b) The charge/discharge curves of MnVO|Mg(TFSI)$_2$/AN|Mg cell at 20 mA g$^{-1}$. 
**Fig. S7** The SEM image of MnVO after 50 cycles at 0.1 A g$^{-1}$.

**Fig. S8** (a) SAED pattern and TEM image of MnVO after 50 cycles at 0.1 A g$^{-1}$.

**Fig. S9** Cycling performances of MnVO at 1 A g$^{-1}$.
Fig. S10 Cycling performances (a, c) and charge-discharge curves (b, d) of MnVO at 0.2 and 0.5 A g\textsuperscript{-1}.

Fig. S11 (a, b) The charge-discharge curves of MnVO under different cycle times is at 2 A g\textsuperscript{-1}.
Fig. S12 (a, b) Cycling performances of MnVO, MnVO-400 and HVO at 0.2 and 1 A g$^{-1}$. 

Fig. S13 (a, b) Charge-discharge curves of MnVO, MnVO-400 and HVO at 0.2 and 1 A g$^{-1}$. 
Fig. S14 (a, b, c) The CV curves of MnVO, MnVO-400 and HVO at scan rates of 0.1 mV s\(^{-1}\).

Fig. S15 (a, b) log(i) versus log(v) plots of the cathodic current response at four peaks shown in (Fig 3c,d).

Fig. S16 (a-c) The electrochemical impedance spectra (EIS) of MnVO in initial and fifth cycles.
Fig S17 1D *In-situ* XRD pattern.

Fig S18 (005) crystal plane in the pristine material.

Fig S19 *Ex-TEM* mapping of MnVO.
**Fig S20** (a) EDX spectrum of charge/discharge states of MnVO. (b) The *ex-situ* ICP of MnVO in different cycle phase.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mn (mg/L)</th>
<th>V (mg/L)</th>
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<tbody>
<tr>
<td>#1</td>
<td>2.891</td>
<td>147.6</td>
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<tr>
<td>#2</td>
<td>2.98</td>
<td>134</td>
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**Table S1** The ICP-OES analysis of MnVO.