Electronic Supplementary Information

Porous LiMn$_2$O$_4$ nanorods with durable high-rate capability for rechargeable Li-ion batteries

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This file contains Figs. S1–S8.

Fig. S1 XRD patterns of (a) MnC$_2$O$_4$ nanorods synthesized through the micro-emulsion method at room temperature and (b) porous Mn$_2$O$_3$ nanorods prepared by calcining the MnC$_2$O$_4$ precursors at 450 °C for 6 h.
**Fig. S2** XRD patterns of the products obtained from the solid-state reaction between porous Mn$_2$O$_3$ nanorods and LiOH at different temperatures: (a) 450 °C, (b) 500 °C, (c) 600 °C, and (d) 700 °C. The asterisk denotes Mn$_2$O$_3$.

**Fig. S3** SEM images of the products obtained from the solid-state reaction between porous Mn$_2$O$_3$ nanorods and LiOH at different temperatures: (a) 500 °C, (b) 600 °C, (c) 700 °C, and (d) 800 °C.
Fig. S4 Differential capacities versus voltage (dQ/dV) from the initial 1C charge and discharge curves of the porous spinel nanorods prepared at 700 °C.

Fig. S5 Charge-discharge curves at the second cycle (at 1 C rate) of the porous nanorods prepared at different temperatures.
Fig. S6 Plots of the peak current density versus the square root of potential scan rate derived from the CVs of LiMn$_2$O$_4$ porous nanorods (a,b), nanorods (c,d) and nanoparticels (e,f). (a,c,e) and (b,d,f) correspond to the reductive peaks centered at lower and higher potential, respectively.
Fig. S7 Electrochemical impedance data (points) and the fitted curve (line) of the porous nanorods measured at potential of 4.2 V versus Li⁺/Li. The inset shows the equivalent circuit for modeling the impedance data.¹ Diffusion coefficient of lithium \( (D) \) can be calculated from the fitted impedance data by applying the following equation:

\[
D = \frac{L^2}{W_T}
\]

where \( W_T \) is the Warburg element and \( L \) is the thickness of the film.¹ The \( W_T \) value is obtained by fitting the impedance data with ZView software and the \( L \) value is measured from SEM image. Thus, the lithium diffusivity for the porous spinel nanorods is \((5 \times 10^{-4})^2 / 3.066 = 8.15 \times 10^{-8} \text{ cm}^2/\text{s}\).
Fig. S8 Charge/discharge curves of LiMn$_2$O$_4$ (a) porous nanorods, (b) nanoparticles, and (c) nanorods at the constant current rate of 1 C.

Reference