Metal Powder-Pure Water System for Rational Synthesis of Metal Oxide Functional Nanomaterials: a General, Facile and Green Synthetic Approach

Lingjie Li, Jie Zhang, Jinglei Lei, Jing Xu, Peipei Liu, Nianbing Li, Fusheng Pan

a. School of Chemistry and Chemical Engineering, Chongqing University, Chongqing, 400044 PR China;
b. School of Chemistry and Chemical Engineering, Southwest University, Chongqing, 400715 PR China;
c. School of Materials Science and Engineering, Chongqing University, Chongqing, 400044 PR China

*Corresponding author: Jinglei Lei. Tel.: +86 13983064116; Fax: +86 23 65112328; E-mail address: JLLei@cqu.edu.cn.
Figure S1. XRD patterns of the samples prepared by metal powder-pure water hydrothermal treatments: (a) Mn powder, (b) Zn powder, and (c) Fe powder.
Figure S2. Photographs, SEM images and XRD patterns of the raw metal powders: (a-c) Mn, (d-f) Zn, and (g-i) Fe.
Figure S3. XRD patterns of the samples after the UAPO step: (a) Mn powder, (b) Zn powder, and (c) Fe powder.
Figure S4. XPS survey spectra of the as-prepared samples: (a) Mn$_3$O$_4$, (b) ZnO, and (c) Fe$_3$O$_4$. 
Figure S5. Some electrochemical characterization results of the as-prepared Mn$_3$O$_4$ as a supercapacitor electrode material. a: galvanostatic charge-discharge curves, b: EIS spectra at open circuit potential with a bottom inset for an enlargement of the high-frequency region and a top inset for the equivalent electrical circuit used for fitting.

**Electrochemical specific capacitance calculation details.**
Calculation of specific capacitance \((C_s, \text{ F g}^{-1})\) in this work is based upon subtraction of the capacitance which belongs to the Ni foam current collector from the total capacitance of the as-prepared Mn\(_3\)O\(_4\) electrode according to following equations:

(1) based upon the CV curves:\(^{1,2}\)

\[
C_s = \frac{Q}{\Delta V \times m} = \frac{1}{v \times m \times (V_c - V_a)} \int_{V_a}^{V_c} i(V) dV
\]

where \(m\) is the mass of the Mn\(_3\)O\(_4\) electroactive material in the electrode (g), \(v\) is the potential scan rate (V s\(^{-1}\)), \(V_a\) is the anodic potential (V), \(V_c\) is the cathodic potential (V), \(i(V)\) is the response current density (A) and \(V\) is the potential (V).

(2) based upon the galvanostatic charge-discharge curves:\(^{1-3}\)

\[
C_s = \frac{I \times \Delta t}{m \times \Delta V}
\]

where \(I\) is the discharge current (A), \(\Delta t\) is the discharge time (s), \(m\) is the mass of the Mn\(_3\)O\(_4\) electroactive material in the electrode (g) and \(\Delta V\) is the potential change during discharge (V).

**Discussion on Figure S5.**

Figure S5a illustrates the galvanostatic charge-discharge curves at different current densities, based upon which the specific capacitances are calculated to be 120, 106, 97, 82, and 68 F g\(^{-1}\) at current densities of 0.25, 0.5, 1, 2, and 5 A g\(^{-1}\), respectively (the calculating details of the specific capacitances are described in the above part), in good agreement with those calculated from the CV results. The good supercapacitive performance of the as-prepared Mn\(_3\)O\(_4\) material is further confirmed by the EIS result (Figure S5b), which displays a typical impedance characteristics for
Further deconvoluting the EIS spectra with the equivalent circuit illustrated in the top inset of Figure S5b, the equivalent series resistance $R_s$ and charge transfer resistance $R_{ct}$ respectively with the values of 1.02 $\Omega$ and 0.27 $\Omega$ can be obtained. The small $R_{ct}$ value indicates the high charge-transfer rate between the electrolyte and the active material due to the nanorod morphology of the as-prepared Mn$_3$O$_4$ material, which is highly desirable for power density improvement.$^6$

References


