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Supporting Information

Paramecium-shaped α-MnO_2 hierarchical hollow structures with enhanced electrochemical capacitance prepared by a facile dopamine carbon-source assisted shell-swelling etching method

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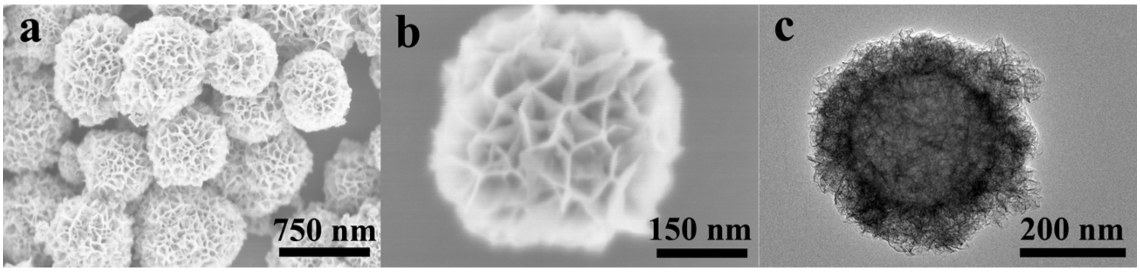

Fig. S1 FESEM and TEM images of MnO_2 hollow spheres for comparable sample

Typically, carbon spheres were synthesized by hydrothermal method using glucose as the carbon source. Carbon@MnO_2 core-shell structures were then prepared by the reaction between carbon spheres and $KMnO_4$ after homogeneously mixing and hydrothermal treatment. MnO_2 hollow spheres were collected after calcination of the core-shell structures in a tubular furnace. The MnO_2 hollow spheres are with external diameter ~ 420 nm and inner diameter ~ 280 nm.

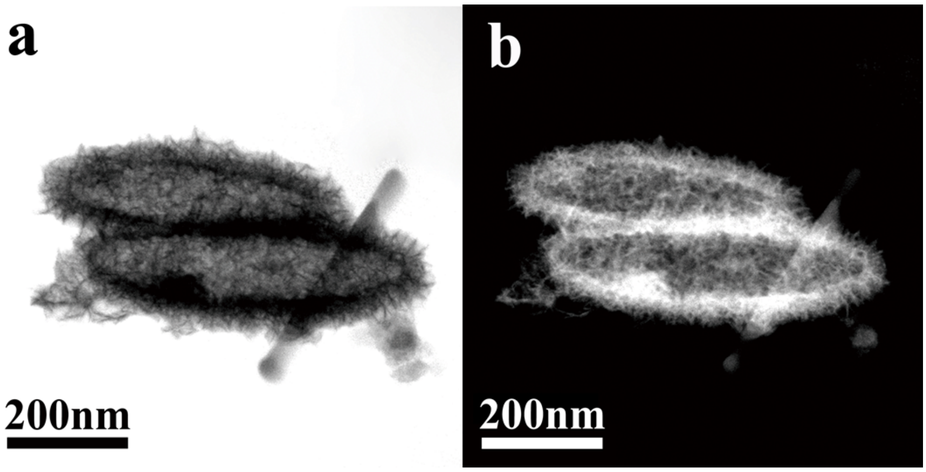

Fig. S2 STEM-BF and STEM-HAADF images of P-MnO_2 sample

STEM-BF and STEM-HAADF tests were carried out to further confirm the unique structure of P-MnO_2. Dark areas represent atomic regions in STEM-BF image, while bright areas represent atomic regions in STEM-HAADF image. Both STEM images clearly indicate the presence of the hollow structure. Besides, flaky sheets of shell can also be confirmed by these two images.

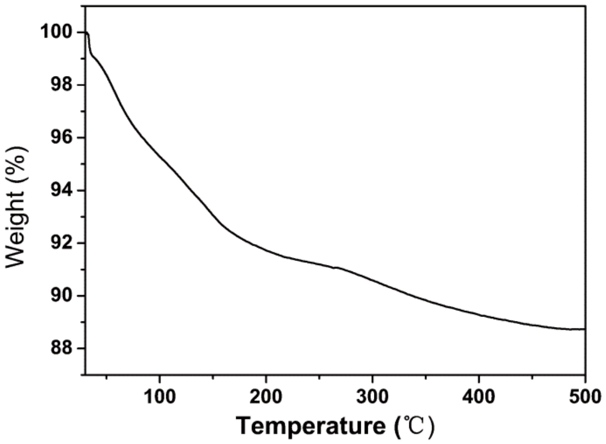

Fig. S3 TGA curve of final product of Paramecium-like MnO2 hierarchical hollow structure

The TGA curve has shown that the residual quantity of carbon of the final product is about 11%.

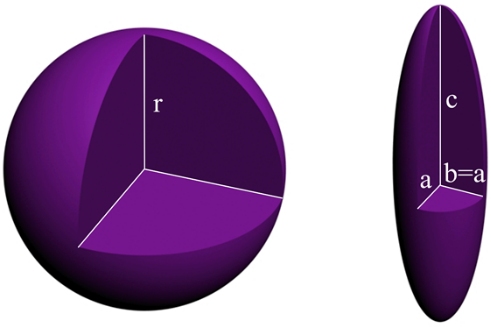

Fig. S4 Space utilization models of S-MnO$_2$ and P-MnO$_2$, respectively

As is shown in Figure 3S, the volumes of sphere and ellipsoid are calculated as the formulae $V_{sp} = \frac{4}{3}\pi r^3$ and $V_{el} = \frac{4}{3}\pi a^2 c$, respectively. While the surface areas of those are obtained by formulae $S_{sp} = 4\pi r^2$ and $S_{el} = 2\pi a^2\left(1 + \frac{c}{ae}\sin^{-1} e\right)$ (where $e = \sqrt{1 - \frac{a^2}{c^2}}\left(c > a\right)$). The latter could be substituted by an approximate formula $S_{el} \approx 4\pi \sqrt[1.6]{\frac{a^{3.2} + 2a^{1.6}c^{1.6}}{3}}$. The ellipsoid has an advantage in space utilization with the larger surface than that of sphere in the case of same volume. We assume c = n·a (n>1) in ellipsoid (defined as prolate spheroid), when $V_{el} = \frac{4}{3}\pi n a^3 = V_{sp} = \frac{4}{3}\pi r^3$, then r gets $\sqrt[3]{n}$·a, and the ratio $q = \frac{V_{el}}{V_{sp}} = \frac{1}{\sqrt[3]{n^2}} \times \sqrt[1.6]{\frac{1 + 2n^{1.6}}{3}}$. The lager n gets, the lager q will be, and the larger surface ellipsoid will obtain. In other word, materials with large aspect ratio will get higher space utilization. According to calculating results, the space utilization of P-MnO$_2$ is nearly three times high as that of S-MnO$_2$, which is supposed to enhance electrochemical properties.