Well-shaped Mn$_3$O$_4$ tetragonal bipyramids with good performance for lithium ion batteries

*Taotao Li*, Chunli Guo*, Bo Sun, Ting Li, Yonggang Li, Lifeng Hou, Yinghui Wei

*a. College of Materials Science and Engineering, Taiyuan University of Technology, Taiyuan, Shanxi, 030024, P.R. China*

*b. Department of Mechanical Engineering, National University of Singapore, 119260, Singapore*

*c. Lvliang College, Lishi Shanxi 033000, China*

*Corresponding author: Chunli Guo and Yinghui Wei, Tel./Fax: +86 351 6018683, Email address: guochunli@tyut.edu.cn and weivinghui@tyut.edu.cn*

![Fig.S1 The X-ray diffraction patterns of the as-prepared product](image)
Fig. S2. XPS spectra of as-prepared Mn$_3$O$_4$

Fig. S3 XRD patterns of the samples recorded at 4h.

Fig. S4 XRD patterns of the samples prepared at 6 h.
\begin{align*}
\text{MnOOH} + \text{H}_2\text{O} & \rightleftharpoons \text{Mn}^{3+} + \text{OH}^- \\
\text{MnCO}_3 + \text{H}_2\text{O} & \rightleftharpoons \text{Mn}^{2+} + \text{CO}_2 + \text{H}_2\text{O} + \text{OH}^- 
\end{align*}

Fig. S5 The chemical reaction equations of MnCO$_3$ and MnOOH.

Fig. S6 A SEM image of the samples prepared at 6 h.

Fig. S7 A SEM image of the samples prepared at 8 h.
Fig. S8 a schematic diagram of 3d electron filling

Fig. S9 The force analysis diagram of the two kinds of O\(^2\)\(^-\) in the octahedral complexes