Supporting information for

# Controlled growth of porous δ-$MnO_2$ nanosheets on carbon fibers as a bi-functional catalyst for rechargeable lithium-oxygen batteries

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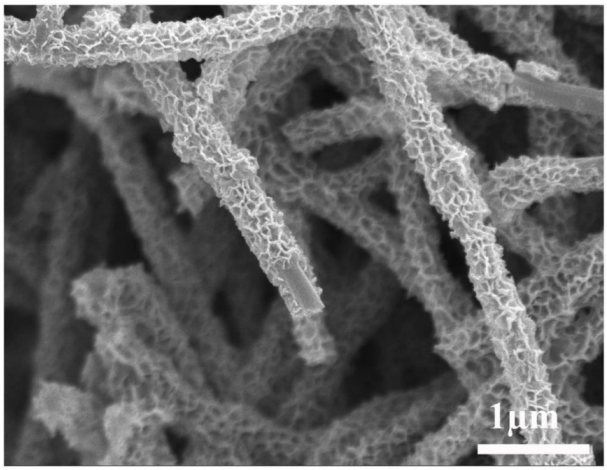


**Figure S1** SEM image of δ-$MnO_2$/CCFs-K80 sample showing a typical core-shell structure.

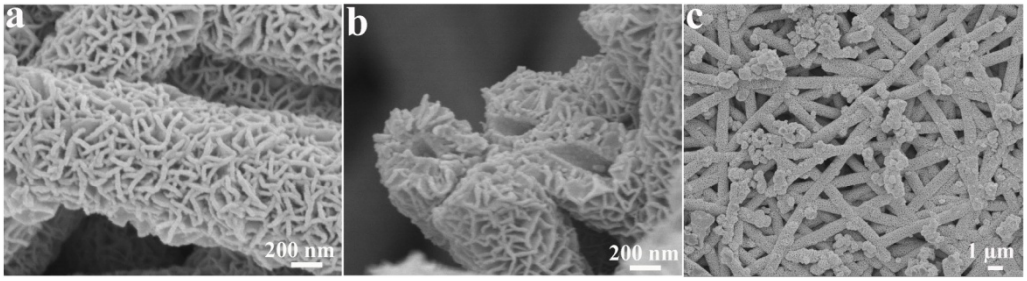


**Figure S2** SEM images of pure δ-$MnO_2$ sample at high (a, b) and low (c) magnification.

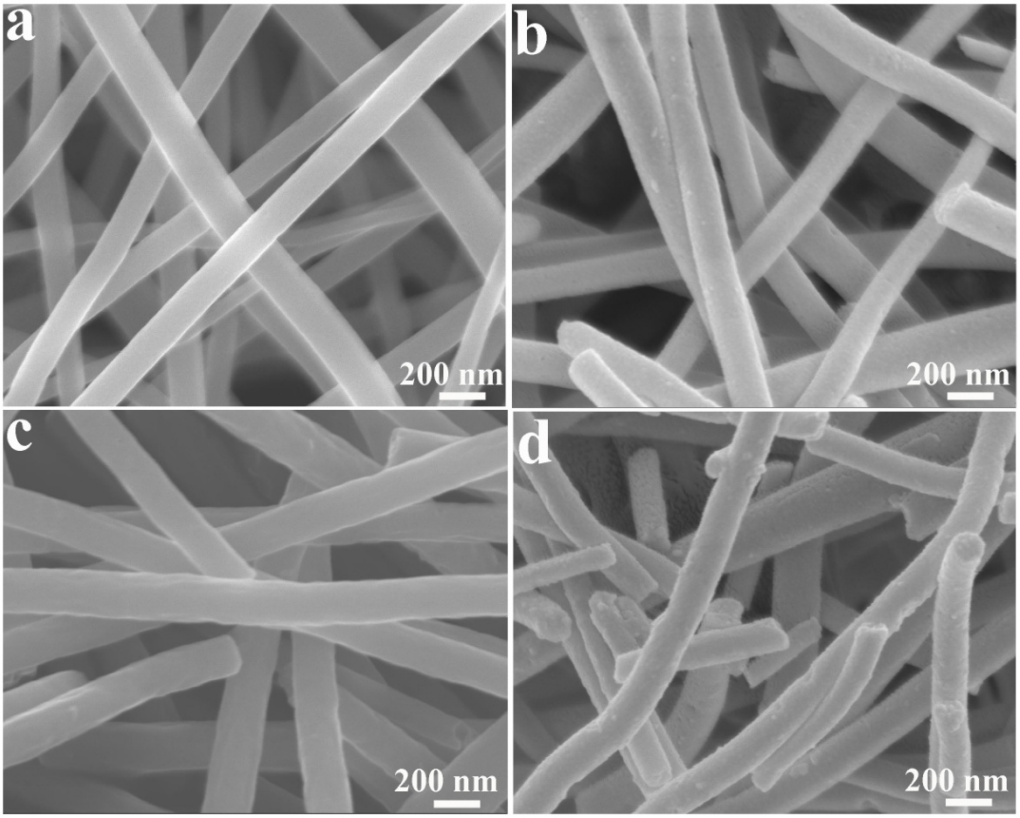


**Figure S3** SEM images of the acid-treated CFs before loading the $MnO_2$ (a) and the SEM images of δ-$MnO_2$/CCFs-K40 (b), δ-$MnO_2$/CCFs-K80 (c) and δ-$MnO_2$/CCFs-K120 (d) after etching the $MnO_2$ phase.

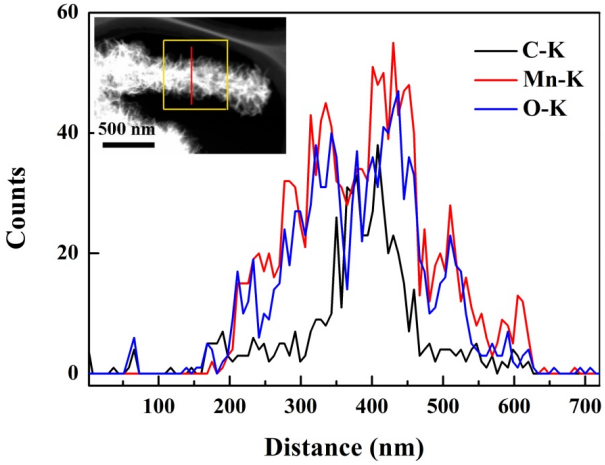


**Figure S4** Line-scanning (marked by the red line in the insert image) elemental profiles of C, Mn and O elements.

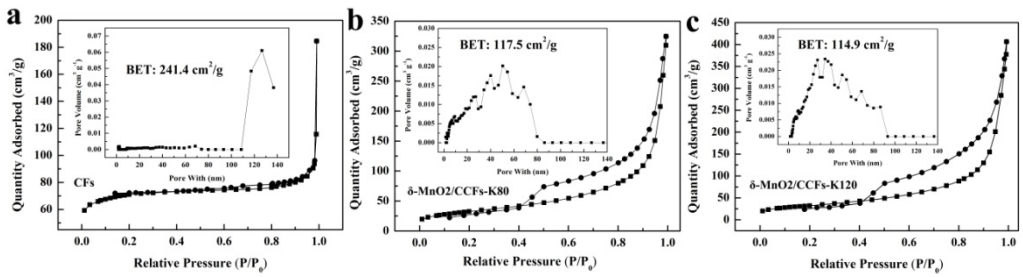


**Figure S5** Nitrogen adsorption-desorption isotherms and the pore size distribution (insert) of CFs (a), δ-$MnO_2$/CCFs-K80 (b) and δ-$MnO_2$/CCFs-K120 (c) samples.

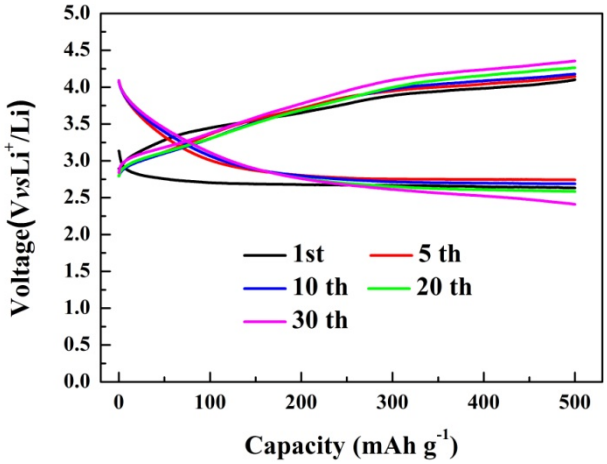


**Figure S6** Charge/discharge curves during of the cycled Li-$O_2$ battery based on the δ-$MnO_2$/CCFs-K80-XC-72 electrode with a limited capacity of 500 mAh $g^{-1}$.

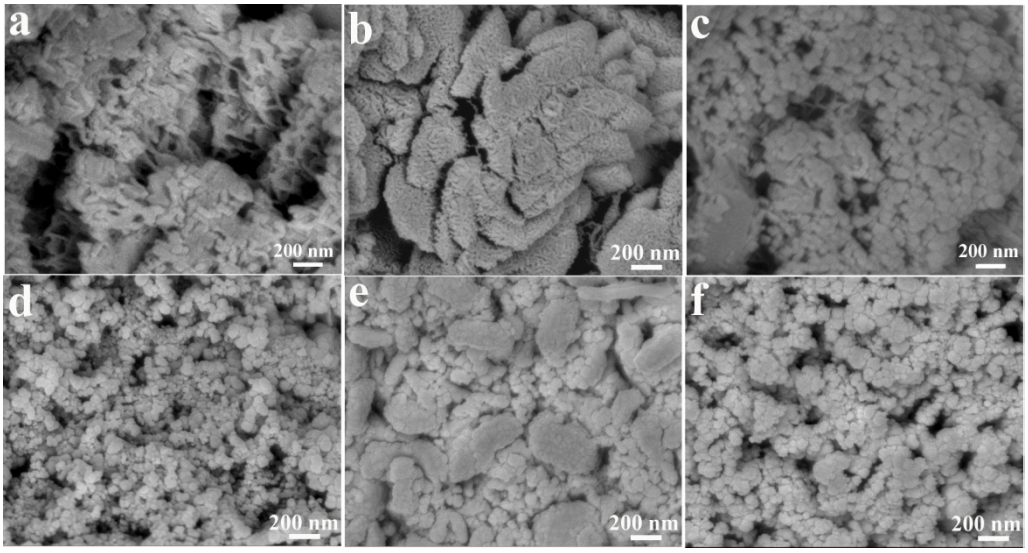


**Figure S7** SEM images of the δ-$MnO_2$/CCFs-K80-XC-72 (a, b, c) and XC-72 (d, e, f) electrodes at before discharge, fully discharged and charged state.

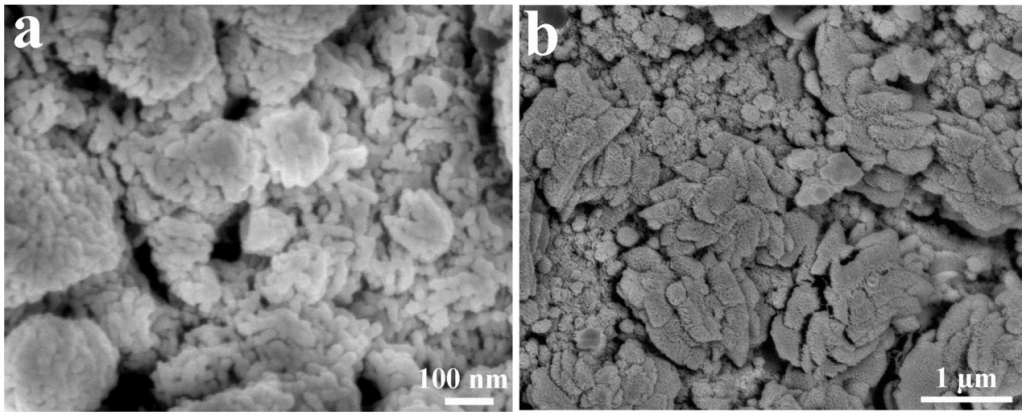


**Figure S8** SEM images of the fully discharged electrode with δ-$MnO_2$/CCFs-K80 catalyst at high (a) and low (b) magnifications.

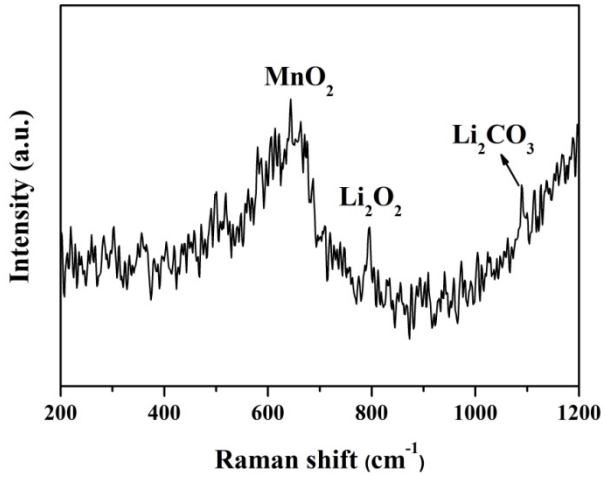


**Figure S9** Raman spectra of δ-$MnO_2$/CCFs-K80 electrode after discharge at the 3rd cycle.

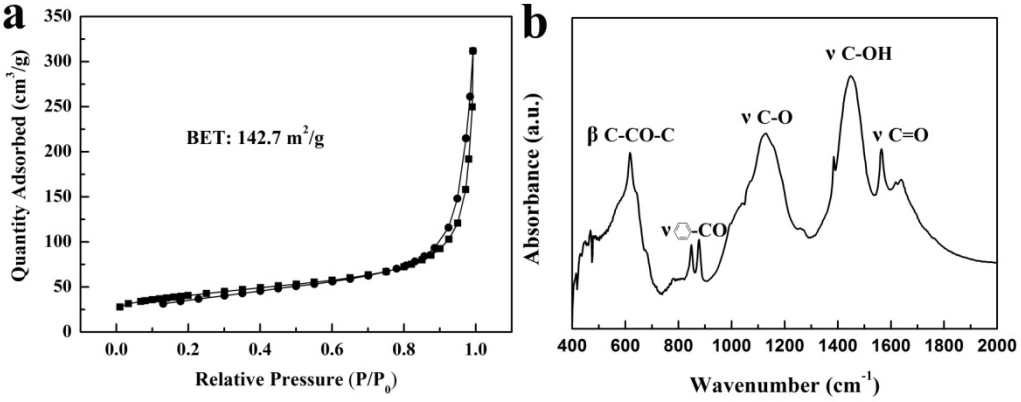


**Figure S10** Nitrogen adsorption-desorption isotherms of XC-72 carbon (a) and the FITR spectrum of XC-72 carbon (b).

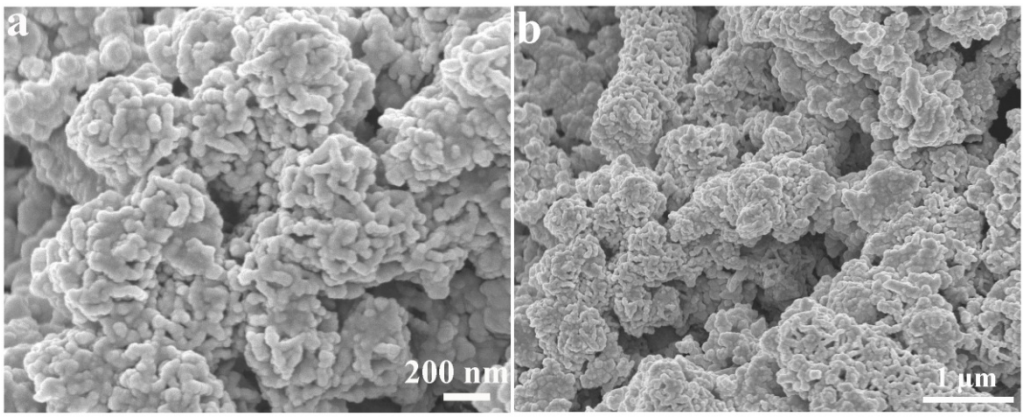


**Figure S11** SEM images of the discharge products of the electrode with δ-$MnO_2$/CCFs-K80 catalyst after discharged at 350 mAh $g^{-1}$.