## **Electronic Supplemental Information**

## One-step synthesis of Mn<sub>3</sub>O<sub>4</sub>/reduced graphene oxide nanocomposites for oxygen reduction in nonaqueous Li-O<sub>2</sub> batteries

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## **Experimental**

Synthesis of  $Mn_3O_4/RGO$  nanocomposites: In a typical reaction, 0.05 g of the commercially obtained RGO was ultrasonically dispersed in 50 ml anhydrous ethanol. Then 0.32 g, 0.64 g, or 1.28 g  $Mn(Ac)_2 \cdot 4H_2O$  with designed RGO to  $Mn_3O_4$  mass ratios (1:2, 1:4, and 1:8) was added to the RGO suspension. After heating the mixture to 60 °C, 2 mol L<sup>-1</sup> KOH-C<sub>2</sub>H<sub>5</sub>OH solution was dropwise added (the molar ratio of  $Mn^{2+}$  and KOH were kept at 1:2), and the reaction was maintained for 24 h. The particles were precipitated by adding ethanol after cooling the reaction mixture to room temperature and were separated and rinsed by repeated centrifugation with ethanol and deionized water. The powder samples were then used without any further size selection.

**Characterization**: Catalyst morphology was characterized by scanning electron microscopy (SEM) on an FEI Quanta 400 ESEM. High-resolution transmission electron microscopy (HR-TEM) images were taken on a JEOL 3000F TEM. The surface area of the carbon-based catalysts was measured by Brunauer-Emmett-Teller method on an Autosorb-IQ/MP-XR instrument using nitrogen adsorption at 77 K. The pore-size distribution was determined from the adsorption isotherm using density functional theory (DFT) with slit pore geometry (Quantachrome analysis

software). The crystallinity of samples was determined by X-ray diffraction (XRD) using a Bruker AXS D8 Avance diffractometer with Cu KR radiation.

Electrochemical Measurements: RDE tests were performed using a CHI Electrochemical Station (model 750b) in a conventional three-electrode cell at a rotating disk speed of 900 rpm and room temperature. The catalyst loading on RDE was controlled at 0.6 mg cm<sup>-2</sup>. A graphite rod and Ag/AgCl (3M NaCl, 2.9 V vs. Li/Li<sup>+</sup>) were used as the counter and reference electrodes. respectively. ORR steady-state polarization curves were recorded in oxygen-saturated 0.1MLiPF6 in 1,2-dimethoxyethane electrolyte (DME) with a potential step of 0.03 V and a period of 30 s. Li-O<sub>2</sub> battery tests were performed on an Arbin BT- 2000 battery station. In order to prepare the cathode electrode, the catalysts were first mixed with PVDF in a mass ratio of 10:1 and dispersed in NMP by bath sonication to prepare "ink". The obtained ink was then applied to the gas diffusion layer (GDL, ELAT LT 1400W, E-TEK) by successive brush-painting until the cathode catalyst loading reached 2.0 mg cm<sup>-2</sup>, followed by a dry in a vacuum oven at 140°C for overnight. Then the fabricated cathode electrodes were assembled with Li metal anode and twolayer Celgard C480 separators into standard 2032 type coin cell cases. Optimal pattern for hole distribution and size  $(16 \times 1.0 \text{ mm})$  was designed and cut by laser on the positive case for oxygen intake. LiPF6 (1.0 mol  $L^{-1}$ ) in tetraethylene glycol dimethyl ether (TEGDME) was used as electrolyte. All battery tests were carried out at 25°C and in a moisture-free glove box fed by continuous O<sub>2</sub> flow.

## **Additional Figures:**



Fig. S1 TEM images of the as-prepared Mn<sub>3</sub>O<sub>4</sub> nanoparticles without the presence of RGO.



**Fig. S2** TEM images of the as-prepared  $Mn_3O_4/RGO$  nanocomposites with an RGO to  $Mn_3O_4$  mass ratio of RGO: $Mn_3O_4$ =1:2.



**Fig. S3** TEM images of the as-prepared  $Mn_3O_4/RGO$  nanocomposites with an RGO to  $Mn_3O_4$  mass ratio of RGO: $Mn_3O_4$ =1:8.



**Fig. S4** HR-TEM images of the as-prepared  $Mn_3O_4/RGO$  nanocomposites with an RGO to  $Mn_3O_4$  mass ratio of RGO: $Mn_3O_4$ =1:2(left), and 1:8 (right).