

## Supporting information

### **Graphene aerogel-supported and graphene quantum dots-modified $\gamma$ -MnOOH nanotubes as a highly efficient electrocatalyst for oxygen reduction reaction**

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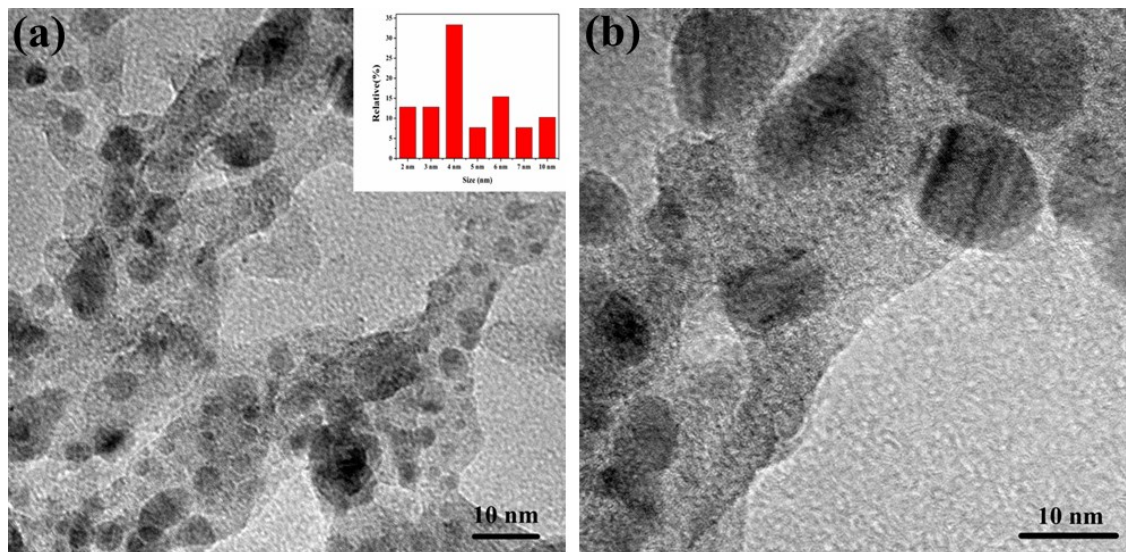
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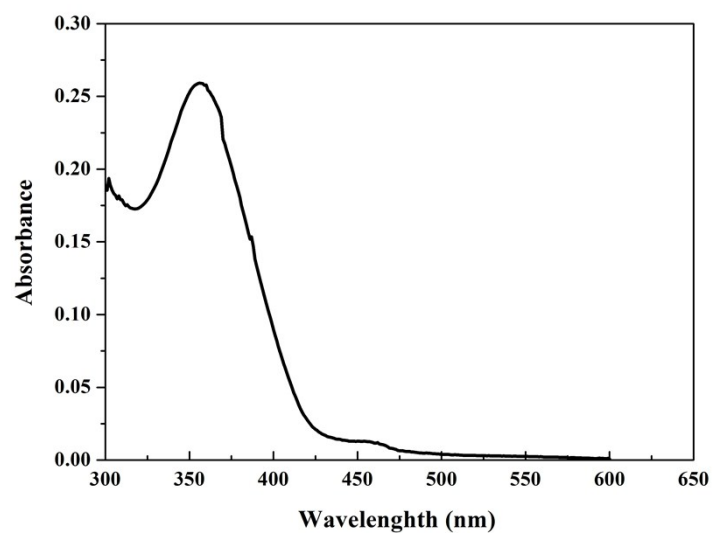
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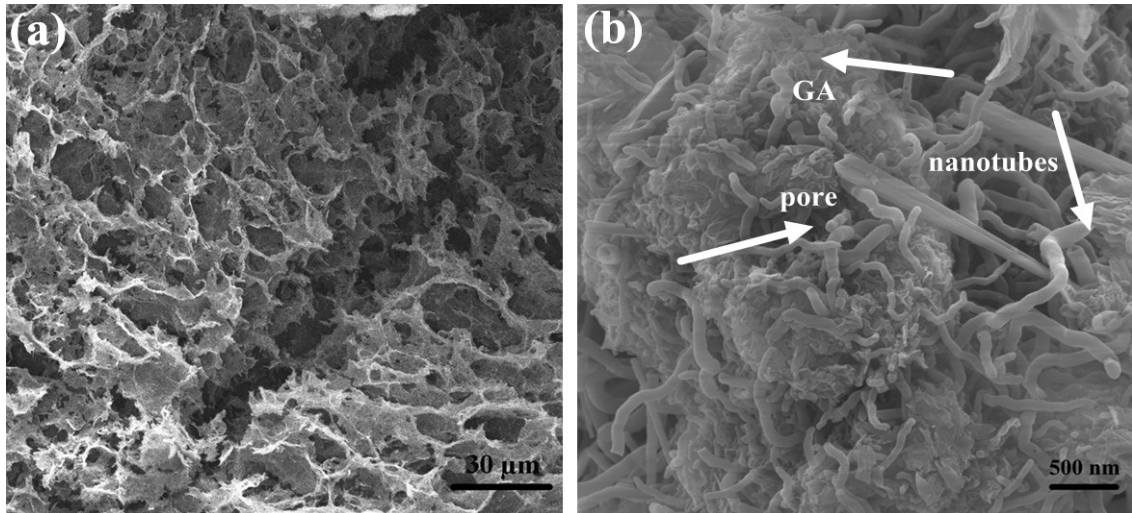
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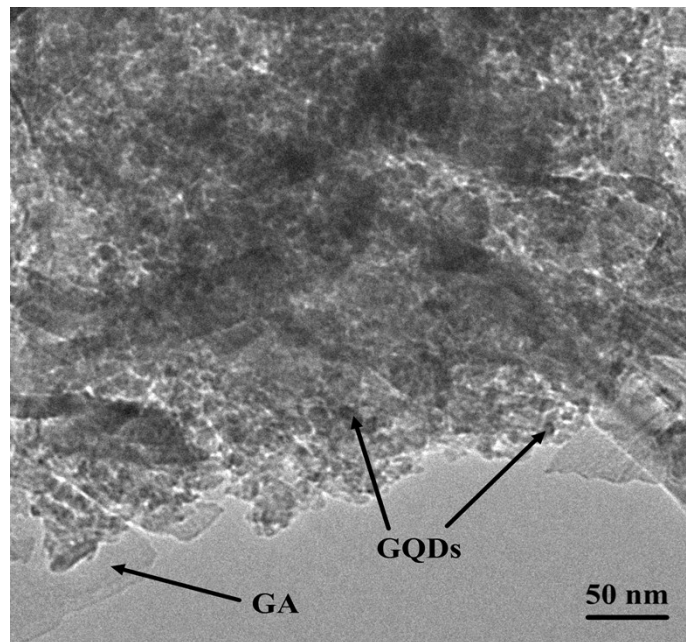
**Figure S1.** HRTEM images of GQDs at different magnification.



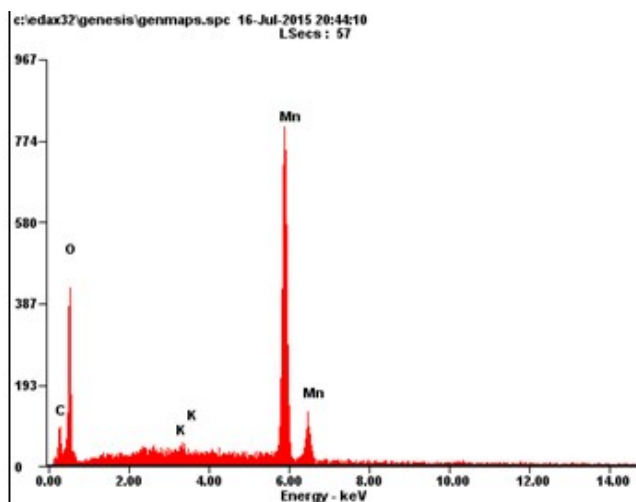
**Figure S2.** UV-vis absorption spectra of GQDs.



**Figure S3.** SEM images of (a) GA, (b)  $\gamma\text{MnOOH}@\text{GA}$  hybrid at different magnification.



**Figure S4.** TEM image for GA/GQDS.

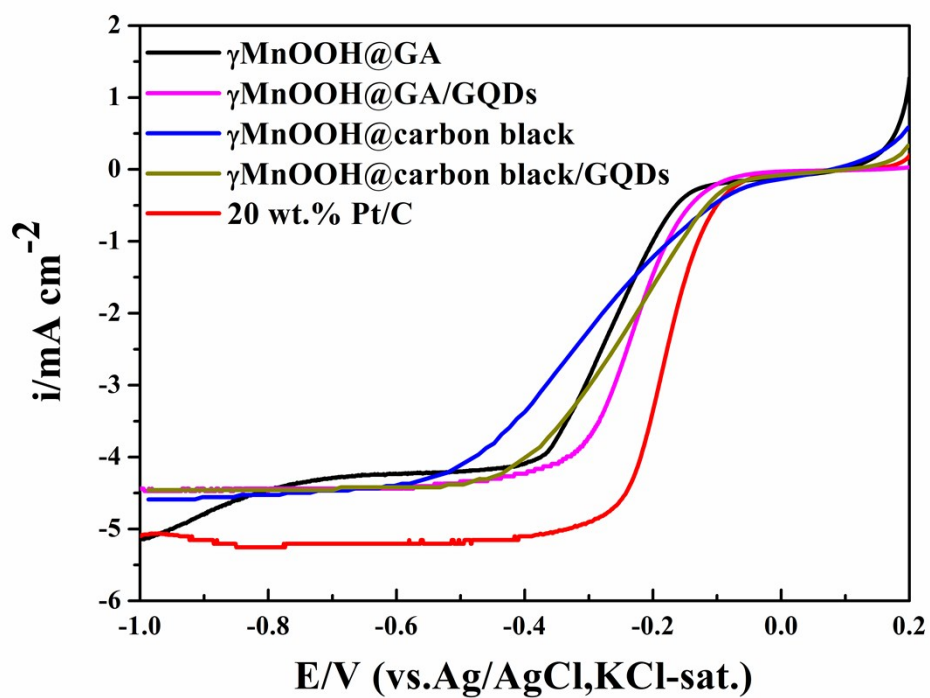


Element	Wt%	At%
CK	14.82	43.95
OK	19.05	32.77
KK	00.79	00.56
MnK	65.34	22.73
Matrix	Correction	ZAF

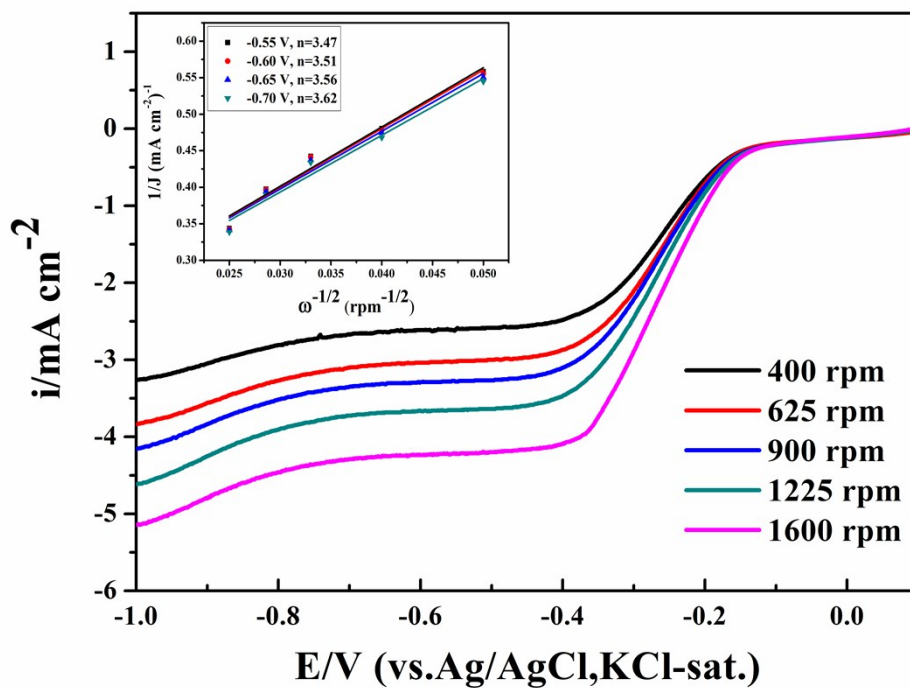
**Figure S5.** EDS spectrum of  $\gamma$ MnOOH@GA.

### Preparation of the MnOOH@carbon black and MnOOH@carbon black/GQDs hybrids

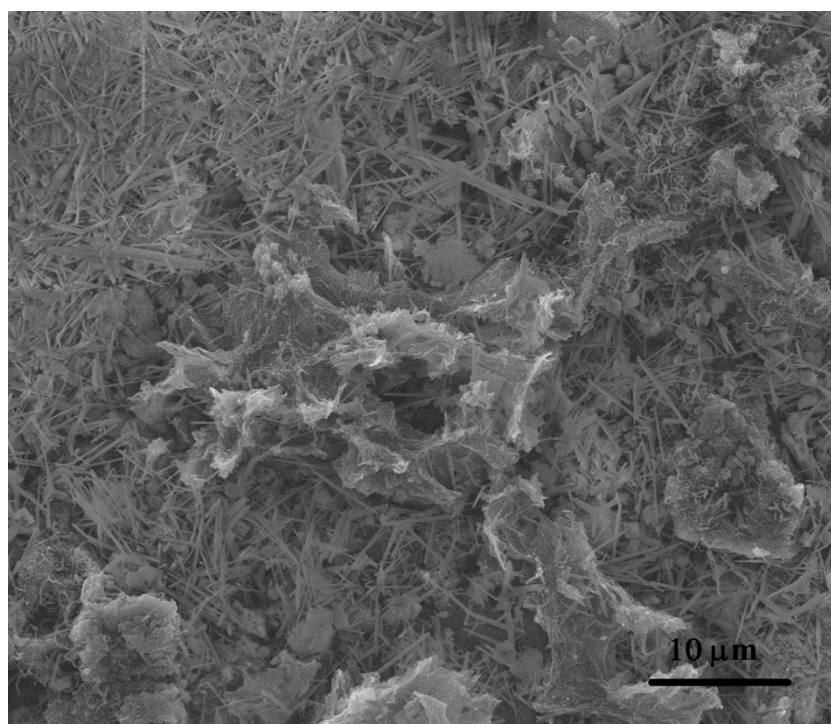
The  $\gamma$ MnOOH @GA hybrid was prepared by hydrothermal treatment. 0.3 mmol of  $\text{MnSO}_4 \cdot \text{H}_2\text{O}$  and 0.9 mmol of  $\text{KMnO}_4$  were added to 50 mL of 4:1 (v/v) water/ethylene glycol mixed solvent and stirred for 30 min. The solution was then transferred into a 100 mL Teflon-lined autoclave. 5 mg carbon black power (Vulcan XC-72, Alfa Aesar) was immersed into the autoclave, which was sealed and heated at 180 °C for 12 h. The autoclave was naturally cooled to room temperature, then the precipitate was collected and centrifuged several times with DI water and ethanol to remove any impurities and excessive metal ions. The obtained black precipitation dried at 60 °C in a vacuum oven for overnight. Then, 50 mg of  $\gamma$ MnOOH@carbon black was added into 5 mL GQDs solution under magnetic stirring vigorously for 2 h. Finally, the mixture was dried at 65 °C in a vacuum oven for 10 h to obtain  $\gamma$ MnOOH @carbon black/GQDs hybrid.



**Figure S6.** LSV curves of  $\gamma\text{MnOOH@GA}$ ,  $\gamma\text{MnOOH@GA/GQDs}$ ,  $\gamma\text{MnOOH@carbon black}$ ,  $\gamma\text{MnOOH@carbon black/GQDs}$  and 20 wt.% Pt/C catalysts on RDE electrode in  $\text{O}_2$ -saturated 0.1 M KOH solution at a rotation rate of 1600 rpm with a scan rate of  $5 \text{ mV s}^{-1}$ .



**Figure S7.** LSV curves of  $\gamma\text{MnOOH@GA}$  on RDE electrode in  $\text{O}_2$ -saturated 0.1 M KOH solution at various rotation rates with a scan rate of  $5 \text{ mV s}^{-1}$ , the inset shows the corresponding Koutecky–Levich plots at different potentials.



**Figure S8.** SEM image of  $\gamma\text{MnOOH@GA/GQDs}$  hybrid after the reduction reaction.