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Supporting Information

$MnCo_2O_4$ Nanowires Anchored on Reduced Graphene Oxide Sheets as Effective Bifunctional Catalysts for Li–O_2 Battery Cathodes

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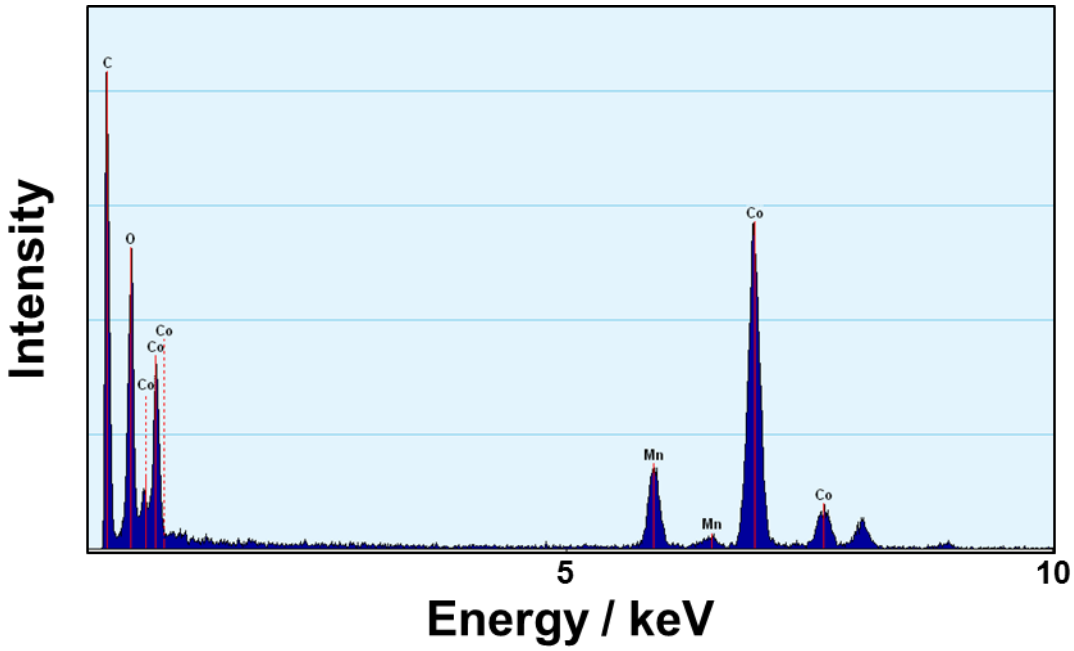

Figure S1. EDX spectrum of the MCO@RGO composites.

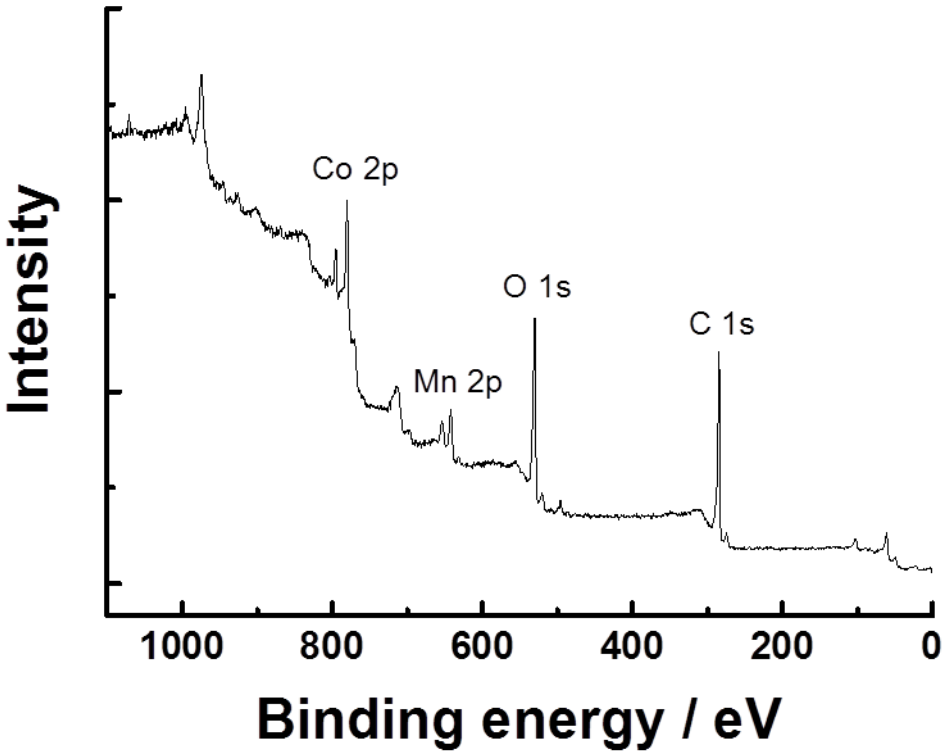

Figure S2. XPS spectra of full scan regions of the MCO@RGO composites.

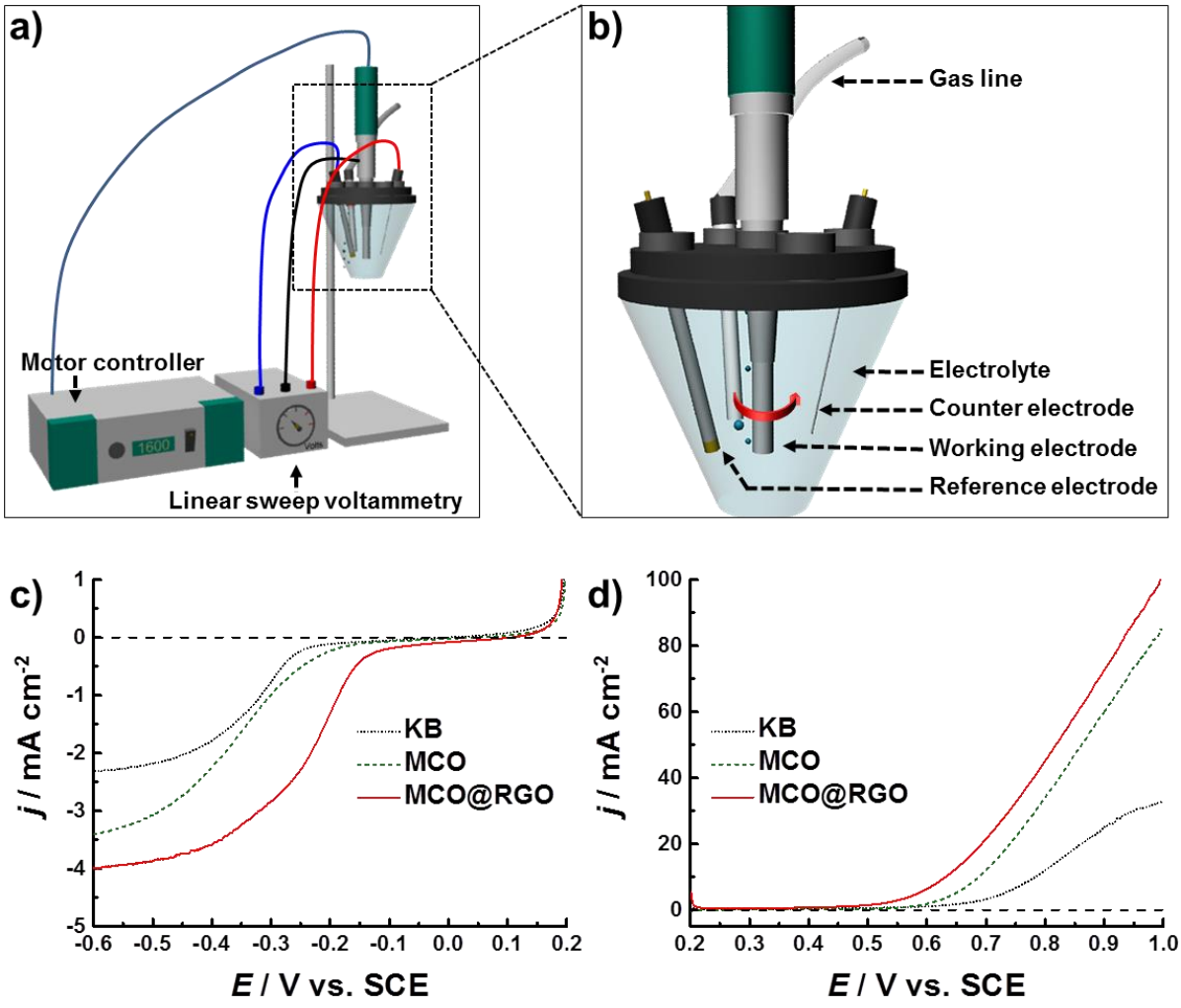

Figure S3. Illustration of the LSV and RDE used for the demonstration of ORR/OER activities of the as-prepared catalysts. LSV profiles of (c) ORR and (d) OER for KB, MCO NWs and MCO@RGO composites in (c) O_2-saturated and (d) N_2-saturated 0.5 M aqueous NaOH electrolyte at a scan rate of 10 mV s^{-1} with a rotating speed of 1600 rpm.

To examine the electrocatalytic activity of catalysts toward the ORR and OER, LSV is evaluated in O_2- and N_2-saturated 0.5 M aqueous NaOH electrolytes at a scan rate of 10 mV s^{-1} using the RDE at 1600 rpm. Schematic diagrams of LSV and RDE are provided in Figure S3a and S3b. As shown in Figure S3c, the MCO@RGO catalyst exhibits more positive ORR onset potential and higher current density than those of MCO NWs and KB, indicating the MCO@RGO catalyst can show higher ORR catalytic activity in the NaOH aqueous electrolyte. The MCO@RGO catalyst also shows more negative OER onset potential and higher OER current density compared with those of MCO NWs and KB, as shown in Figure S3d. These results indicate that the MCO@RGO system can work as the effective bifunctional catalyst for both of ORR and OER, which could improve the charge/discharge efficiency of the Li-O_2 cells.

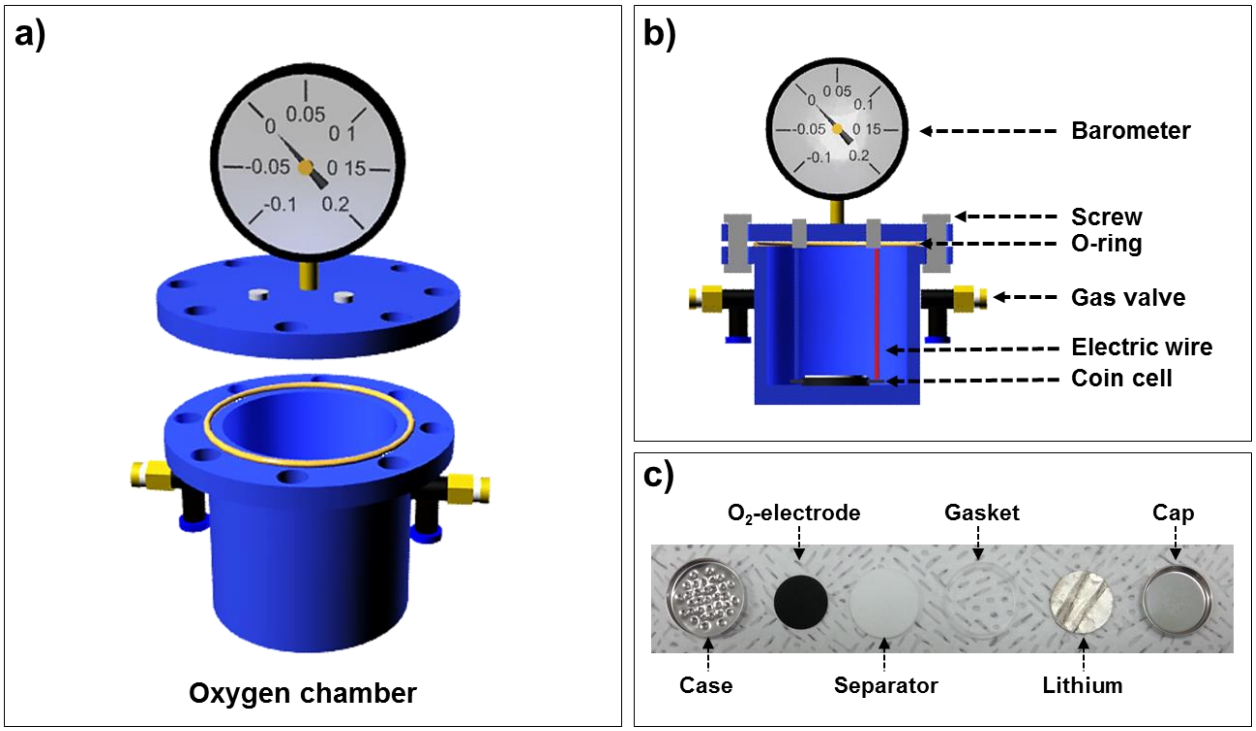

Figure S4. (a) Illustration of oxygen chamber of Li-O_2 cells. (b) Cross-sectional scheme of assembled Li-O_2 cells. (c) An optical image of coin cell components used in this study.

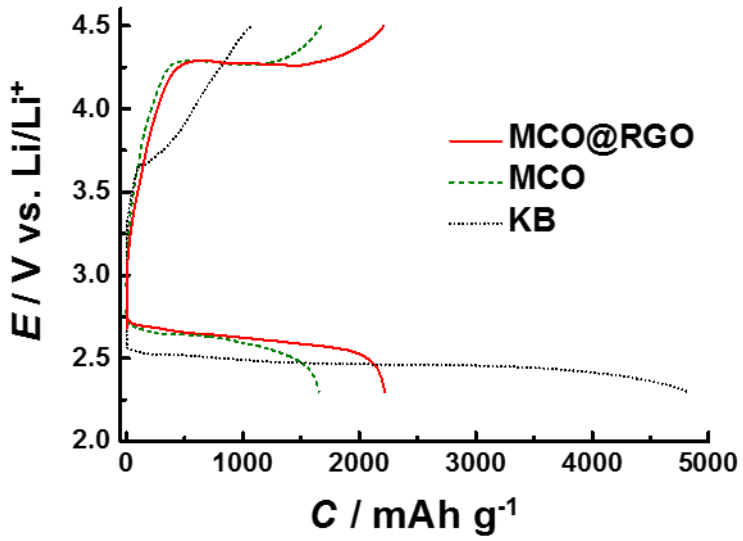

Figure S5. The first discharge-charge profiles of Li-O_2 cells with KB, MCO NWs, and MCO@RGO composites. The capacities are normalized by the total mass of electrode (carbon + binder + catalyst).

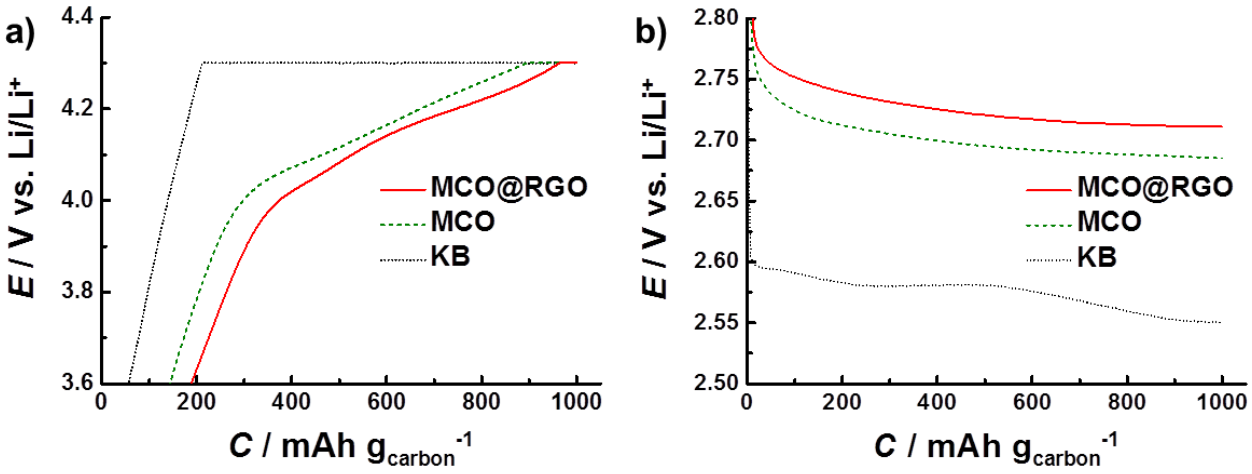

Figure S6. Magnified voltage profiles for (a) first charging and (b) first discharging of the Li-O_2 cells with KB, MCO NWs, and MCO@RGO composites at a current density of 200 mA g_{carbon}^{-1} in a potential window between 4.3 and 2.3 V under capacity limit of 1000 mAh g_{carbon}^{-1}.

To compare the degree of overpotential of pure KB, MCO NWs, and MCO@RGO catalyst during charge/discharge, the magnified potential-capacity curves for the first cycle are provided in Figure S6. The charge potential of Li-O_2 cell with the MCO@RGO catalyst was lower than that with pure KB and MCO NWs. Moreover, the discharge potential of Li-O_2 cell with the MCO@RGO catalyst was higher than that with pure KB and MCO NWs. Low charge potential means Li_2O_2 by-products are decomposed easily, while high discharge potential means Li_2O_2 by-products are formed easily. Therefore, this result demonstrates that the MCO@RGO as a bifunctional catalyst exhibited high electrocatalytic activity in both OER and ORR, as compared with pure KB and MCO NWs.

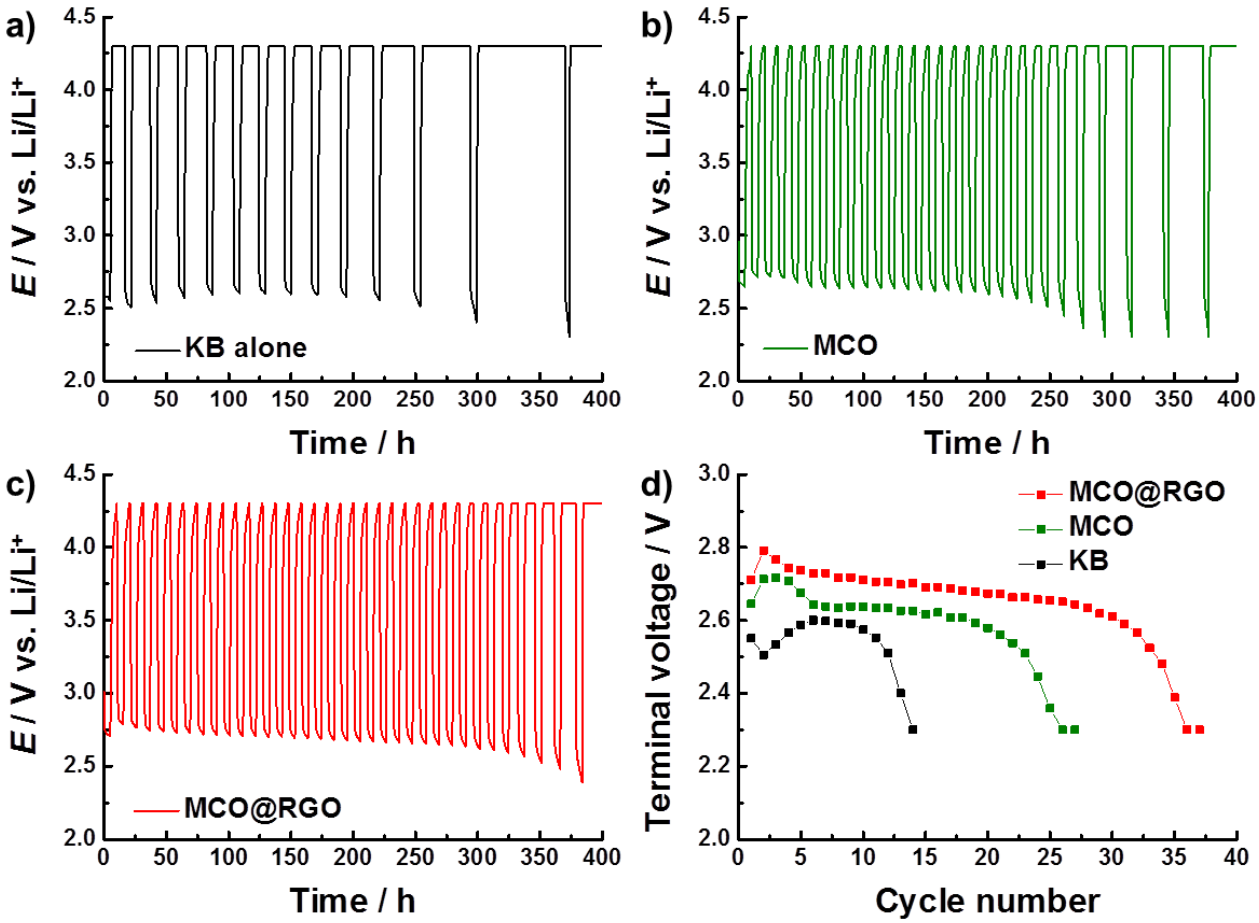

Figure S7. Potential-time curves of Li-O_2 cells with (a) KB, (b) MCO NWs, and(c) MCO@RGO composites. (d) Plot of terminal voltage as a function of cycle number.

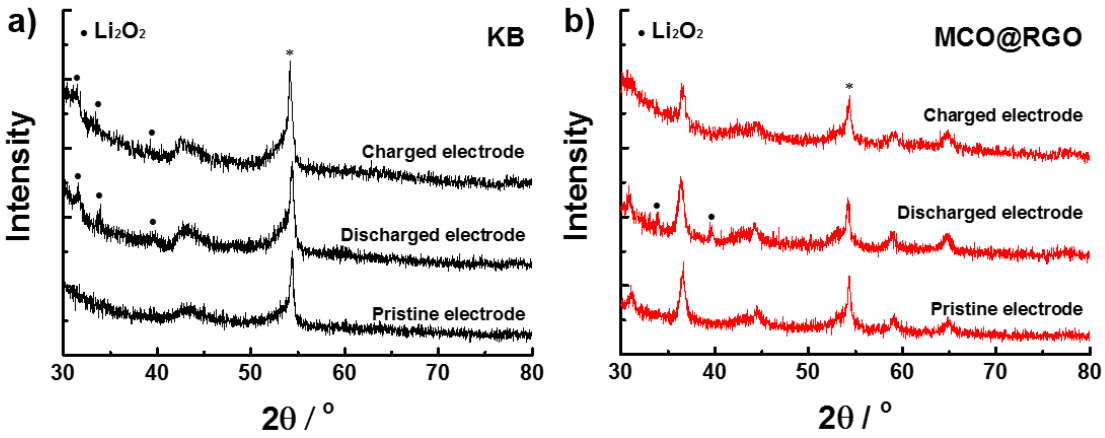

Figure S8. XRD patterns of the electrodes with (a) KB and (b) MCO@RGO at different discharge/charge stages. Peaks marked with asterisks derive from the carbon paper.

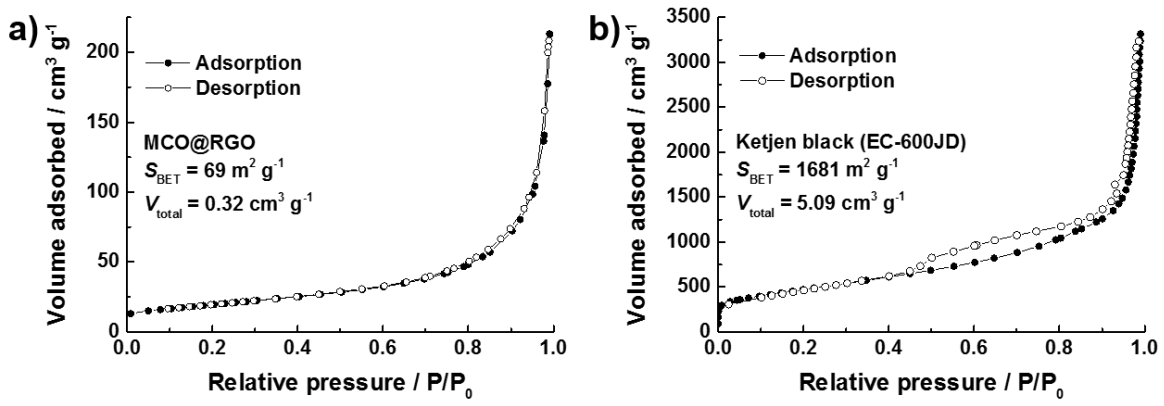

Figure S9. N_2 adsorption/desorption isotherms of (a) the MCO@RGO composites and (b) the KB.

The N_2 adsorption-desorption isotherms of the MCO@RGO composites and KB were measured at 77 K, as shown in Figure S9. From the adsorption data, the BET specific surface areas (S_{BET}) and total pore volumes (V_{total}) were found to be 69 m^2 g^{-1} and 0.32 cm^3 g^{-1} for the MCO@RGO and 1681 m^2 g^{-1} and 5.09 cm^3 g^{-1} for the KB, respectively.

Table S1. The electrical resistance of MCO NWs and MCO@RGO composites.

Sample	Sheet resistance [Ω sq^{-1}]
MCO NWs	6×10^6
RGO	16
MCO@RGO	73.7