Microwave-assisted synthesis of ZnO-rGO core-shell nanorod hybrids with photo- and electro-catalytic activity; *Supporting information*

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Synthesis of graphene oxide (GO):GO was prepared by the modified Hummers' method. In a typical reaction, 1 g graphite (Purity 99.5%, VWR International Ltd) and 1 g sodium nitrate ($NaNO_3$) (Alfa Aesar, >99%) were added to a flask with 46 mL Sulphuric acid (Fisher Scientific, >95%). Theresulting solution was stirred for 4 h in an ice bath. 6 g $KMnO_4$wassubsequently added to the solution slowly with stirring. The green-purple solution was transferred from the ice bath and stirred for a further 1 h. 92 ml deionised water was addedto the reaction flask, whichwas transferred to a hot plate and stirred at 35°C for 1 h. The solution was then heated to 98°C and held at this temperature for 2h before cooling naturally to room temperature. After adding 200 mL water and stirring for 1 h, 20 mL of 30% (w/w) $H_2O_2$was added to the solution stirred for 1 h. The golden-brown solution was centrifuged and washed once with 5 ml HCL(Fluka, 36.5-38%) and then with water until the pH of the solution reached 6. The resulting product was dried in an oven overnight at 50°C.

PXD analysis of graphene oxide (GO) and reduced GO (rGO): Figure S1 shows the PXD patterns of GO and as-prepared rGO respectively. The GO interlayer distance was determined from the (002) peak to be 0.797 nm (7.97 Å). Graphite exhibits a basal reflection (002) at 26.6° which corresponds to a 0.335 nm d-spacing.[1]After oxidation and formation of GO, the interlayer distance increases. The interlayer distance in GOis strongly dependant on the amount of absorbed water molecules and the number of oxygen-containing functional groups attached to the graphene layers.The PXD pattern of the rGO sample indicates that the GO has been fully reduced to rGO in the MW process. The peak at 25.19° can be indexed to the graphene (002) reflection, while the weaker intensity peak at 43.13° can be identified asthe (100) reflection.

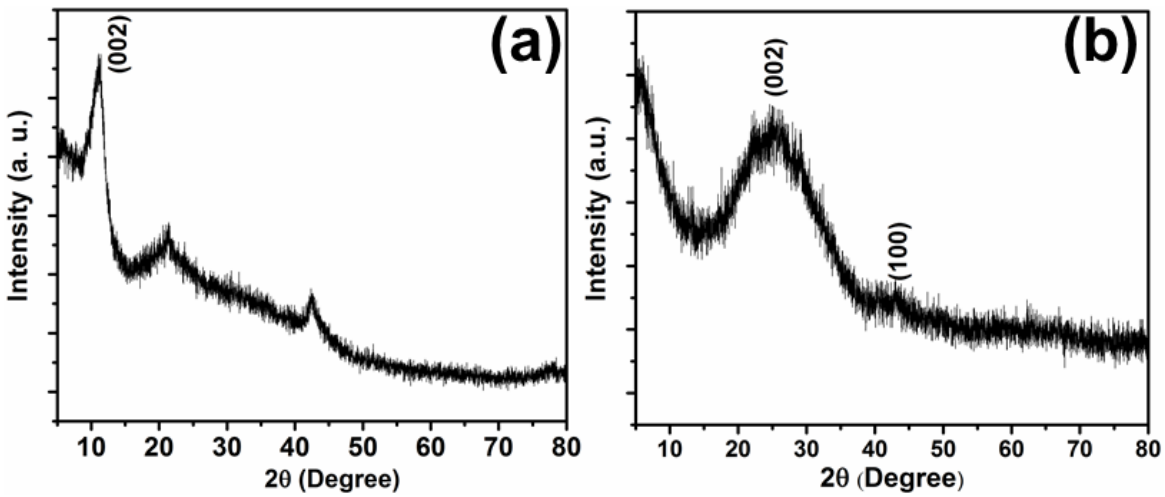

Figure S1:PXD patterns of (a) GO and (b) rGO.

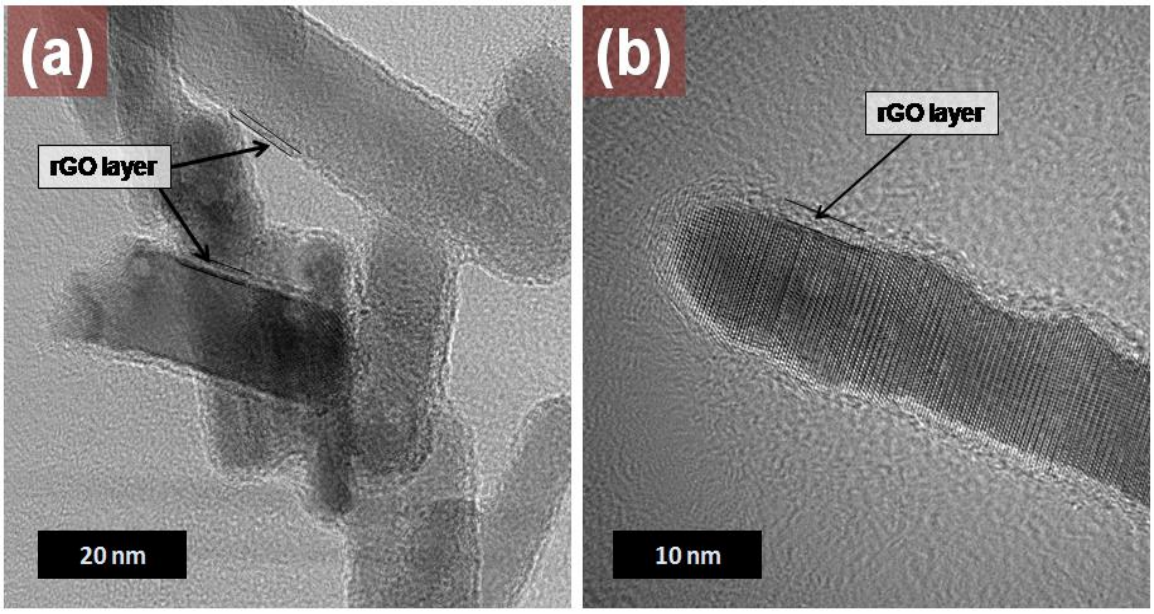

Figure S2: (a, b) TEM images of ZnO-rGO NR hybrid.

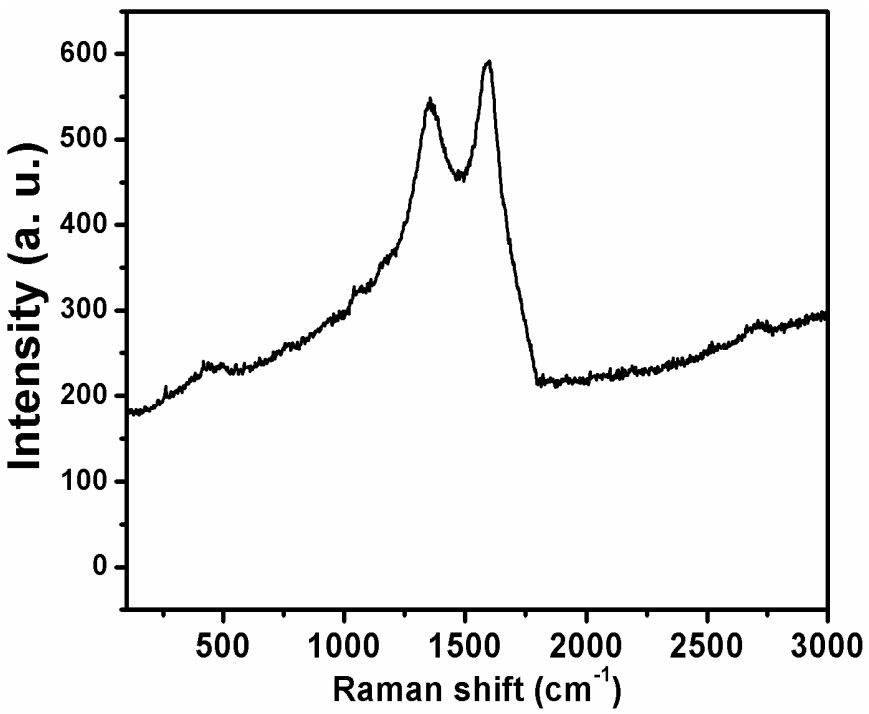

Figure S3: Raman spectrum of GO.

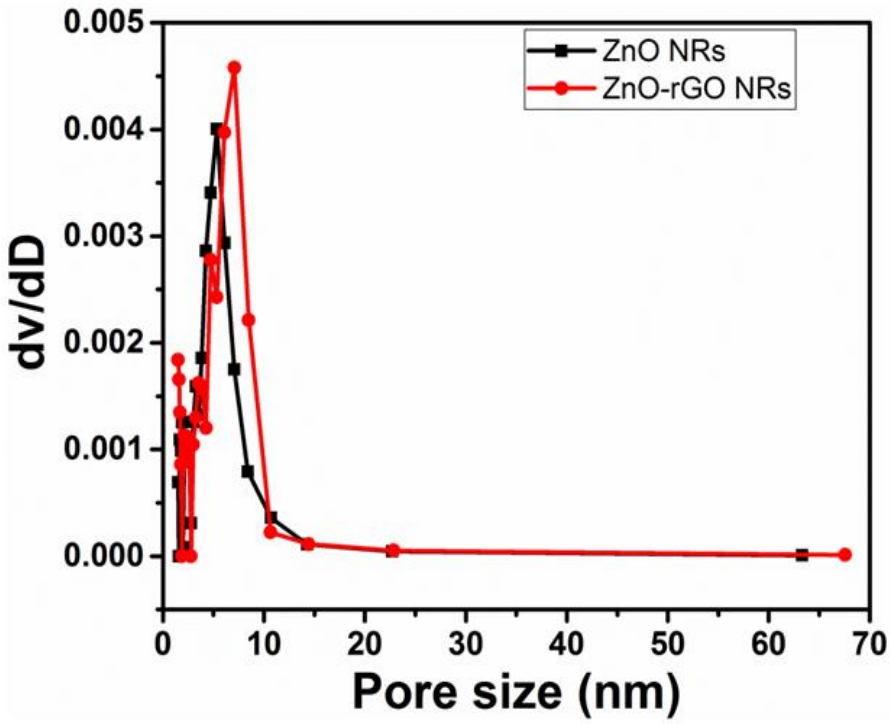

Figure S4: BJH pore size distribution curves of ZnO and ZnO-rGO NRs.

FTIR spectrum of graphene oxide (GO): Figure S5 shows the FTIR spectrum measured for the sample of GO.All the peaks can be assigned to vibrations from epoxide, alkoxide and O-H functionalities.

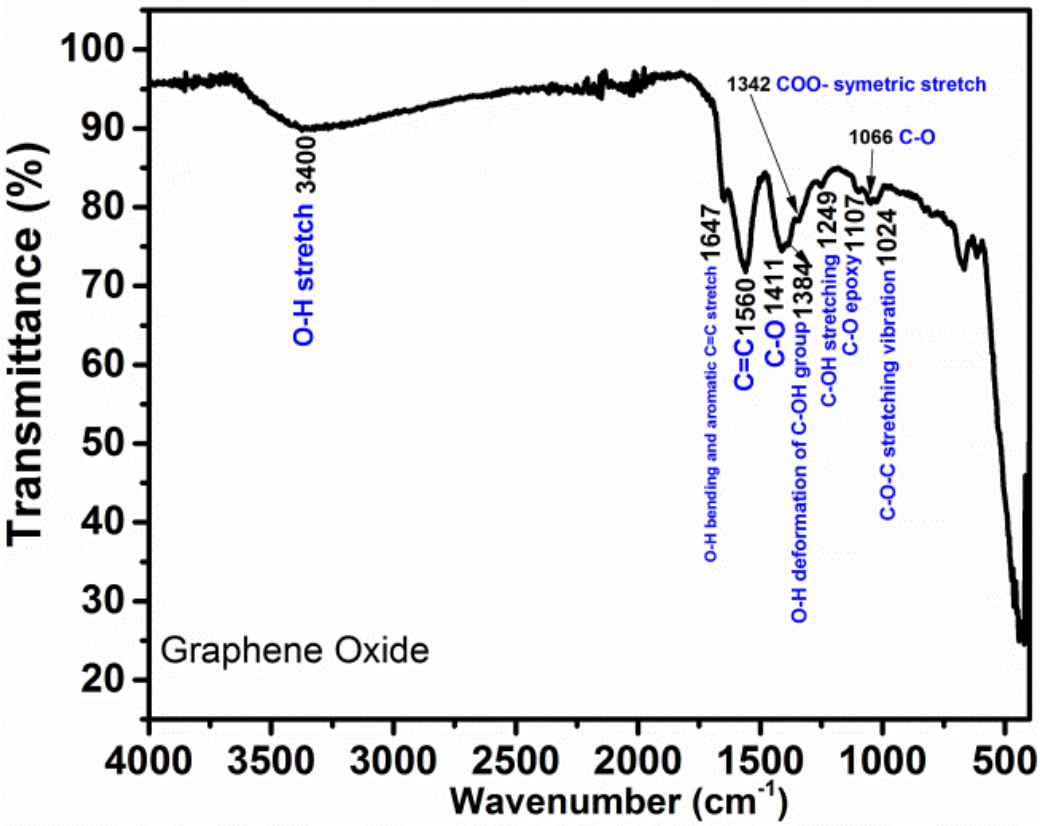

Figure S5: FTIR spectrum of graphene oxide (GO) prepared by the modified Hummers' method described above.

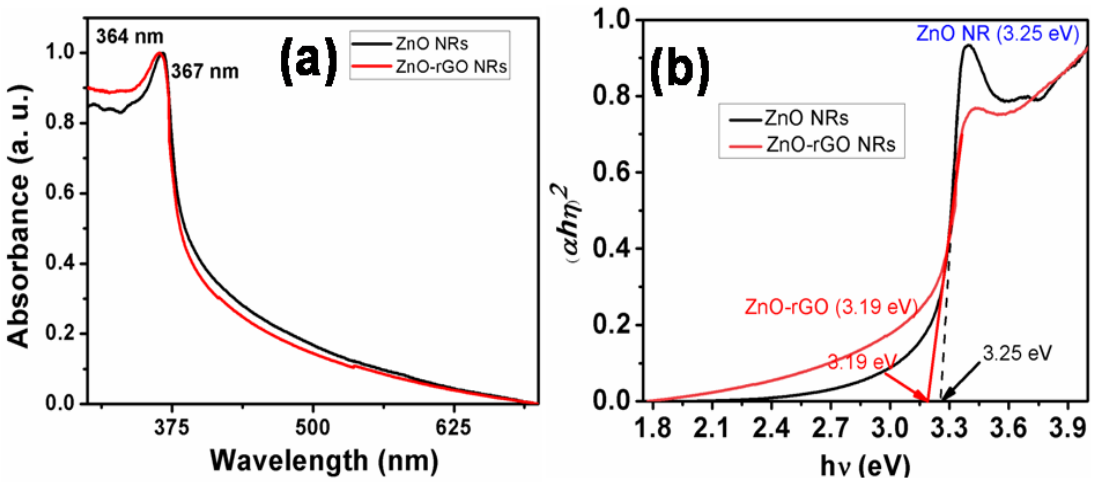

Figure S6: (a) UV-Vis absorption spectra and (b) Tauc plots taken from the DR UV-Vis data for the ZnO and ZnO-rGO hybrid NRs.

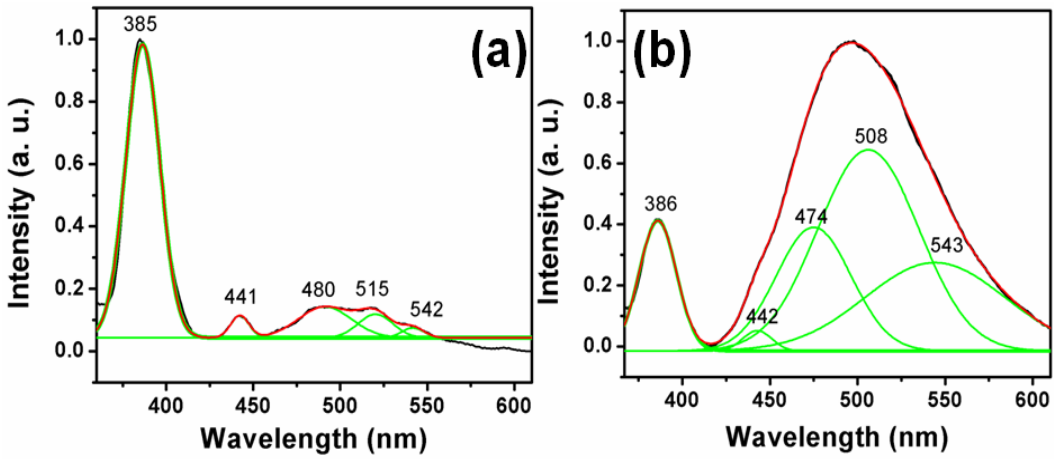

Figure S7: PL spectra of samples of: (a) pure ZnO NRs and (b) the ZnO-rGO NR hybrid, each deconvoluted to 5 Gaussian peaks.

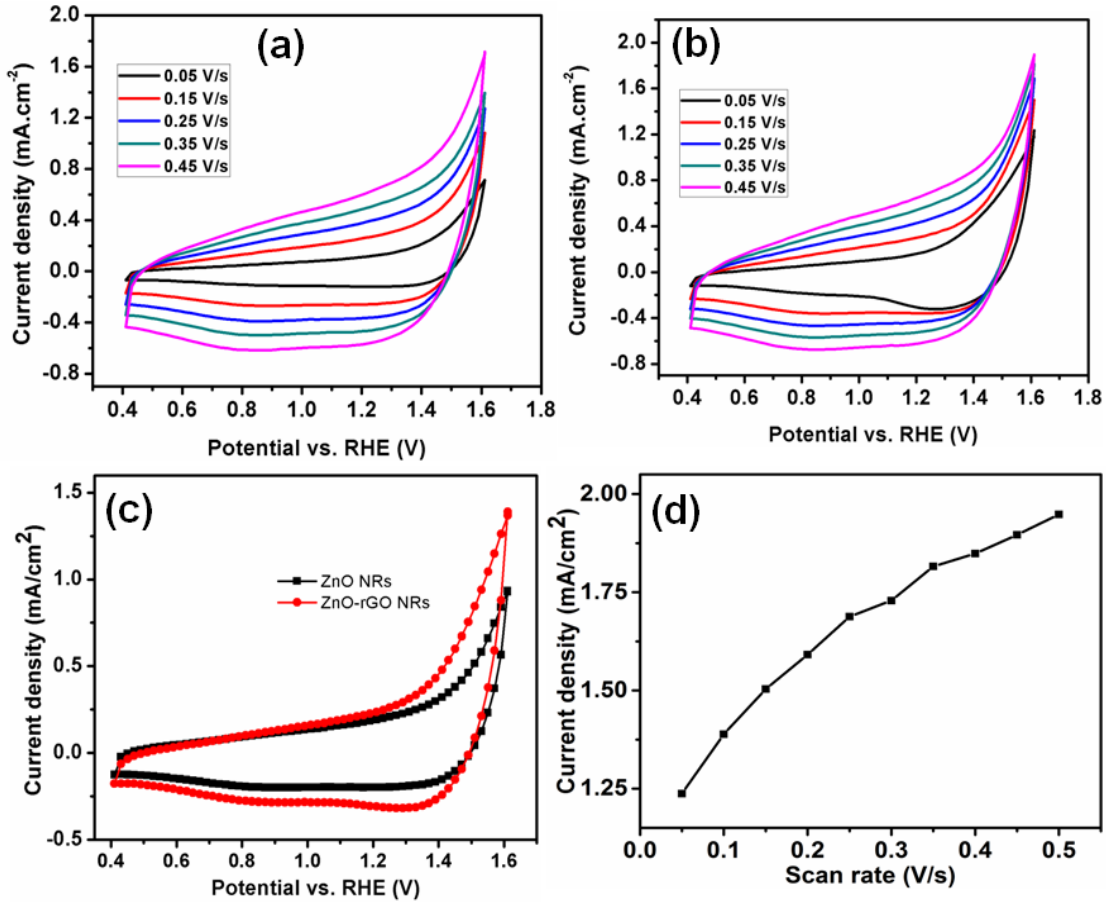

Figure S8: C-V curves taken at various scan rates using 0.1M Na_2SO_4 electrolyte solutions with: (a) ZnO NRs and (b) ZnO-rGO NRs as electrodes respectively; (c) a comparison of the C-V curves of ZnO NRs (black squares) and ZnO-rGO NRs (red circles) taken at the same sweep rate of 0.1 V s^{-1} and (d) a plot of peak current versus scan rate for ZnO-rGO NRs.

UV-Vis spectra for RhB degradation with time: Figure S9(a) shows the UV-Vis absorption spectra taken from the time-resolved degradation of RhB. FigureS9(b) shows a schematic of the corresponding proposed photocatalytic process.

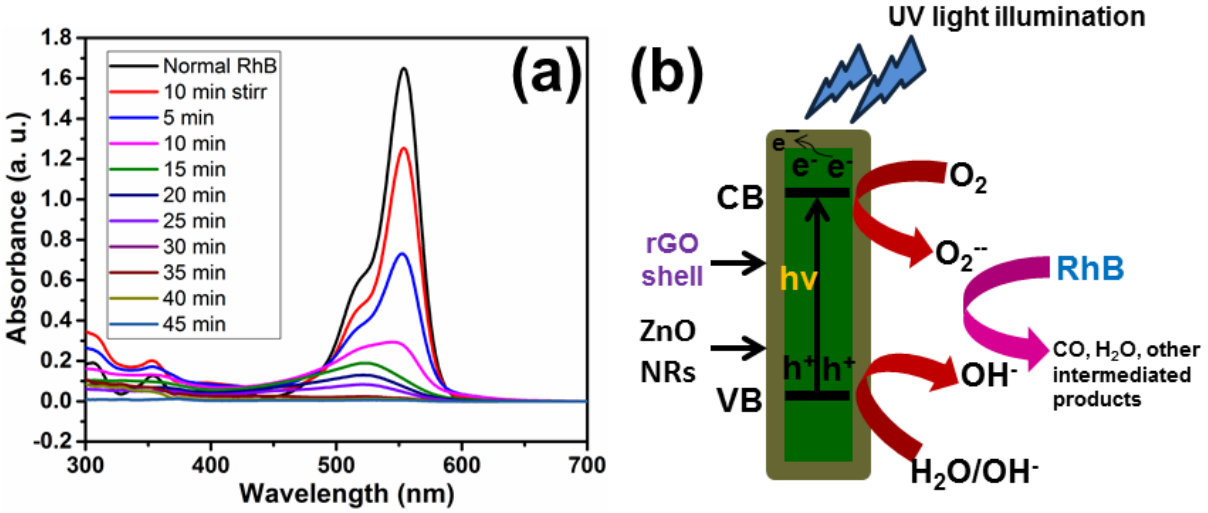

Figure S9: (a) UV-Vis spectra of RhB dye as a function of time sampled from the dye degradation process using a ZnO-rGO NR hybrid catalyst; (b) proposed dye degradation mechanism of RhB catalysed by the ZnO-rGO NR hybrids.

Chronoamperometric measurementsfor ZnO-rGO nanorod hybrids: Figure S10 shows the results of the chronoamperometric experiment performed on the ZnO-rGO nanorod hybrids, which was performed to study the stability of the electrode in alkaline solution over time.

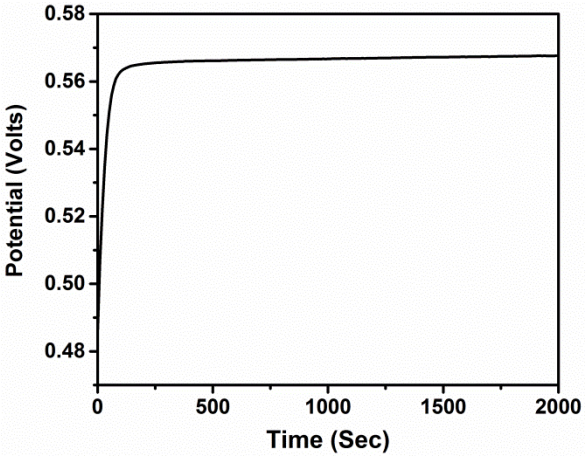

Figure S10: Chronoamperometric data for the ZnO-rGO NR hybrids.

SQUID magnetometry of ZnO nanorods and ZnO-rGO nanorod hybrids: Figure S11 shows the M-H hysteresis curves over the entire applied field range at 300 K for both ZnO and ZnO-rGO hybrid nanorod samples.

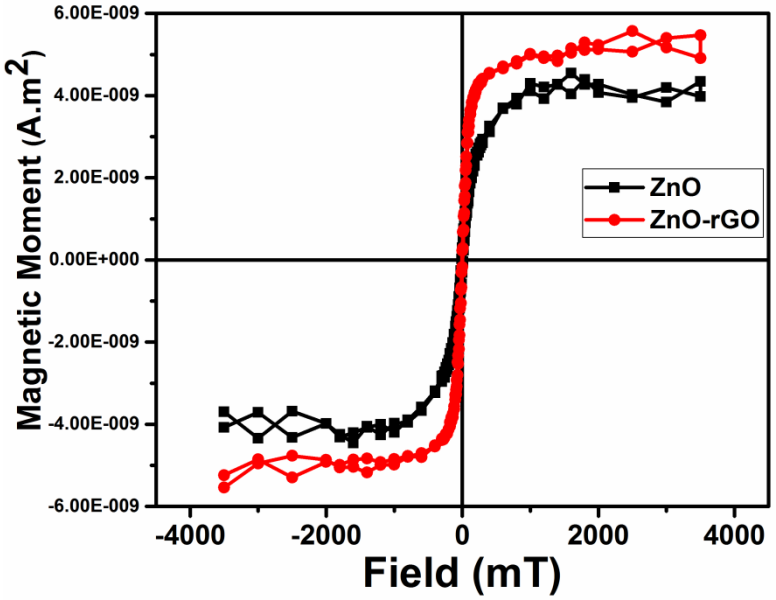

Figure S11: M-H hysteresis curves for ZnO and ZnO-rGO nanorods at 300 K.

References

[1]Z. Bo, X. Shuai, S. Mao, H. Yang, J. Qian, J. Chen, J. Yan, K. Cen, *Sci. Rep.***2014**, *4*, 4684.