Electronic Supplementary Information

$ZnFe_2O_4$@C/graphene nanocomposite as excellent anode materials for lithium batteries

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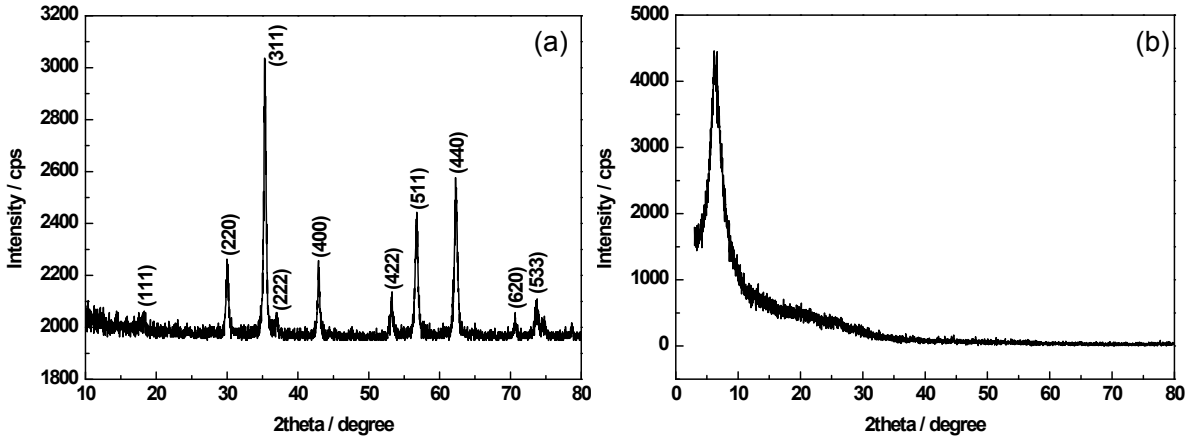


Fig. S1. XRD patterns of (a) $ZnFe_2O_4$ nanoparticles and (b) graphite oxide (GO).

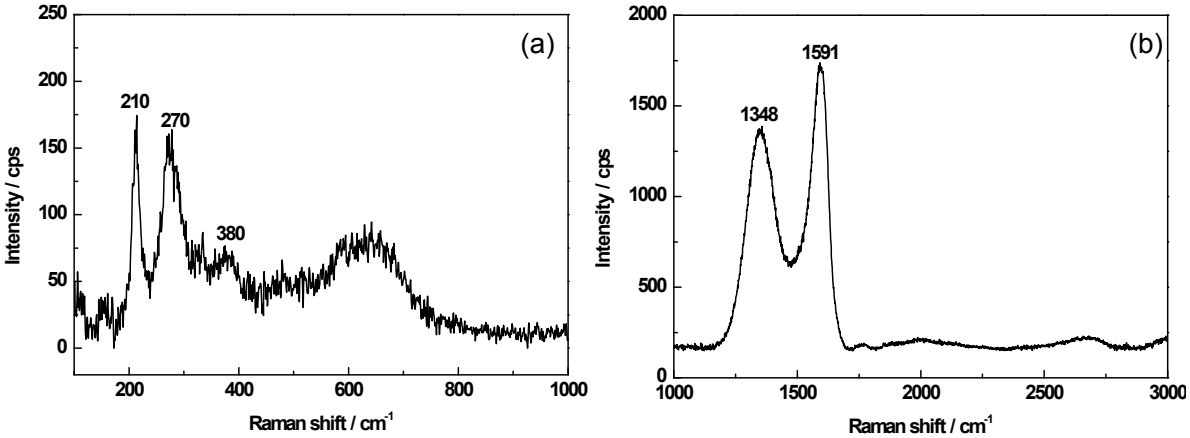


Fig. S2. Raman spectra of (a) $ZnFe_2O_4$ nanoparticles and (b) graphite oxide.

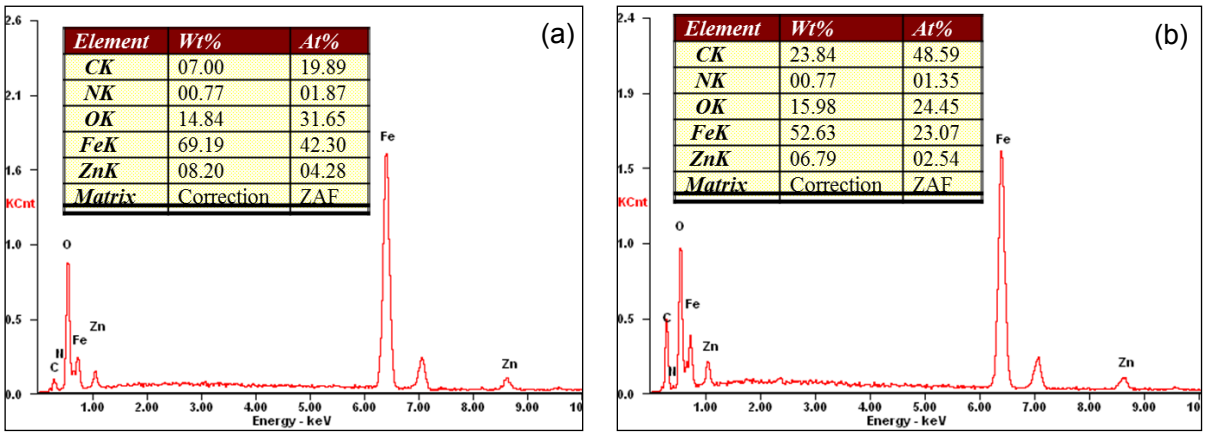


Fig. S3. EDX plots of (a) core-shell $ZnFe_2O_4$@C nanoparticles and (b) $ZnFe_2O_4$@C/G nanocomposite.

Fig. S3 is the EDX plots of $ZnFe_2O_4$@C nanoparticles and $ZnFe_2O_4$@C/G nanocomposite. Both samples show a low Zn/Fe mole ratio. The low Zn content is mainly attributed to the following reasons. Firstly, owing to relatively low content of Zn in $ZnFe_2O_4$@C nanoparticles, the characteristic peaks of Zn may be overlapped by

the continuum X-rays produced in the excitation process. Secondly, X-rays might be absorbed by other atoms of the nanoparticles. Especially, the carbon shells of the nanoparticles may accelerate the absorption.[1] All these factors reduce the detected intensity of Zn element.

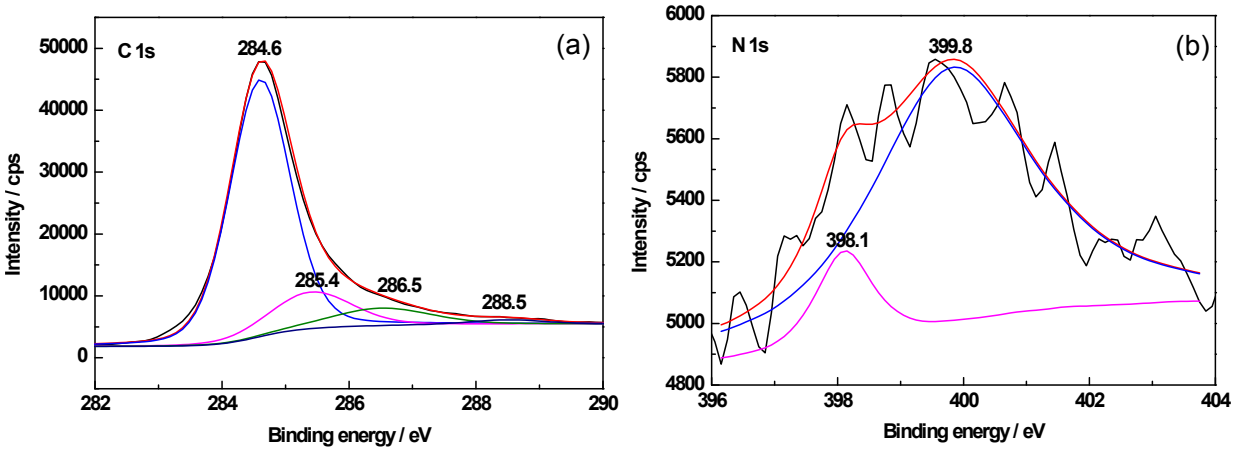
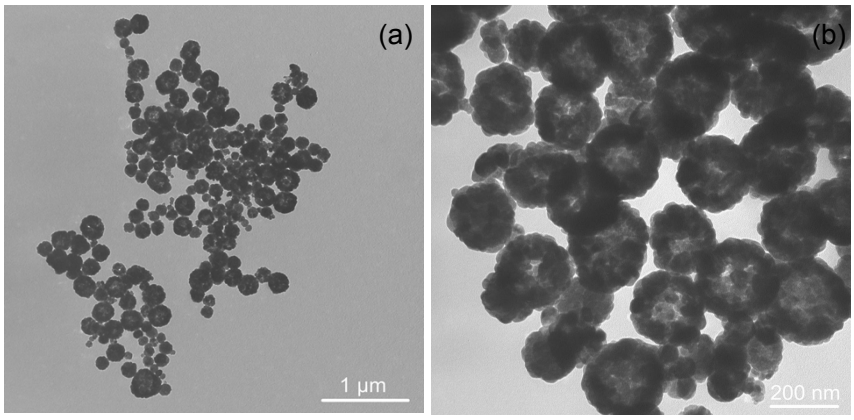


Fig. S4. C 1s (a) and N 1s (b) spectra of $ZnFe_2O_4$@C/G nanocomposite.

XPS measurement was performed to investigate the surface chemistry of $ZnFe_2O_4$@C/G nanocomposite. Four peaks at 284.6 eV, 285.4 eV, 286.5 eV and 288.5 eV are observed in the C 1s spectrum (Fig. S4a), corresponding to the components of C-C, C-N, C=N and C=O, respectively.[2,3] N 1s spectrum (Fig. S4b) shows two components of C-N (399.8 eV) and C=N (398.1 eV), which is consistent with the previous report on N-doped carbon coated Fe_3O_4 composites.[4]



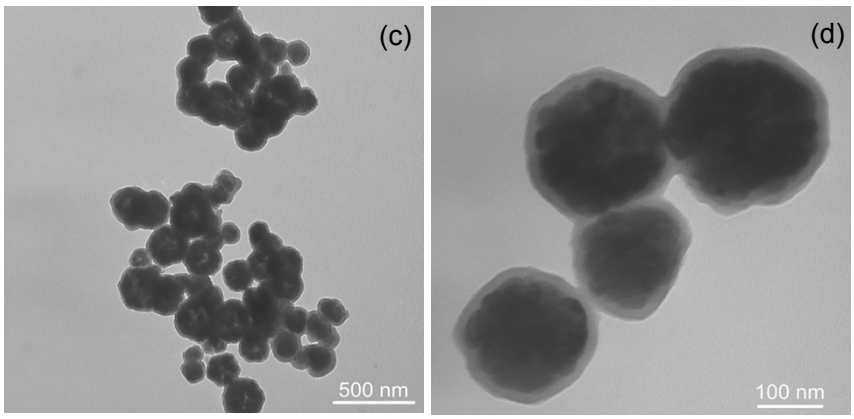


Fig. S5. TEM images of (a, b) $ZnFe_2O_4$ nanoparticles and (c, d) core-shell $ZnFe_2O_4$@PDA nanoparticles.

Fig. S5 shows the TEM images of the pristine $ZnFe_2O_4$ and core-shell $ZnFe_2O_4$@PDA nanoparticles. The former has a diameter of ~200 nm (Fig. S5a-5b), while the later is uniformly encapsulated by polydopamine (PDA) layers with average thickness of ~20 nm (Fig. S5c-5d). The PDA layers on the nanoparticles are homogenous and continuous, suggesting that polydopamine has high affinity to $ZnFe_2O_4$ nanoparticles and thus reducing severe agglomeration to some extent.

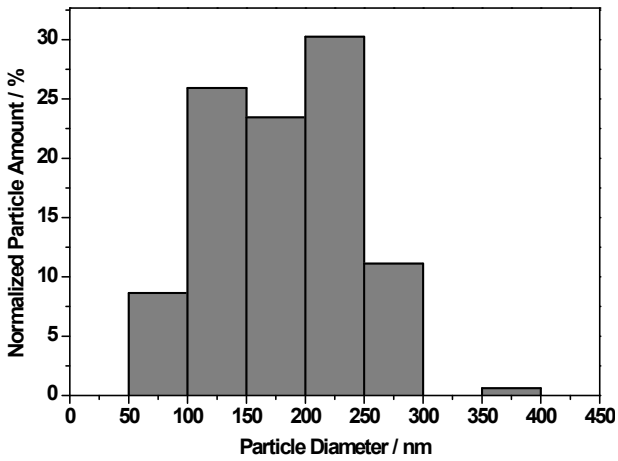


Fig. S6 Size distribution of $ZnFe_2O_4$ nanoparticles.

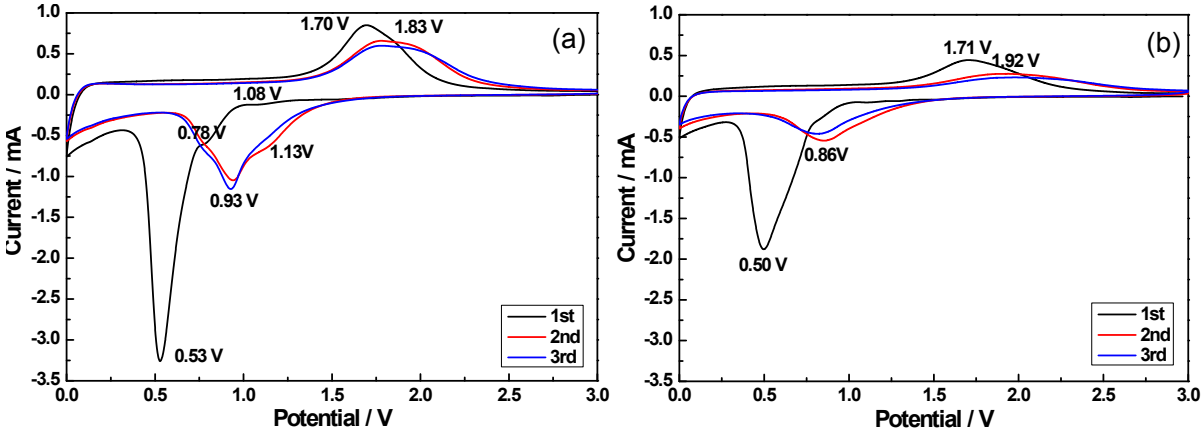


Fig. S7. Cyclic voltommograms of the (a) $ZnFe_2O_4$@C/G and (b) $ZnFe_2O_4$@C electrodes.

Fig. S7a shows the CV curves of the $ZnFe_2O_4$@C/G electrode in the first three cycles. In the initial cathodic process, a sharp peak appears at 0.53 V, indicating the conversion of $ZnFe_2O_4$ into Zn^0, Fe^0, Li_2O, as well as the formation of Li-Zn alloy and solid electrolyte interface (SEI) film.[5,6] A small cathodic peak located at 1.08-0.78 V is attributed to the incomplete lithiation of $ZnFe_2O_4$ to $Li_{0.2}ZnFe_2O_4$ or $Li_{0.5}ZnFe_2O_4$ and $Li_2ZnFe_2O_4$.[5,7] This peak is not observed for the CV curves of the $ZnFe_2O_4$@C electrode (Fig. S7b). In the subsequent anodic process, a peak ascribed to the de-alloying of Li-Zn and oxidation of Zn^0, Fe^0 to Zn^{2+}, Fe^{3+} is observed at 1.7 V.[5,8] In the subsequent scanning cycles, both cathodic and anodic peaks shift to 0.93 and 1.83 V with decreased intensity, respectively, suggesting the variation of $ZnFe_2O_4$ structure and the presence of irreversible capacity loss.[5] However, the CV curves of the $ZnFe_2O_4$@C/G electrode show better reproducibility that those of its $ZnFe_2O_4$@C counterpart, implying that the presence of graphene is beneficial for the reversibility of $ZnFe_2O_4$-based electrodes.

References

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