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Supplementary Information

Mild Solution Synthesis of Graphene Loaded with LiFePO₄-C Nanoplatelets for High Performance Lithium Ion Batteries

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Thermogravimetric analysis (TGA) is used to determine the percentage of carbon in all samples. The powder sample is loaded into the TGA equipment (NETZSCH STA409) and heated from room temperature to 700 °C in air atmosphere with a heating rate of 10 °C per min. As shown in Fig. S1, the mass loss above 500 °C corresponds to the oxidation of carbon in the sample. The total carbon contents in all samples can be calculated as following [1-3] where 5.07% is the weight gain of pure LFP:

$$\text{Carbon weight\%} = 1 - (1 + \text{weight gain \%}) / (1 + 5.07\%)$$

Therefore, the carbon contents of LFP/C, LFP/G and LFP/G/C composites are 2.63%, 3.47% and 3.96%, which are very close to the initial loading as 3.0%, 3.5% and 4.0%, respectively. The loss of carbon in LFP/C composite may result from the lack of interaction between LFP and amorphous carbon. The amorphous carbon coating can be easily lost by centrifugation treatment.

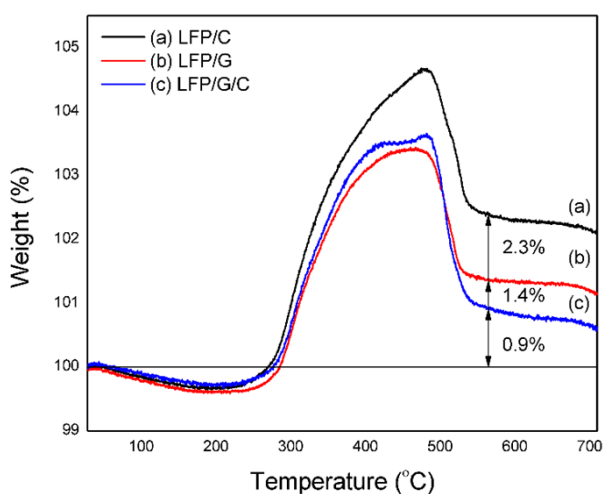


Fig. S1. TGA curves of LFP/C (a), LFP/G (b) and LFP/G/C (c) composites.

As shown in Fig. S2, the introduction of graphene significantly improves the capacity of LFP/C, but keeping adding the graphene leads to a drop on the capacity. In consideration of the extremely low density of graphene, it would be a great increase on the volume of the additive. Moreover, as the capacity of composite is proportional to the theoretical capacity and active material percentage (%), higher graphene percentage would lead to a lower specific capacity of composite. Adding graphene would increase the conductivity and decrease the active material percentage at the same time, and a carbon content more than 4% will lower the theoretical capacity down below 160 mAh g^{-1} and lead to a relatively low performance.

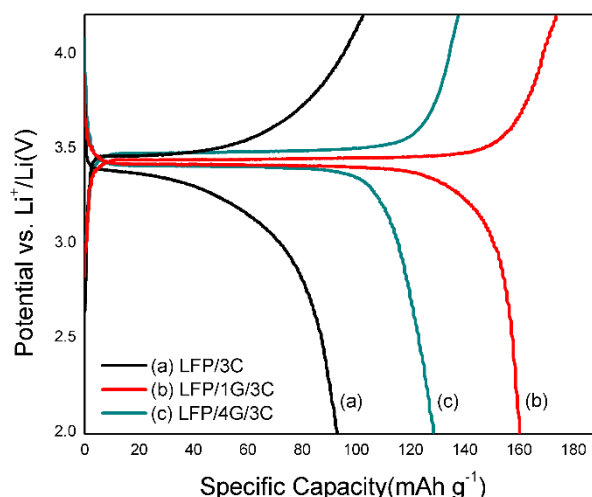


Fig. S2. The first charge and discharge profiles of 3% carbon coated LFP composites with graphene free (a), 1% graphene (b) and 4% graphene (c).

As measured by TEM, the carbon coated LFP nanoparticles with 1% graphene are much regular and circular than that without graphene (Fig. S3a and b). In Fig S3c, the large amount of graphene nanosheets provide too many active sites which increase the crystal domains and decrease the crystal size. These nanoparticles with thick graphene layers would obstruct the paths for lithium ion migration and eventually lead to a poor performance, explaining the decline of capacity in Fig. S2.

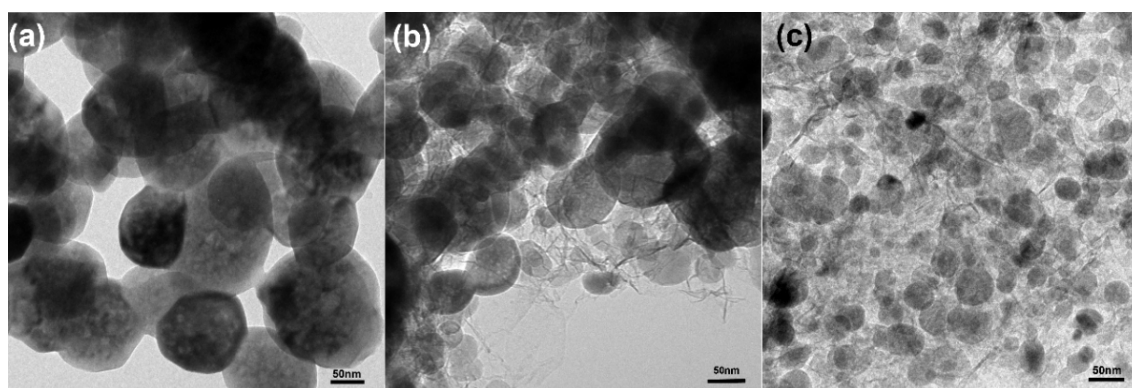


Fig. S3. The TEM images of 3% carbon coated LFP composites with graphene free (a), 1% graphene (b) and 4% graphene (c).

Reference

- [1] I. Belharouak, C. Johnson and K. Amine. *Electrochem. Commun.* 2005, **7**, 983.
- [2] Y. L. Cao, L. H. Yu, T. Li, X. P. Ai and H. X. Yang. *J. Power Sources*, 2007, **172**, 913.
- [3] W. Wei, S. Gao, Z. Yang and L. Guo. *RSC Adv.*, 2014, Accepted Manuscript.