Supporting Information

Hybrid Graphene@MoS_2@TiO_2 Microspheres for Use as a High Performance Negative Electrode Material for Lithium Ion Batteries

Qiang Pang[a, c], Yingying Zhao[a], Xiaofei Bian[a], Yanming Ju[a], Xudong Wang[c], Yingjin Wei[a, *], Bingbing Liu[b], Fei Du[a], Chunzhong Wang[a, b, *], Gang Chen[a, b]

[a.] Key Laboratory of Physics and Technology for Advanced Batteries (Ministry of Education), College of Physics, Jilin University, Changchun 130012, P. R. China.

[b.] State Key Laboratory of Superhard Materials, Jilin University, Changchun 130012, P. R. China.

[c.] Department of Materials Science and Engineering, University of Wisconsin-Madison, Madison, WI 53706, USA.

Corresponding author: yjwei@jlu.edu.cn (Y. J. Wei), wcz@jlu.edu.cn (C. Z. Wang), Tel & Fax: 86-431-85155126.

Preparation of MoS_2@TiO_2: Typically, 20 mg graphene oxide powder was dispersed in 30 mL deionized water under ultra-sonication for 2 hours. Then, 0.3 g $NaMoO_4 \cdot 2H_2O$ (Sinopharm Chemical Reagent Co.) and 1.25 g L-Cysteine (Sinopharm Chemical Reagent Co.) were dissolved in the graphene oxide solution under constant stirring. Next, the solution was transferred into a 50 mL Teflon-lined stainless autoclave and heated at 220 °C for 24 h. After cooling to room temperature, the precipitate was collected and washed with deionized water and ethanol for several times and dried at room temperature. The powder was calcined at 800 °C for 2 h in a H_2/Ar (10:90) atmosphere to obtain the MoS_2@graphene composite.

Table S1. Comparison of electrochemical performance of the graphene@MoS_2@TiO_2 material with state-of-the-art MoS_2@TiO_2 based anode materials.

Materials	Cycling Performance				Rate Capability		Ref.
	Current Density (A g^{-1})	Cycle Number	Remaining Capacity (mAh g^{-1})	Capacity Lose per Cycle (%)	Current Density (A g^{-1})	Specific Capacity (mAh g^{-1})	
MoS_2@TiO_2 nanotube	0.1	100	472	0.36	1	461	1
TiO_2-MoS_2 nanoparticle	0.1	100	604	0.10	1	472	2
MoS_2@TiO_2 nanobelt	0.1	100	710	0.05	1	417	3
MoS_2@TiO_2 nanowire	0.1	100	544	0.37	1	414	4
MoS_2/C/TiO_2 nanosheet	0.1	100	805	0.14	2	508	5
MoS_2@firework-shaped TiO_2	0.1	200	714	0.07	1	459	6
TiO_2@MoS_2 nano-onions	0.1	100	632	0.10	1	600	7
graphene@MoS_2@TiO_2 microspheres	**0.1**	**200**	**980**	**0.05**	**2**	**602**	**This work**

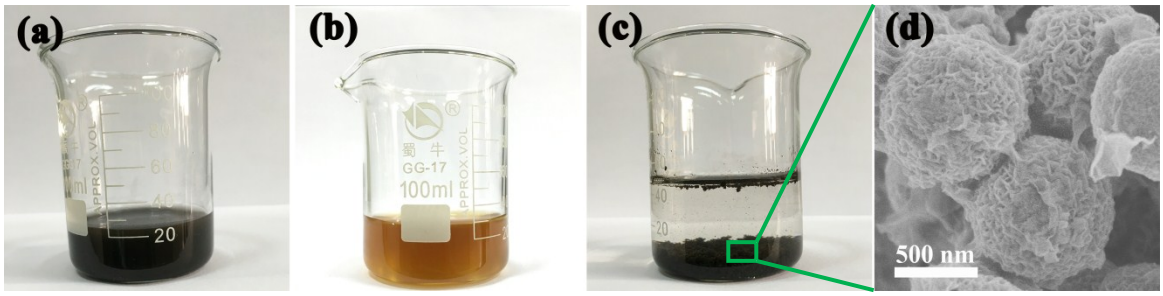

Figure S1. Photographs of the (a) APTMS-treated MoS_2@TiO_2 suspension, (b) graphene oxide suspension, (c) graphene@MoS_2@TiO_2 suspension after standing, (d) FESEM image of the graphene@MoS_2@TiO_2 suspension.

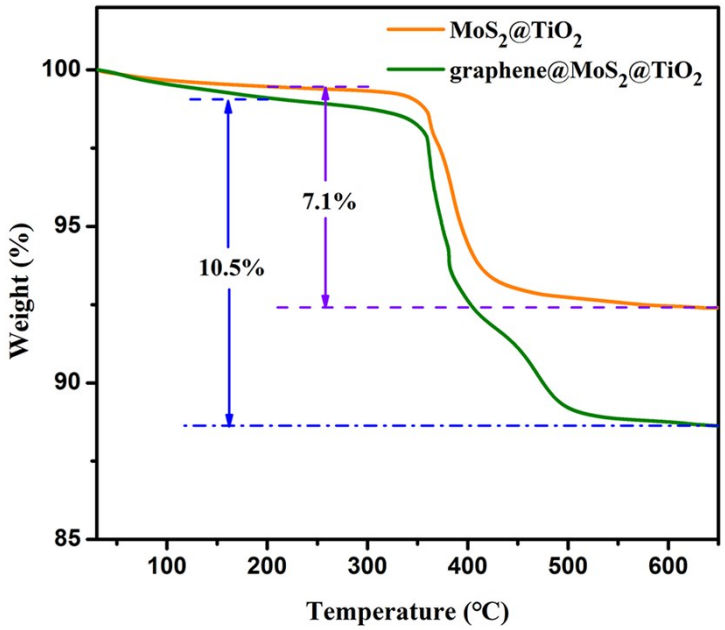

Figure S2. TG curves of the MoS_2@TiO_2 and graphene@MoS_2@TiO_2 samples.

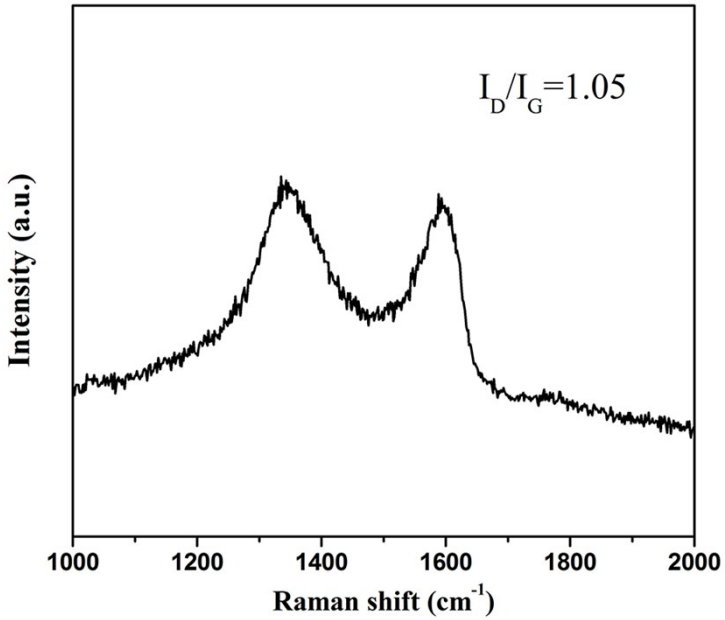

Figure S3. Raman scattering pattern of the graphene oxide.

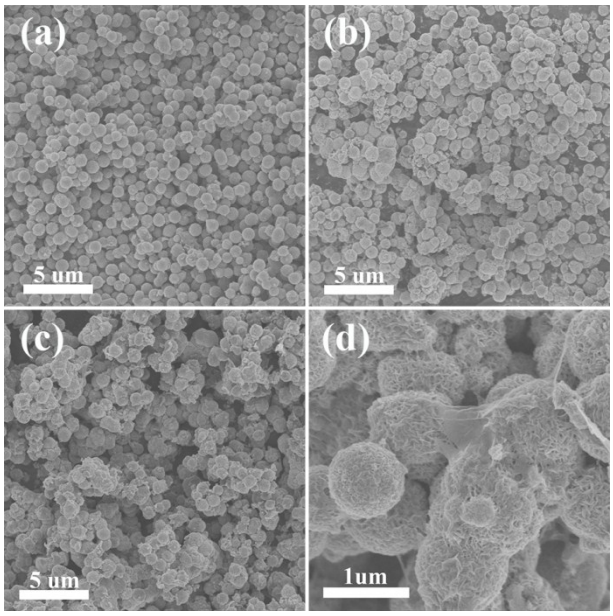

Figure S4. Low magnification FESEM images of the TiO_2 (a), MoS_2@TiO_2 (b) and grahpene@MoS_2@TiO_2 (c, d) samples.

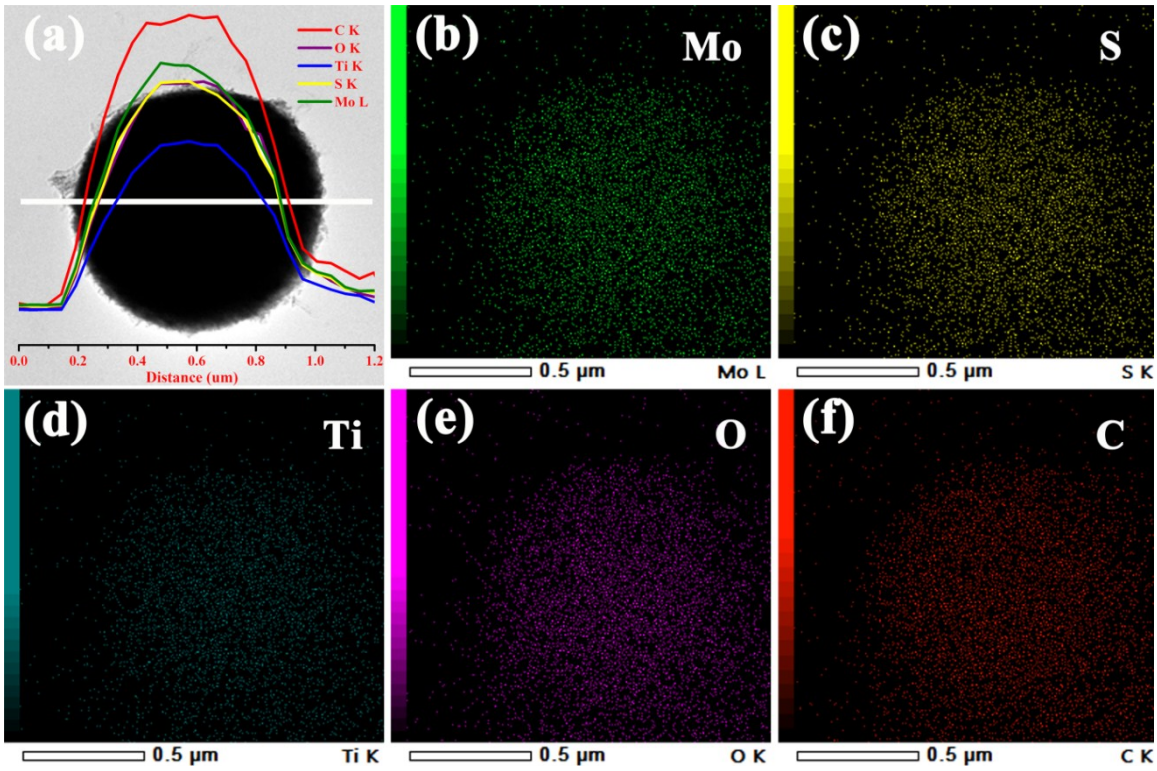

Figure S5. Mappings of Mo, S, Ti, O and C elements in the graphene@MoS_2@TiO_2 sample.

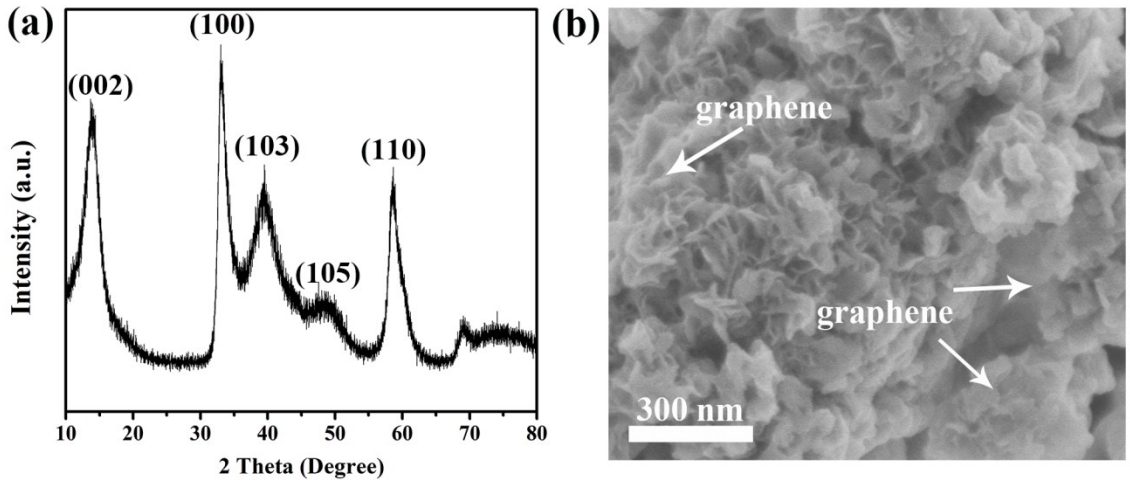

Figure S6. XRD pattern (a) and FESEM image (b) of the MoS_2@gaphene sample.

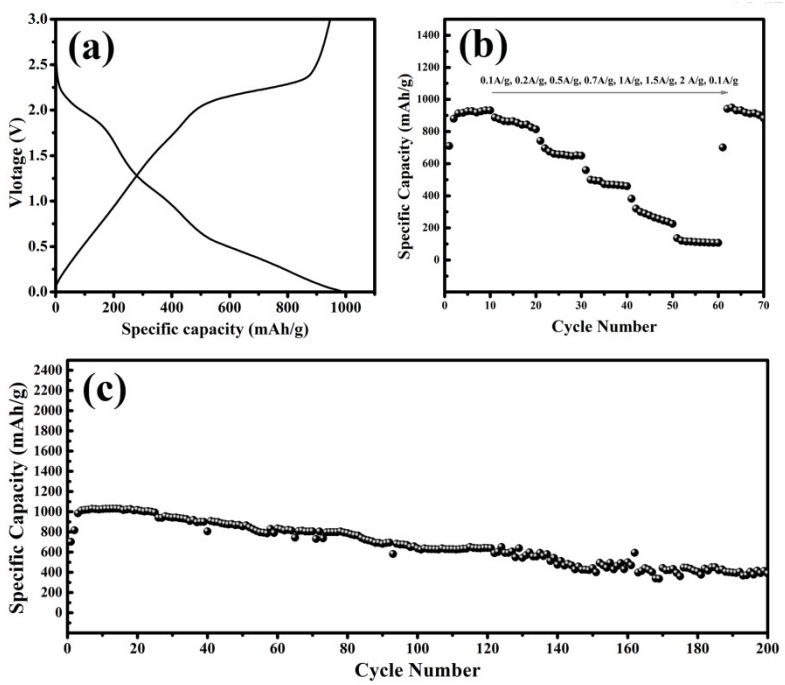

Figure S7. Typical charge-discharge profiles (a), rate capability (b), and cycling performance (c) of the MoS_2@gaphene sample.

References：

1. X. Xu, Z. Fan, S. Ding, D. Yu and Y. Du, *Nanoscale*, 2014, 6, 5245-5250.

2. X. Zhu, C. Yang, F. Xiao, J. Wang and X. Su, *New J.Chem.*, 2015, 39, 683-688.

3. M. Mao, L. Mei, D. Guo, L. Wu, D. Zhang, Q. Li and T. Wang, *Nanoscale*, 2014, 6, 12350-12353.

4. X. Li, W. Li, M. Li, P. Cui, D. Chen, and T. Gengenbach, L. Chu, H. Liu and G. Song, *J. Mater. Chem. A*, 2015, 3, 2762-2769.

5. B. Chen, E. Liu, F. He, C. Shi, C. He, J. Li and N. Zhao, *Nano Energy*, 2016, 26, 541-549.

6. B. Guo, K. Yu, H. Fu, Q. Hua, R. Qi, H. Li, H. Song, S. Guo and Z. Zhu, *J. Mater. Chem. A*, 2015, 3, 6392-6401.

7. R. Dai, A. Zhang, Z. Pan, A. M. Al-Enizi, A. A. Elzatahry, L. Hu and G. Zheng, *Small*, 2016, 12, 2792-2799.