Electronic Supplementary Information

Hetero-assembly of $Li_4Ti_5O_{12}$ nanosheets and multi-walled carbon nanotubes nanocomposite for high-performance lithium and sodium ion batteries

Y. Tian, Z. L. Wu, G. B. Xu, L. W. Yang*, J. X. Zhong

Hunan Key Laboratory of Micro-Nano Energy Materials and Devices, School of Physics and Optoelectronics, Xiangtan University, Hunan 411105, China

*Corresponding authors: ylwxtu@xtu.edu.cn;

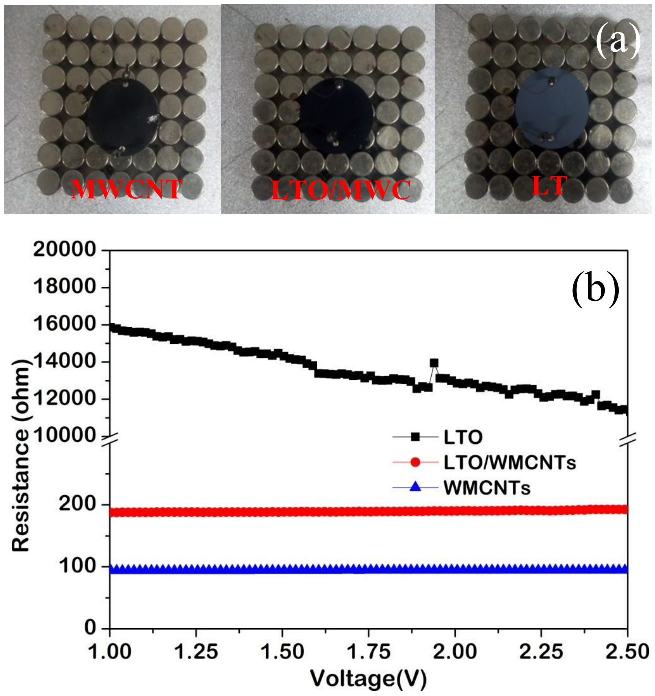

Figure S1. (a)-(b) The electrical conductivity experiments of the LTO/MWCNTs nanocomposite, LTO and MWCNTs were performed at the same distance over a voltage range of 1-2.5 V using a I-V test of keithley 2612B system. The measuring electrodes were fabricated as follows: each sample was dissolved with PVDF (1:9 in weight ratio) in N-methyl-2-pyrrolidinone (NMP) to form slurry under stirring. The slurry was coated onto a circular Cu foil and dried at 120 ℃ in vacuum for 12 h. The MWCNTs exhibits highest electrical conductivity. Meanwhile, the presence of MWCNTs in the LTO/MWCNTs nanocomposite shows superior electrical conductivity than that of pure LTO.

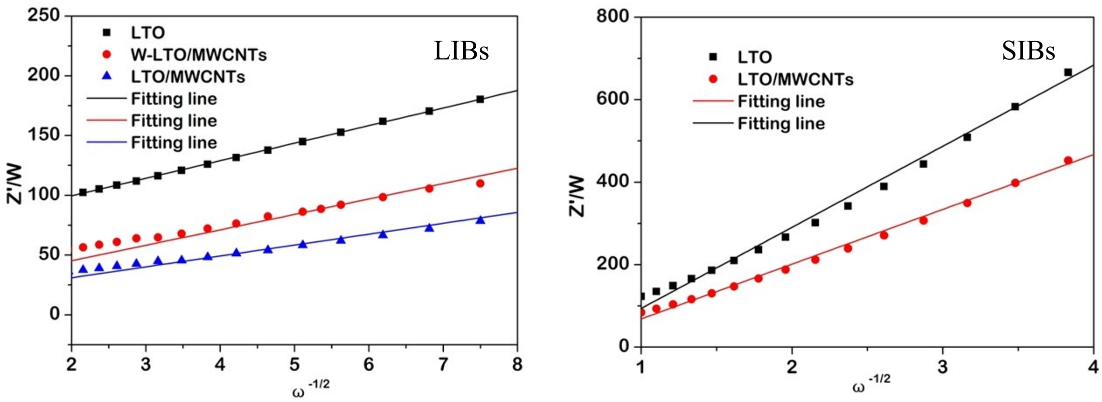

Figure S2. Plots between Z' and $\omega^{-1/2}$ for LTO/MWCTNs and reference samples, respectively.

Table SI Rate performance and cycling performance of the structured $Li_4Ti_5O_{12}$ (LTO) composite material prepared through different methods for LIBs.

Compound	10Ccapacity [$mAhg^{-1}$] (LIBs)	100C capacity [$mAhg^{-1}$] (LIBs)	Capacity retention at 10C (LIBs)	Reference
LTO/MWCNTs	**162**	**151(30C)**	**89.8% over 500 cycles**	**This work**
LTO/graphene nanosheets	135	82.7(60C)	97.5% over 100 cycles	[1]
Cubic LTO/carbon composite	151	134.9(20C)	80.3% over 200 cycles	[2]
N-doped carbon coating LTO	152	123	98.5% over 100 cycles	[3]
LTO/reduced graphite oxides	145	100	96% over 100cycle	[4]
LTO-C Nanotube Arrays	154	81	93% over 500 cycles	[5]
Carbon-Templating LTO nanocrystal	161	>150	97.6% over 100 cycles	[6]
NC-LTO-700 nanosheets	145.8	/	94.7% over 400 cycles (5C)	[7]
CN-LTO-NMS	129	/	95% during the 1000 cycles at 1C	[8]
Porous LTO with 7.0% NC	129	/	83% after 2200 cycles at 2 C	[9]
NC-LTO	133.4	/	95.9% after 1000 cycles at 1C	[10]
Reduce graphene oxide modified $Li_4Ti_5O_{12}$ nanoparticles	158	143	54.6% after 2000 cycles at 80C	[11]
Confined growth of Li4Ti5O12 nanoparticles in nitrogen-doped mesoporous graphene fibers	100	72 (30C)	89.6% after 1000	[12]
Li4Ti5O12/Hollow Graphitized Nano-Carbon Composites	120	85.8 (30C)	91.2% after 500 cycles at 5C	[13]

Table SII Rate performance and cycling performance of the structured $Li_4Ti_5O_{12}$ (LTO) composite material prepared through different methods for SIBs.

Compound	0.5C capacity [$mAhg^{-1}$] (SIBs)	5C capacity [$mAhg^{-1}$] (SIBs)	Capacity retention at 1C (SIBs)	Reference
LTO/MWCNTs	**147**	**83**	**75.6% over 200 cycles**	**This work**
Carbon-coated $Li_4Ti_5O_{12}$ nanowires	158	130	97% after 50 cycles at 0.2C	[14]
$Li_4Ti_5O_{12}$-RT	180	132	97% after 200 cycles and 67% after 400 cycles	[15]
$Li_4Ti_5O_{12}$@C	133	72 (2C)	92% after 100 cycles at 0.2C	[16]
Porous $Li_4Ti_5O_{12}$	121	55	/	[17]
$Li_4Ti_5O_{12}$ Nanosheets	139	100 (2C)	93% after 150 cycles at 0.5C	[18]

References

1. L. Shen, C. Yuan, H. Luo, X. Zhang, S. Yang and X. Lu, *Nanoscale*, 2011, **3**, 572-574.
2. B. Li, C. Han, Y.-B. He, C. Yang, H. Du, Q.-H. Yang and F. Kang, *Energy & Environmental Science*, 2012, **5**, 9595-9602.
3. N. Li, G. Zhou, F. Li, L. Wen and H. M. Cheng, *Advanced Functional Materials*, 2013, **23**, 5429-5435.
4. H.-K. Kim, S.-M. Bak and K.-B. Kim, *Electrochemistry Communications*, 2010, **12**, 1768-1771.
5. J. Liu, K. Song, P. A. van Aken, J. Maier and Y. Yu, *Nano letters*, 2014.
6. X. Hao and B. M. Bartlett, *Advanced Energy Materials*, 2013, **3**, 753-761.
7. C. Han, Y. He, B. Li, H. Li, J. Ma, H. Du, X. Qin, Q. Yang and F. Kang, *ChemSusChem*, 2014, **7**, 2567-2574.
8. G.-N. Zhu, H.-J. Liu, J.-H. Zhuang, C.-X. Wang, Y.-G. Wang and Y.-Y. Xia, *Energy & Environmental Science*, **4**, 4016-4022.
9. H. Li, L. Shen, X. Zhang, J. Wang, P. Nie, Q. Che and B. Ding, *Journal of power sources*, 2013, **221**, 122-127.
10. H. Li, L. Shen, K. Yin, J. Ji, J. Wang, X. Wang and X. Zhang, *Journal of Materials Chemistry A*, 2013, **1**, 7270-7276.
11. C. Chen, Y. Huang, H. Zhang, X. Wang, G. Li, Y. Wang, L. Jiao and H. Yuan, *Journal of Power Sources*, 2015, **278**, 693-702.
12. X. Jia, Y. Lu and F. Wei, *Nano Research*, 2016, **9**, 230-239.
13. L. Fan, X. Tan, T. Yu and Z. Shi, *RSC Adv.*, 2016, **6**, 26406-26411.
14. K.-T. Kim, C.-Y. Yu, C. S. Yoon, S.-J. Kim, Y.-K. Sun and S.-T. Myung, *Nano Energy*, 2015, **12**, 725-734.
15. Lin Yu Yang, Hui Zhong Li, Jun Liu, Sha Sha Tang, Ya Kun Lu, Si Te Li, Jie Min, Ning Yan and Ming Lei, *Journal of Materials Chemistry A*, 2013, **00**, 1-8.
16. J. Liu, K. Tang, K. Song, P. A. van Aken, Y. Yu and J. Maier, *Physical Chemistry Chemical Physics*, 2013, **15**, 20813.
17. G. Hasegawa, K. Kanamori, T. Kiyomura, H. Kurata, K. Nakanishi and T. Abe, *Advanced Energy Materials*, 2015, **5**, n/a-n/a.

18. X. Feng, H. Zou, H. Xiang, X. Guo, T. Zhou, Y. Wu, W. Xu, P. Yan, C. Wang, J.-G. Zhang and Y. Yu, *ACS Applied Materials & Interfaces*, 2016, **8**, 16718-16726.