Electronic Supporting Information

Expanded Graphite Incorporated With $Li_4Ti_5O_{12}$ Nanoparticles as High Stable Fast Charging Anode for Lithium-Ion Batteries

JunkangZhao,[ab] XiayuZhu,[bc] WenfengZhang,[bc] JingyiQiu,[bc] FeiyueZai,[bd] HuiminZhang,[bc] GaopingCao,[bc] ShengjiGao,[ab] FeiDing,*[a] YuXiang*[bc]

a.Hebei University of Technology, Tianjin 100131,
b.Chemical Defense Institute, Academy of Military Sciences, Beijing 100191, China.
c.Beijing Key Laboratory of Advanced Chemical Energy Storage Technology and Materials, Beijing 100191, China.
d.Beihang University, Beijing 100191, China

*Corresponding authors.
Email addresses: hilldingfei@163.com; drxiangyu2016@126.com

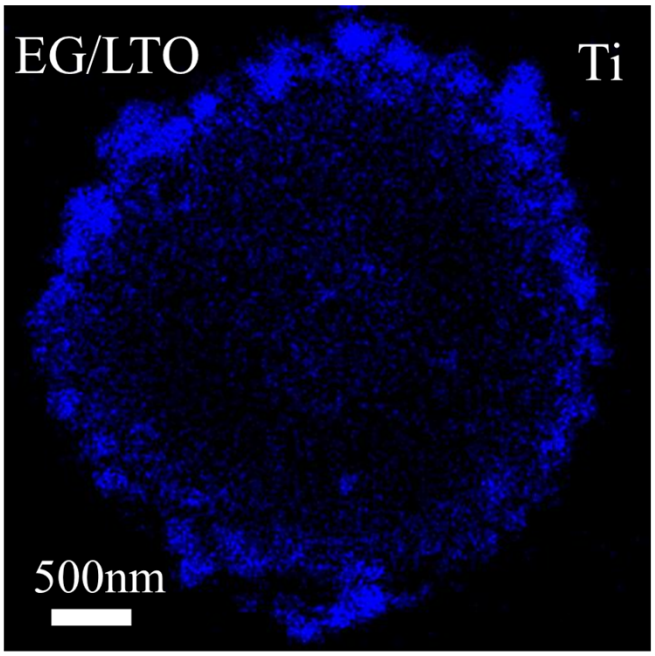

Figure. S1 Elemental mapping recorded from EG/LTO particles with corresponding mappings of Ti elements.

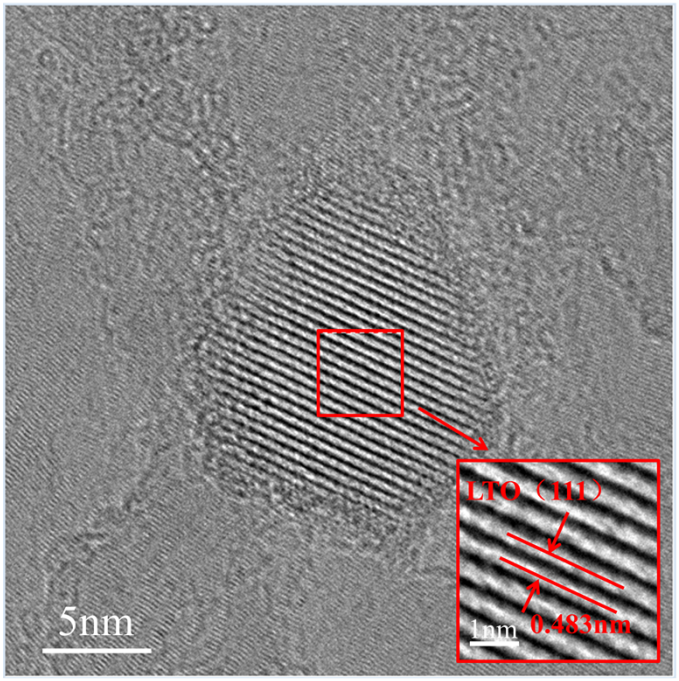

Figure. S2 TEM image of EG/LTO particles

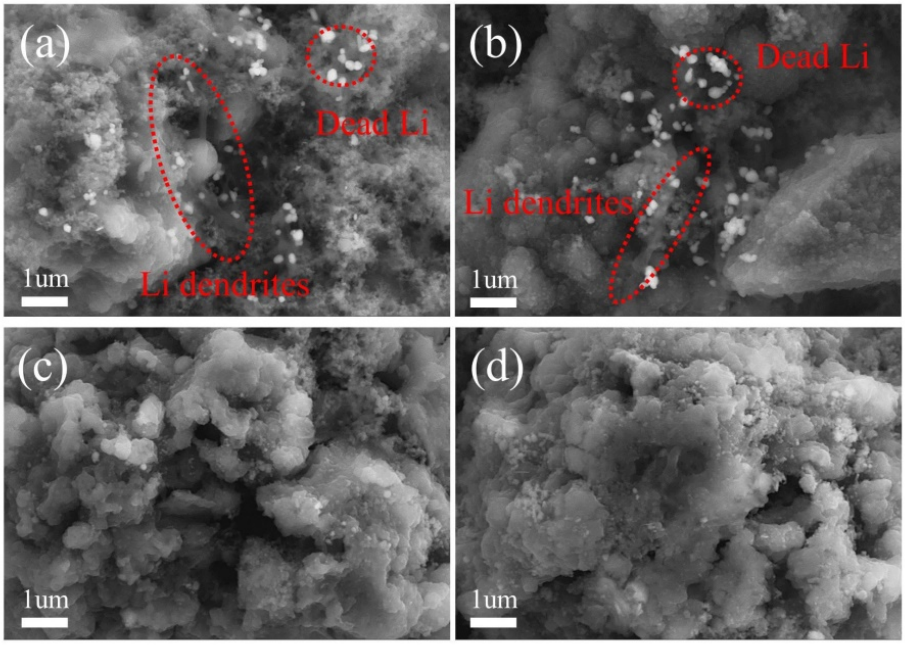

Figure. S3 SEM images of G and EG/LTO electrode after 500 cycles : (a) and (b) G; (c) and (d) EG/LTO

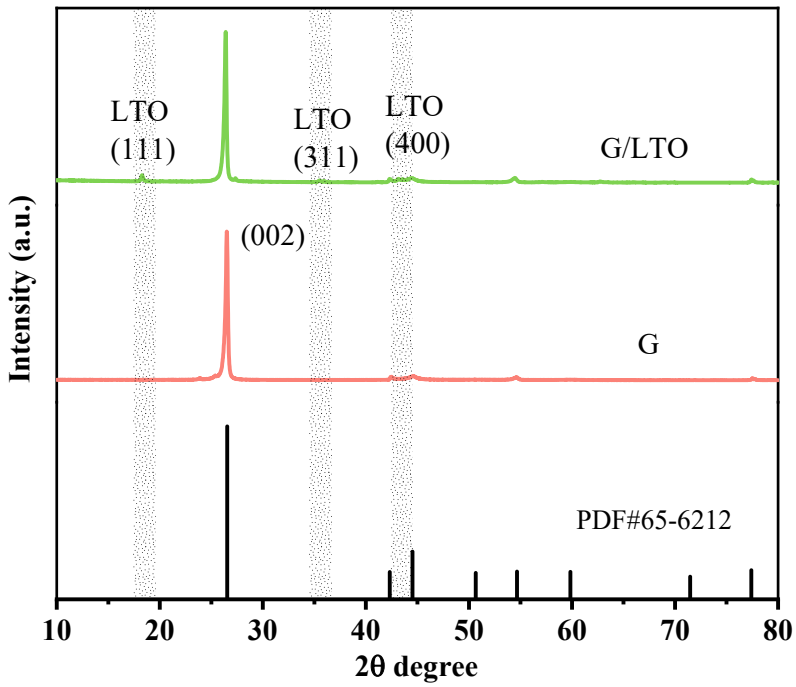

Figure. S4 XRD patterns of G and G/LTO powders

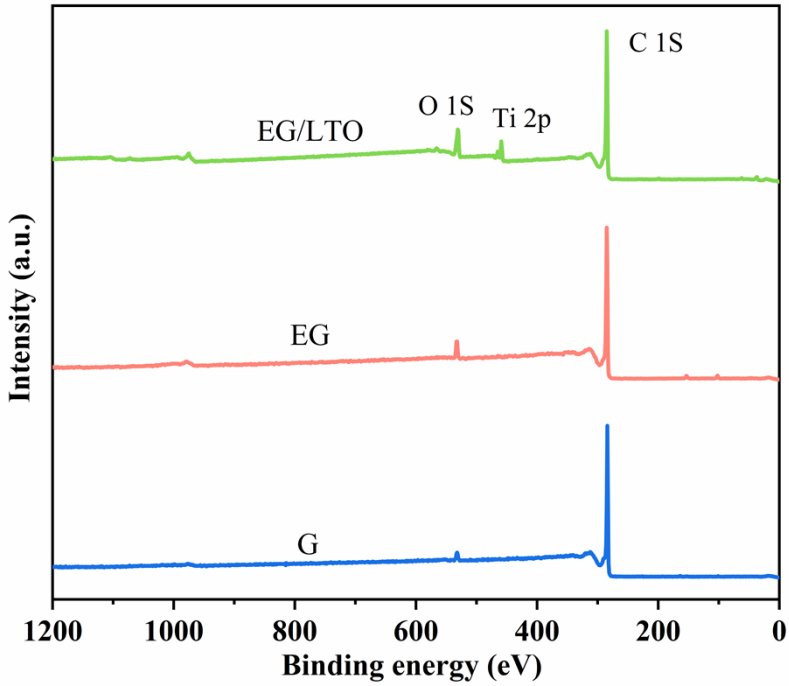

Figure. S5 XPS survey spectra of G, EG and EG/LTO.

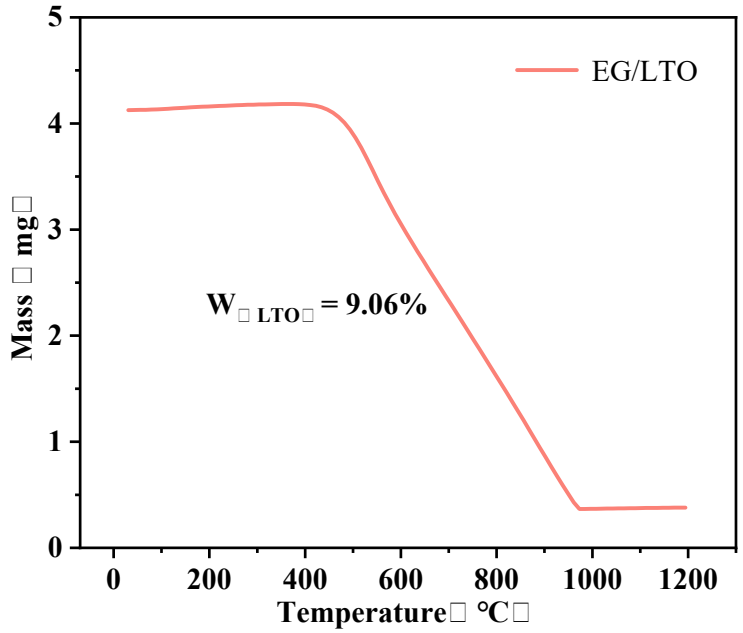

Figure. S6 Thermogravimetric analysis of EG/LTO

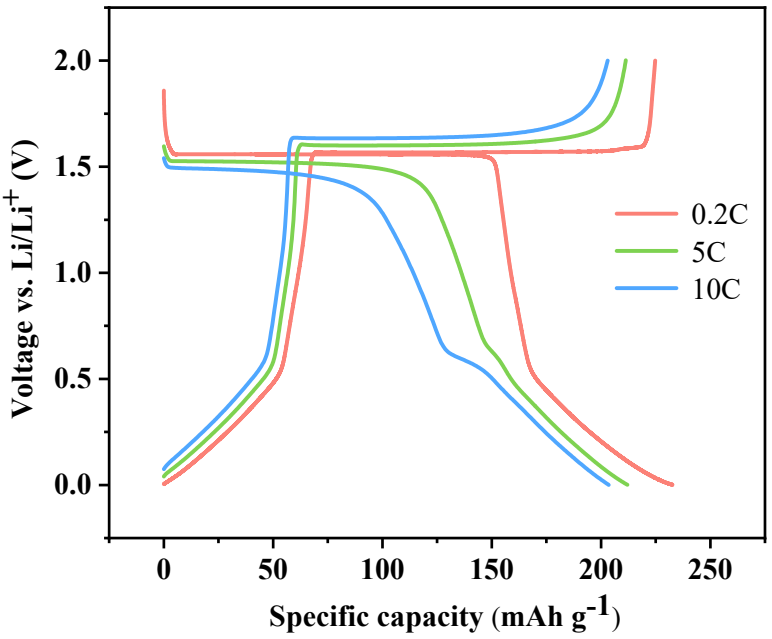

Figure. S7 The charge and discharge curves of LTO at 0.2, 5, 10C in voltage range from 0.001-2 V.

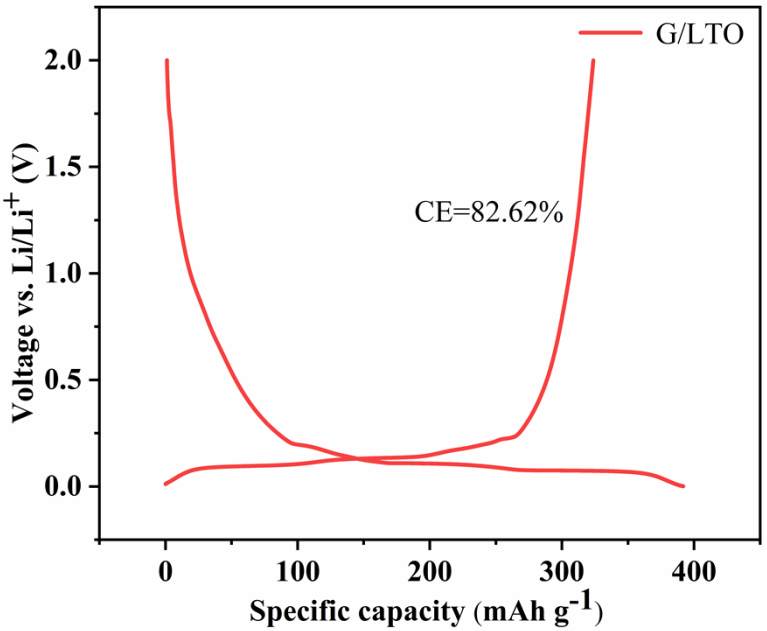

Figure. S8 The initial charge and discharge curves of G/LTO withot mild oxidization method.

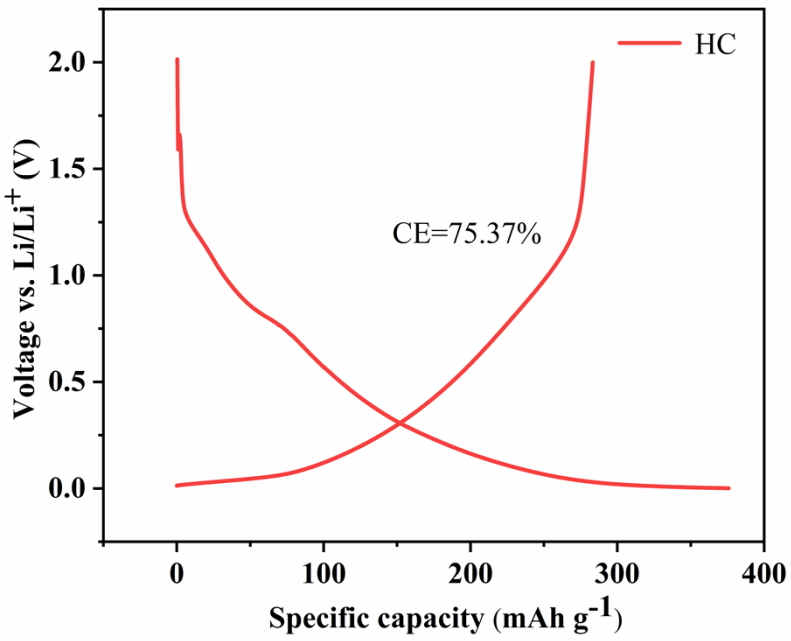

Figure. S9 The initial charge and discharge curves of HC.

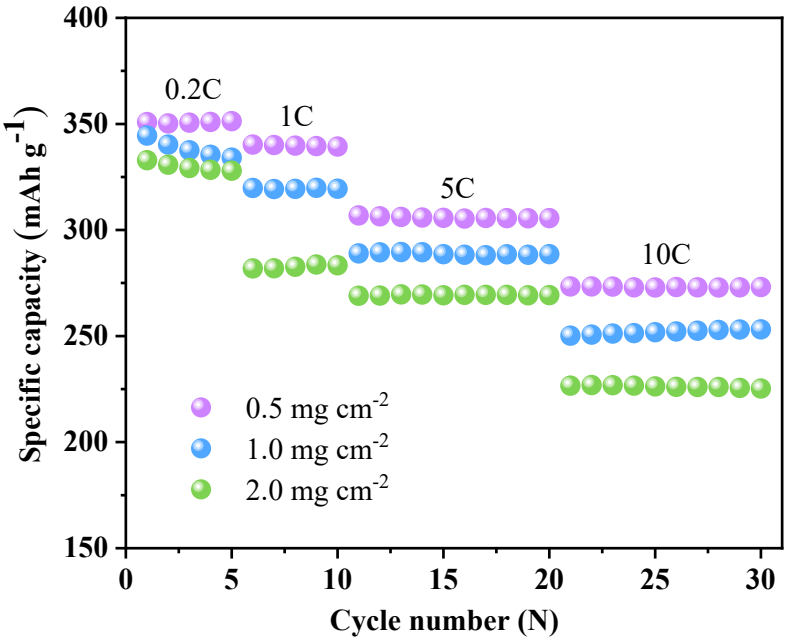

Figure. S10 Rate performance for EG/LTO electrodes with different mass loadings

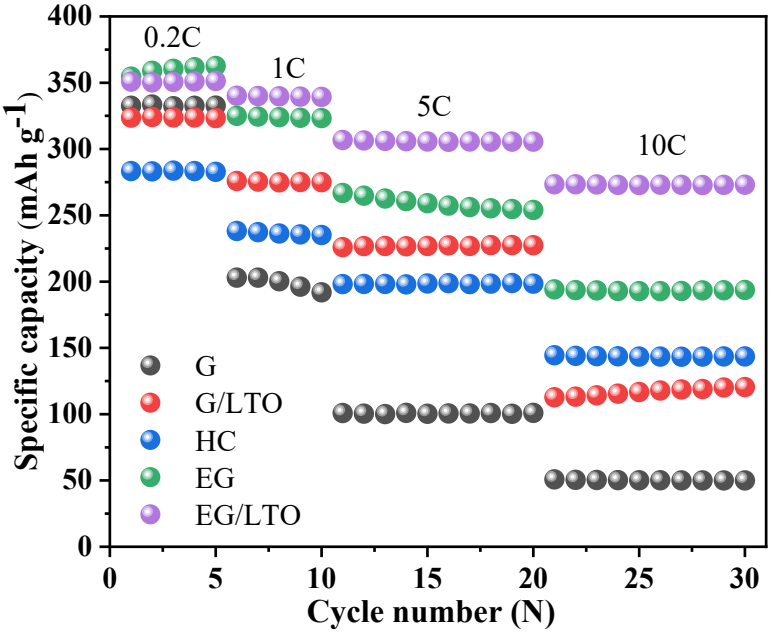

Figure. S11 Rate performaces of five materials.

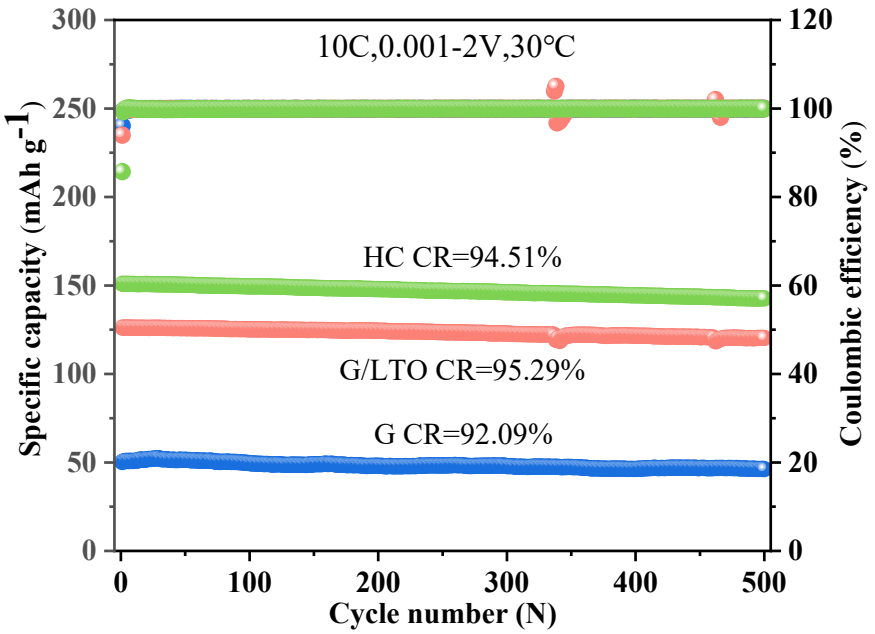

Figure. S12 Cycle life testing of G, G/LTO and HC.

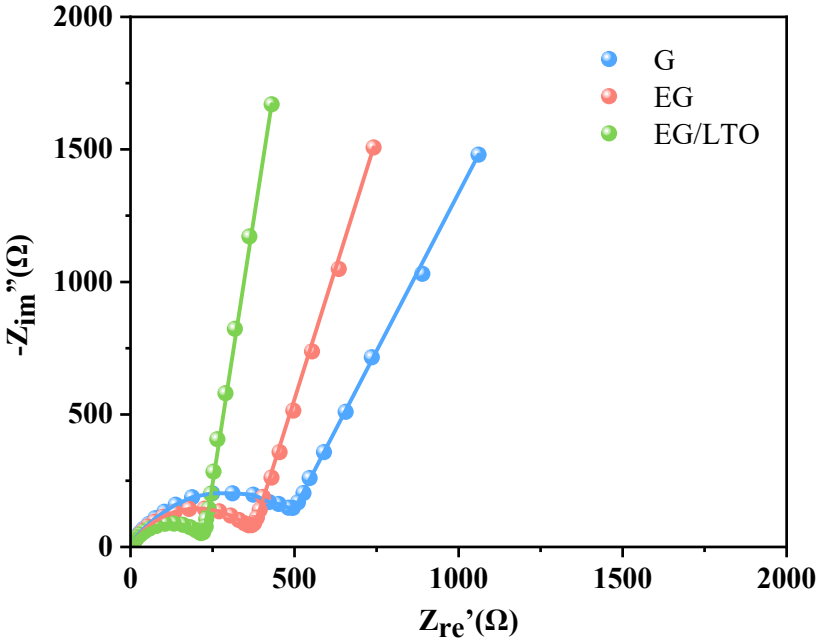

Figure. S13 Typical Nyquist plots of fresh electrode of G, EG, EG/LTO at 25℃

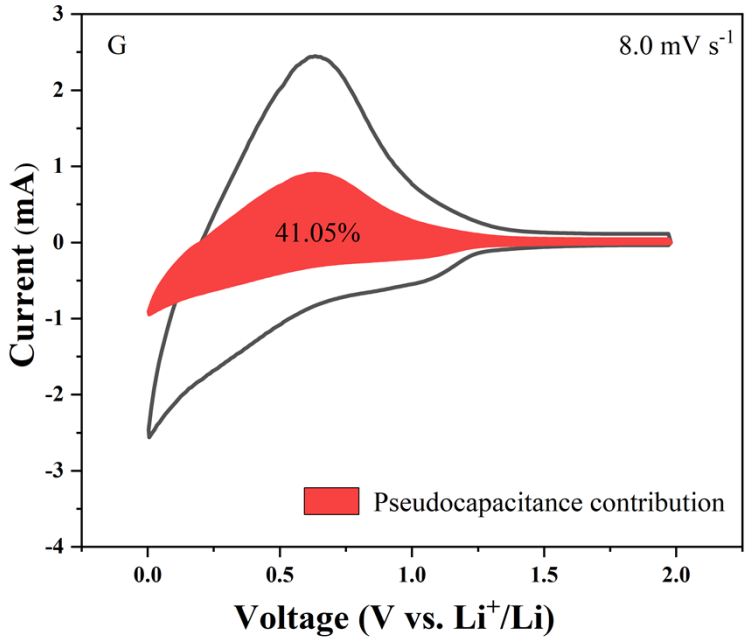

Figure. S14 Pseudocapacitive contribution of G at a scan rate of 8 mV s^{-1}

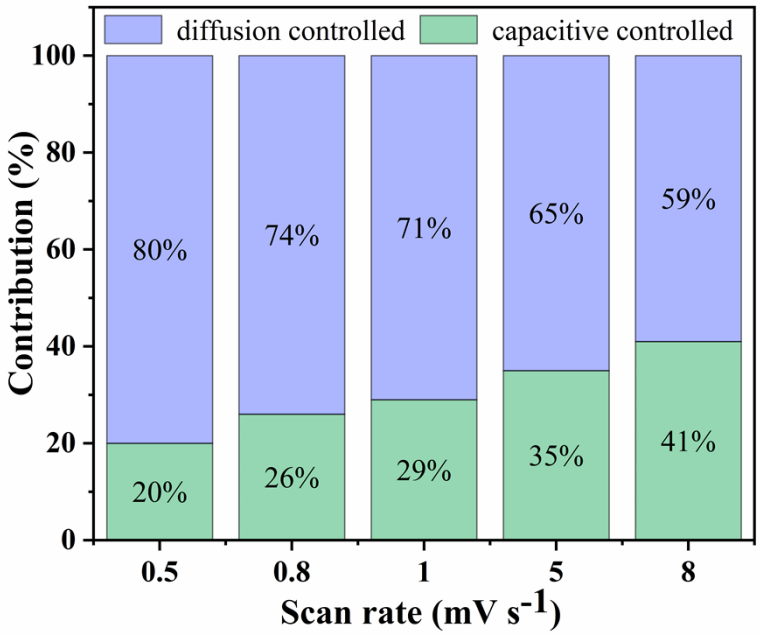

Figure. S15 The capacitive contribution ratio of G at various scan rates.

Table. S1 BET、v-t、BJH and DFT results of the G, EG and EG/LTO.

	Multi-Point BET	v-t	BJH（adsorption/desorption）		DFT
G	0.991 $m^2 g^{-1}$	0.991 $m^2 g^{-1}$	1.938 $m^2 g^{-1}$ 0.007 ccg^{-1} 3.39 nm	2.076 $m^2 g^{-1}$ 0.007 ccg^{-1} 3.81 nm	0.998 $m^2 g^{-1}$ 0.004 ccg^{-1} 4.543 nm
EG	29.946 $m^2 g^{-1}$	29.946 $m^2 g^{-1}$	19.551 $m^2 g^{-1}$ 0.110 ccg^{-1} 3.408 nm	28.903 $m^2 g^{-1}$ 0.115 ccg^{-1} 3.824 nm	22.292 $m^2 g^{-1}$ 0.072 ccg^{-1} 3.794 nm
EG/LTO	18.579 $m^2 g^{-1}$	18.579 $m^2 g^{-1}$	12.853 $m^2 g^{-1}$ 0.083 ccg^{-1} 3.395 nm	25.428 $m^2 g^{-1}$ 0.090 ccg^{-1} 3.825 nm	14.027 $m^2 g^{-1}$ 0.044 ccg^{-1} 3.969 nm

Table. S2 The performances of high-rate graphite anode materials

Modification	Voltage Range (V)	Initial Coulombic Efficiency (%)	Specific Current (A g^{-1})	Specific Capacity (mAh g^{-1})	Ref.
EG/LTO	0.001-2.0	63.5	3.74	272.8	This work
GLG	0.001-2.0	56	3.74	125	[1]
EG	0.001-1.5	-	3.0	112	[2]
BG/Al_2O_3	0.001-3.0	85	3.0	200.4	[3]
Al_2O_3@graphite	0.001-2.0	94.6	4.0	337.1	[4]
TiO_2 coated graphite	0.001-2.0	87.6	3.6	345.2	[5]
LTO-MCMB	0.001-1.5	72.5	0.75	100	[6]
Graphite-LTO	0.001-2.0	89	0.37	171	[7]
MoS_2@AG	0.001-2.5	86.1	2.4	255.8	[8]
VC@C	0.001-3.0	54.9	2.0	328	[9]

Table. S3 The capacity of EG in EG/LTO at different rate

	0.2C	5C	10C
$Q_{(EG/LTO)}$	350.3 mAh g^{-1}	305.6 mAh g^{-1}	272.8 mAhg^{-1}
contribution of$_{(LTO)}$	5.84%	6.26%	6.69%
contribution of $_{(EG)}$	94.16%	93.74%	93.31%

Reference:

1. Q. Cheng, Y. Okamoto, N. Tamura, M. Tsuji, S. Maruyama and Y. Matsuo, *Scientific reports*, 2017, **7**, 14782.
2. D.-K. Son, J. Kim, M. R. Raj and G. Lee, *Carbon*, 2021, **175**, 187-201.
3. H. Ma, Z. Yu, J. Chen, D. Wang, C. Dong and Z. Mao, *ACS Applied Energy Materials*, 2023, **6**, 1389-1395.
4. D. S. Kim, Y. E. Kim and H. Kim, *Journal of power sources*, 2019, **422**, 18-24.
5. D. S. Kim, D. J. Chung, J. Bae, G. Jeong and H. Kim, *Electrochimica acta*, 2017, **258**, 336-342.
6. K. Gao and S.-D. Li, *Journal of power sources*, 2014, **270**, 304-311.
7. M.-L. Lee, Y. H. Li, S.-C. Liao, J.-M. Chen, J.-W. Yeh and H. C. Shih, *Electrochimica acta*, 2013, **112**, 529-534.
8. Y. A. Lee, K. Y. Jang, J. Yoo, K. Yim, W. Jung, K.-N. Jung, C.-Y. Yoo, Y. Cho, J. Lee and M. H. Ryu, *Materials*, 2023, **16**, 4016.
9. M. Mahajan, K. Roy, S. Parmar, G. Singla, O. Pandey, K. Singh, R. Vaidhyanathan and S. Ogale, *Carbon*, 2020, **161**, 108-116.