Supporting information

Reduced graphene oxide/LiI composite lithium ion battery cathodes

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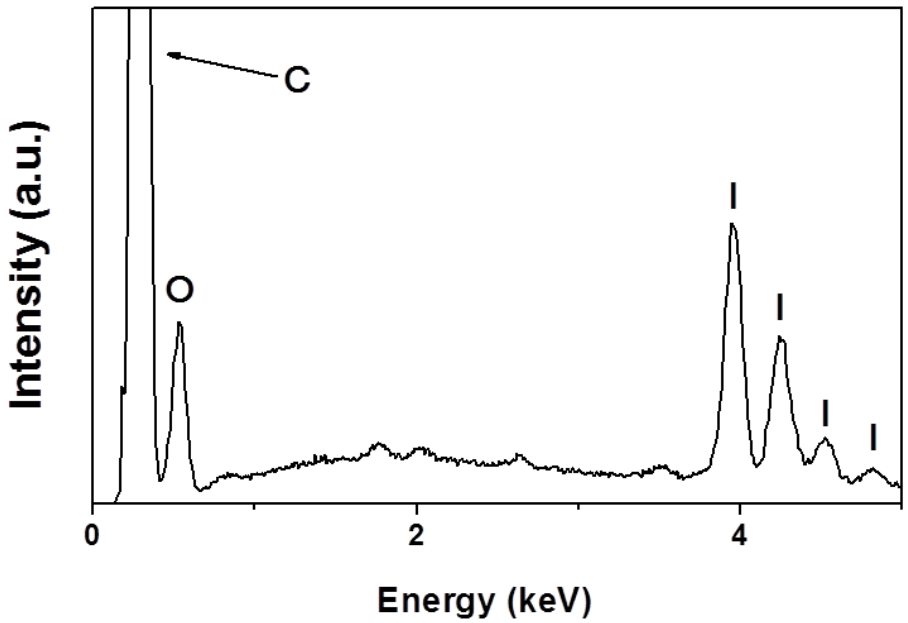

Figure S1. EDS spectrum of rGO/LiI composite.

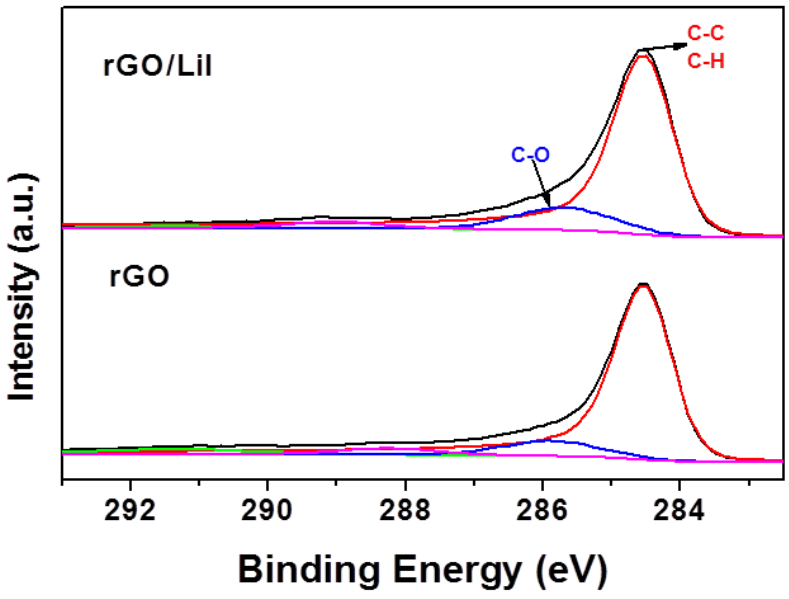

Figure S2. XPS spectra of C 1s region obtained from rGO and rGO/LiI sample.

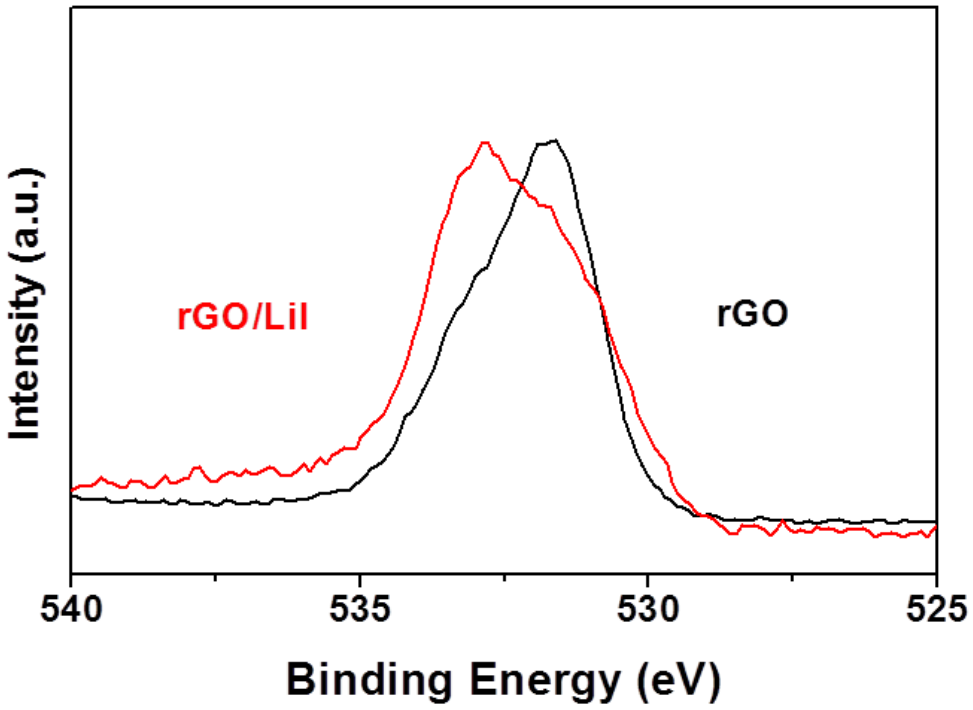

Figure S3. XPS spectra of O 1s from rGO and rGO/LiI.

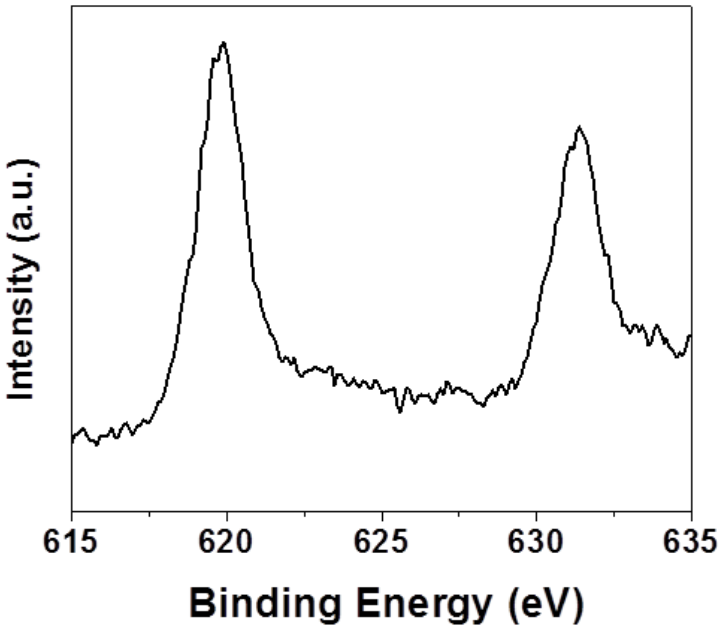

Figure S4. XPS spectra of I 3d from rGO/LiI electrode after first charge process.

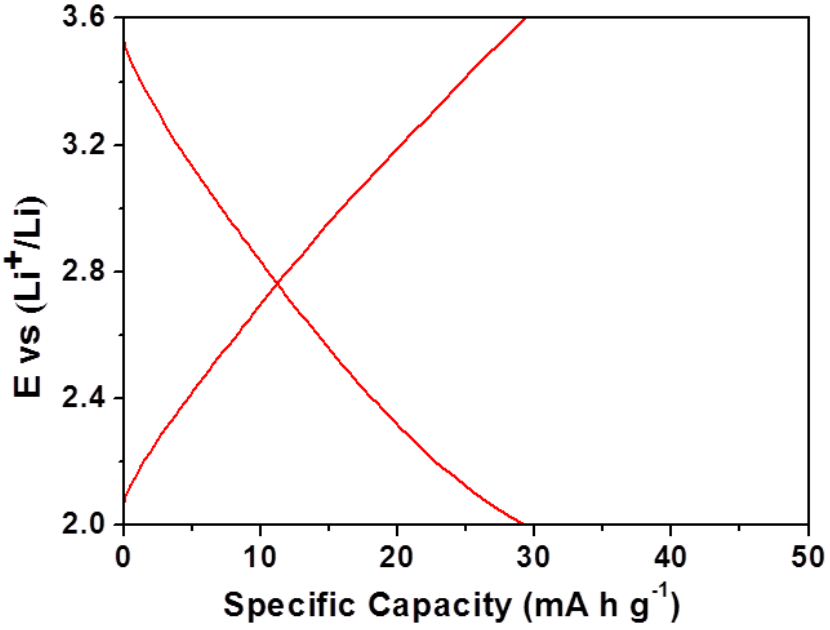

Figure S5. Typical discharge and charge curves of bare rGO.

As a result of the rGO capacity, there was a maximum of a 15 % LiI-based specific capacity error due to the somewhat indeterminate capacity of rGO in the rGO/LiI electrodes..

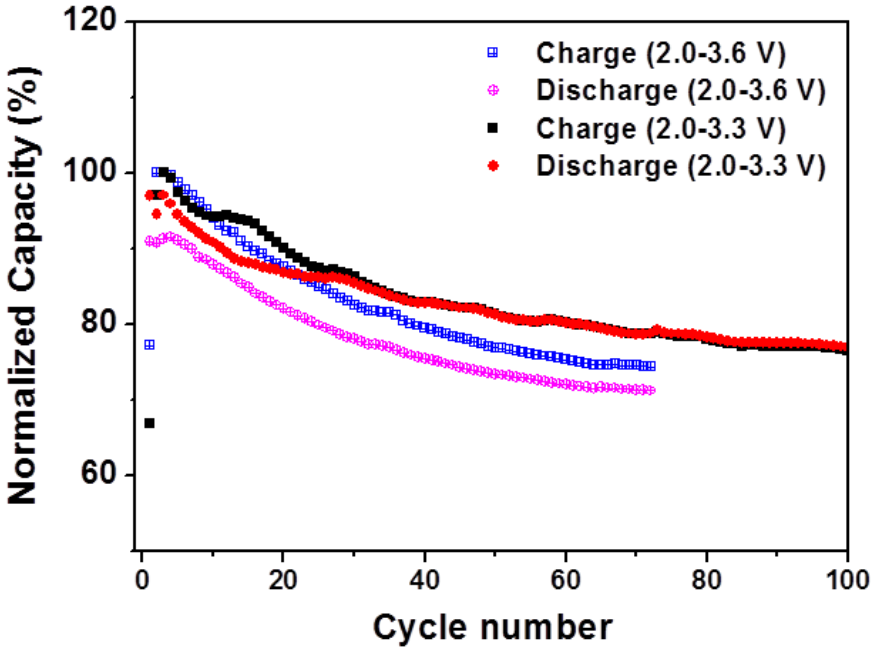

Figure S6. Normalized Capacity behavior of LiI/rGO electrodes cycled at 1 C over the voltage ranges of 2.0-3.6 V and 2.0-3.3 V.

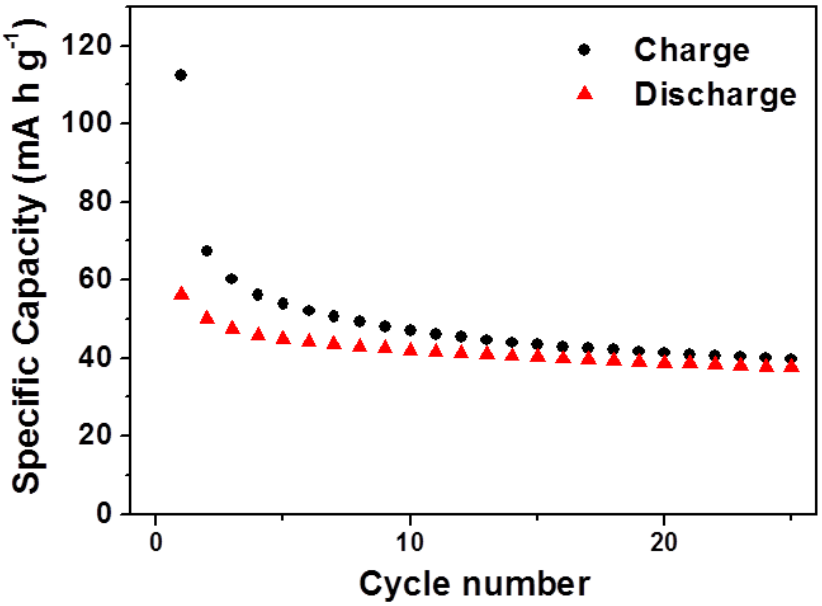

Figure S7. Cycling performance of CNT/LiI composite at 0.5 C.

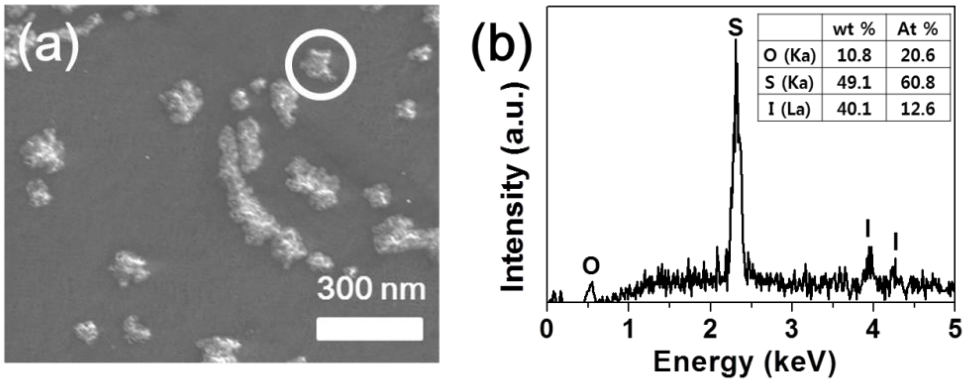

Figure S8. (a) SEM image of a Li electrode after cycling and (b) EDS spectrum taken from marked region in Figure S8a.

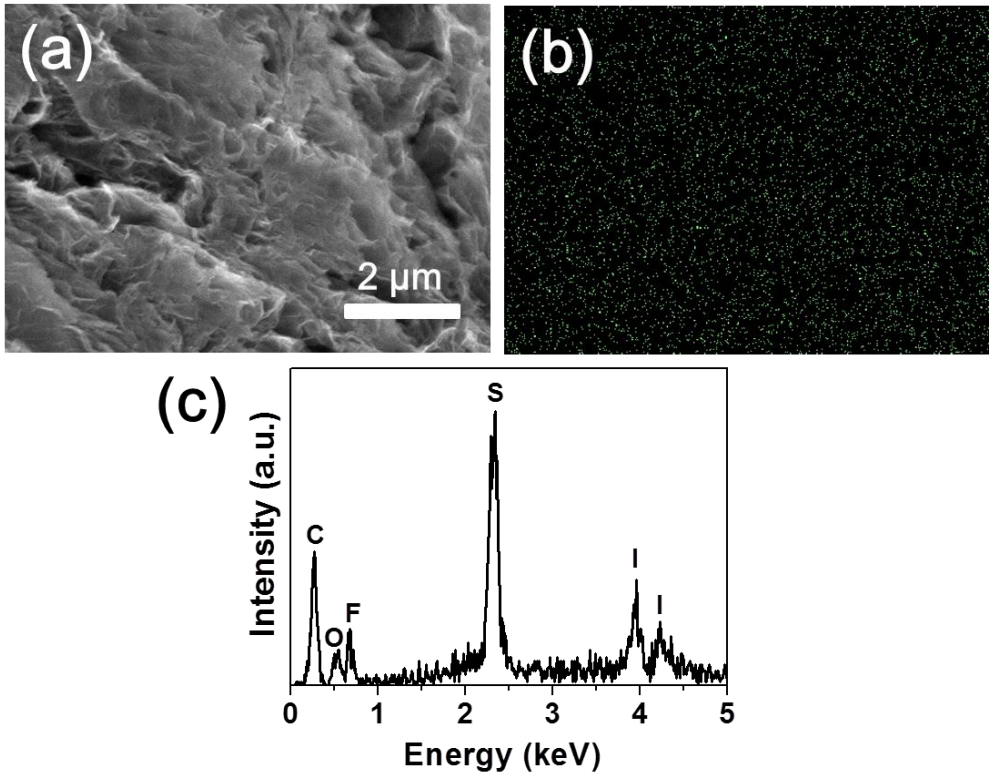

Figure S9. (a) Cross-sectional SEM image, (b) corresponding EDS mapping with element I and (c) EDS spectrum of rGO/LiI electrode after cycling.

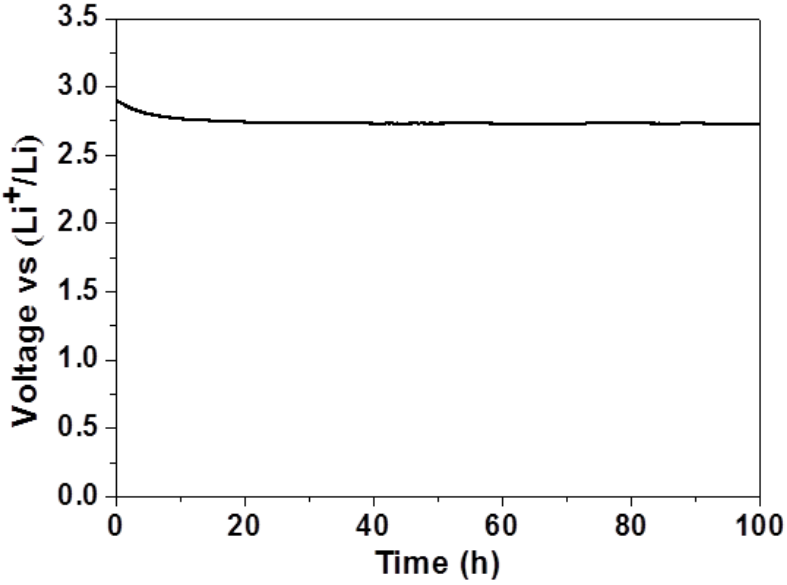

Figure S10. Voltage vs time curve at open circuit voltage before cycling.

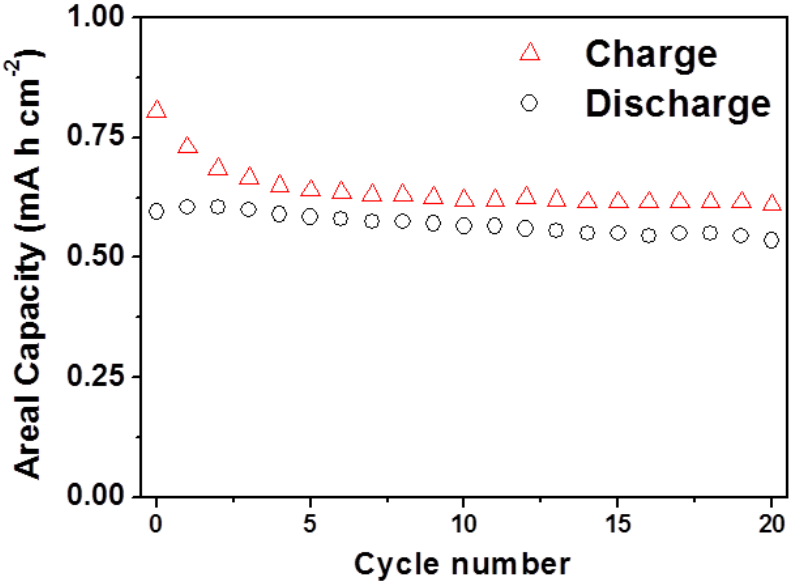

Figure S11. 0.5 C areal capacity of electrode formed by pressing two rGO/LiI electrodes together.

Table S1. Electrochemical characteristics of some commercial Li-ion battery cathode materials and LiI.[1-3]

	$LiCoO_2$	$LiMn_2O_4$	$LiFePO_4$	LiI
Density (g cm^{-3})	5.1	4.3	3.6	4.1
Potential (V)	3.9	4.05	3.4	2.95
Specific capacity (mA h g^{-1})	140	120	160	200
Specific energy vs. Li (Wh kg^{-1})	546	486	544	590
Volumetric capacity (mA h cm^{-3})	714	516	576	820
Energy density (Wh L^{-1})	2785	2090	1958	2419

Table S2. Fitting data from Figure 6a.

	R_s (Ω)	R_{ct1} (Ω)	R_{ct2} (Ω)
after 10 cycles	12.74	382.9	242
after 20 cycles	12.76	376.3	278.9
after 30 cycles	12.27	376.1	301.5

Table S3. Electrochemical performance of previous reported iodine/C electrodes and the present work (LiI/rGO electrodes). All capacities are specific capacities calculated based on the weight of active materials

Electrode	Active Material Content	Cycling Conditions	Electrolyte	Initial discharge capacity	Final discharge capacity	Ref.
Iodine-conductive carbon black composite	24 %	101 mA g^{-1}, 20 cycles	1 M $LiPF_6$ EC/EMC/DMC (1:1:1 by volume)	≒250 mA h g^{-1}	≒190 mA h g^{-1}	4
Iodine/Nanoporous Carbon	22 %	105 mA g^{-1}, 300 cycles	1 M LiTFSI in DOL /DME (1:1 by volume) with 1 wt % $LiNO_3$	299 mA h g^{-1}	195 mA h g^{-1}	5
Iodine/N-doped hollow carbon fold-hemisphere	32 %	105 mA g^{-1}, 100 cycles	1 M LiTFSI in DOL /DME (1:1 by volume) with 1 wt % $LiNO_3$	≒300 mA h g^{-1}	≒250 mA h g^{-1}	6
Iodine/3D bio-foam composites (Bio-carbon host)	≒36 %	210 mA g^{-1}, 100 cycles	1 M LiTFSI in DOL /DME (1:1 by volume) with 1 wt % $LiNO_3$	≒185 mA h g^{-1}	≒176 mA h g^{-1}	7
Iodine/Active Graphene	45 %	210 mA g^{-1}, 500 cycles	1 M LiTFSI and 0.2 M $LiNO_3$ in DOL/TEGDME (1:1 by volume)	216 mA h g^{-1}	146 mA h g^{-1}	8
LiI/Reduced Graphene Oxide	31 %	100 mA g^{-1}, 100 cycles	1 M LiTFSI in DOL /DME (1:1 by volume) with 1 wt % $LiNO_3$	270 mA h g^{-1}	200 mA h g^{-1}	Present Work
	33 %	2000 mA g^{-1}, 200 cycles		183 mA h g^{-1}	168 mA h g^{-1}	

REFERENCES

(1) Etacheri, V.; Marom, R.; Elazari, R.; Salitra, G.; Aurbach, D. *Energy Environ. Sci*. **2011,** *4*, 3243-3262.

(2) Julien, C. M.; Mauger, A.; Zaghib, K.; Groult, H. *Inorganics* **2014,** *2*, 132-154.

(3) Xu, B.; Qian, D.; Wang, Z.; Meng, Y. S. *Mater. Sci. Eng. R-Rep.* **2012,** *73*, 51-65.

(4) Wang, Y.; Sun, Q.; Zhao, Q.; Cao, J.; Ye, S. *Energy Environ. Sci* **2011,** *4*, 3947-3950.

(5) Zhao, Q.; Lu, Y.; Zhu, Z.; Tao, Z.; Chen, J. *Nano Lett.* **2015,** *15*, 5982-5987.

(6) Li, K.; Lin, B.; Li, Q.; Wang, H.; Zhang, S.; Deng, C. *ACS Appl. Mater. Interfaces* **2017**, *9*, 20508-20518.

(7) Wang, H.; Zhang, G.; Ke, L.; Liu, B.; Zhang, S.; Deng, C. *Nanoscale* **2017,** *9*, 9365-9375.

(8) Zhang, Q.; Wu, Z.; Liu, F.; Liu, S.; Liu, J.; Wang, Y.; Yan, T. *J. Mater. Chem. A* **2017,** *5*, 15235-15242.