Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supplementary information

- **Name of LIC fabricated**: AC/RG LIC
- ✓ **Anode**: Prelithiated RG electrode (80:10:10)

Slurry coated (80% RG+10% conductive carbon+10% PVdF binder) on Cu foil

- ✓ **Cathode**:AC electrode (80:10:10)

80% AC +10% conductive carbon +10% TAB 2 binder, ethanol solvent

- ✓ **Electrolyte**: 1M $LiPF_6$ in EC: DMC (1:1)
- ✓ **Separator**: whatman filter paper

LIC fabricated	Mass of RG active material (mg)	Mass of AC active material (mg)	Total mass of active material in both electrodes (mg)	Mass loading ratio
LIC 1	2.54	9.769	12.31	3.85
LIC 2	2.56	8.86	11.42	3.46
LIC 3	2.232	8.29	10.522	3.714
LIC 4	2.232	9.026	11.258	4.043

- **Preparation of the AC electrode:**
  - According to Mass loading formula

$$Q = q_{positive} * m_{positive} = q_{negative} * m_{negative}$$

Where Q=Discharge (mAh)
q=Specific capacity in second discharge cycle (mAh g^{-1})
m=mass of active material in the electrode

for the negative electrode, (prelithiated RG) 3rd discharge capacity is considered with which swage lok cell is dismantled)

- **Energy and Power Density calculation**
  - Charge Q, (mAh) = Current (mA) * time (h)
  - Capacity C, (mAh g^{-1}) =Q/m
    - m= total mass of active material in both the electrodes
  - Energy density (Wh kg^{-1}) = C*V
    - V= Intersecting voltage of the second charge-discharge curve.
    - Ohmic drop calculated from galvanostatic charge-discharge data
  - Power Density= Energy density/time (h)

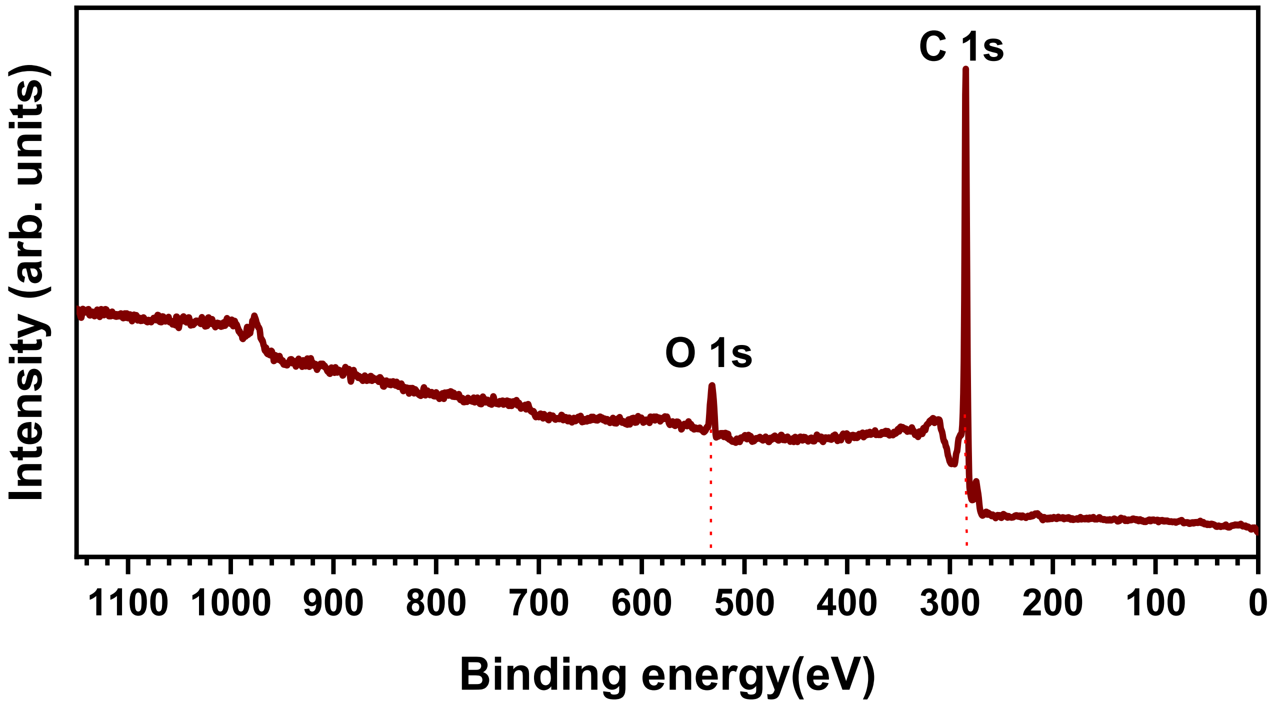

Figure S_1: Raw XPS spectra of RG.

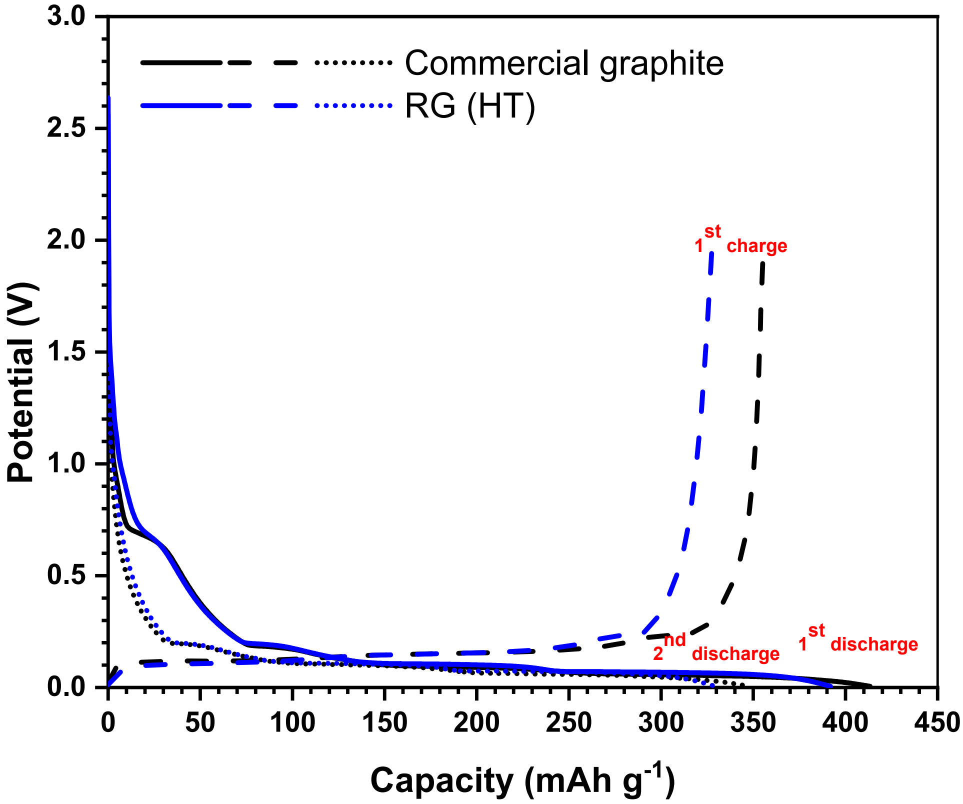

Figure S$_2$: Performance comparison of Recovered graphite sample with commercial graphite at the current density of 100 mA g^{-1} (Sigma-Aldrich).

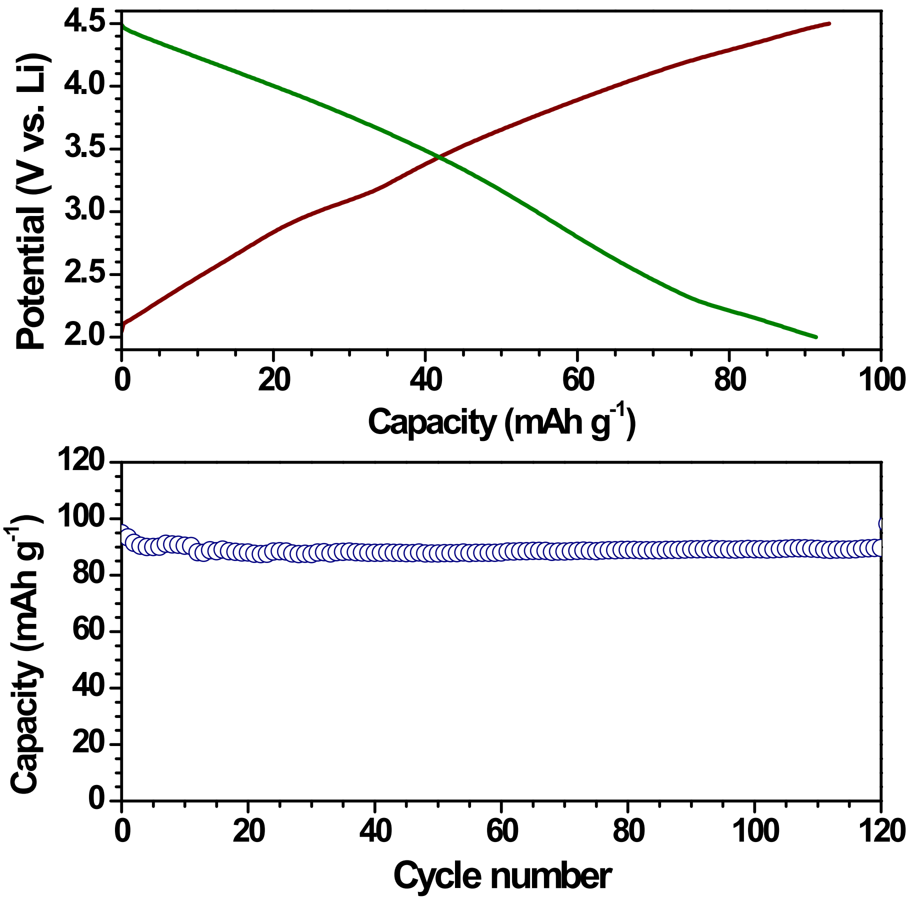

Figure S3: Half-cell performance of Li/AC, (a) Typical galvanostatic charge-discharge profile at a current density of 0.1 A g^{-1}, and (b) Cyclic stability performance.

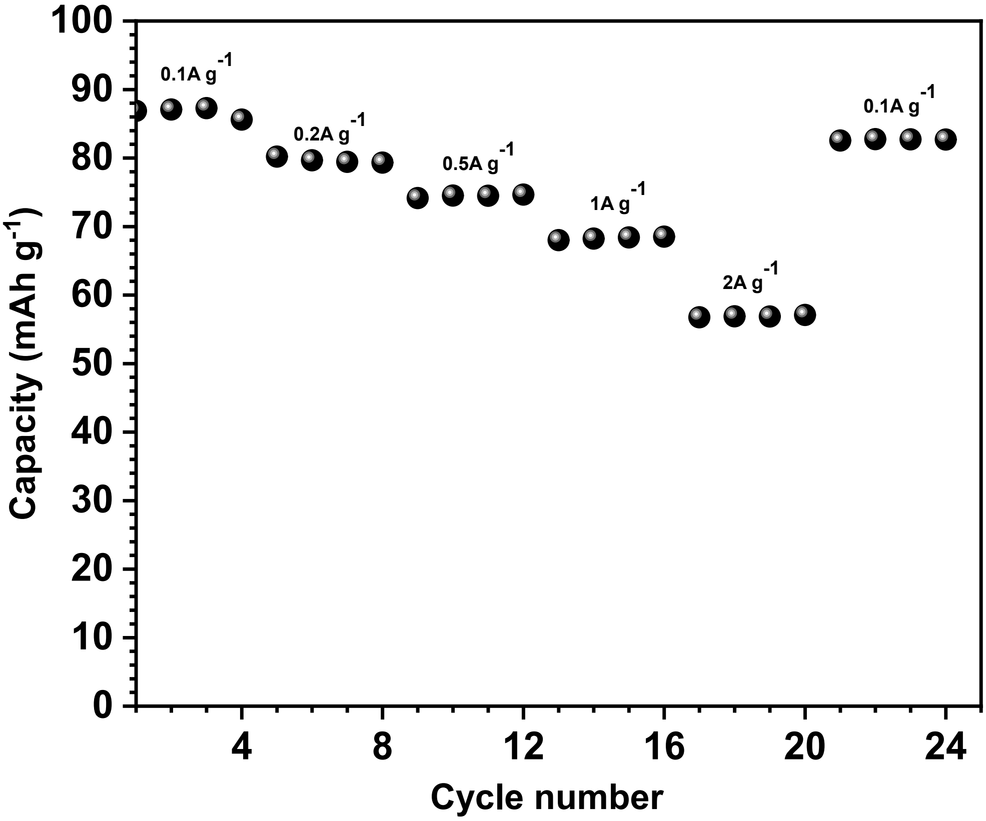

Figure S_4: Rate performance study of Li/AC half-cell.

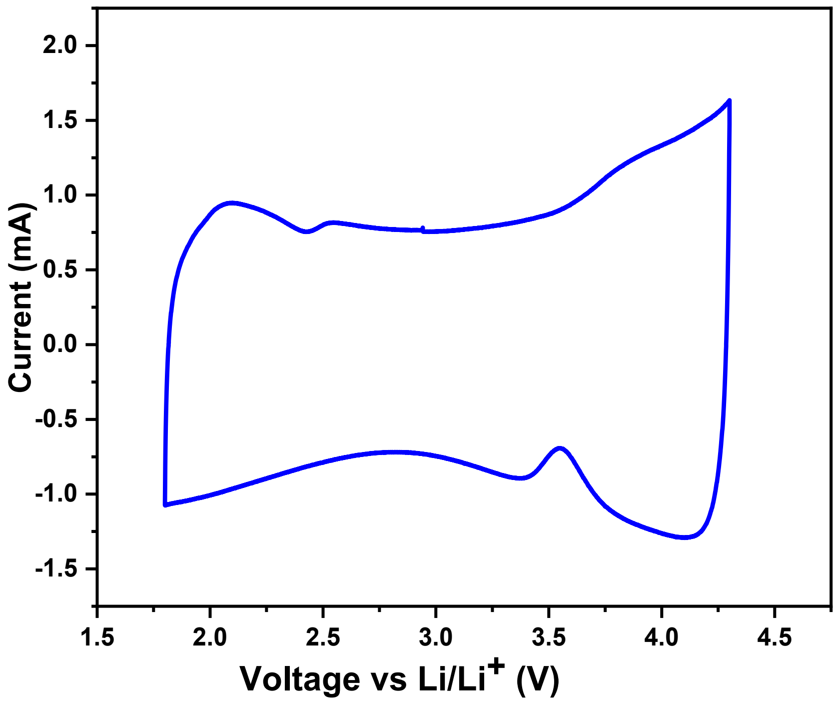

Figure S$_5$: Typical CV profile of fabricated DC-LIC at 1 mV s^{-1}

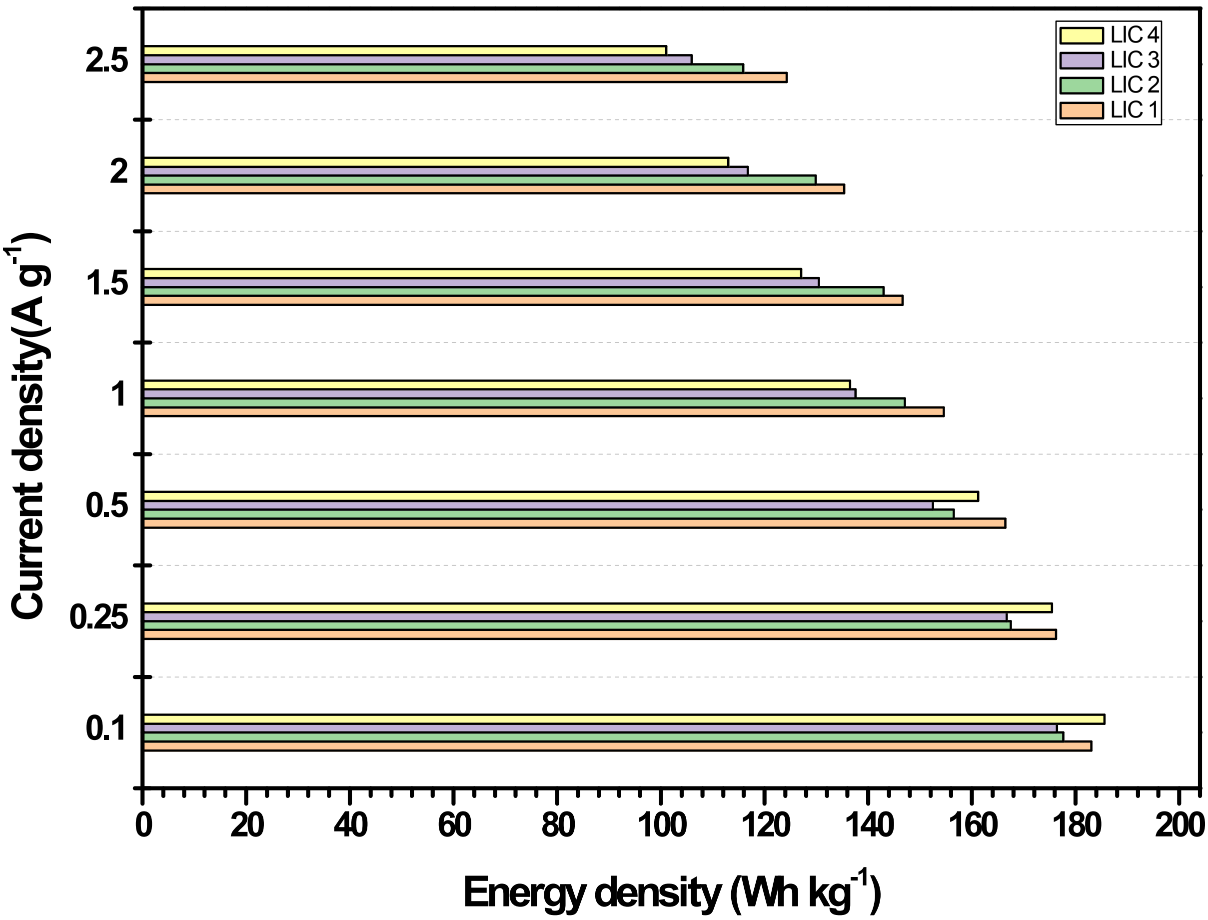

Figure S_6: Comparison graph of the energy storage capacity of four different DC-LICs assembled and tested at 25 °C.

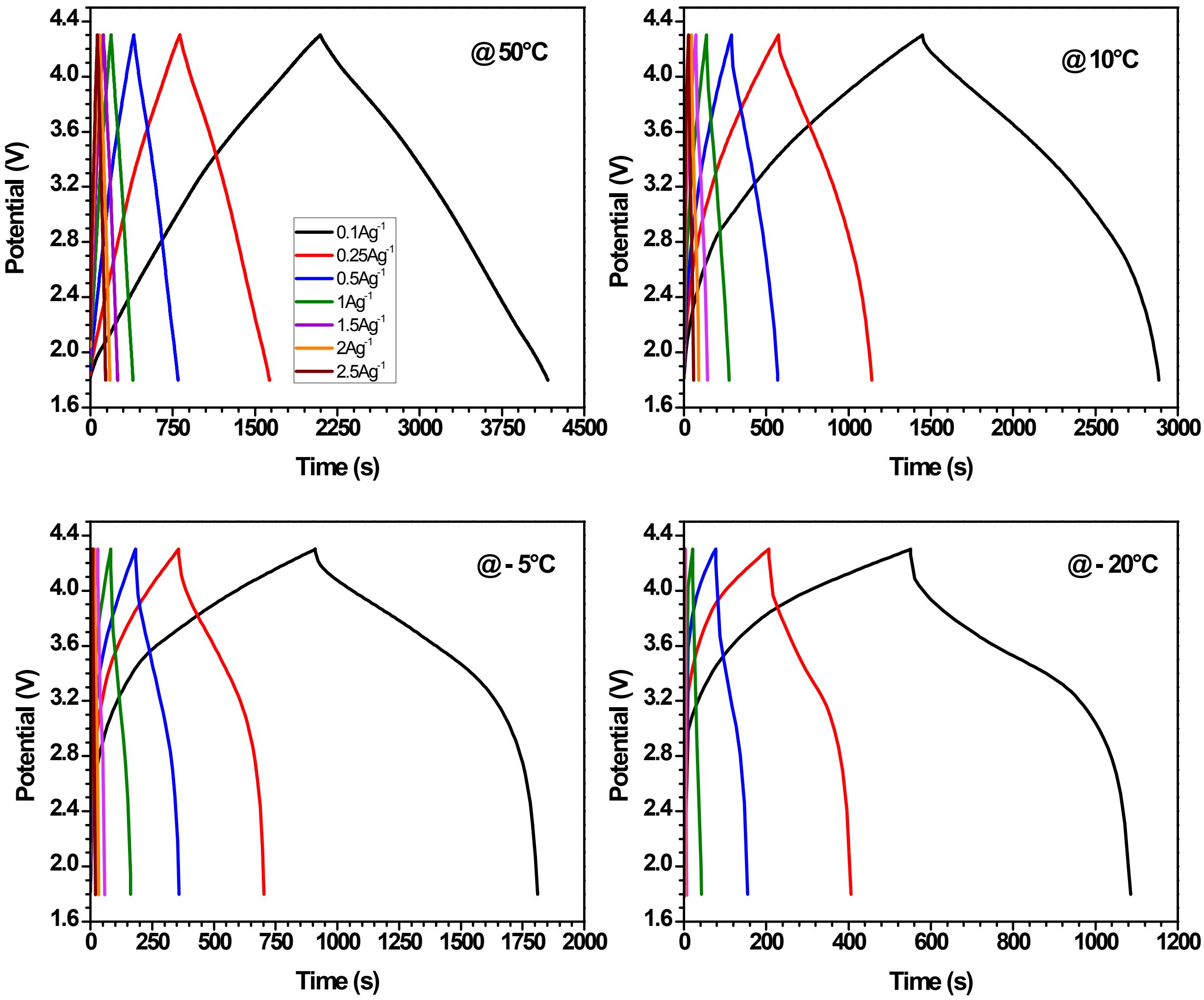

Figure S$_7$: Potential *vs.* time profile of the assembled DC-LIC @ different temperatures.

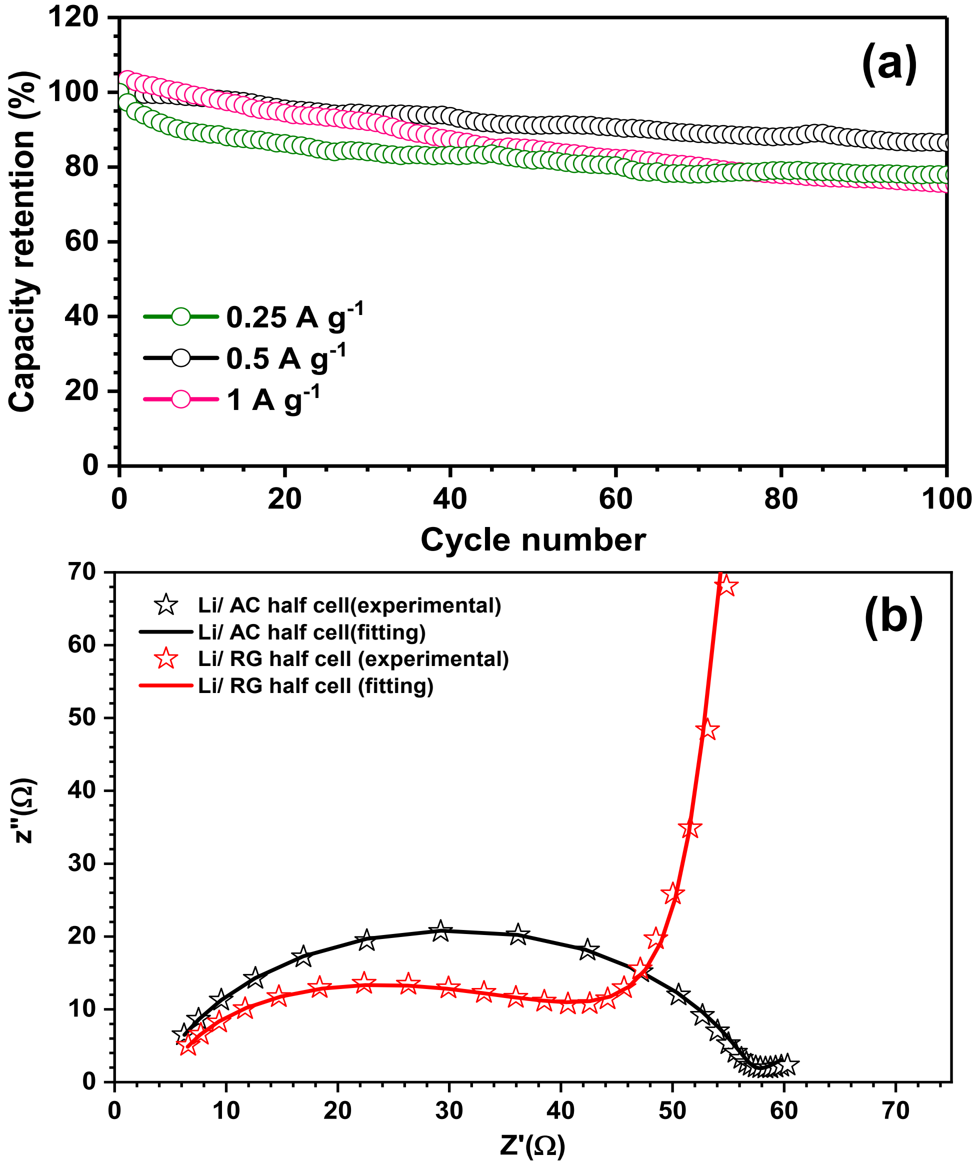

Figure S_8: (a) Comparison of cyclic performance of the DC-LIC at different current densities, and (b) Nyquist plots for the EIS analysis for the AC and RG half-cells.

Table S1. Comparison of DC-LIC

Negative electrode	**Positive electrode**	**Electrolyte**	**Potential window (V)**	**Maximum Energy Density (Wh kg^{-1})**	**Maximum Power density (kW kg^{-1})**	**Ref.**
Commercial Graphite(SLC 1025)	Activated carbon (Super P)	1M $LiPF_6$ in 1:1 EC/DMC	1.5-5	145.8	10	1
Pre-lithiated MWCNTs/Graphite composite electrode	Activated carbon	1M $LiPF_6$ in 1:1 EC/DMC	2.2-3.8	96	10.1	2
Pre-lithiated Graphite	B and N dual doped carbon	1M $LiPF_6$ in 1:1 EC/DMC	1-4	115.5	10	3
Pre-lithiated graphitized carbon from vegetable cooking oil	Activated carbon	1M $LiPF_6$ in 1:1 EC/DMC	2-4.3	108	9	4
Pre-lithiated Graphite	Activated carbon	1M $LiPF_6$ in 1:1:1 EC/EMC/DMC (1:1:1 v/ v)	2-3.9	106.1	6	5
Pre-lithiated Graphite	Activated carbon	1M $LiPF_6$ in 1:1 EC/DMC	2-4.1	100	-	6
Pre-lithiated Graphite	Activated carbon	1M $LiPF_6$ in 1:1 EC/DMC	2-4	162.3	5	7
Pre-lithiated Graphite (Recovered from spent LIB)	Activated carbon	1M $LiPF_6$ in 1:1 EC/DMC	1.8-4.3	185.54 (25 °C) 187.75 (50 °C)	8	Present study

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2. Cai, M.; Sun, X.; Chen, W.; Qiu, Z.; Chen, L.; Li, X.; Wang, J.; Liu, Z.; Nie, Y., Performance of lithium-ion capacitors using pre-lithiated multiwalled carbon nanotubes/graphite composite as negative electrode. *Journal of materials science* **2018,** *53* (1), 749-758.
3. Jiangmin, J.; Nie, P.; Fang, S.; Yadi, Z.; An, Y.; Fu, R.; Dou, H.; Zhang, X., Boron and nitrogen dual-doped carbon as a novel cathode for high performance hybrid ion capacitors. *Chinese Chemical Letters* **2018,** *29*.

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5. Maharjan, M.; Ulaganathan, M.; Aravindan, V.; Sreejith, S.; Yan, Q.; Madhavi, S.; Wang, J.-Y.; Lim, T. M., Fabrication of High Energy Li–Ion Capacitors from Orange Peel Derived Porous Carbon. *ChemistrySelect* **2017,** *2* (18), 5051-5058.
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