Supporting information

# The effect of graphitization degree of carbonaceous material on the electrochemical performance for aluminum-ion batteries

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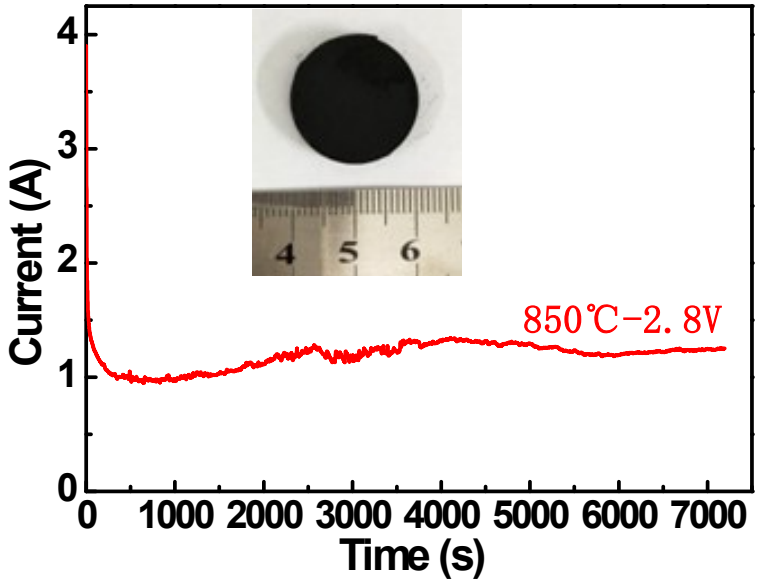


Fig. S1. The current response of carbon black cathode at a constant cell voltage of 2.8 V at 850 °C in $CaCl_2$-LiCl salt.

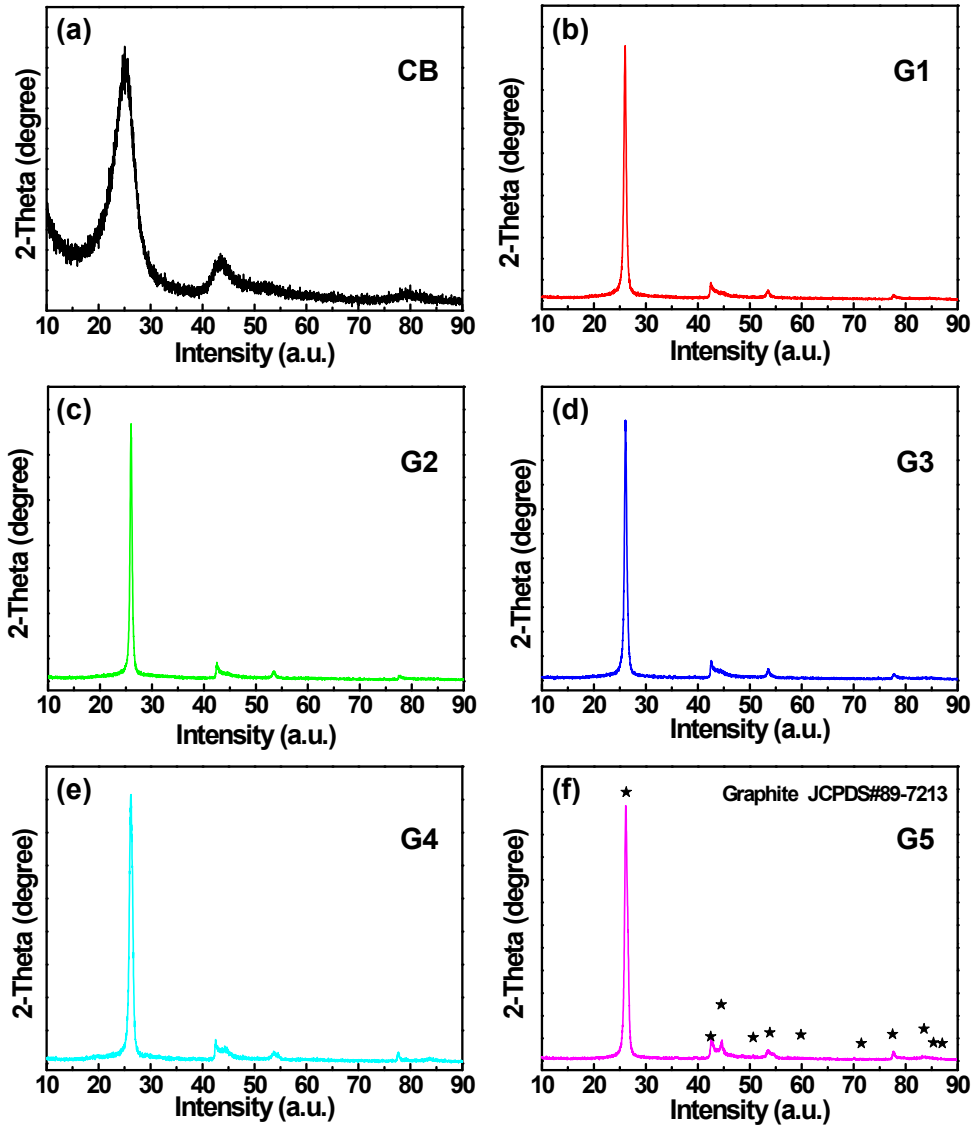


Fig. S2. The enlarged XRD patterns of all samples.

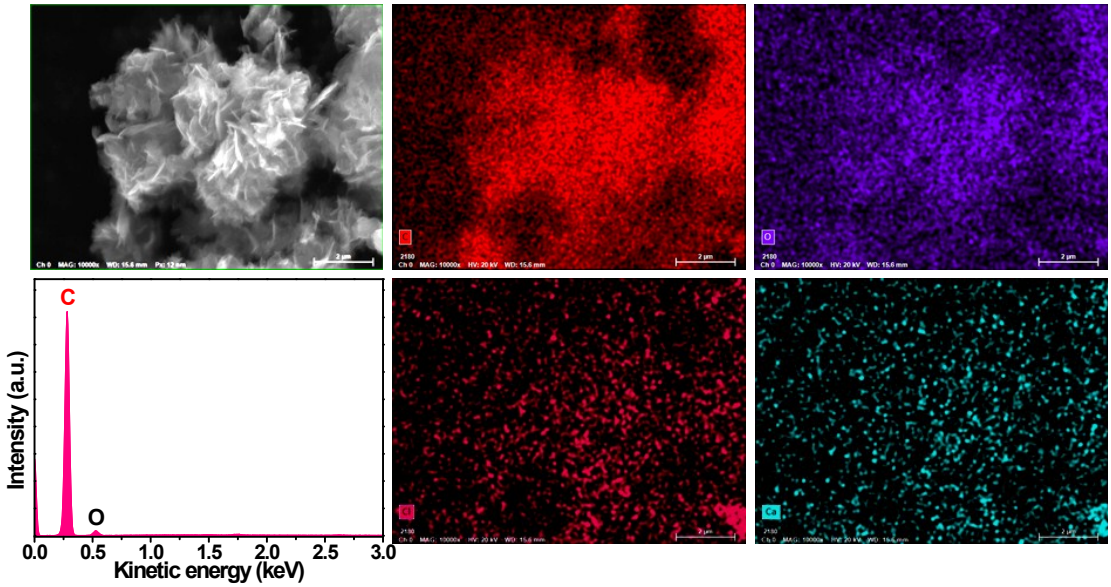


Fig. S3. SEM image and element mapping images of C, O, Ca and Cl of G2 sample with EDX element analysis.

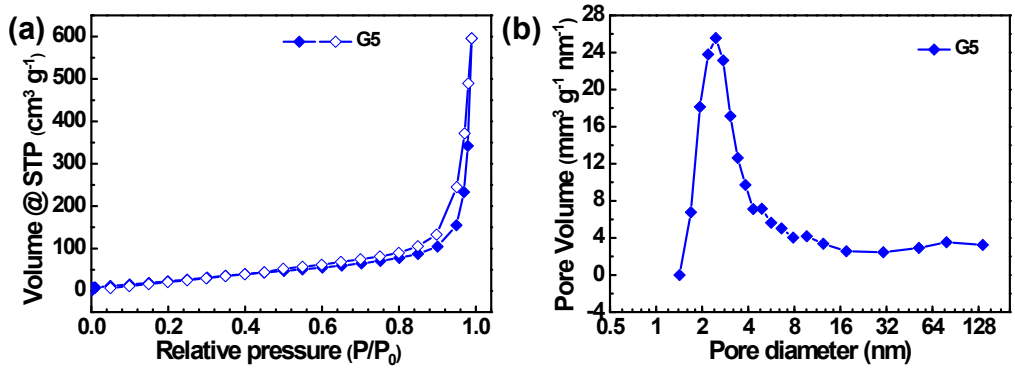


Fig. S4. (a) Nitrogen adsorption (closed symbol)-desorption (open symbol) isotherms of the G5 sample. (b) The pore size distribution curves of the G5 sample.

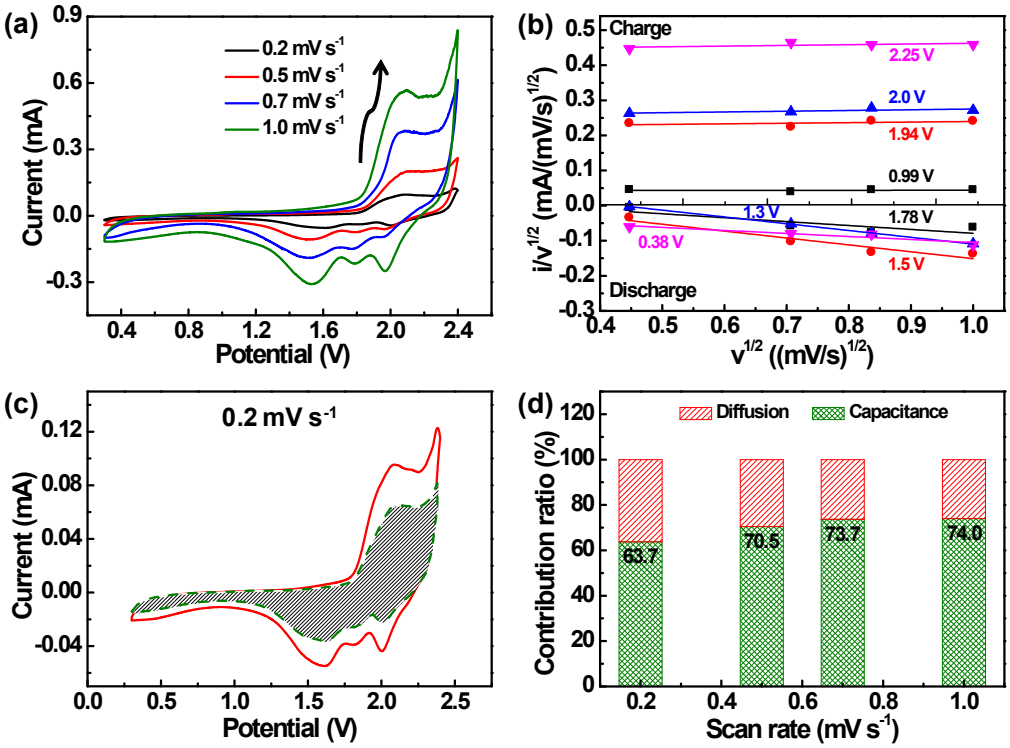


Fig. S5. (a) CV curves at various scan rates of G5 cathode. (b) Plots of $v^{1/2}$ *vs.* $I/v^{1/2}$ at different potentials. (c) The capacitive and diffusion-controlled contributions at a scan rate of 0.2 mV $s^{-1}$. (d) Contribution ratio of the capacitive and diffusion-controlled at different scan rates.

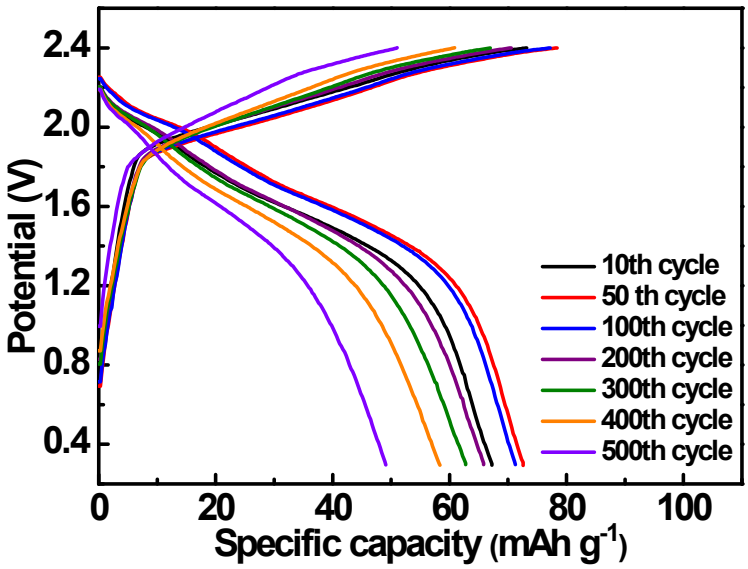


Fig. S6. The charge-discharge curves for different cycles of G5 electrode at a higher current density of 500 mA $g^{-1}$.

Table S1. The calculated $I_D/I_G$ and graphitization degree of carbon black before and after cathodic electrolysis under different conditions.

| Samples No. | Conditions | $I_D/I_G$ | g (%) |
|---|---|---|---|
| **CB** | Carbon black | 1.054 | -103.804 |
| **G1** | 800 °C -2.6V-2h | 0.324 | 16.165 |
| **G2** | 800 °C -2.8V-2h | 0.223 | 19.477 |
| **G3** | 850 °C -2.8V-0.5h | 0.118 | 23.084 |
| **G4** | 850 °C -2.8V-1h | 0.117 | 35.057 |
| **G5** | 850 °C -2.8V-2h | 0.112 | 46.067 |

Table S2. EDX element analysis results of G2 sample.

| Element | Weight/% | Atom/% |
|---|---|---|
| **C** | 90.53 | 92.76 |
| O | 9.36 | 7.20 |
| **Ca** | 0.05 | 0.01 |
| **Cl** | 0.07 | 0.02 |
| **Total** | 100.00 | 100.00 |

Table S3. Comparative electrochemical performance of graphite nanoflakes with other cathode materials recently reported.

| **Cathode materials** | **Electrolyte** | **Discharge capacity (mAh $g^{-1}$)** | | **Cycle number** | **Current density (mA $g^{-1}$)** | **Ref.** |
|---|---|---|---|---|---|---|
| | | **1st cycle** | **Last cycle** | | | |
| **Graphite nanoflakes** | $AlCl_3$:[EMIm]Cl (1.3:1) | 66.5 | 66.3 | 100 | 100 | This work |
| **Polypyrrole** | $AlCl_3$:[EMIm]Cl (1.5:1) | 71 | 48 | 100 | 20 | 1 |
| **Carbon paper** | $AlCl_3$:[EMIm]Cl (1.3:1) | 50 | 62.7 | 50 | 150 | 2 |
| **Pyrolytic graphite** | $AlCl_3$:[EMIm]Cl (1.3:1) | 60 | 66 | 200 | 66 | 3 |
| **$Ni_3S_2$** | $AlCl_3$:[EMIm]Cl (1.3:1) | 350 | 60 | 100 | 100 | 4 |
| **Pyrolytic graphite** | $AlCl_3$:[EMIm]Cl (1.5:1) | 62 | 72 | 2000 | 75 | 5 |

Reference:

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