

Graphite Anode Half-Cell Formation and Rate Performance Evaluation

A powerful diagnostic tool for evaluating anode utilization, formation quality, and rate performance.

Introduction

Graphite is the most common commercial lithium-ion battery anode material because it offers high reversibility, low operating potential versus Li/Li^+ , good cycling stability, and a practical theoretical capacity of 372 mAh/g. In a half-cell configuration, graphite is paired with lithium metal so that the graphite electrode can be evaluated without cathode-side limitations. This makes the graphite half-cell a useful diagnostic platform for studying active-material utilization, formation quality, voltage profile, and rate capability.

This application note describes the assembly, Neware cycling protocol, and electrochemical interpretation of graphite anode half-cells. The cells were formed at C/20 and subsequently evaluated at C/10, C/5, and C/2. The resulting voltage-specific-capacity profiles are used to determine whether the measured performance is reasonable relative to the graphite theoretical capacity.

Why This Test Is Performed

Formation and rate testing are performed to answer two questions. First, the formation step evaluates whether the graphite electrode forms a stable interphase and delivers the expected graphite lithiation/delithiation profile. Second, rate testing shows how much capacity remains accessible as current increases. A strong graphite half-cell should approach the theoretical capacity at low rate and retain a significant fraction of that capacity at higher rate.

Neware Cycling Protocol

Electrochemical testing was performed using a Neware battery cycler. The procedure initiated with a controlled formation cycle at C/20 to establish a stable solid electrolyte interphase (SEI) layer on the graphite anode. Following formation, rate capability testing was conducted across varying C-rates to evaluate the cell's capacity retention, internal resistance, and mass transport limitations under different operating conditions.

Formation Results

The formation cycle was performed at C/20. As shown in Figure 1, the voltage-specific-capacity profile shows the expected graphite behavior, including low-voltage lithiation/delithiation regions associated with staged lithium intercalation. The measured capacity approaches the theoretical graphite capacity of 372 mAh/g, indicating good active-material utilization and acceptable cell assembly quality.

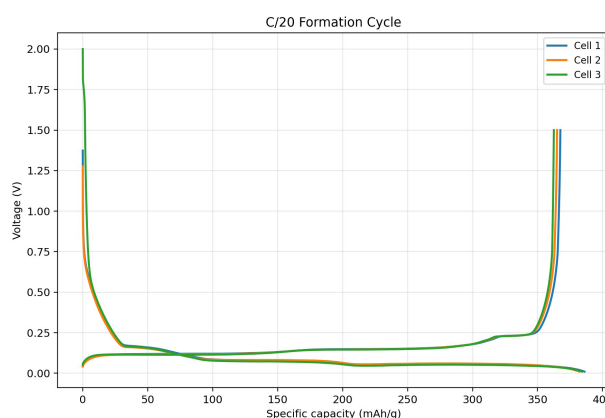


Figure 1. Formation voltage-specific-capacity profiles of graphite half-cells at C/20.

Rate Capability Results

The rate comparison includes C/20, C/10, C/5, and C/2 data. As shown in Figure 2, at low rate the graphite half-cell approaches the theoretical graphite capacity of 372 mAh/g, indicating strong utilization of the graphite active material. The voltage curves also show the expected graphite half-cell profile, including the characteristic low-voltage regions associated with lithium intercalation and deintercalation.

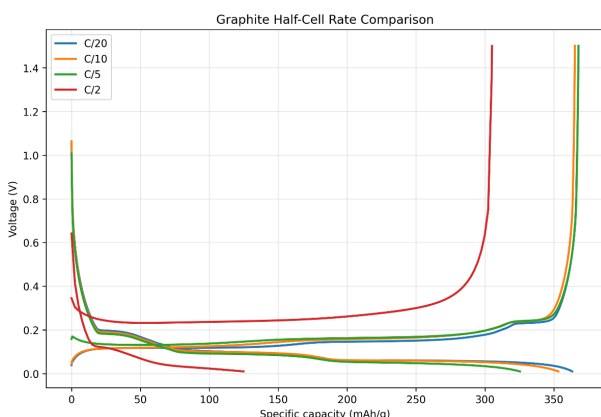


Figure 2. Graphite half-cell rate comparison using voltage-specific-capacity curves.

As the rate increases, the accessible capacity decreases and the voltage profile becomes more polarized. This is expected because higher current increases kinetic and transport

limitations. At C/2, the available capacity is lower than at C/20 or C/10 because the cell reaches the voltage cutoff before all active material can be accessed. This behavior is consistent with graphite electrodes where lithium diffusion, electrolyte transport, SEI resistance, and electrode tortuosity become more important at higher current.

The results are reasonable for graphite half-cells. Low-rate capacity close to 372 mAh/g suggests good electrode utilization, while the capacity decrease at C/2 reflects normal rate-dependent polarization rather than a clear cell failure. Because the low-rate capacity is close to the theoretical value, active-material mass accuracy should be.

Conclusion

Graphite anode half-cells were assembled in an argon-filled glovebox and tested using a Neware battery cycler. The cells were formed at C/20 and evaluated at C/10, C/5, and C/2. The formation and rate data show that the graphite electrode delivers high low-rate capacity close to the theoretical graphite capacity of 372 mAh/g, with expected capacity reduction at higher rate. Overall, the results indicate good graphite active-material utilization, reasonable cell assembly quality, and expected rate-dependent behavior for a graphite half-cell.

Table 1. Maximum charge and discharge specific capacities of graphite half-cells at different C-rates, with charge capacity compared with the theoretical graphite capacity of 372 mAh/g.

Rate	Max charge capacity (mAh/g)	Max discharge capacity (mAh/g)	Charge capacity vs. 372 mAh/g
C/20	367.9	363.4	98.9%
C/10	365.3	353.3	98.2%
C/5	367.8	325.5	98.9%
C/2	305.2	124.8	82.0%