Bern University
of Applied Sciences

BFH Energy Storage Research Centre

Infrastructure

Battery Cycle Life Assessment through High-Precision Coulombic Efficiency Measurements

Lifetime assessment

Lithium-ion batteries play an important role in the electrification of mobility and therefore battery lifetime prediction is a fundamental aspect with regard to the economic attractiveness of E-vehicles.

Conventional lifetime analyses are based on cycling the batteries until they “die”, which requires unacceptably large amounts of time.

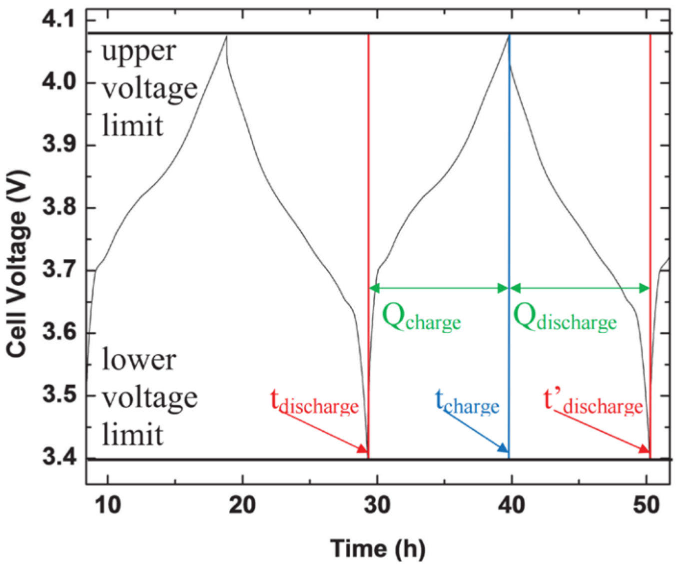
Being able to identify the best cell available in the market for a given application in a timely efficient manner is crucial for battery system manufacturers. Likewise, researchers who are developing materials and additives which are designed to improve cell life need results quickly. Therefore, a means of quickly and accurately evaluating the lifetime of batteries is required.

High-precision coulombic efficiency (CE) provides a solution to this challenge.

Capacity loss in Li-ion batteries is the result of parasitic reactions which consume active components of the cell. CE analysis captures the rate of Li-ion i. e. charge loss per cycle and time unit during the charging and discharging phases.

CE values between 1.0000 and 0.9995 are perfectly normal. Therefore, the measurement equipment must be highly precise to capture any differences between them. When measured precisely, the time required for lifetime analysis is significantly reduced.

Coulombic efficiency fundamentals



$$Q_{charge} = \int_{t_{discharge}}^{t_{charge}} I(t)dt \qquad Q_{discharge} = \int_{t_{charge}}^{t'_{discharge}} I(t)dt$$

$$CE = \frac{Q_{discharge}}{Q_{charge}}$$

(if = 1.0000 → perfect cycle)

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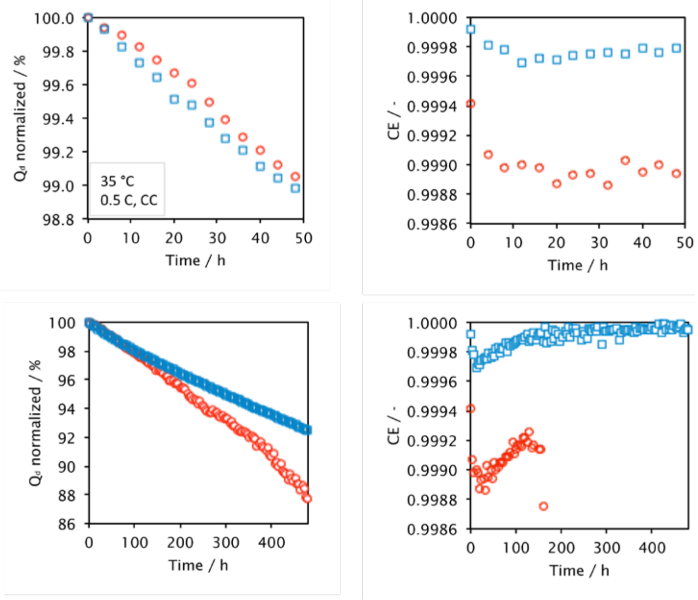
Some results on in-house CE analysis

- Precise coulombic efficiency measurements were performed on two different cells from the same manufacturer in a temperature controlled chamber at 35 °C in an inert gas atmosphere.
- The closer CE values are to the ideal value of 1.0000, less Li-ions are lost during cycling
- CE values showed which cell would live longer after only a few cycles (every point in the graph represents a cycle). After only 2 days, CE analysis showed which cell was more durable. The conventional Q-analysis technique required more than twice the time to show the same degradation trend predicted by CE.

After 2 days **After 20 days**



Test equipment specifications

General Characteristics

- 4-point measurement, 72 channels
- Sampling frequency: 1 msec (100 µsec internal)
- Rise, fall & switch time: < 1 µsec (typically 100 µsec)

Voltage

– Range:	0 to + 5 Vdc & 0 to + 100 Vdc
– Control accuracy:	±0.05% FSD
– Measurement acc.:	±0.005% FSD

Temperature Chambers

– Range:	0 to 50 A
– Fluctuation:	±0.3 K

Current

– Range:	0 to 50 A (4 automatic switched current ranges 50 mA, 500 mA, 5 A and 50 A)
– Control accuracy:	±0.03% FSD in each range
– Resolution:	1 µA (range 50 mA), 10 µA, range (500 mA), 100 µA (range 5 A), 1mA (range 50 A)

Contact

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