Data: Accelerated Impedance-Based Aging Modeling for NCA/Gr-SiOx Batteries and the Impact of Reduced Test Duration

Battery specification:

Manufacturer	Samsung
Type	SDI INR18650 35E
Format	18650
Chemistry (Anode)	Graphite/Silicon-Oxide
Chemistry (Cathode)	Nickel-Cobalt-Aluminium
Nominal capacity	3.35 Ah
Voltage range	2.65 V - 4.2 V
Max. charge/discharge current	2 A / 8 A

Test description:

All EIS measurements were performed using a Digatron EISmeter within a Binder MK53 climate chamber, in which the chosen test temperature is adjusted and controlled with an accuracy of ± 1 K.

EIS and pulse measurements were performed for five different temperature levels (5 °C, 15 °C, 25 °C, 35 °C, 45 °C) at 11 equidistant SOCs between 100 % - 0 %. The cell was allowed to rest for 12 hours at the respective testing temperature. Before starting the EIS and pulse characterization routine, the cell is fully charged until the upper cut-off voltage is reached with C/3 in CC CV mode until the float current falls below C/50 (68 mA). Following a 15-minute resting phase, a low-current measurement with C/15 in discharge and charge direction is performed between the respective cut-off voltages. Afterwards, a capacity test at C/3 in discharge and charge direction is performed. After the final CC CV charging phase of the capacity test, starting in fully charged state (that is, SOC = 100 %), impedance spectra were recorded with the AC amplitude of the applied signal perturbation being 10 mV and an applied current of less than 2 A. Each EIS measurement was performed in a frequency range from 6 kHz to 10 mHz with eight frequencies per decade resulting in a total of 48 measured frequencies. After the initial measurement, the targeted SOCs were adjusted in ascending order Ah-based using the prior obtained C/3 discharge capacity from the capacity test performed at the respective temperature level with a C-rate of C/3. Afterwards, a rest period is employed until either the voltage fluctuation falls below 5 mV or a maximum of 3 hours has passed after reaching each targeted SOC.

After measuring the impedance spectra, pulse measurements are performed at the respective SOC and temperature. For this purpose, pulses with a C-rate of 0.7 C, 1 C, and 1.4 C were successively applied in charge and discharge direction for a duration of 20 seconds. In order to compensate for the additional charge throughput after each charge/discharge pulse, the charged/discharged amount

of capacity is withdrawn or added before performing the next pulse measurement using a C/3 discharge or charge.

Data description:

The raw data can be found in the .zip file named "Raw_Data.zip." Additionally, the corresponding converted mat-files are included in "Mat_Files.zip." The structure of the data is consistent across both .zip files. Within the lowest folder hierarchy, the folders are labeled according to the respective temperatures at which the tests were conducted. By clicking on a folder, you will find the data available either in .CSV format for the raw data or in .mat format for the mat files.

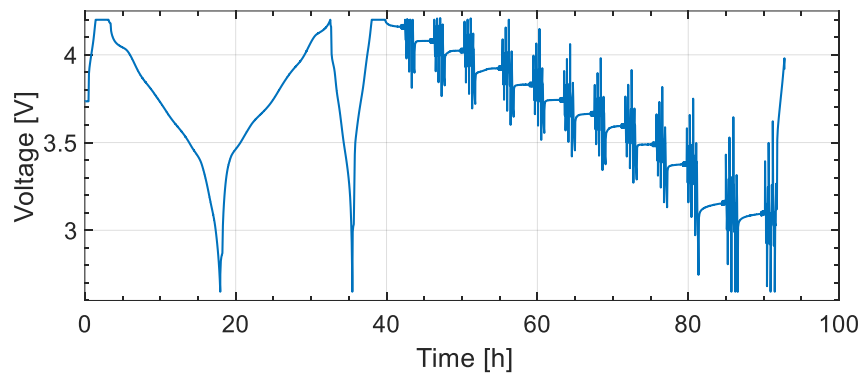| Name	Name	Name
5deg	5deg_Overview	5deg_Overview
15deg	5deg_SOC0	5deg_SOC0
25deg	5deg_SOC10	5deg_SOC10
35deg	5deg_SOC20	5deg_SOC20
45deg	5deg_SOC30	5deg_SOC30
	5deg_SOC40	5deg_SOC40
	5deg_SOC50	5deg_SOC50
	5deg_SOC60	5deg_SOC60
	5deg_SOC70	5deg_SOC70
	5deg_SOC80	5deg_SOC80
	5deg_SOC90	5deg_SOC90
	5deg_SOC100	5deg_SOC100

Each EIS measurement performed at a specific SOC has its own separate data file. The key columns/variables within this data are summarized in the following table:

Variable/Column name	Description
Zimg1	Imaginary part of the complex impedance measured during EIS with a specific frequqency
Zreal1	Real part of the complex impedance measured during EIS with a specific frequqency
ActFreq	Actual frequency during EIS measurement
U1	Voltage during EIS measurement

The overview file contains pulse, QOCV, and capacity measurements for each temperature. Please note that some column/variable names within the overview data are provided in German. A list of important translations for these column/variable names is included here:

German	English
Schritt	Step
Spannung	Voltage
Strom	Current
Zeit	Time
Programmdauer	Program Duration

The figure below illustrates the voltage data plotted against program duration from the overview file: