Influence of the cell formation parameters on the aging of lithium-ion cells

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It is well known for conventional Li-ion cells that a so called solid-electrolyte interface (SEI) grows on carbonaceous anodes during the formation process of the cell. However, only few information is available on the interaction between the cell formation parameters and the aging and cell performance.

In this study the influence of the C-rate throughout the formation process on the degradation of Li-ion cells is investigated. Thus, the formation of commercial coin cells with 100 mAh was performed at five different C-rates (from 0.02 to 1.0 C). After formation each cell was subjected to 500 cycles at three different temperatures (Figure 1). Surprisingly it was found that the C-rate during formation has only marginal influence on the cell degradation, whereas the effect of elevated temperatures was much more significant.

Further study on the formation process was accomplished with a graphite/Li half-cell setup and repetitive electrochemical impedance spectroscopy (EIS) measurements after the 1st and 10th cycle at an SOC of 30% (Table 1). The resistance of the SEI (R_{SEI}) was obtained by fitting a common *Randles* circuit with two RC elements, one representing the SEI-film properties. The irreversible capacity of the 1st cycle as well as the R_{SEI} is higher for the formation with 0.2 C. This indicates, that the SEI-building mechanism during the initial cycle depends on the applied C-rate. After 9 more cycles with 0.2 C, the R_{SEI} for the formation with 1.0 C is only slightly changing, while for the formation with 0.2 C it is reduced from 17.3 to 11.5 Ω. This may be caused by rearrangement reactions of the SEI-film components during those cycles. However, this needs to be investigated in more detail by analyzing the SEI-film composition after the formation and after the 10th cycle.

Nevertheless, the aging of the commercial coin cells is only little influenced by the C-rate during the formation. Consequently, it is possible to accelerate the formation process by using higher C-rates without influencing the aging behavior. However, further work is needed to identify if those results apply to cells with much higher capacity, which are currently of interest for automotive applications.

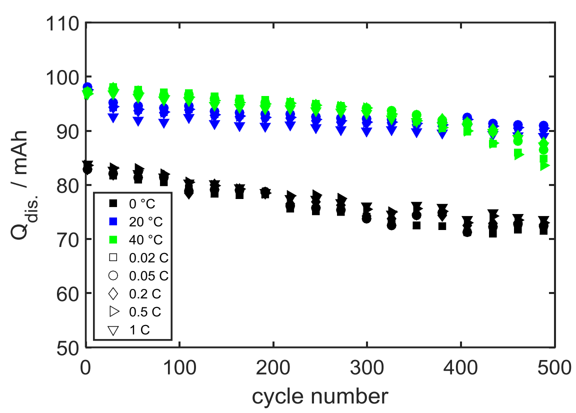

Figure 1: Discharge capacity ($Q_{dis.}$) during the cycling of the commercial coin cells.

Table 1: Irreversible capacity ($Q_{irr.}$) and SEI-resistance from EIS (R_{SEI}) from the half-cell analysis.

C-rate	$Q_{irr.}$ / mAh g^{-1}		R_{SEI} / Ω	
	1st cycle	10th cycle	1st cycle	10th cycle
0.2 C	23.6	33.1	17.3	11.6
1.0 C	22.0	31.6	11.5	10.4

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