Aging of commercial sodium-ion batteries with layered oxides: how to measure and analyze it? - Additional Figures

Mathias Rehm,*[a] Julius Bahrke,[a] Johannes Natterer,[a,b] Leon Milutinovic,[a] Franz Roehrer,[a] and Andreas Jossen[a]

Additional figures referenced in the main article are provided here to support and extend the results. Their full discussion appears in the main article, with brief descriptions in the captions below.

[a] *Technical University of Munich (TUM), TUM School of Engineering and Design; Department of Energy and Process Engineering, Chair of Electrical Energy Storage Technology (EES), Arcisstr. 21, 80333 Munich, Germany.*
[b] *Infineon Technologies AG, Am Campeon 1-15, 85579 Neubiberg, Germany.*
* *E-mail: mathias.rehm@tum.de*

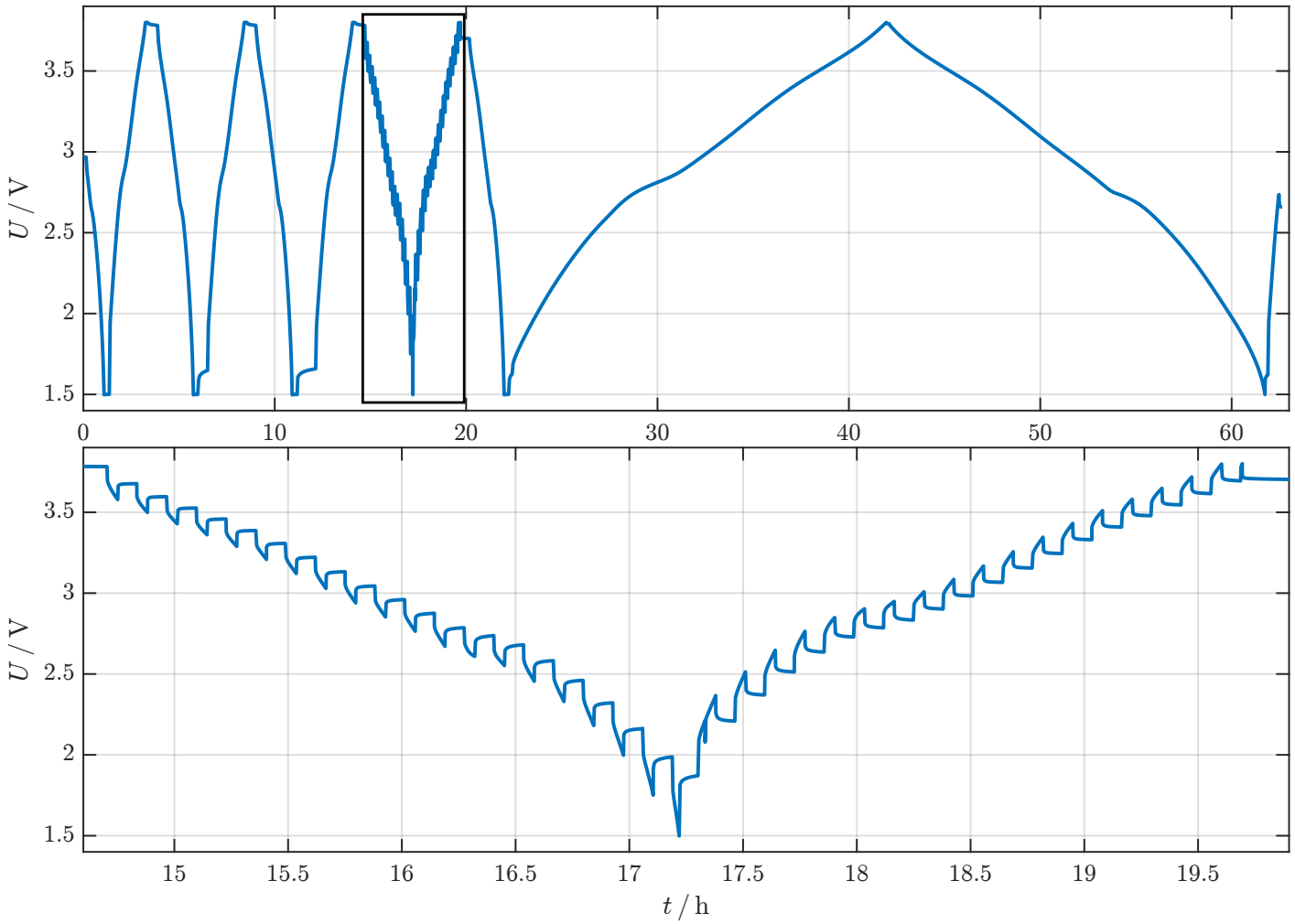

Fig. 1 Reference performance test (RPT) procedure used within the aging study. It consists of two initial cycles with constant current constant voltage (CCCV) charging with $0.5\,\mathrm{C}$ and $0.05\,\mathrm{C}$ as termination criteria, and open-circuit voltage (OCV) measurements in both charge and discharge direction: Relaxed-OCV measurements were done with current rates of $1\,\mathrm{C}$ in steps of 5% state-of-charge (SOC), but short relaxation pauses of $300\,\mathrm{s}$. The pseudo-open-circuit voltages (pOCVs) were performed using current rates of $0.05\,\mathrm{C}$.

Fig. 2 Anodes of cell ① (a), ② (b) and cell ④ (c) at end of test (EOT). In each case, the outer part of the jelly roll (side showing toward the outer part of the jelly roll) is presented. The silver deposits visible at the edges of the anode are sodium plating.

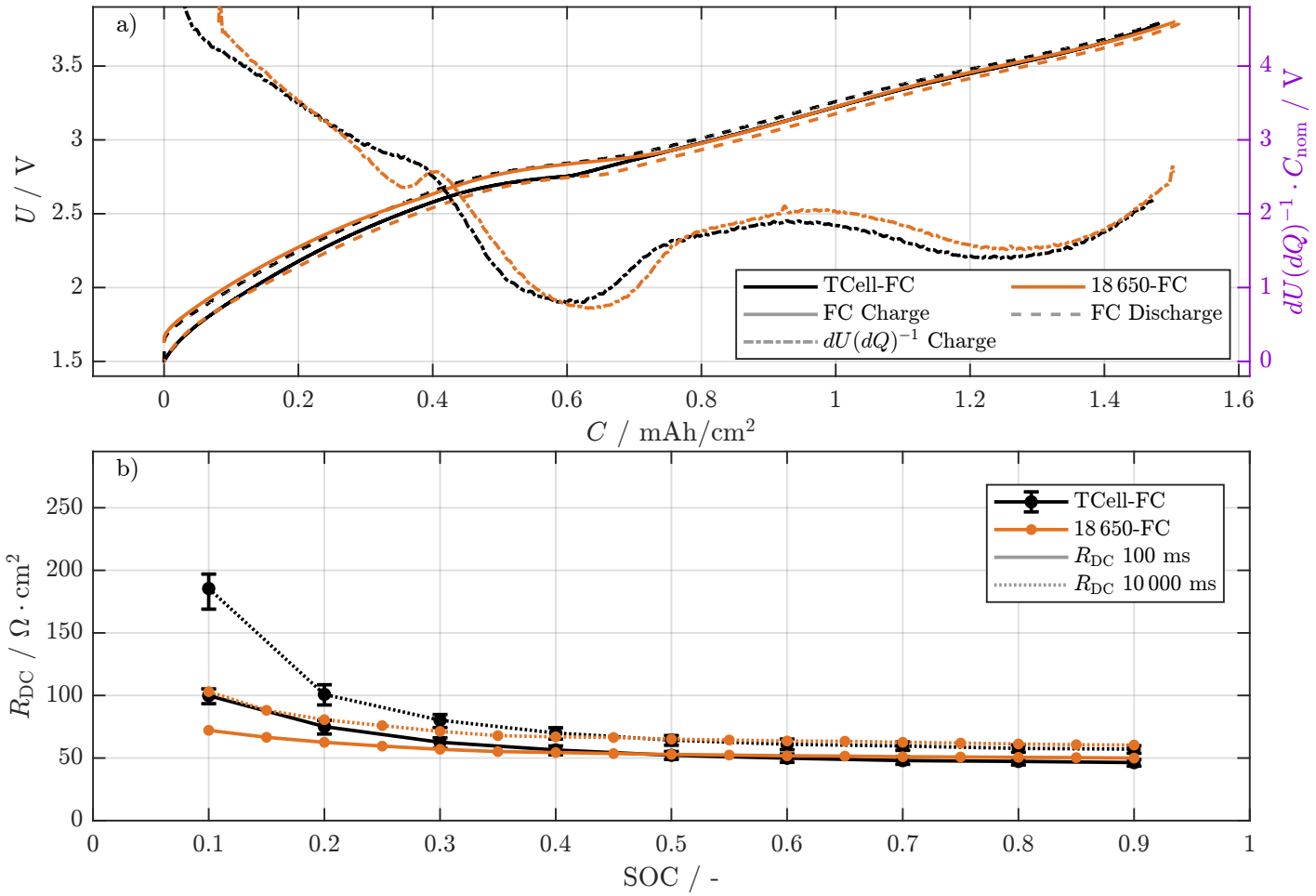

Fig. 3 The pOCVs of the 18 650 cell ① at EOT and a corresponding full-cell T-cell (a) and the resistance over SOC for the 18 650 cell compared to three full-cell T-cells (b). The capacities and the resistance values are normalized to the area of the electrodes (T-cell) and the area of the cathode of the 18 650 cell measured in [1], respectively. The pOCVs are determined with current rates of 0.05 C for the 18 650 cell and the T-cells, and the resistance is calculated from a 0.1 C pulse in discharge direction of the full-cell.

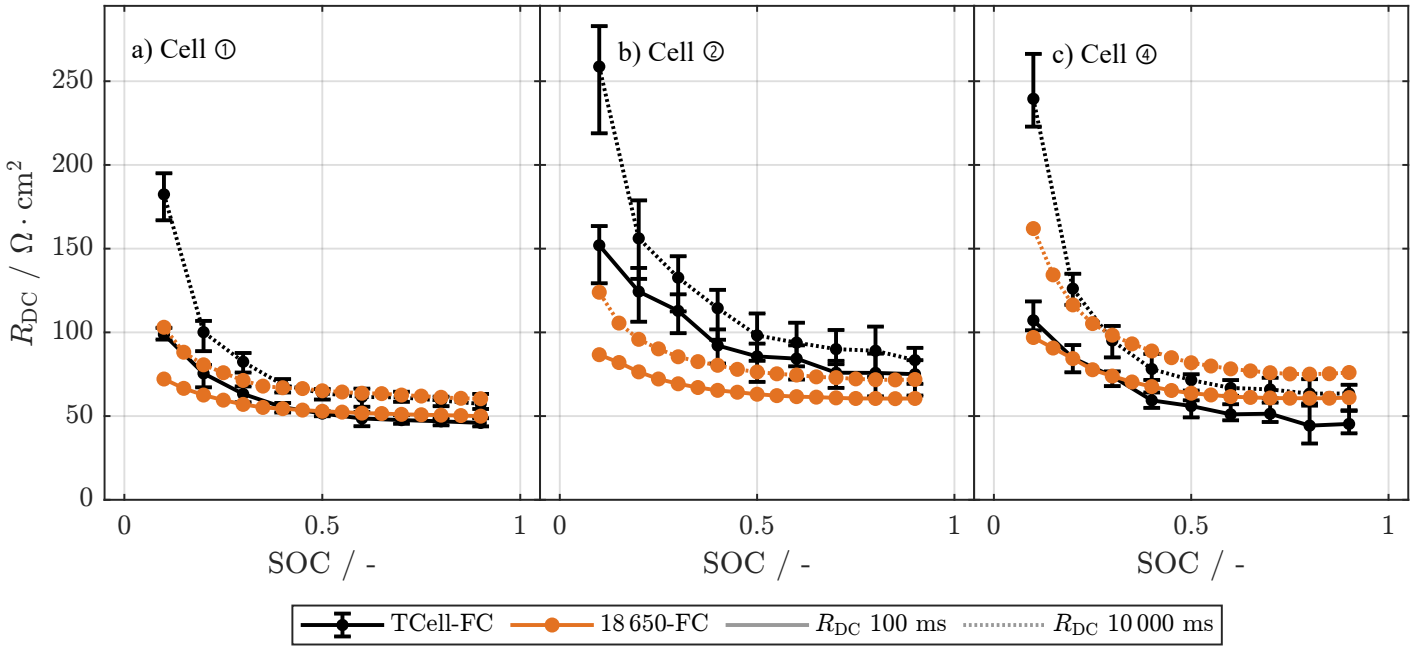

Fig. 4 The direct current resistance (R_{DC}) of the 18 650 cell and the corresponding full-cell T-cell of cell ① (a), cell ② (b), and cell ④ (c) at EOT. The resistance values are normalized to the area of the electrodes (T-cells) and the area of the cathode of the 18 650 cell measured in [1], respectively. The resistance values are calculated from 1 C and 0.1 C pulses in discharge direction for the 18 650 cell and the T-cells, respectively. Error bars represent the minimum and maximum values of three T-cells harvested from the same cylindrical cell.

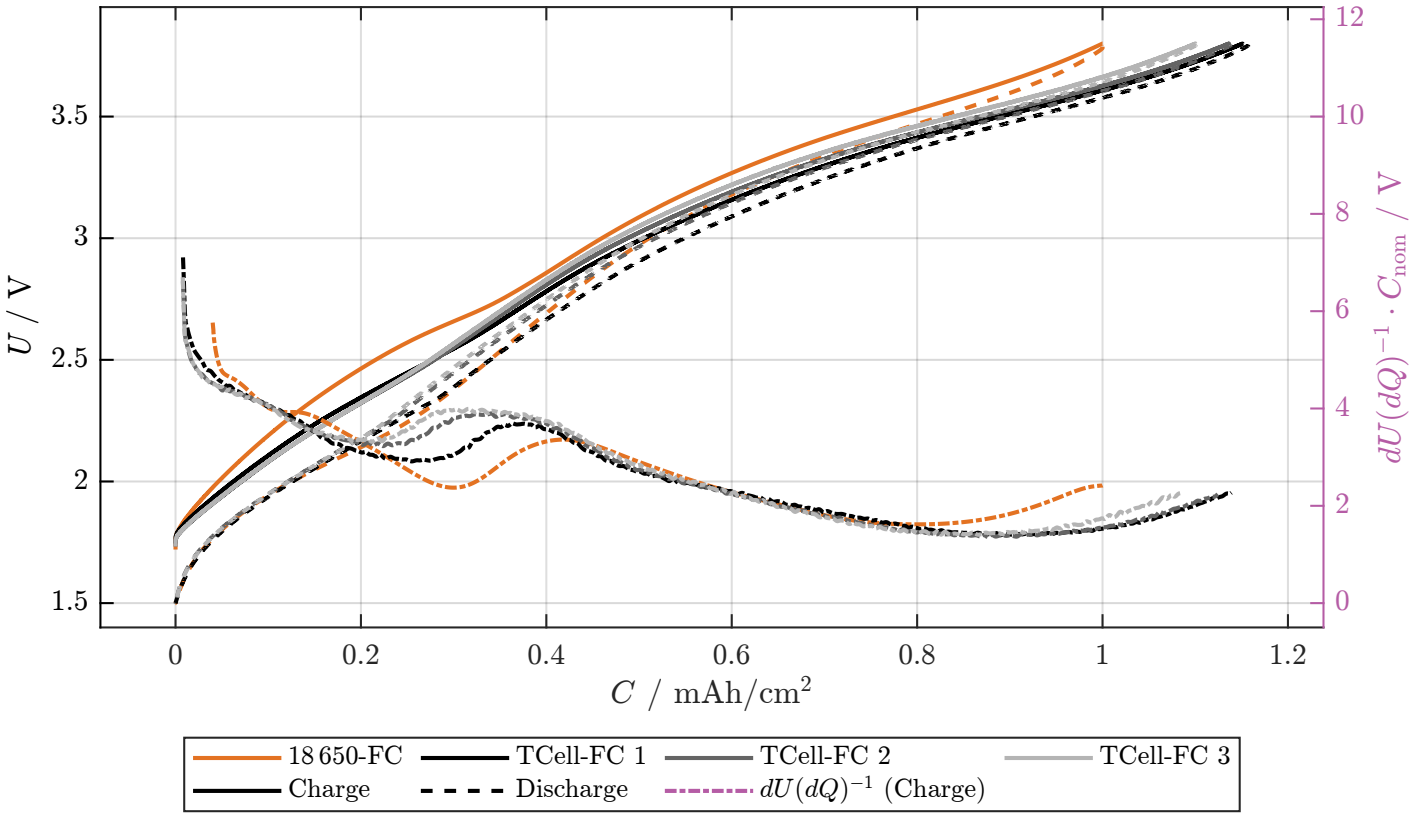

Fig. 5 The pOCVs of the 18 650 cell ④ at EOT and of three corresponding full-cell T-cells. In addition, the differential voltage (DV) of all cells in charge direction is shown. The capacities are normalized to the area of the electrodes (T-cell) and the area of the cathode of the 18 650 cell measured in [1], respectively. The pOCVs are determined with current rates of 0.05 C for the 18 650 cell and the T-cells.

Notes and references

1 M. Rehm, M. Fischer, M. R. Gomez, M. Schütte, D. U. Sauer and A. Jossen, *Journal of Power Sources*, 2025, **633**, 236290.