Long term multi-observable measurements for SOC/SOH analysis and crossover modelling

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Motivation

- Efficient Vanadium flow battery (VFB) operation needs half cell specific estimates of the state of charge (SOC) and state of health (SOH).
- In commercial VFB systems the SOC is often estimated by using a cell voltage or Coulomb counting, which cannot predict half cell specific SOCs. Several SOC and some SOH monitoring methods have been proposed [1].

⇒ We aim to develop a stable SOC/SOH monitoring method based on the measurement of multiple SOC/SOH related observables and create a data basis for SOC, temperature and SOH dependencies to derive an empiric crossover model.

Test rig

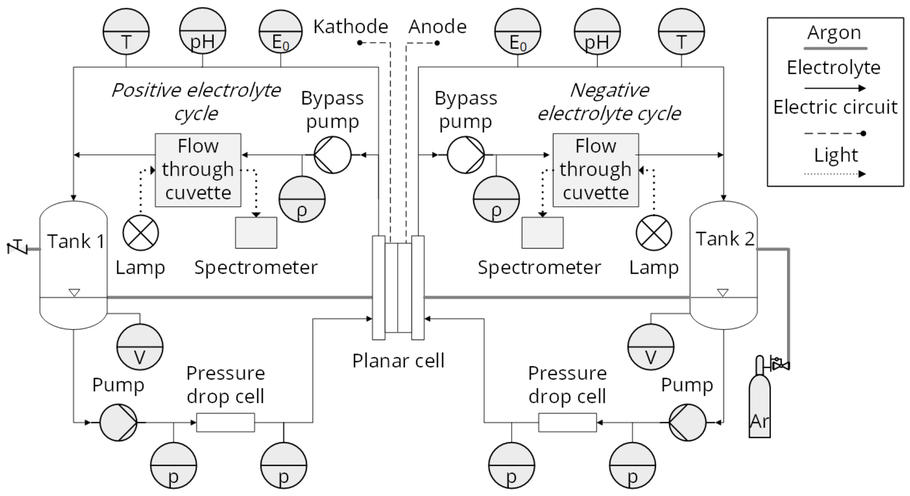

Fig. 1– Schematic of test rig.

+ Potentiometric titration

Experimental

Temperature correction: Observables monitored for SOC 25%, 50% & 75% @ T~12°C, ~20°C & ~30C.

SOC Calibration: Observables monitored for a full charge/discharge cycle.

Long term test: 500h of charge/discharge cycling, calibration and recalibration cycle for stability analysis of SOC methods. Electrolyte withdrawal for titration on day 2, 4, 9 and after the test for crossover and SOH analysis.

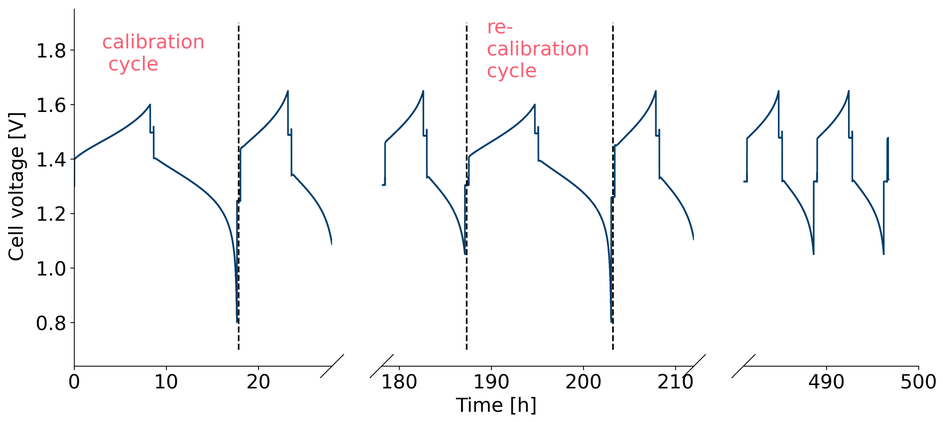

Fig. 2– Cell voltage during long term test.

Results

Temperature data

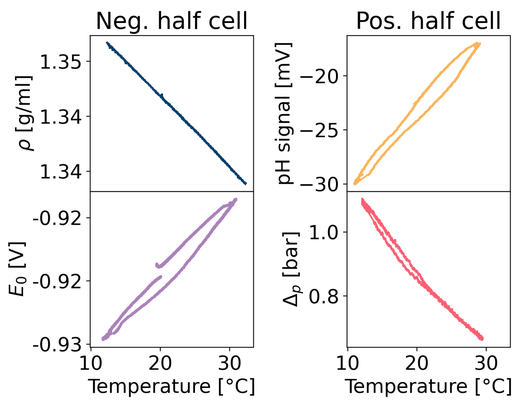

Fig. 3 - Observables over temperature, @SOC=25%.

SOC data

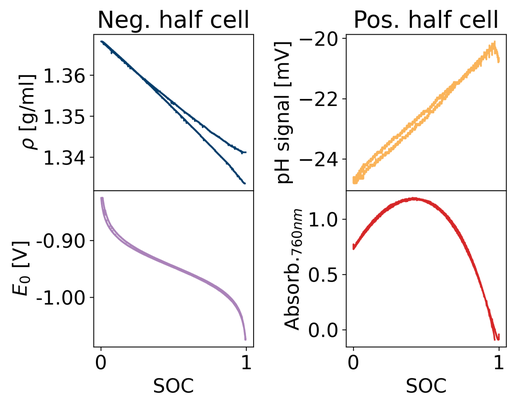

Fig. 4 - Observables over SOC, SOC from half-cell potentials [2,3], @T≈21°C.

Long term test data

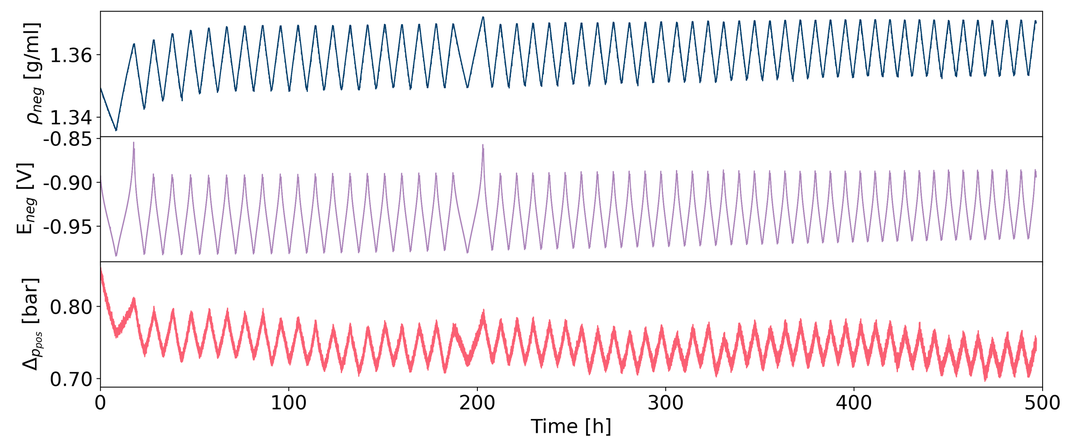

Fig. 5 - Exemplary data of long term test over time.

First SOH analysis

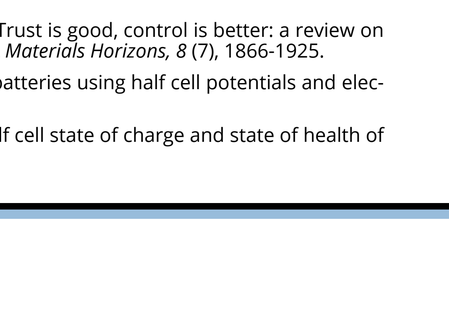

Fig. 6 - SOH based on titration and fill level.

$$SOH = \frac{Q(t)}{Q(t_0)}; \qquad Q(t) = V_c(t) * c_V(t) * F$$

t_0: after electrolyte formation.

With corrected volume $V_c(t)$:

$$V_c(t) = V(t) + \sum_{i=1}^{n} \Delta V(t_i)$$

ΔV: withdrawn volume.

Conclusions and Outlook

- Extensive data basis for SOC/temperature and SOH correlations.
- Trends in half cell SOHs identified.

-> Implement temperature correction and analyse SOC stabilities.

-> Analysis of SOH based on UVVIS & fill level and half cell potentials.

-> Combination of observables to estimate SOC/SOH and crossover.

Acknowledgements

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References

[1] Nolte, O., Volodin, I. A., Stolze, C., Hager, M. D., & Schubert, U. S. (2021). Trust is good, control is better: a review on monitoring and characterization techniques for flow battery electrolytes. *Materials Horizons, 8* (7), 1866-1925.

[2] Ressel et al. (2018). State of charge monitoring of vanadium redox flow batteries using half cell potentials and electrolyte density. *Journal of Power Sources, 378*, 776-783.

[3] Struckmann et al. (2020). A combined in situ monitoring approach for half cell state of charge and state of health of vanadium redox flow batteries. *Electrochimica Acta, 362,* 137174.

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