State-of-Charge Monitoring Methods for VFB: Amperometry

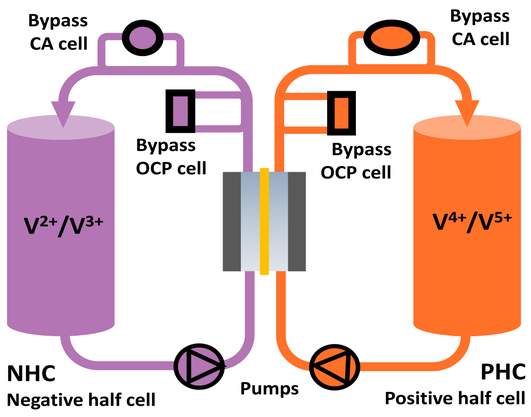
Claudia Weidlich, Felix Lulay, Meiser Valencia, DECHEMA-Forschungsinstitut, Frankfurt, Germany
claudia.weidlich@dechema.de

Scope

- Several analytical methods have already been used in order to predict the State-of-Charge (SOC) for Vanadium-Flow-Batteries (VFB) [1] - [4]
- We show the feasibility of amperometric monitoring and Open Circuit Potential (OCP) measurements for SOC determination in VFB half cells under operation
- Results are in good accordance with SOC determined from titration of electrolyte samples

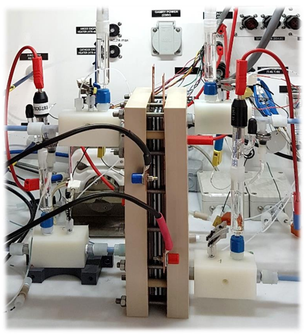
Battery

Electrolyte:
1.6 M V in
2 M H_2SO_4,
GfE



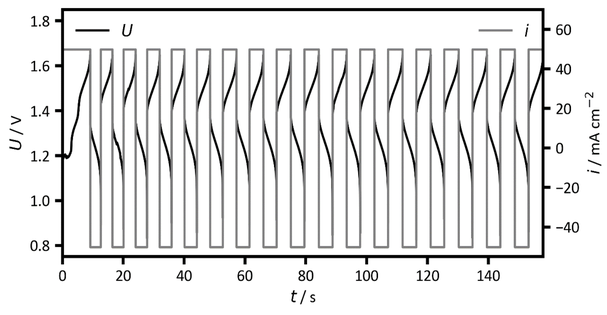
Battery cell

Manufactured cell: 20 cm^2 active area, fumasep FAP450® fumatech, Sigracell® GFD 4.6 SGL



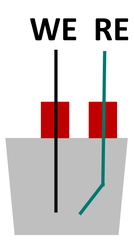
Battery operation

Charge / Discharge
50 mA cm^{-1}
Electrolyte flow
50 mL min^{-1}



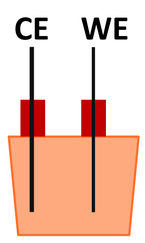
Test setup for Open Circuit Potential and Amperometric monitoring

OCP Monitoring



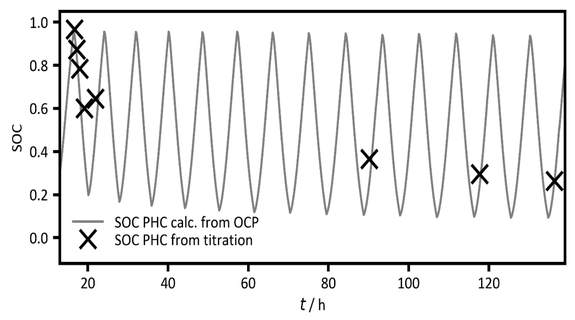
Manufactured flow-cell

Amperometry (CA)

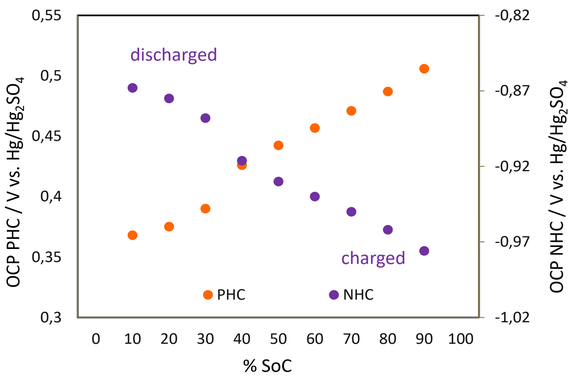


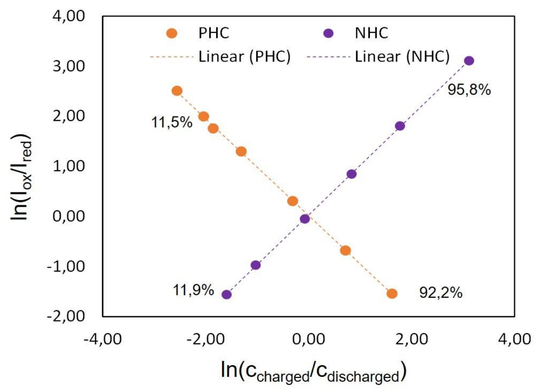
Equipment and Experiment

- **CA** WE: GC rod (2 mm Ø), CE: GC rod (2 mm Ø)
- **OCP** WE: GC rod (2 mm Ø), RE: Hg/Hg_2SO_4
- Amperometric measurement (30 s interval) at different potentials (+/-0,4V to +/-1,2), Potentiostat Gamry 3000
- Potentiometric titration (5 ml samples) using 0.1 M $Ce(SO_4)$, Titrando 888, Metrohm



Calibration of OCP and Amperometric monitoring



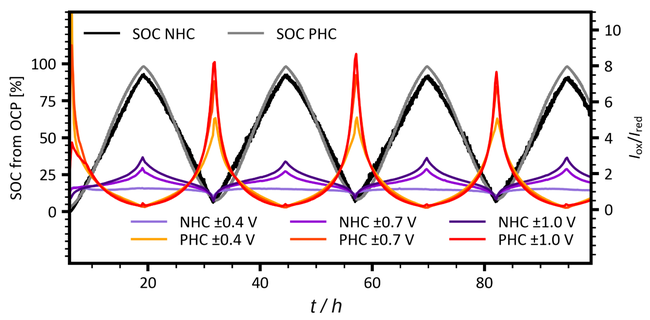


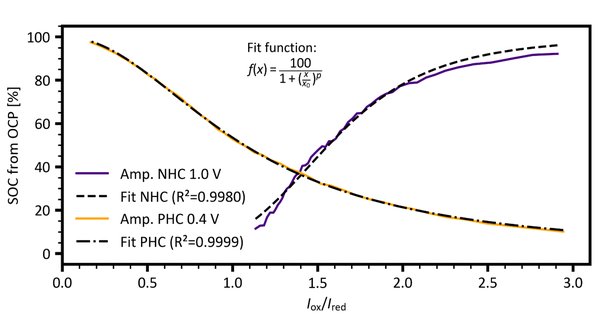
- OCP measured during stepwise discharge after first charge cycle
- $\ln(I_{ox}/I_{red})$ from amperometric measurements and concentration of the charged and discharged vanadium species determined by potentiometric titration as $\ln(c_{charged}/c_{discharged})$

- **Dependence of OCP and $\ln(I_{ox}/I_{red})$ on SOC is shown for PHC and NHC**
- **Applicability of amperometric measurements for VFB is demonstrated** [6]

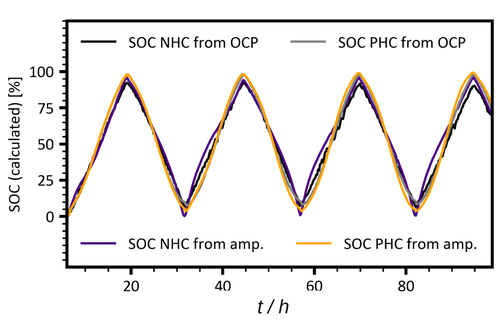
Amperometric monitoring *in situ* at PHC and NHC

Battery under operation





- Amperometric monitoring during charging and discharging using different potentials (+/-0,4 V to +/- 1,0V): Resulting (I_{ox}/I_{red}) and half cell SOC calculated from OCP
- Logistic fit function for SOC (I_{ox}/I_{red}) found
- SOC from OCP and amperometric monitoring using ±1.0V (NHC) and ±0.4V (PHC)



Literature

[1] T. Haisch, Electrochimica Acta, 336, 35573, 2020. [2] S. Ressel, Journal of Power Sources, 776, 2018. [3] T. Struckmann, Electrochimica Acta, 362, 137174, 2020.
[4] T. Haisch, Membranes, 11, 232, 2021. [5] C. Stolze, Chemistry of Materials, 5363-5369, 2019.
[6] C. Weidlich, F. Lulay, M. Wieland, Journal of Electrochemical Science and Engineering, 13, 5, 2023.

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