Activity and Dissolution Stability of Ir/Ru- based Electrocatalysts Tested in a Model Proton Exchange Membrane Water Electrolyzer

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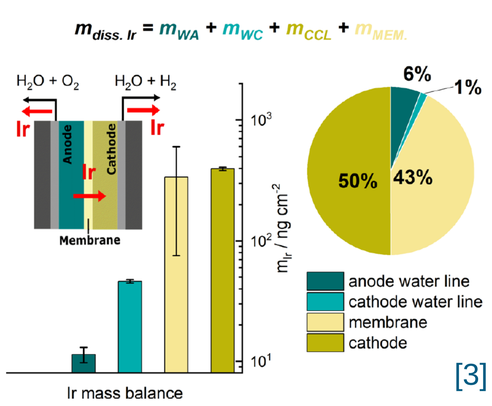
Motivation

Increasing demand and rising material prices for iridium (Ir)
→ Replacement of Ir with other PGMs, such as ruthenium (Ru) [1]

Aqueous model systems (AMS): rotating disk electrode (RDE) or scanning flow cell (SFC) extensively studied Ru
→ Ru exhibits higher activity but lower stability than Ir [2]



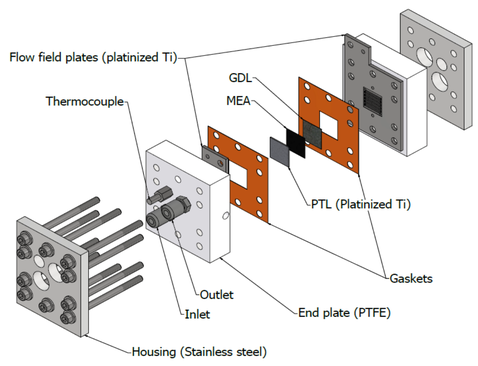
[3]

Activity and dissolution stability of Ir/Ru electrocatalysts tested in a model PEMWE

Method

In-house designed **Metal-free PEMWE testing station** [3]

Tracking catalyst dissolution: **water sampling points** within the anode water loop and the cathode outlet line

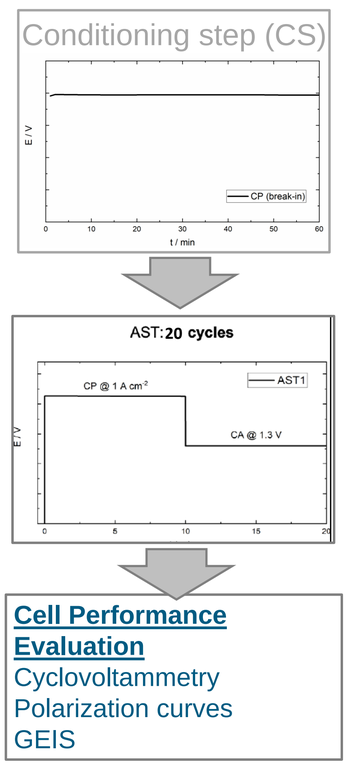


MEA specifications:
Anode – 2 mg cm^{-2} Ir:Ru in ratios of 6:1, 3:1, 1:1
Cathode - 0.5 mg cm^{-2} Pt/C
Membrane - N212

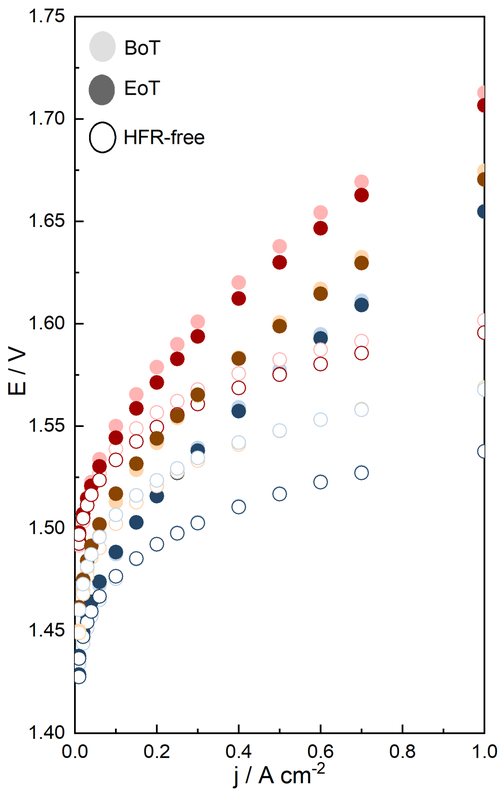
Operating conditions:
60°C, 1bar, Q_{H2O} = 5 ml min^{-1}

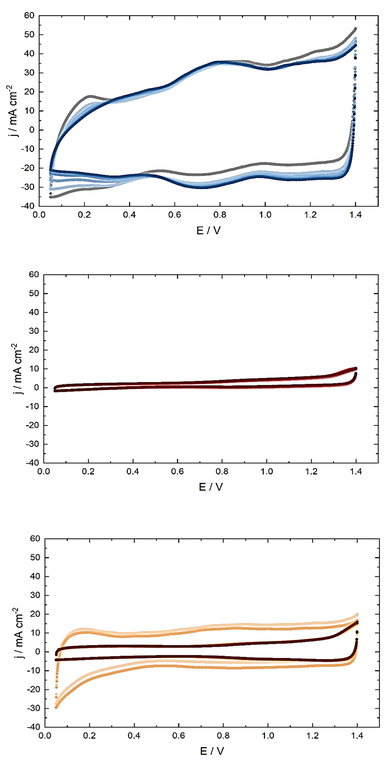
Activity: Ir:Ru 6:1, Ir:Ru 3:1, Ir:Ru 1:1

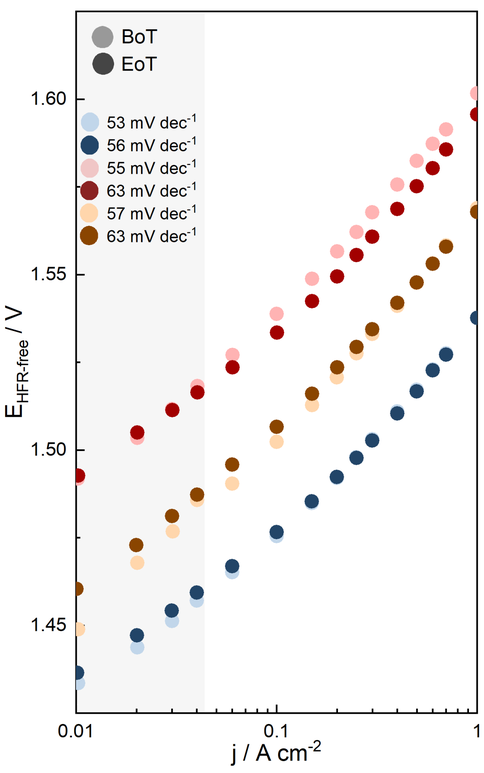
AST Protocol



Cell Performance Evaluation
Cyclovoltammetry
Polarization curves
GEIS







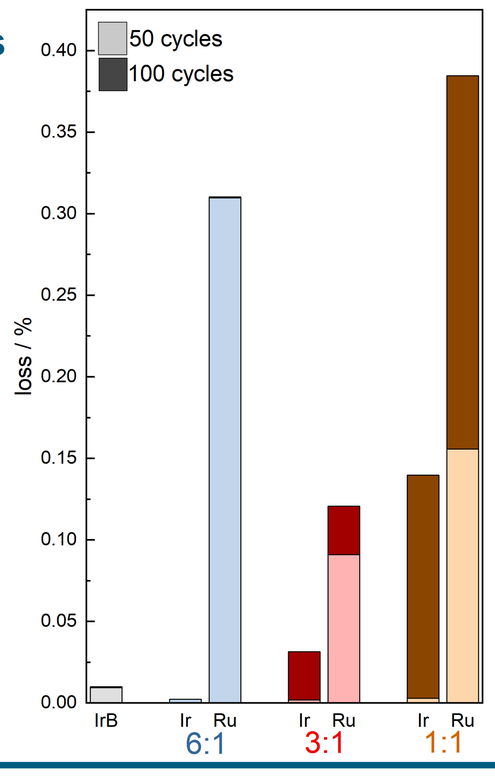
- Reproducible and stable performance throughout the applied protocol
- **Activity:** **Ir:Ru 6:1 > Ir:Ru 1:1 > Ir:Ru 3:1**
- Changes in 1:1 CVs: Possibility of Ru dissolution and redeposition

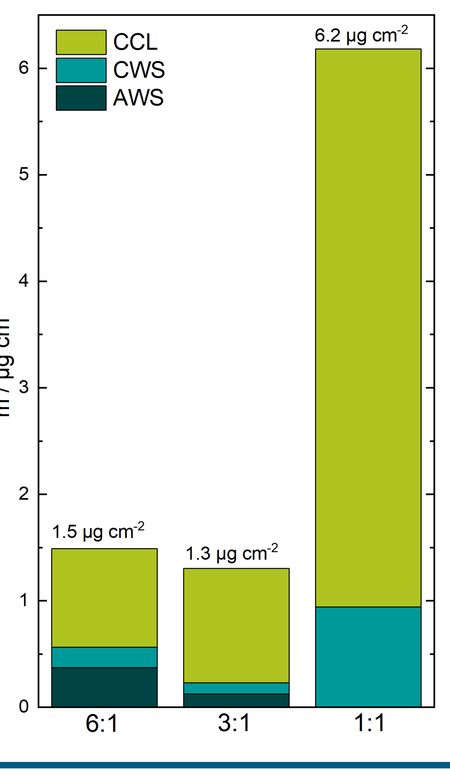
→additional physical characterization is necessary

Dissolution Stability

Comparison 50 cycles – 100 cycles

- Ru dissolves quicker than Ir
- Comparison to Ir_B: adding **Ru stabilizes Ir** in the first 50 cycles
- **Dissolution stability** **Ir:Ru 3:1 > Ir:Ru 6:1 > Ir:Ru 1:1**





Mass Balance

- In agreement with the previous study: most of the dissolved **anode catalyst redeposits on the cathode** catalyst layer
- Cathode water: dissolution only after CS
- Anode water: Most **Ru dissolves during CS and redeposits** afterward

→Additional physical characterization is necessary

→TEM measurements for quantification of membrane

References:

[1]M. Carmo, D. L. Fritz, J. Mergel, and D. Stolten, International Journal of Hydrogen Energy, 2013, 38, 4901–4934
[2]S. Cherevko, S. Geiger, O. Kasian, N. Kulyk, J. Grote, A. Savan, B. R. Shrestha, S. Merzlikin, B. Breitbach, A. Ludwig and K. J.J. Mayrhofer, Catalysis Today, 2016, 262, 170–180
[3]M. Milosevic, T. Böhm, A. Körner, M. Bierling, L. Winkelmann, K. Ehelebe, A. Hutzler, M. Suermann, S. Thiele and S. Cherevko, ACS Energy Letters, 2023, 8, 2682-2688

Acknowledgments:

SEALHYDROGEN
Ref. Ares(2023)4053441 - 12/06/2023

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