



# In-situ photometric reflectance measurements of carbon steel surfaces upon cathodic protection

**Other Conference Item****Author(s):**

[Martinelli-Orlando, Federico](#) ; [Angst, Ueli](#) 

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848794 - Towards mastering the long-standing challenge of ageing infrastructures in corrosive environments (EC)



# In-situ photometric reflectance measurements of carbon steel surfaces upon cathodic protection

**Eurocorr 2023 - Brussels**

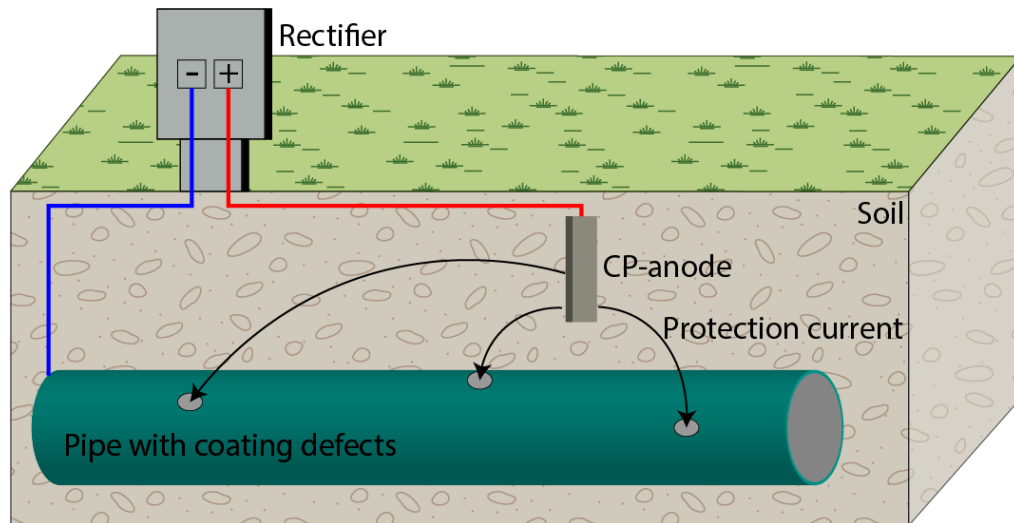
31<sup>st</sup> August 2023

Federico Martinelli-Orlando and Ueli Angst



# Introduction

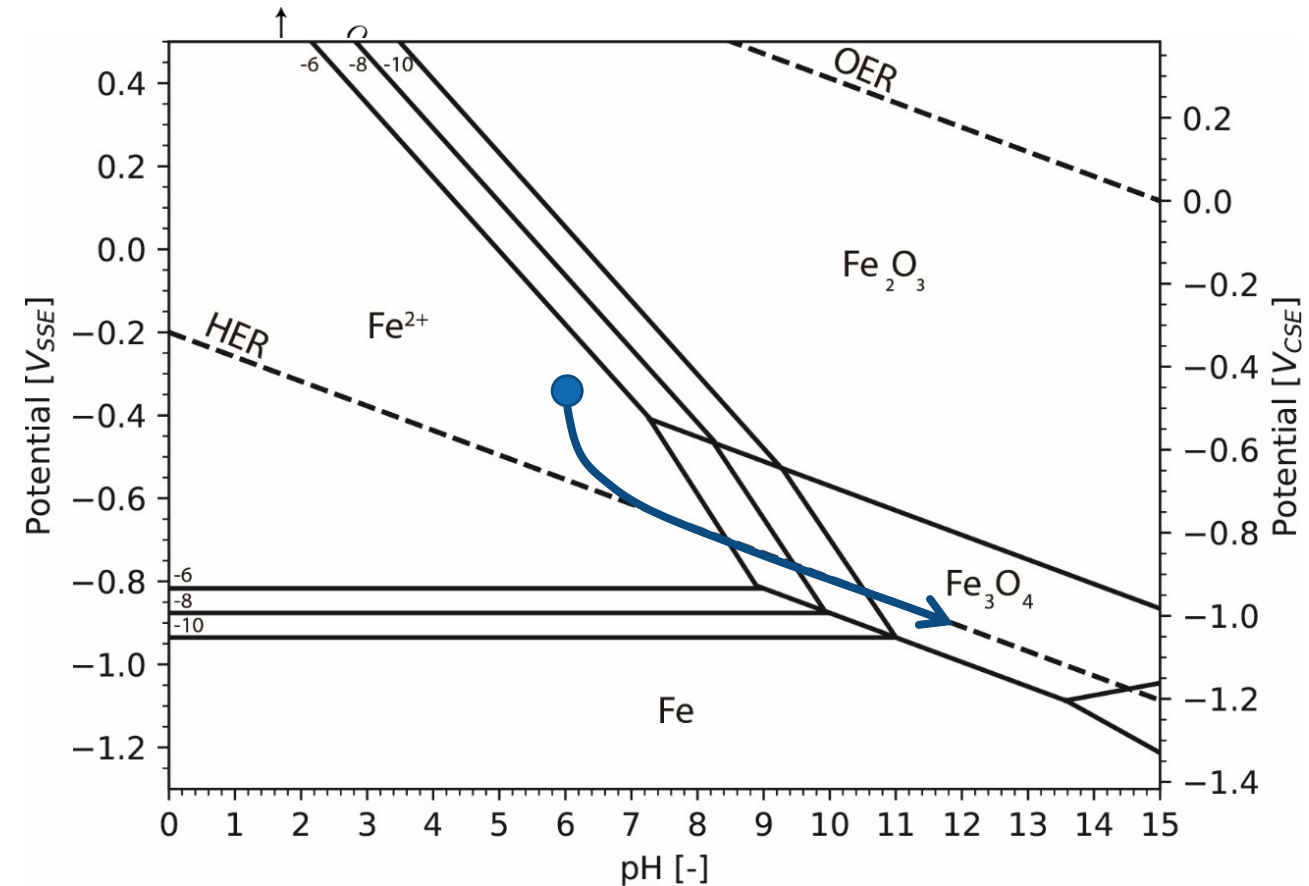
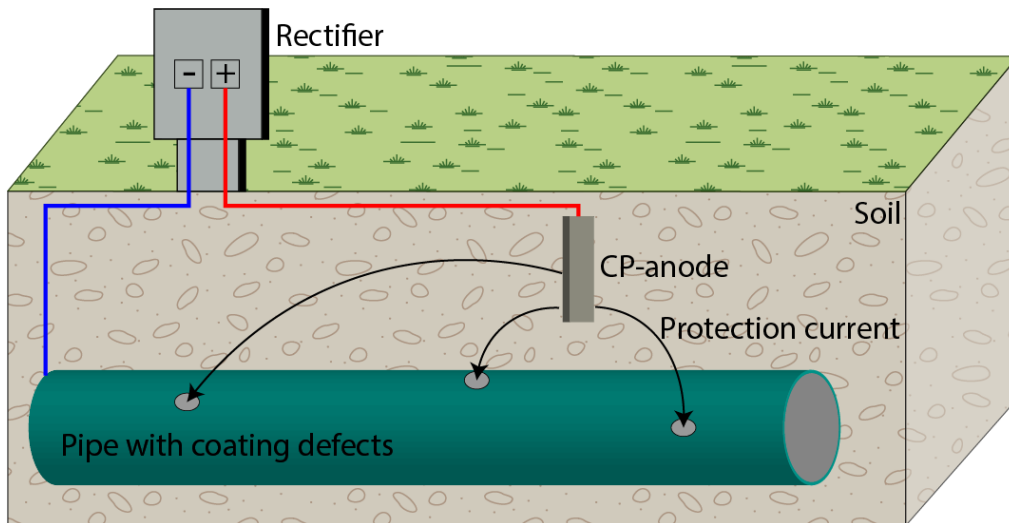
- Cathodic protection (**CP**) electrochemical technique to **limit corrosion rate**
- **Exactly 200 years from the first experiments**
- Some **protection criteria** based on **empirical findings**



# Introduction

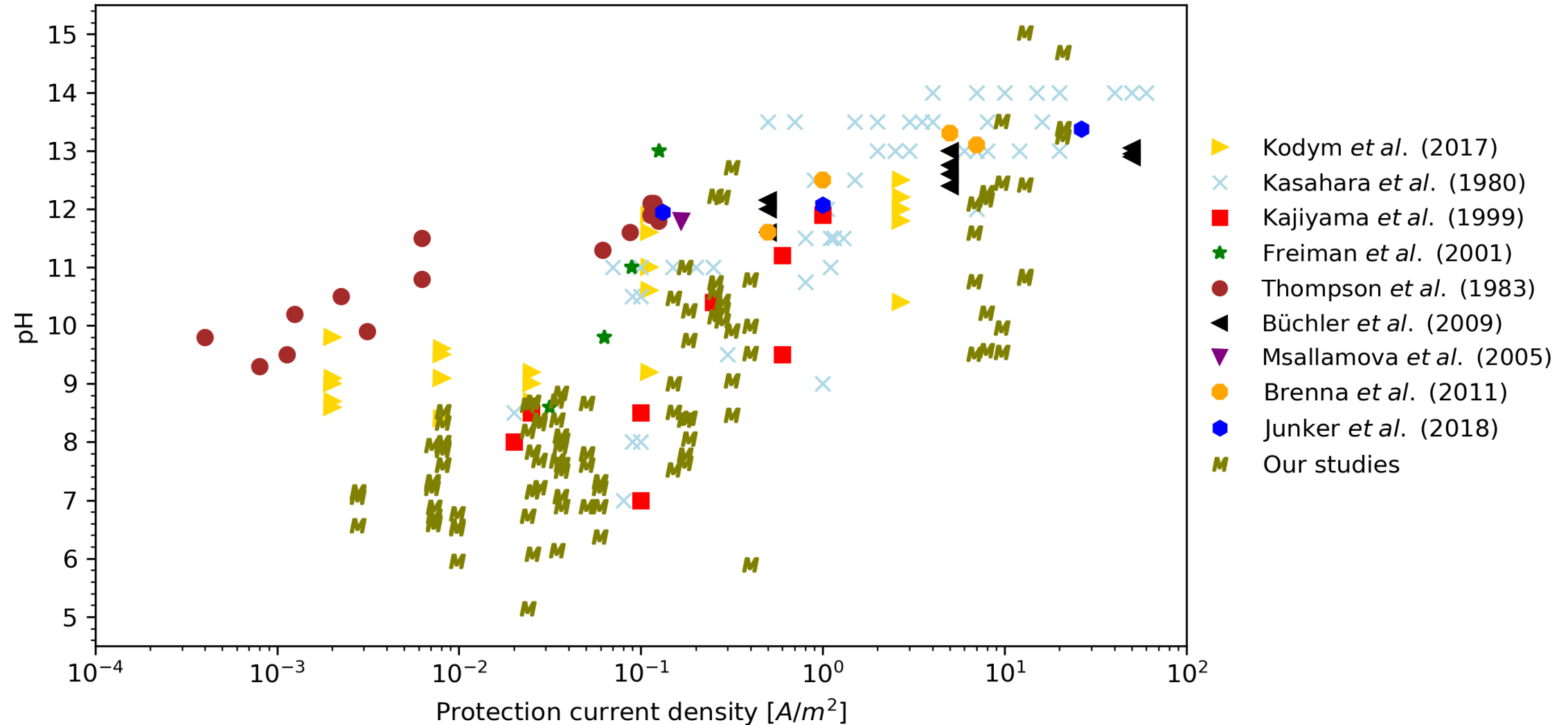
CP working mechanisms are still under debate

- Activation polarisation
- Concentration polarisation



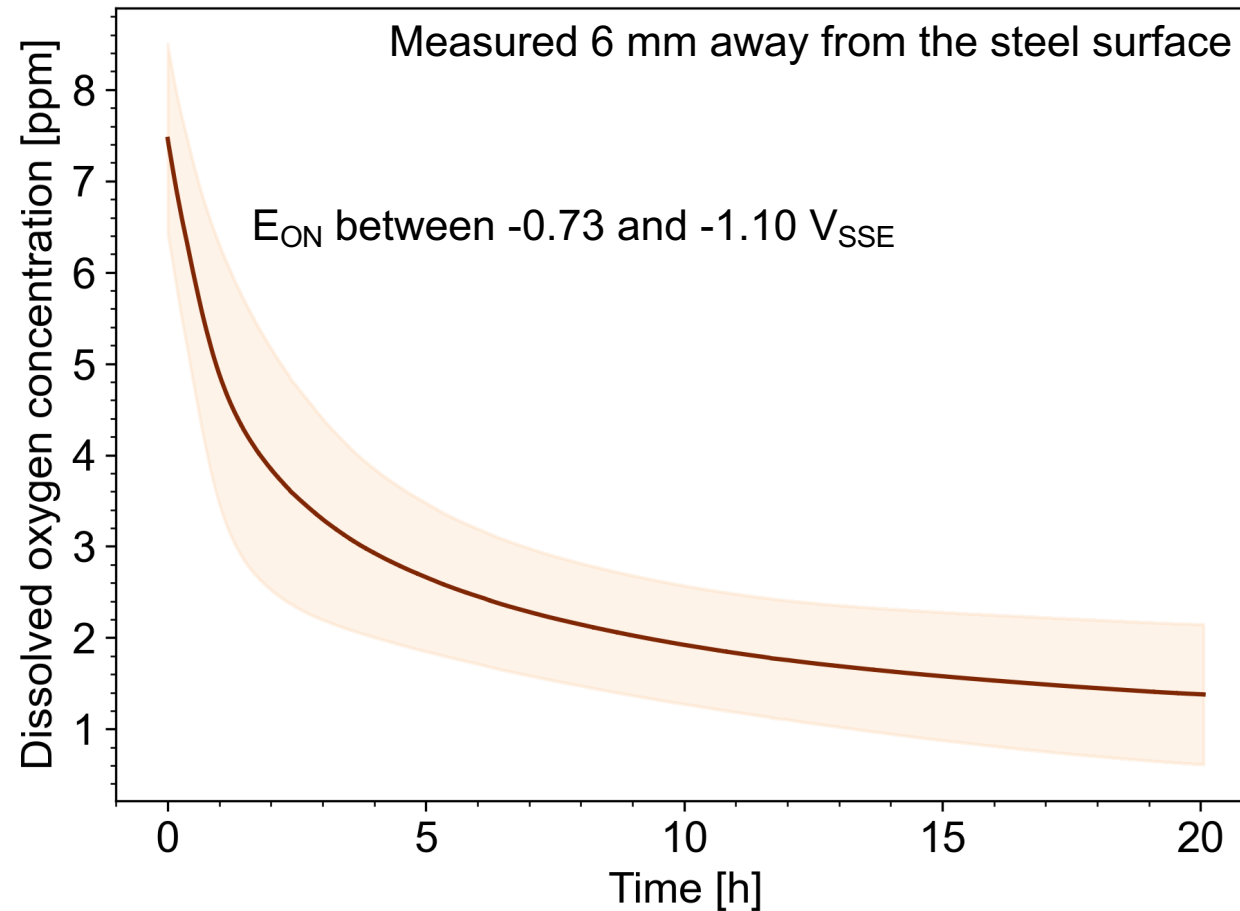
# Introduction

- Several studies showed **increase in pH** as a function of the **protection current density**



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- A few studies reported changes in **oxygen concentration upon CP**



# Introduction

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- **Passive film** on steel extensively studied in alkaline electrolytes:
  - **Electrochemical** methods to monitor or induce passive film formation
  - **Characterization** techniques mostly done **ex-situ**
- A **few studies** reported **in-situ** characterization of passive film:
  - **Potentiodynamic polarization or cyclic voltammetry**
  - **Potentiostatic polarization (anodic)**

# Introduction

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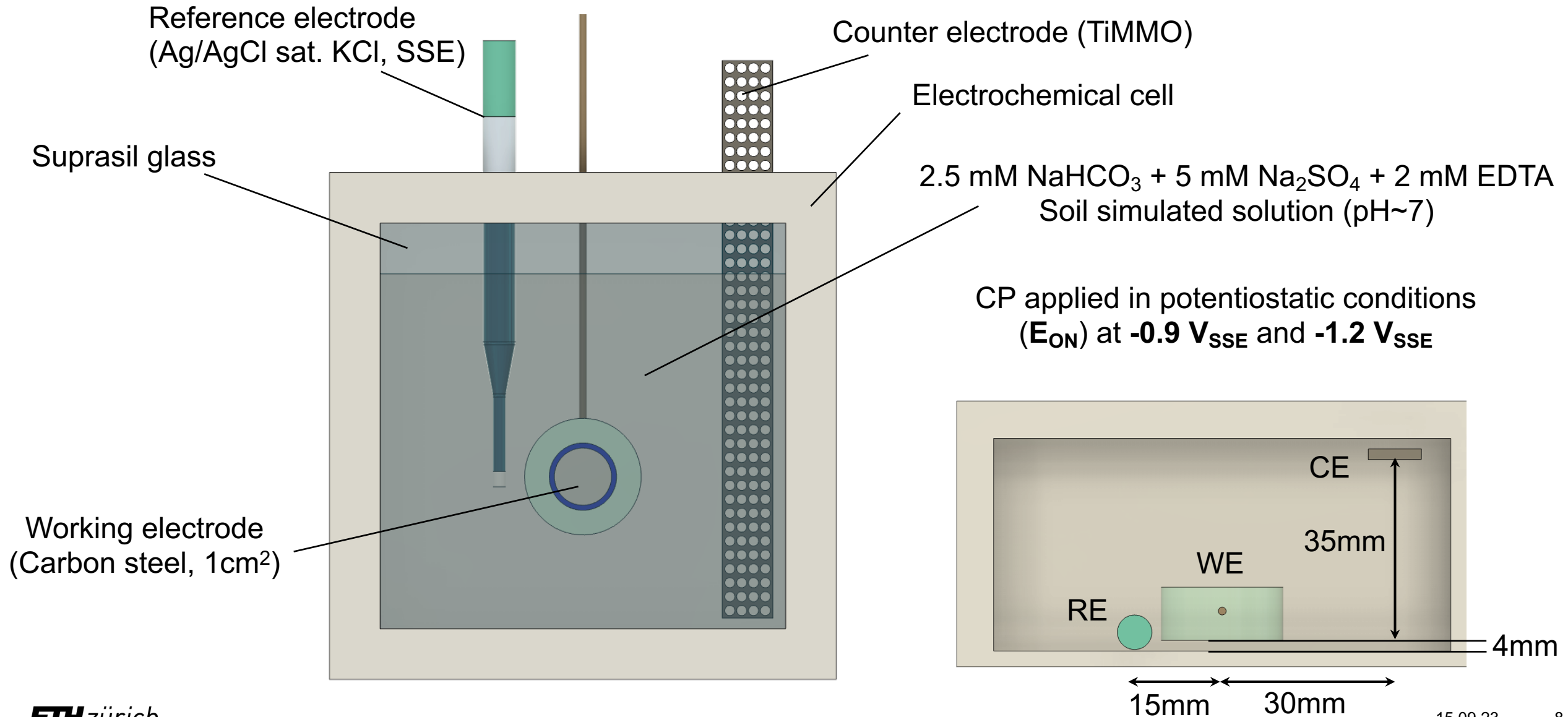
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  - Electrochemical methods to monitor or induce passive film formation
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## Aim of the work

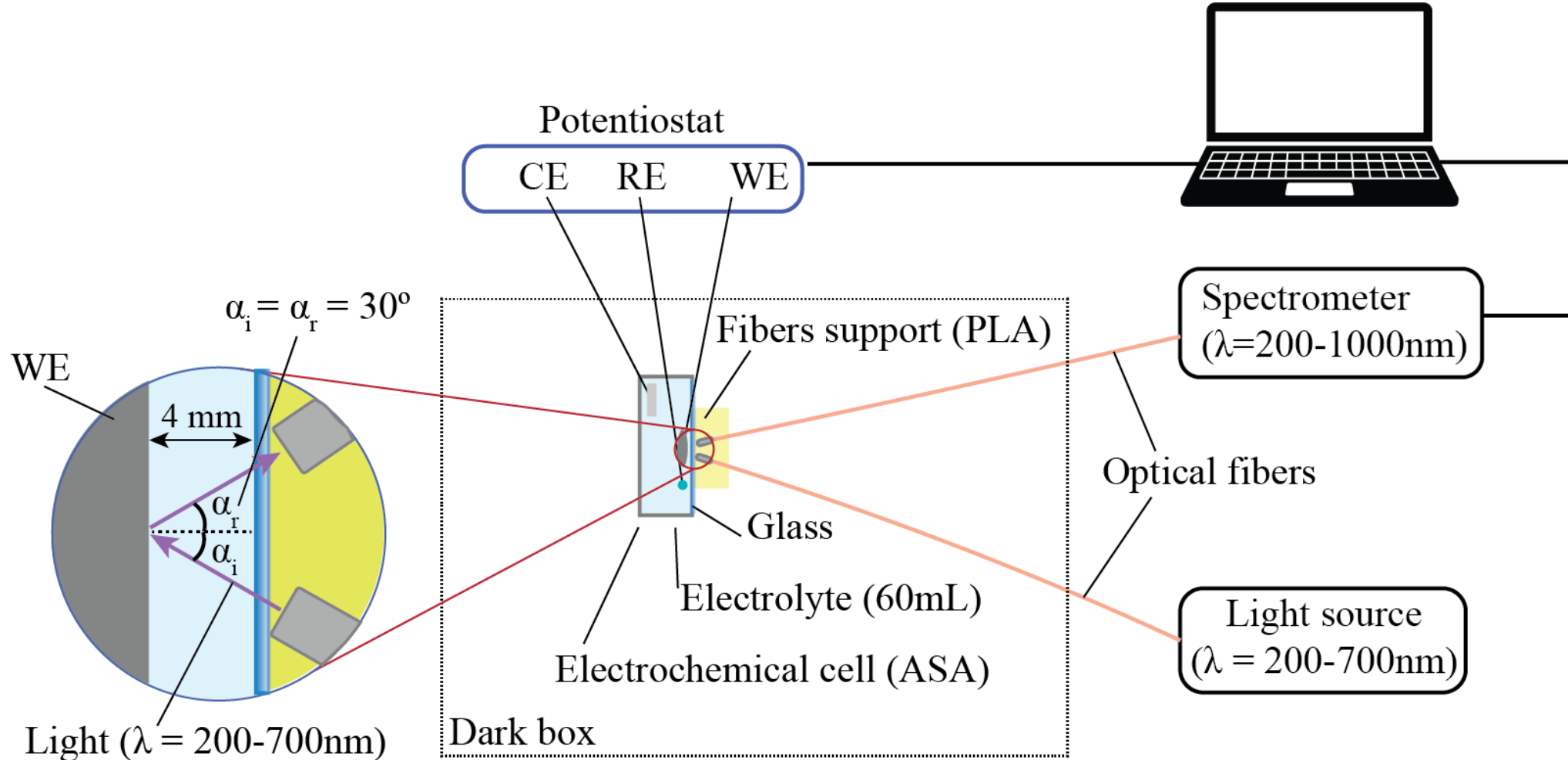
Study the **oxide film** formation and growth upon application of **cathodic currents combined with in-situ light reflectance measurements**



# Methods – Photoelectrochemical cell

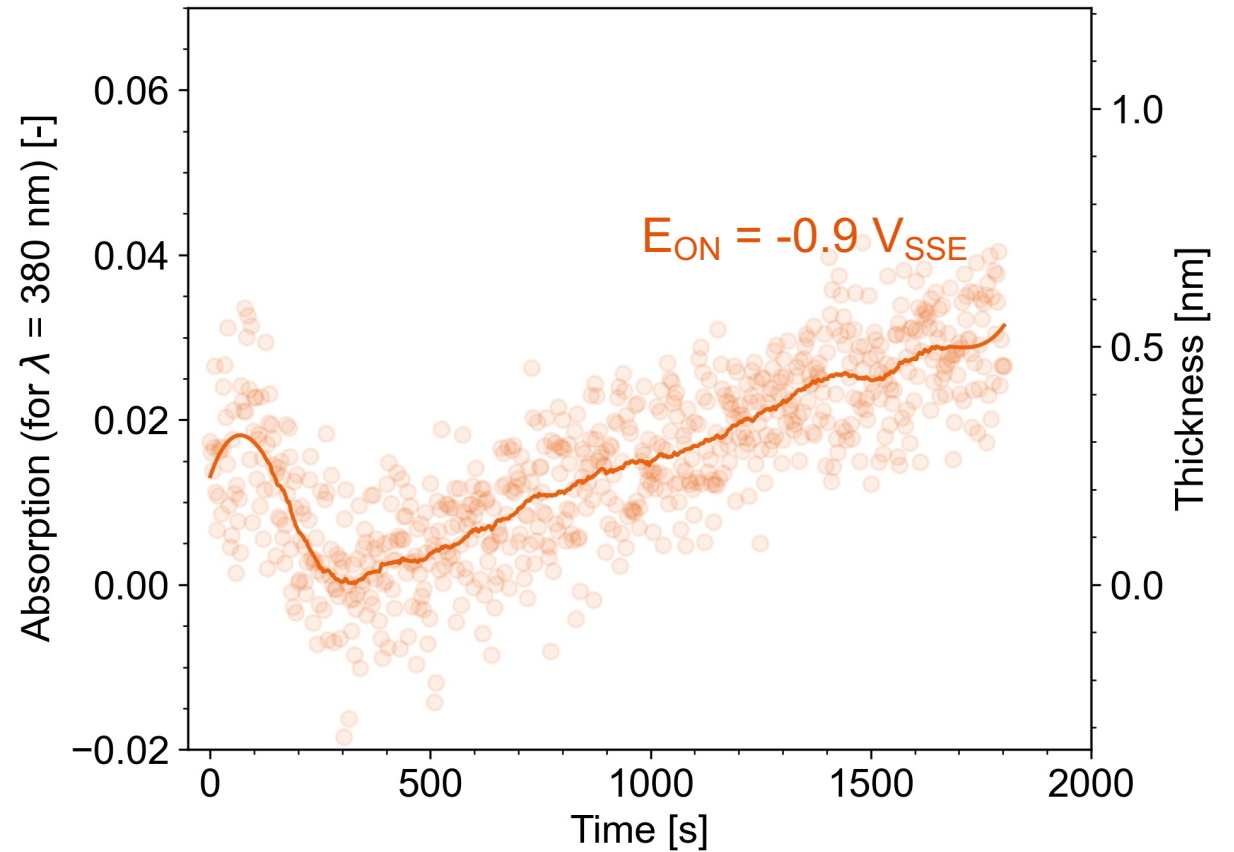
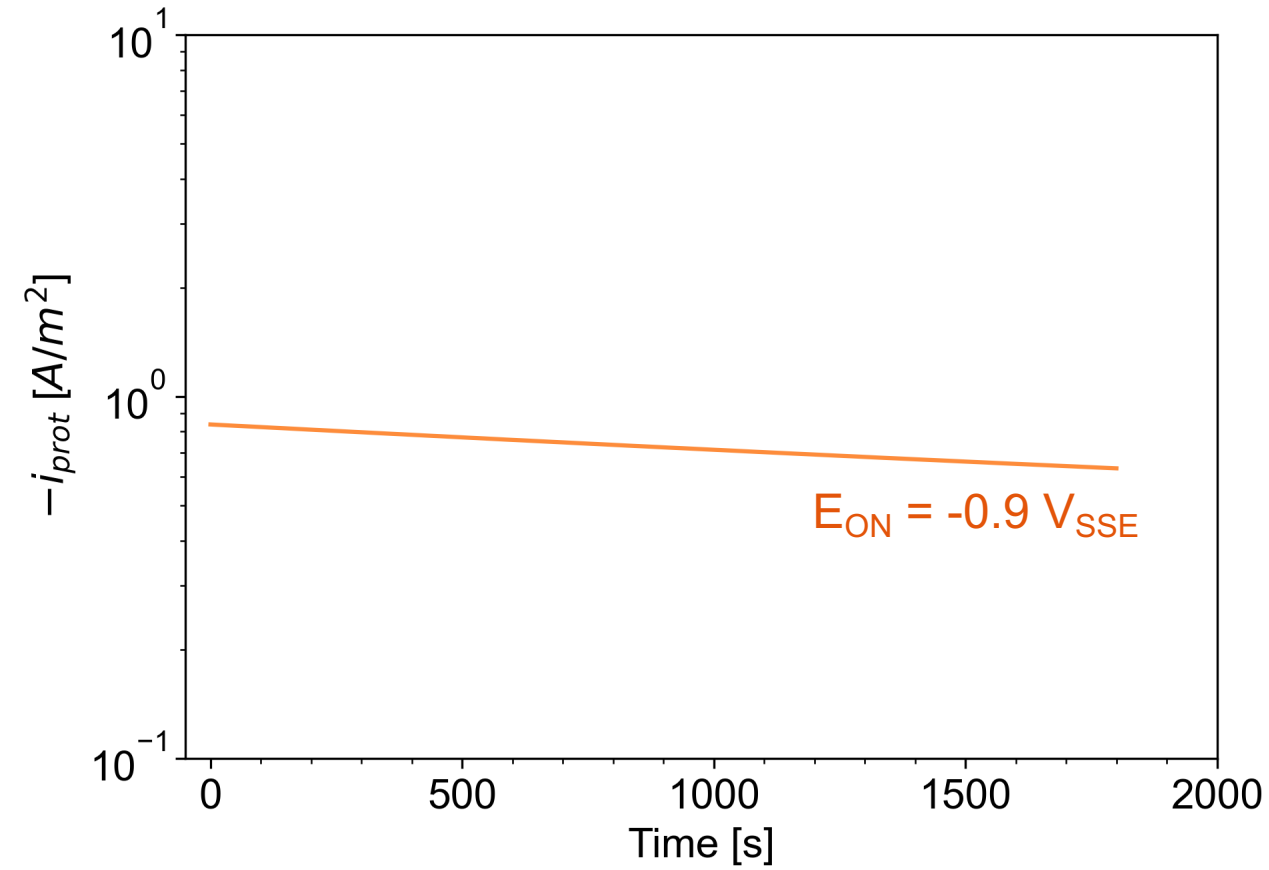


# Methods – Photometric reflectance measurements (PRM)

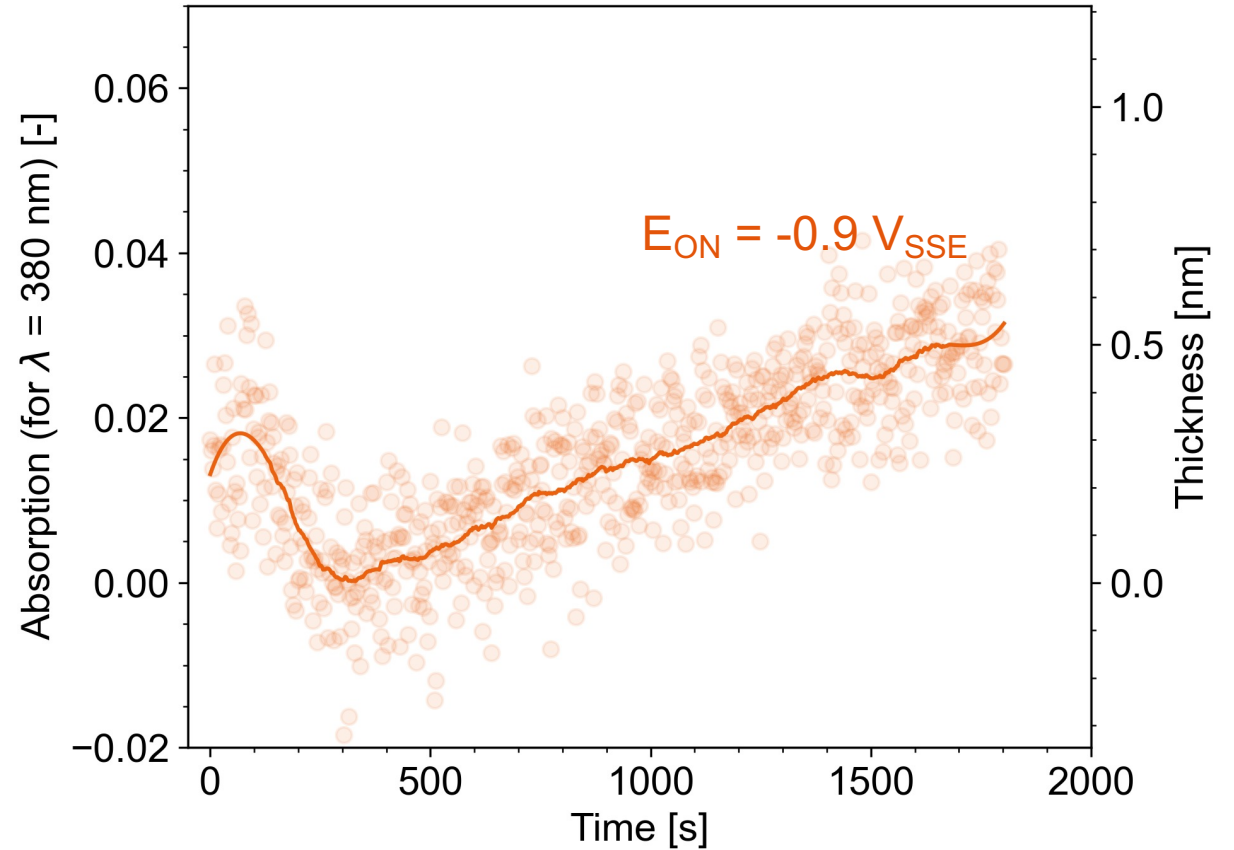
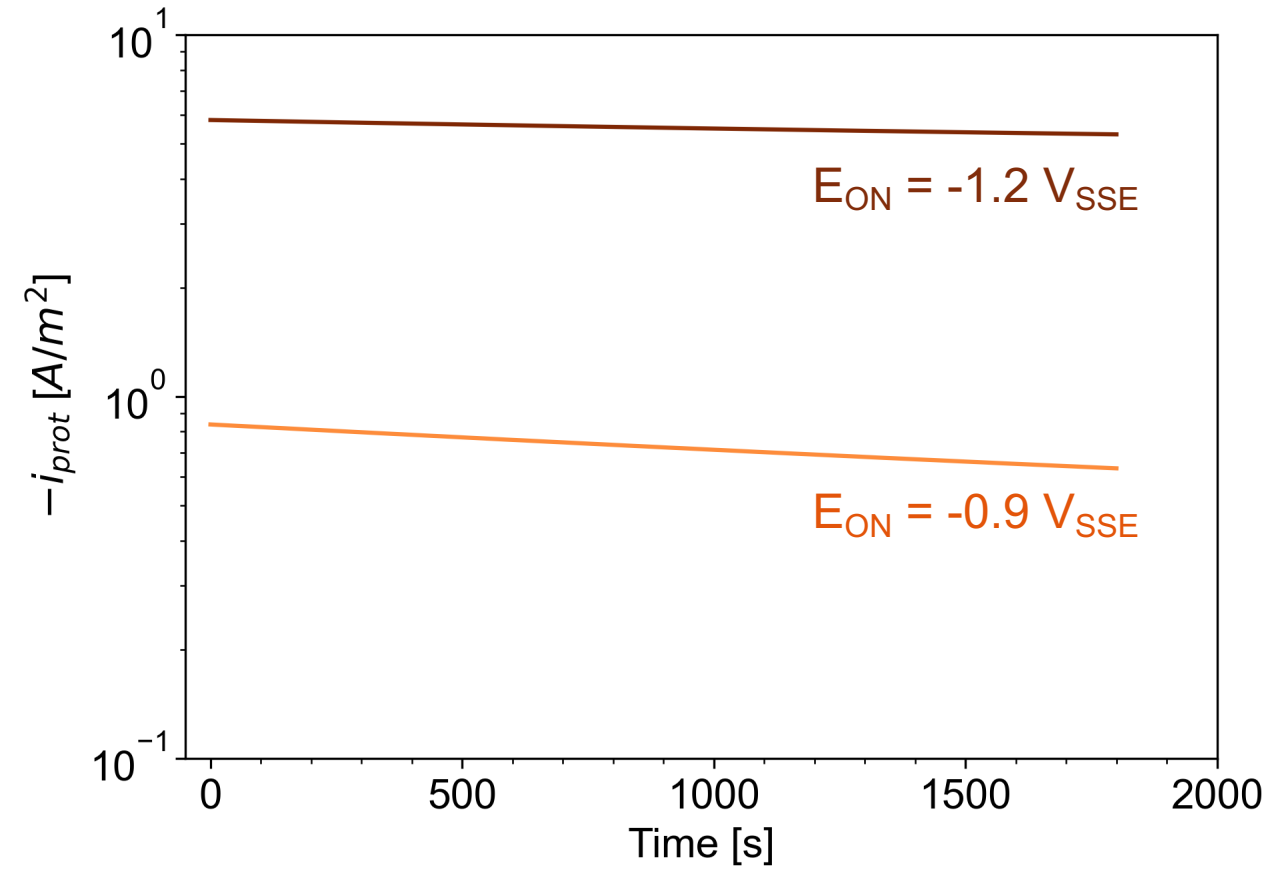


Data evaluated at 380 nm to allow estimation of oxide film thickness

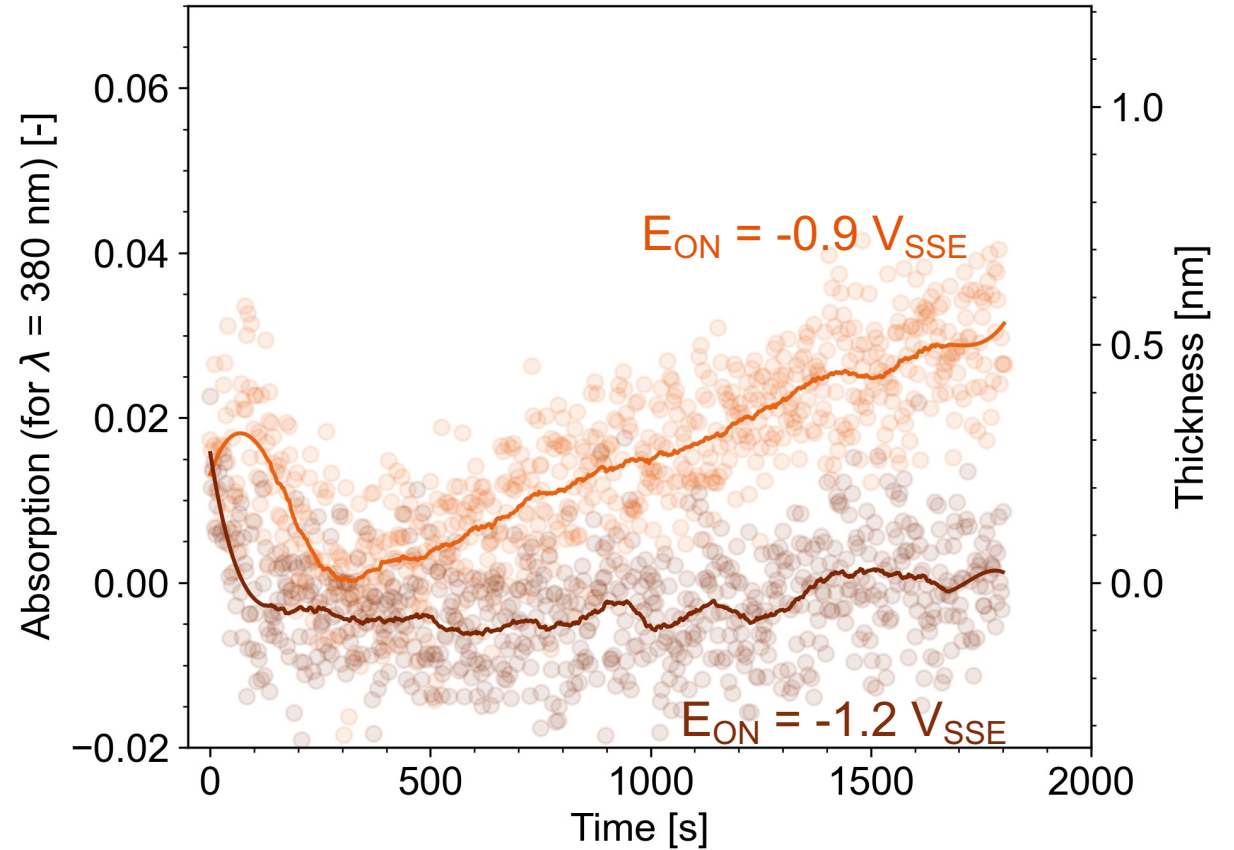
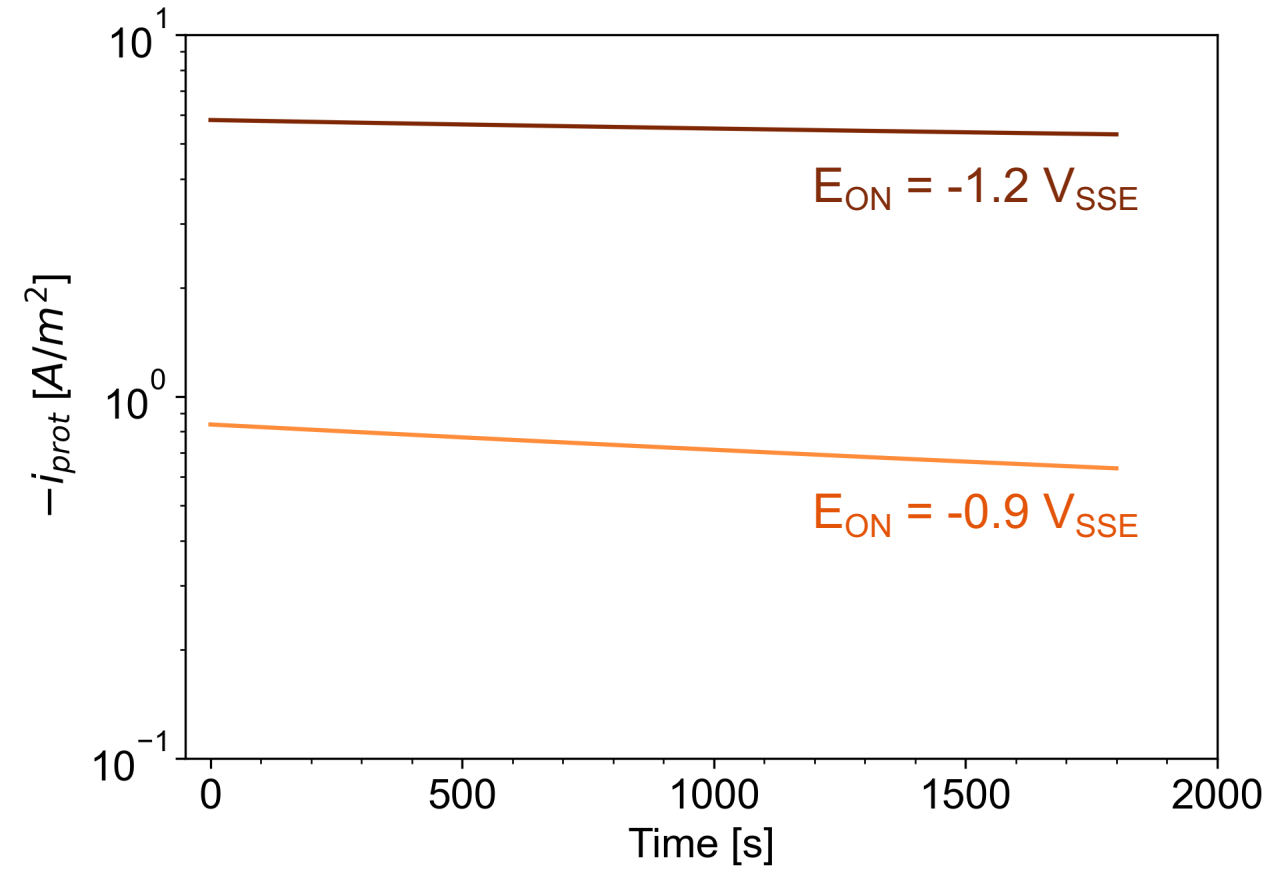
# In-situ PRM upon CP



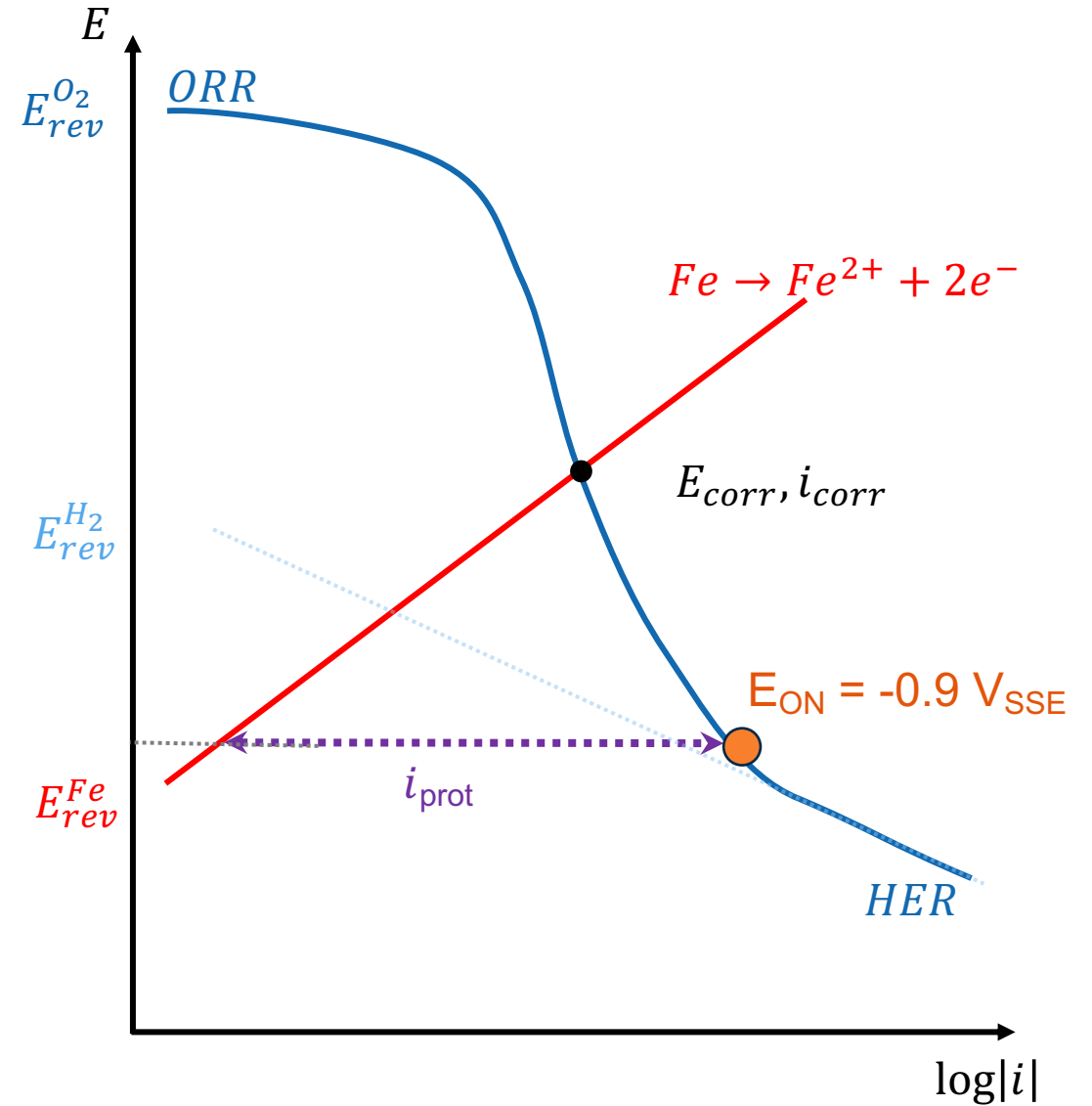
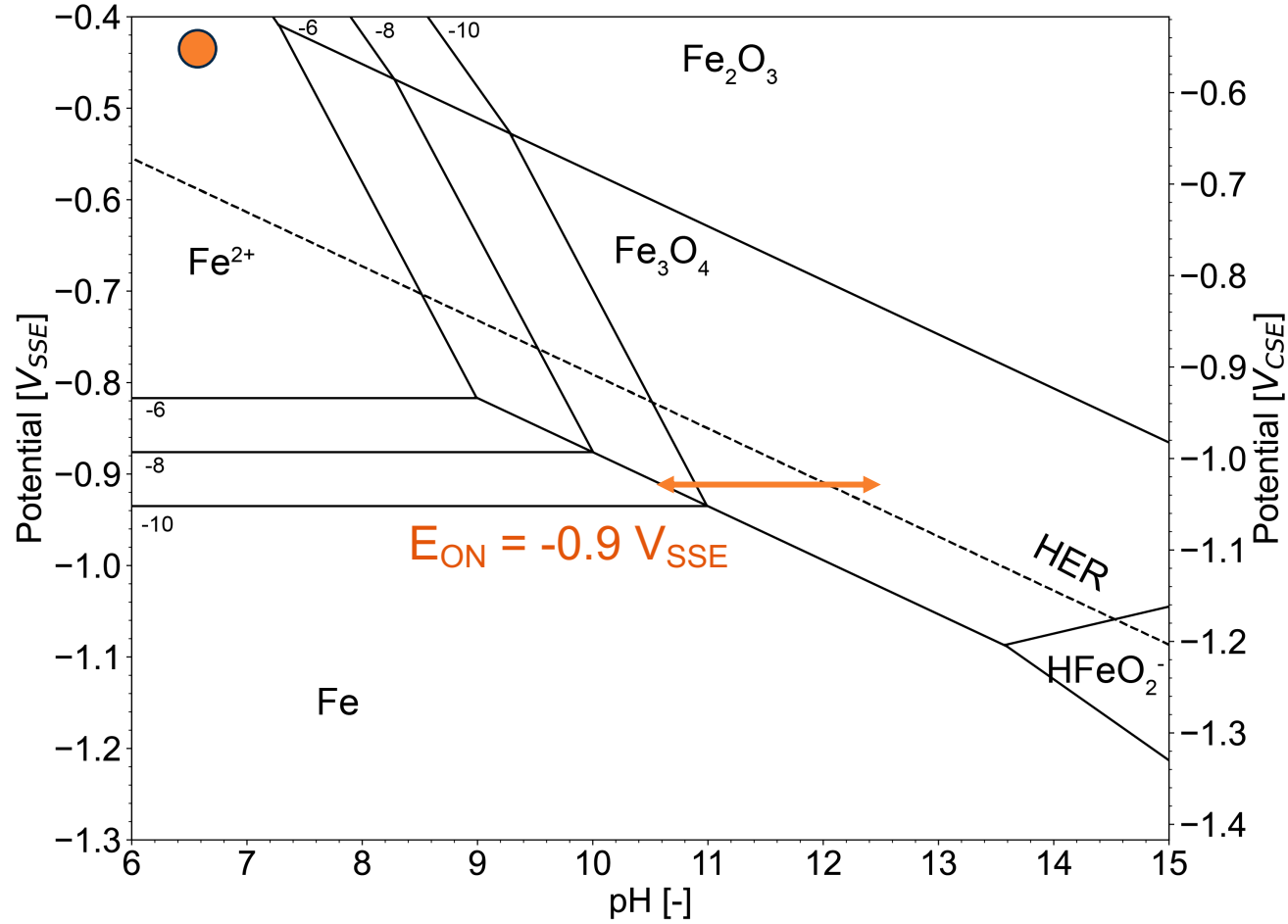
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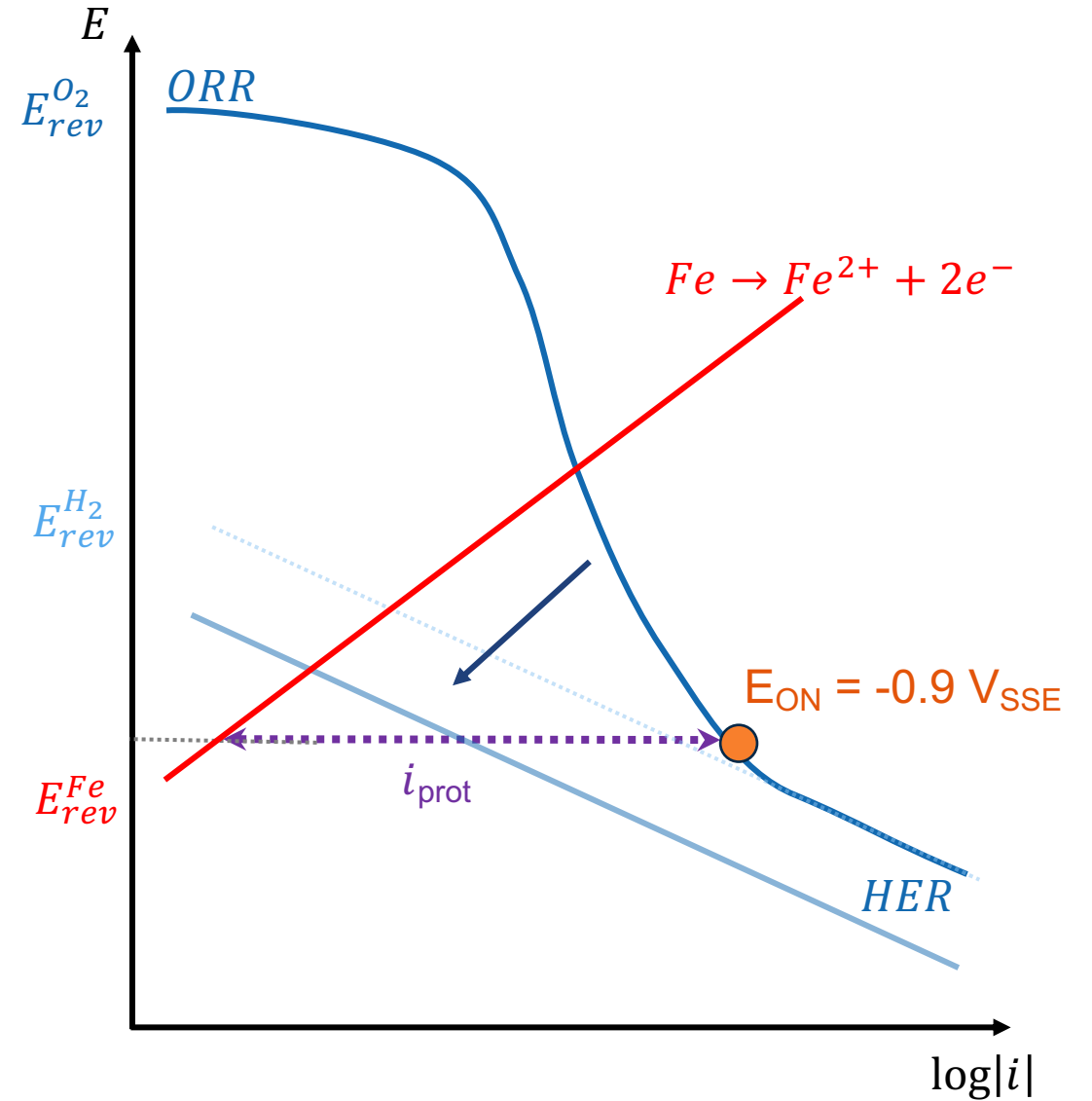
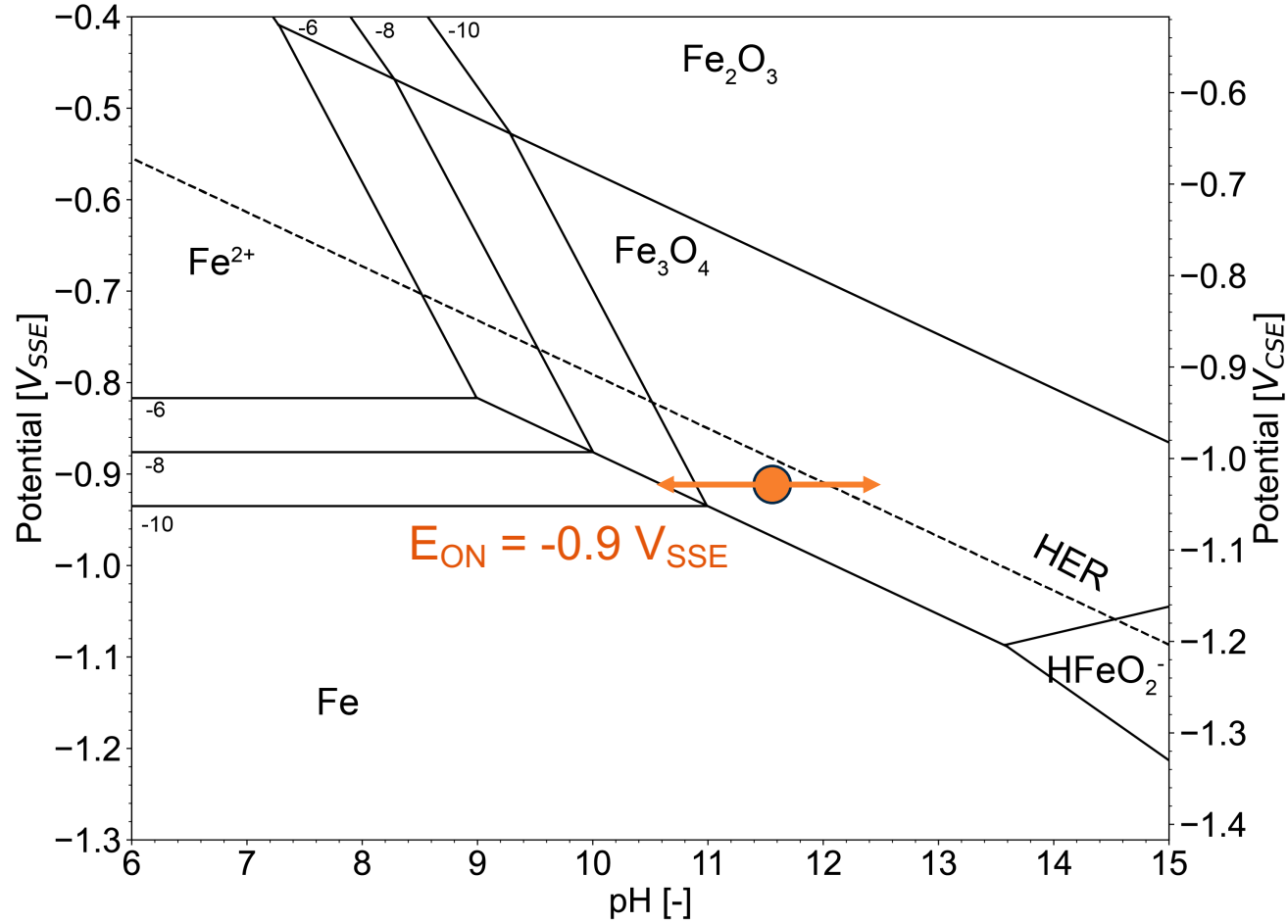
# In-situ PRM upon CP



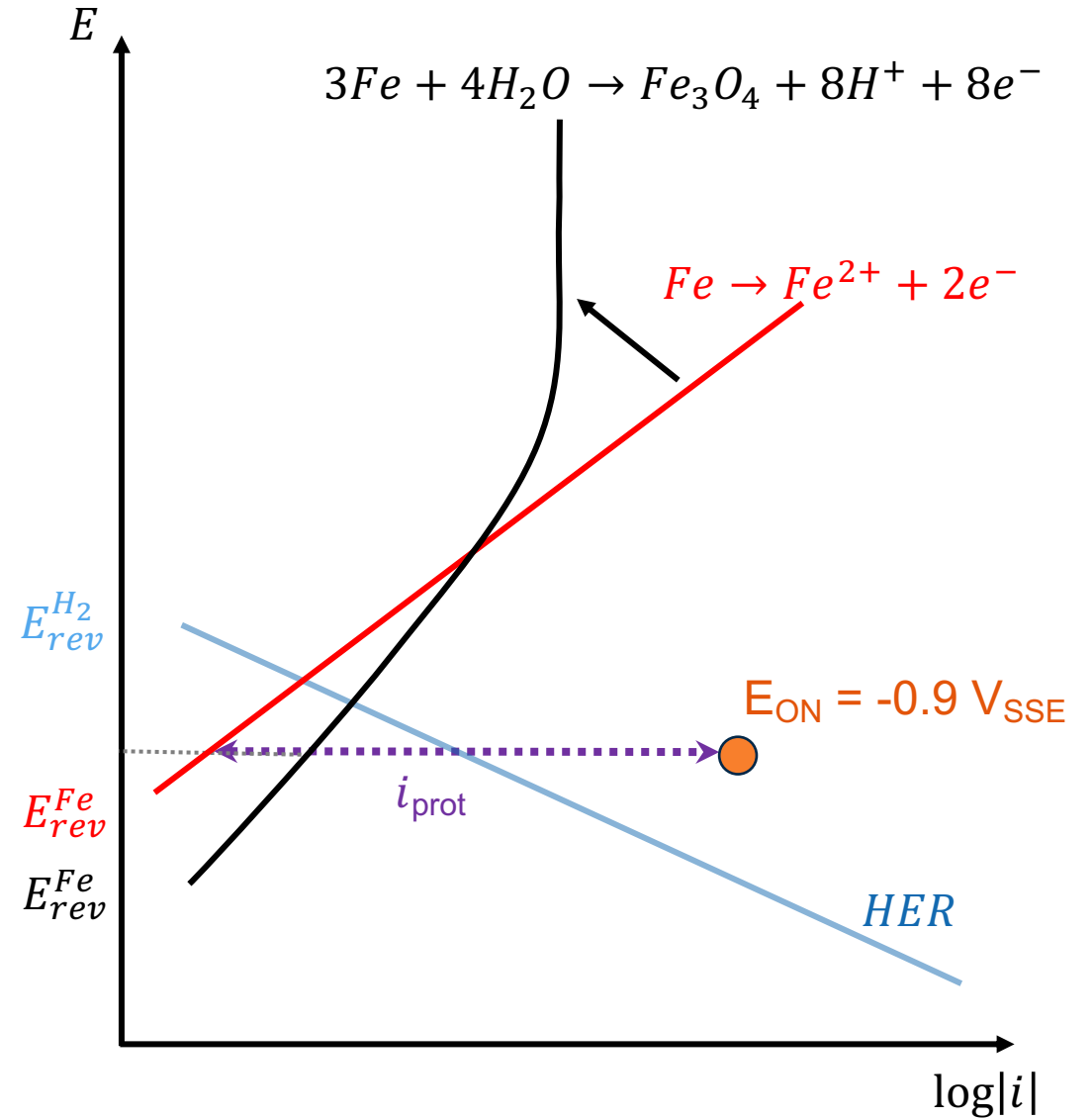
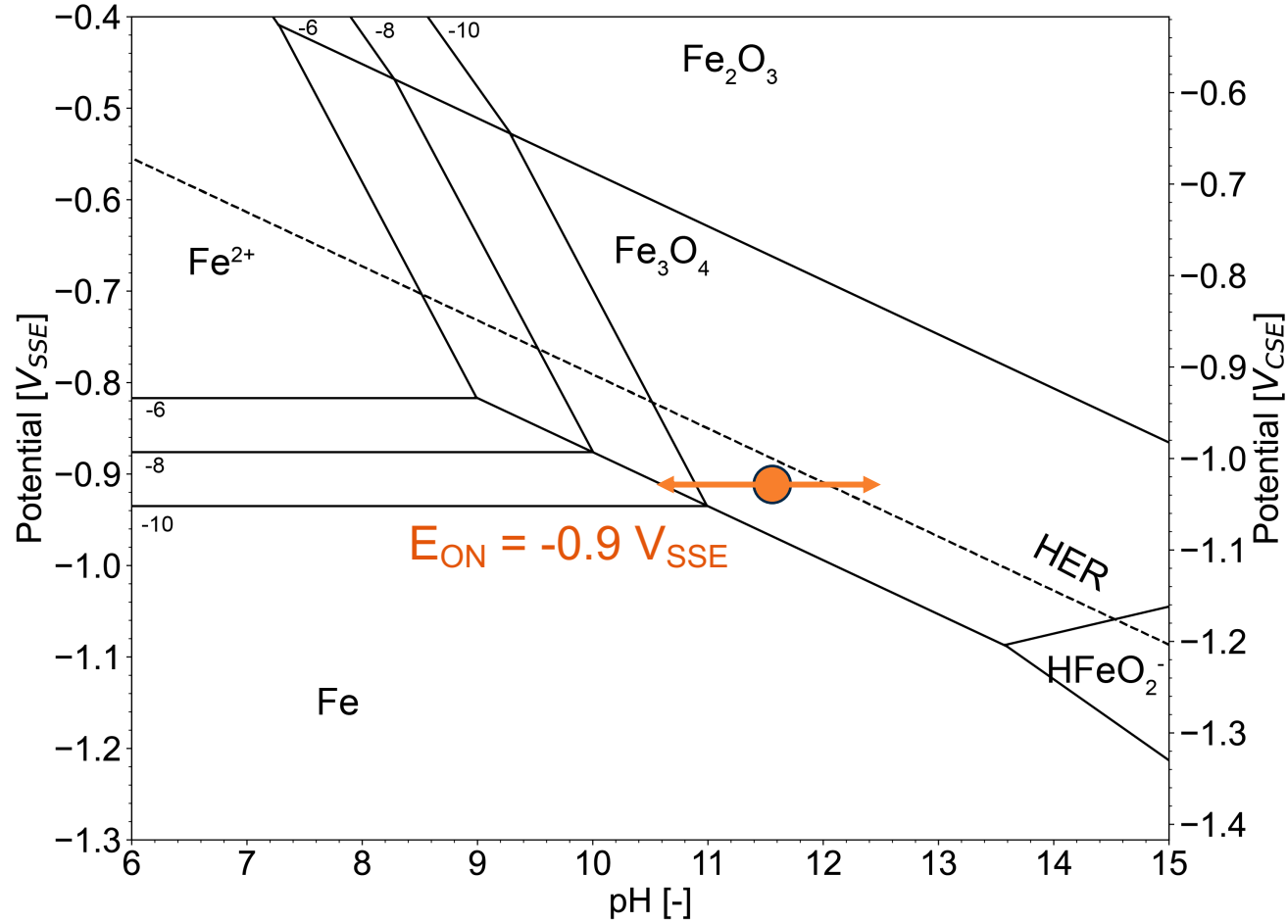
# Thermodynamic and kinetic considerations



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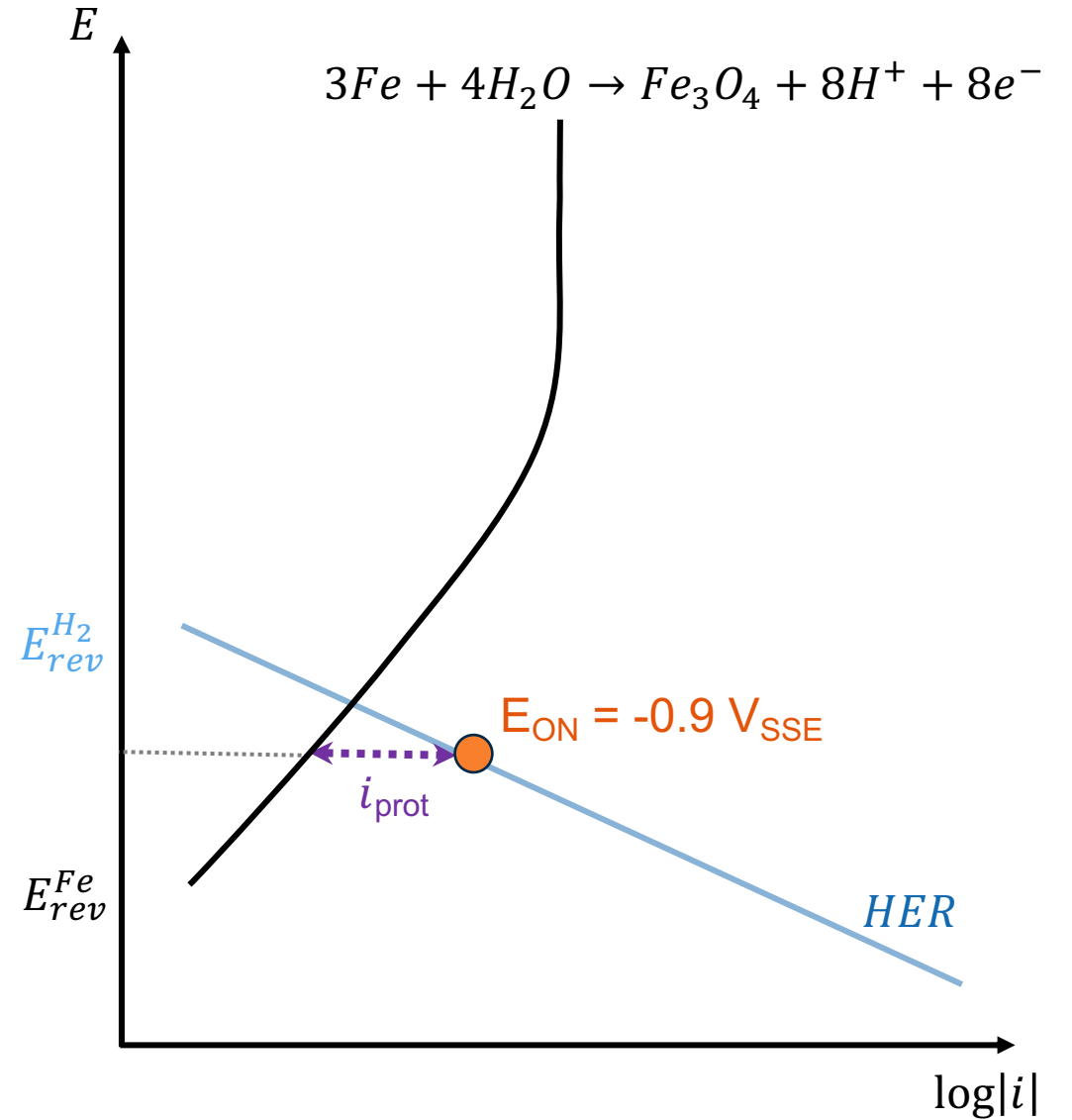
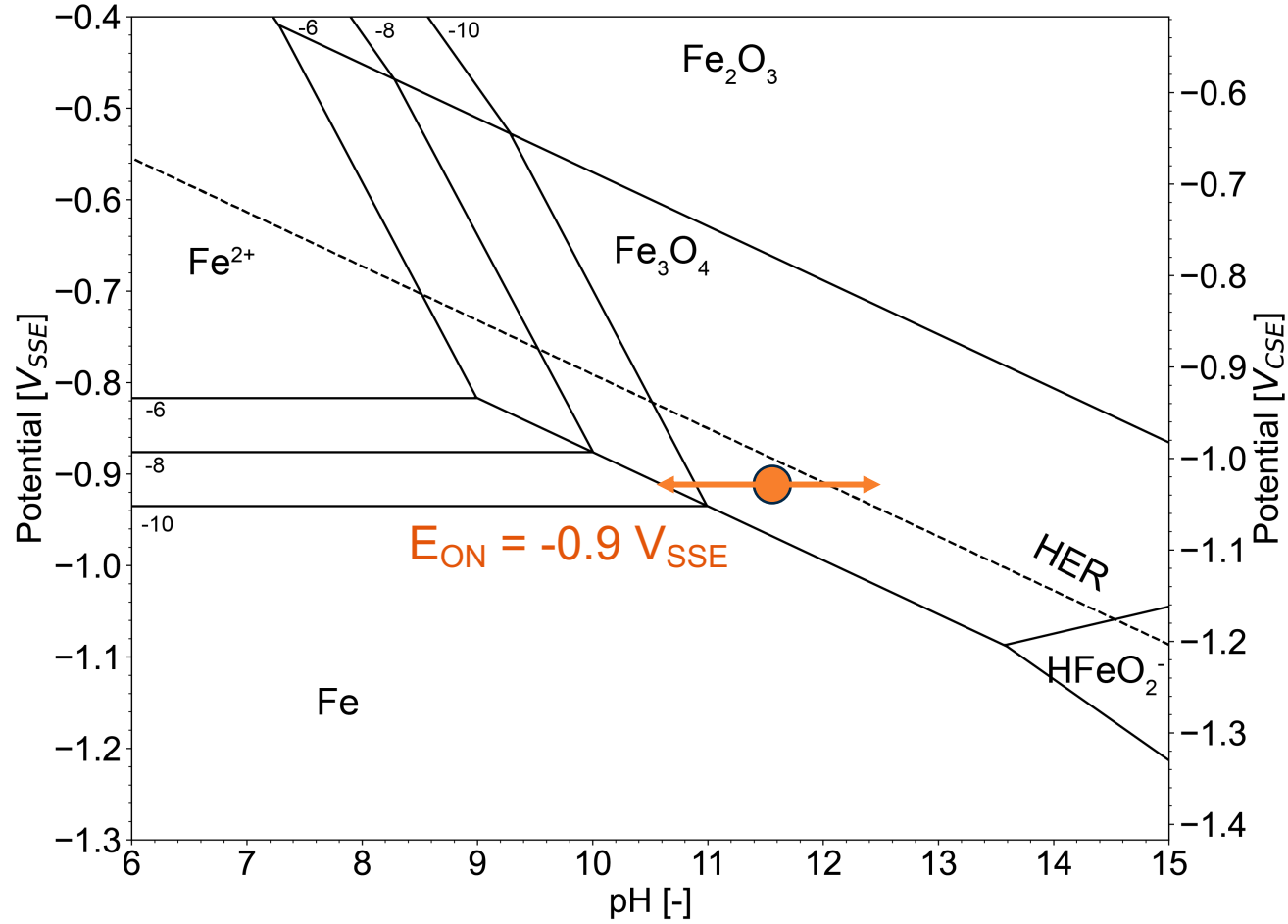


# Thermodynamic and kinetic considerations

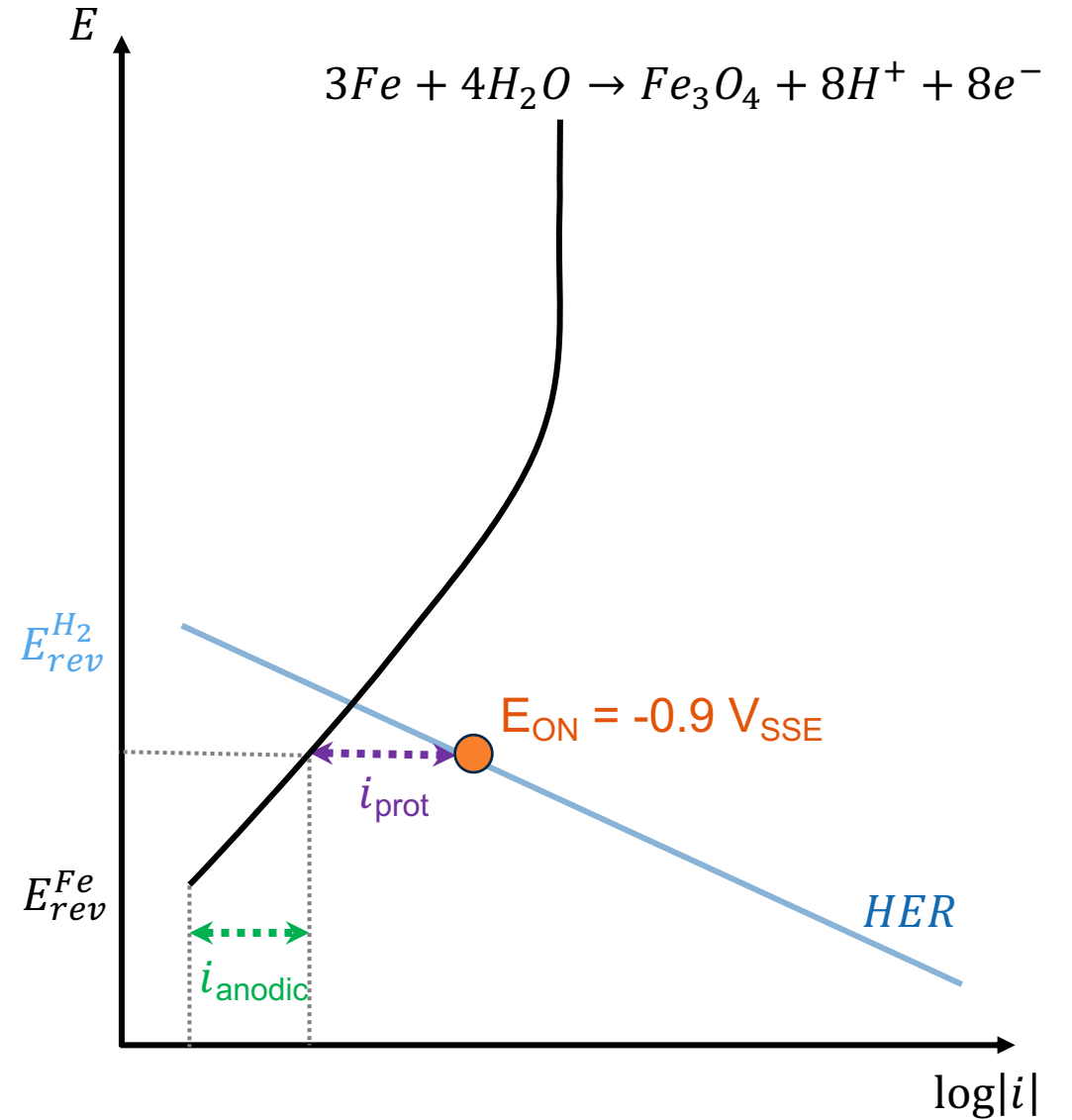
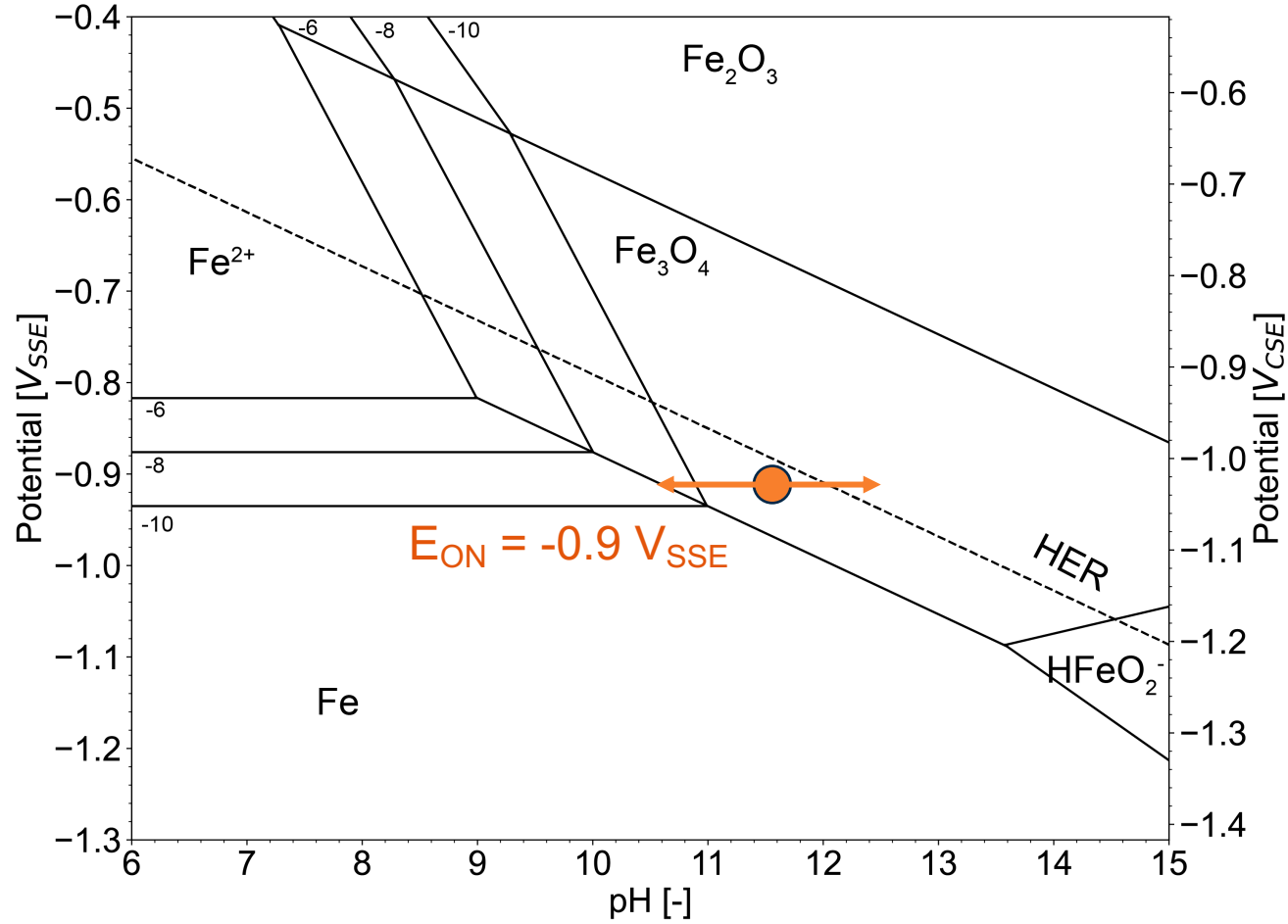




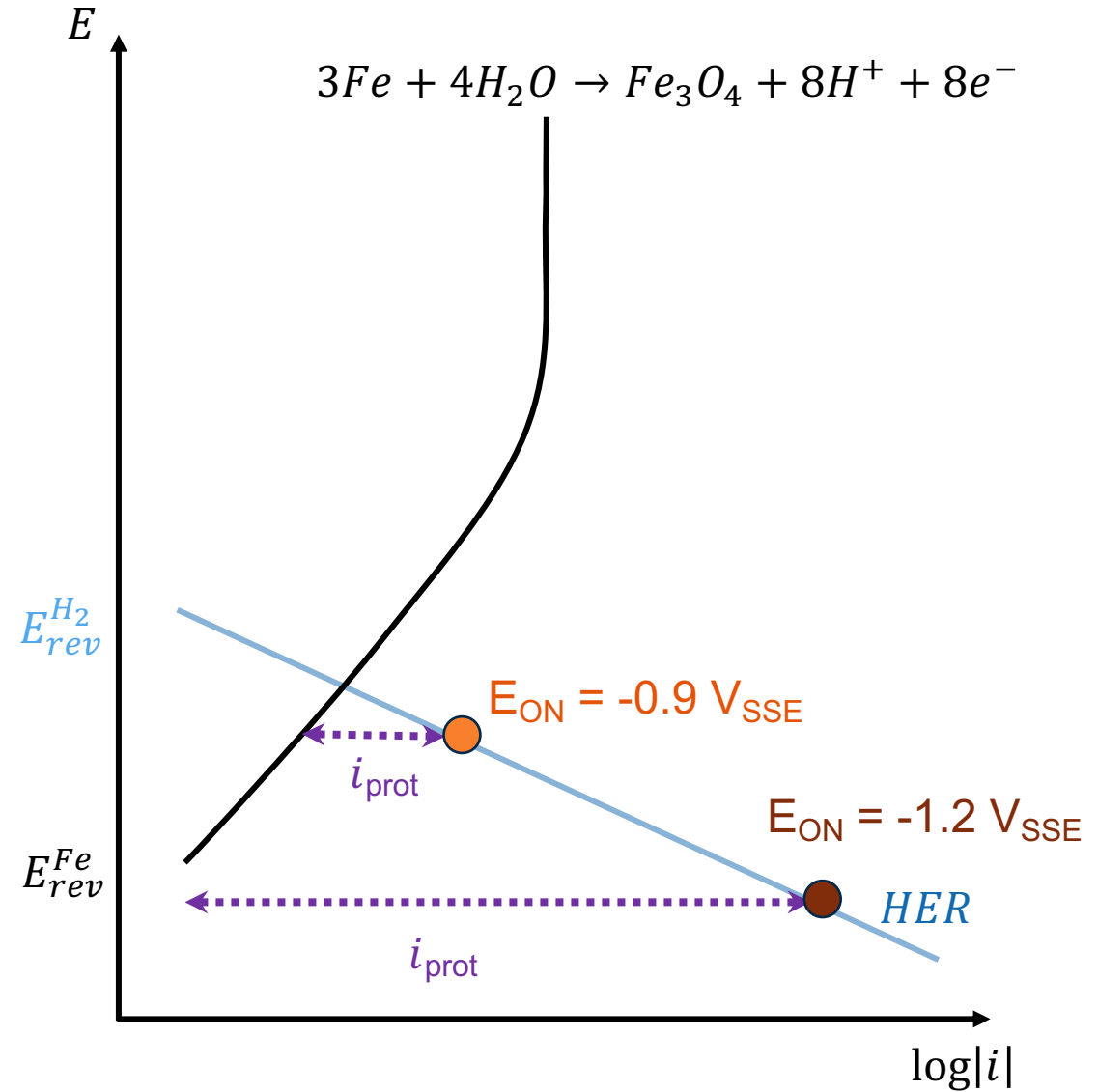
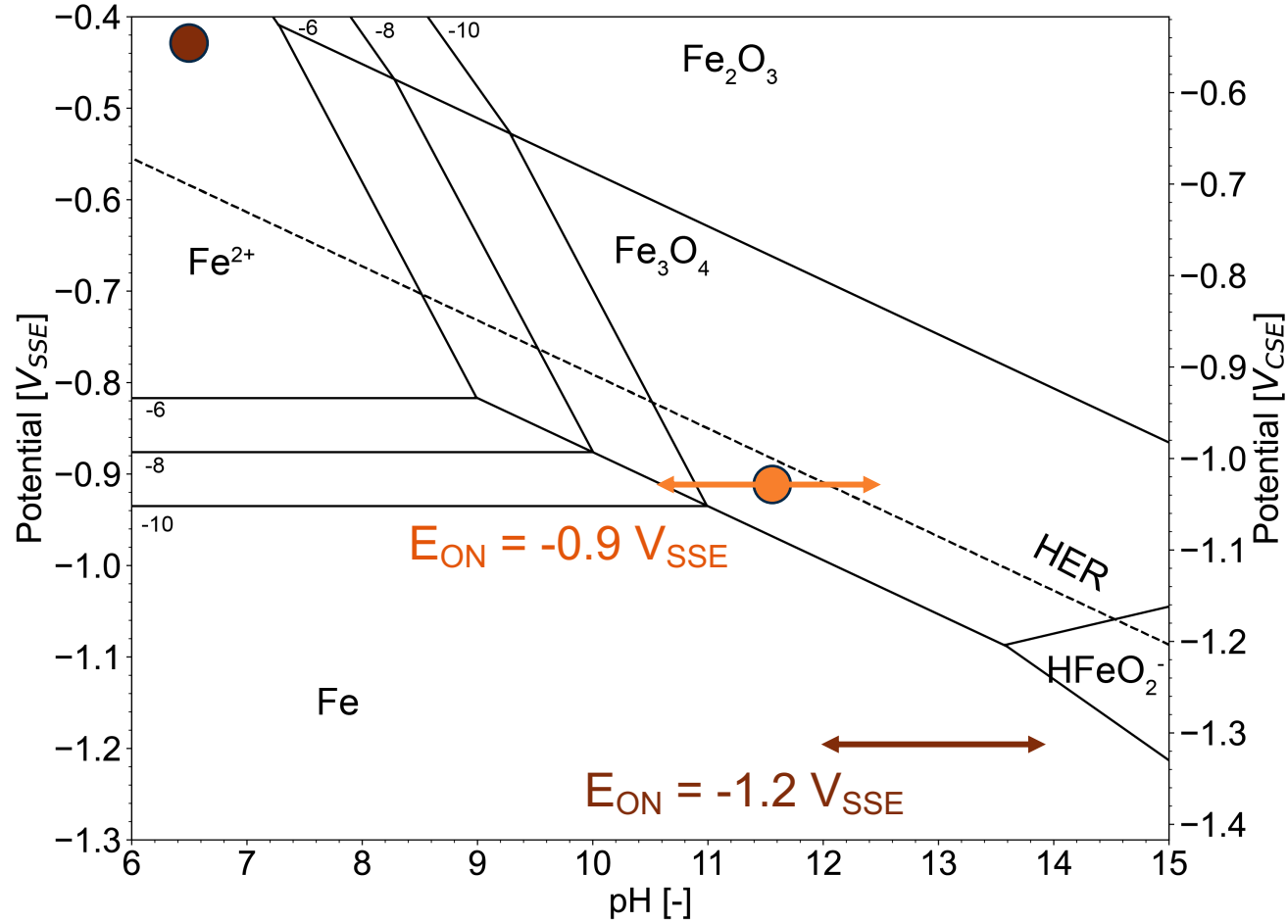
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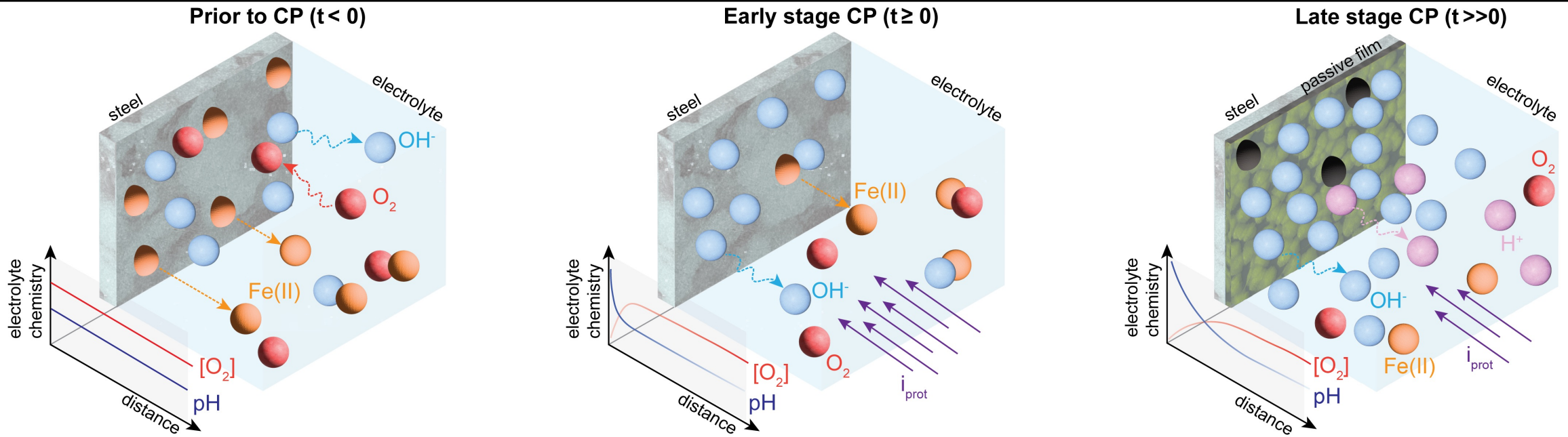
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# Thermodynamic and kinetic considerations



# Conclusions



Pre-print available at: <http://arxiv.org/abs/2308.15953>

- Concentration polarization and activation polarization considered complementary
  - **Mechanism** described by **thermodynamic** and **kinetics** considerations
  - Possible formation of **oxide film** (mainly based on  $\text{Fe}_3\text{O}_4$ )
- If **alkalinity** is produced and the **potential** is above  $E_{rev}^{Fe}$ , the **oxide film** can be formed
- **Thickness** of the film **increases** with the **time** of the experiment (up to 0.7 nm)

Thank you for your attention

Federico Martinelli-Orlando

[fmartine@ethz.ch](mailto:fmartine@ethz.ch)

[www.linkedin.com/in/f-martinelliorlando](http://www.linkedin.com/in/f-martinelliorlando)



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