Project 12: Electrochemical evaluation of catalyst material for PEM-fuel cell

TRA105 – Fuel Cell Systems || conducted with the **Physics Department – Division of Chemical Physics**

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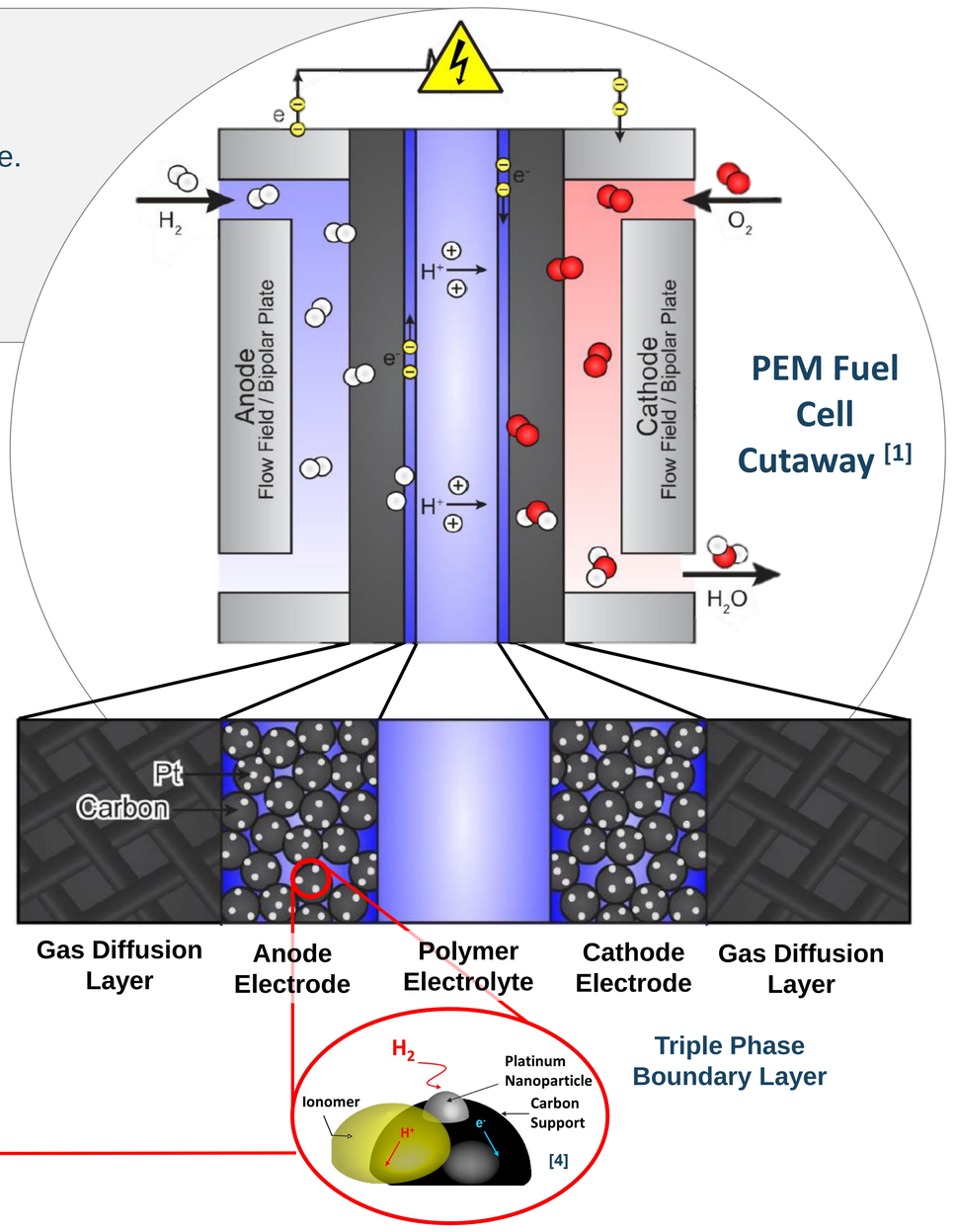
1. Introduction:

- **Aim:** Understanding the electron transfer processes and diffusion-convection kinetics of the anodic and cathodic reaction kinetics of a platinum (Pt - nanoparticle) - carbon catalyst for a PEMFC in acidic electrolyte.
- Characterizing anode (**H**ydrogen **O**xidation **R**eaction - **HOR**) and cathode (**O**xygen **R**eduction **R**eaction - **ORR**) reaction kinetics by performing **C**yclic **V**oltammetry (**CV**) at different mass flow rates using **R**otating **D**isk **E**lectrode (**RDE**).



PEM Fuel Cell Cutaway [1]

Triple Phase Boundary Layer

2. Background and Method:

Ink preparation

- Dilute 2 mg catalytic material (50% by wgt. Pt on C) in 1 ml H_2O + 1 ml ethanol solution, add 10 µl Nafion ® solution.

GCE preparation

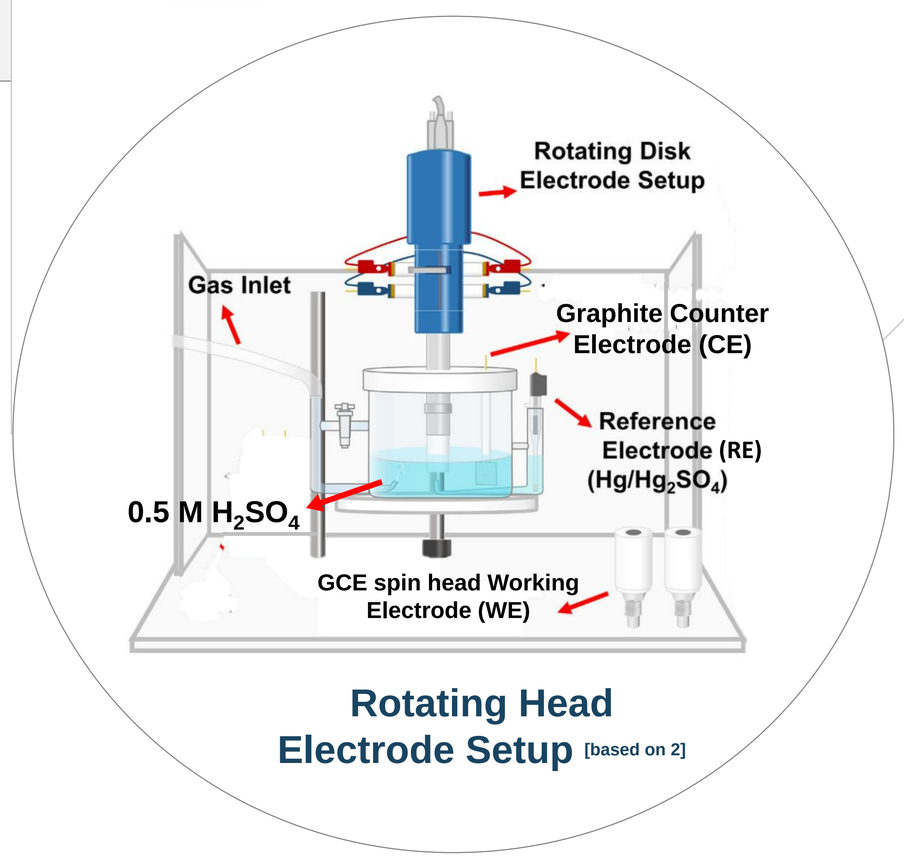
- Clean the **G**lassy **C**arbon **E**lectrode (**GCE**).
- Drop cast 2 x 10 µl of ink on the GCE and spin dry to achieve a loading of 10 µg/cm^2.

RDE setup

- Affix the GCE to the RDE with the fixture.
- Affix the Hg/$HgSO_4$ RE, the graphite CE & the gas supply.
- Fill 0.5 M H_2SO_4 electrolyte in the glass jacket.

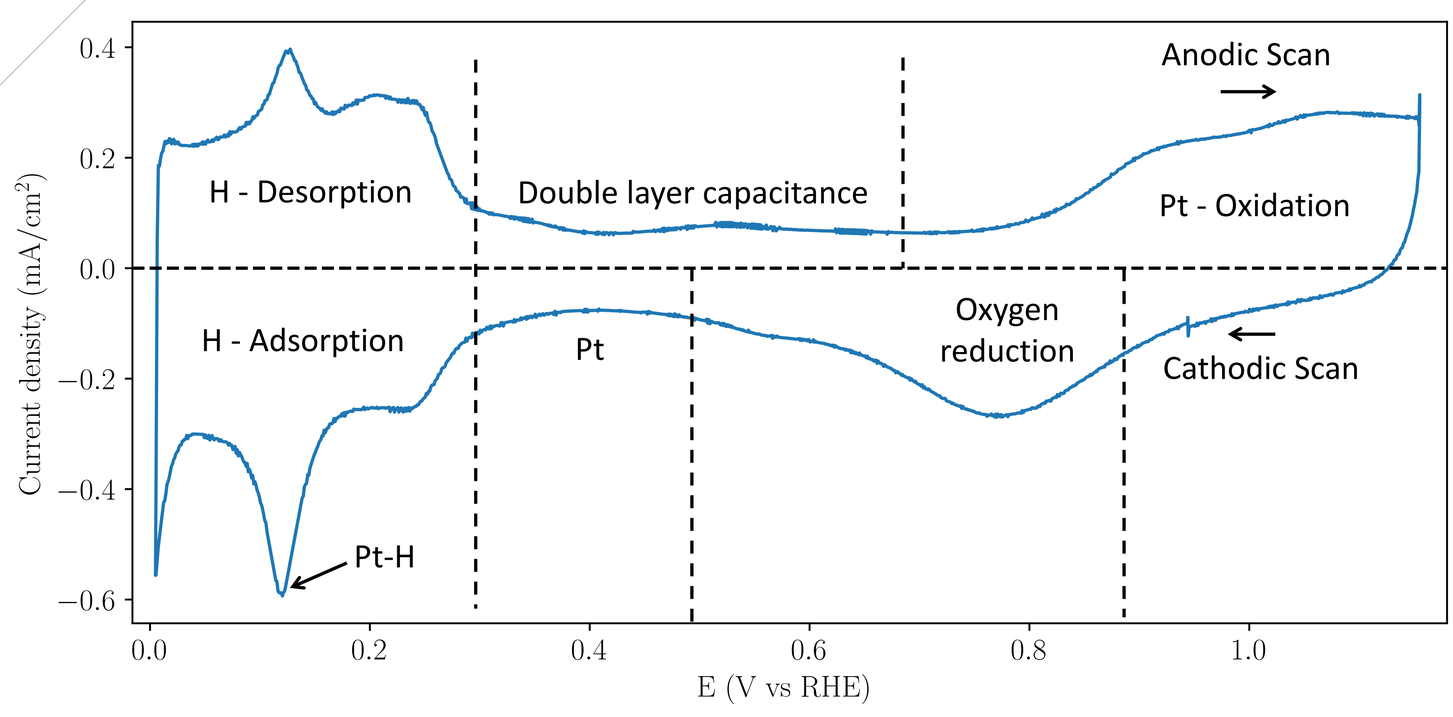
CV & surface area

- Saturate electrolyte with H_2 & O_2 and measure over different rpms.
- Calculate the **E**lectro**c**hemical **S**urface **A**rea (**ECSA**) with CO-stripping.

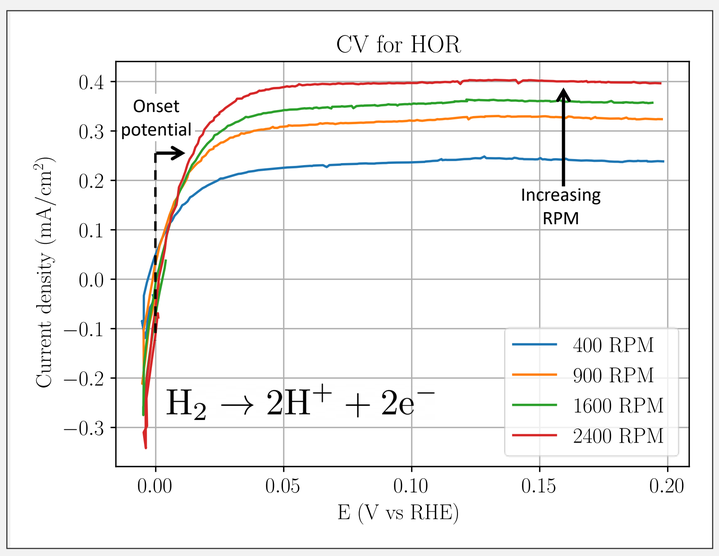


Rotating Head Electrode Setup [based on 2]

Typical CV of Polycrystalline Pt [based on 3]



3. Results:



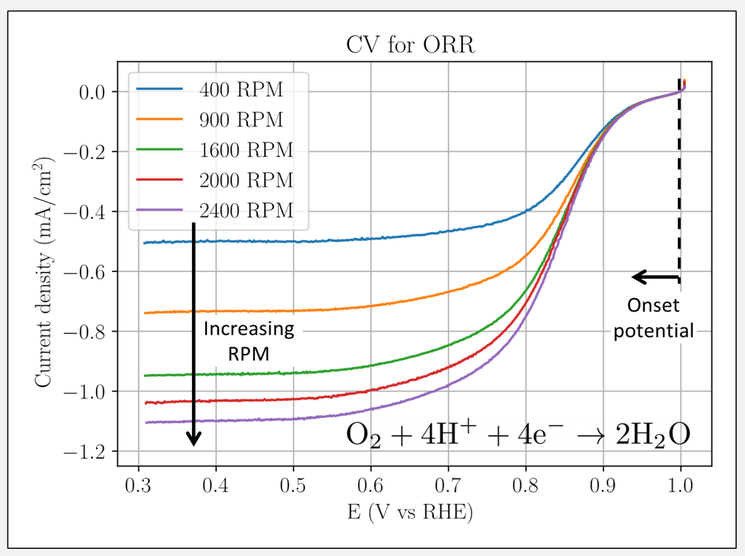
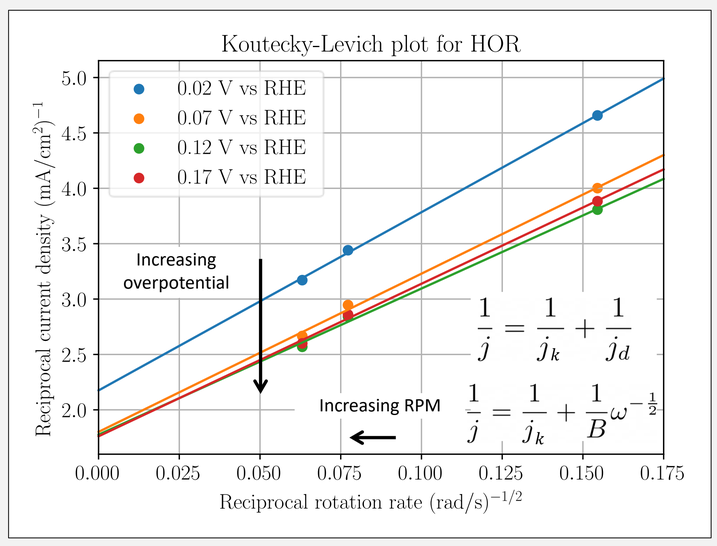
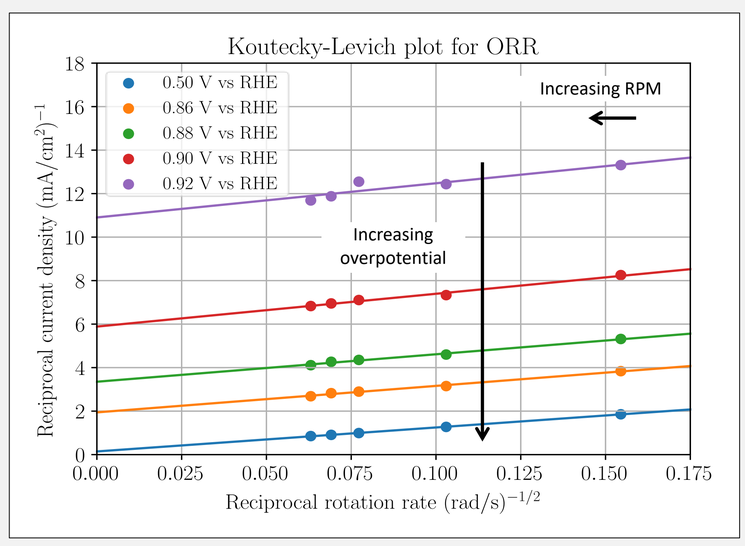


Table of Measurements:	ORR	HOR
Onset Potential (V_{RHE})	0.987	0.00035
Electrochemical Surface Area (cm^2) by CO-Stripping	1	1





4. Conclusions:

- We tested the influence of kinetics and mass transport limitations on the catalytic reactions.
- By increasing the rotational speed, we eliminated mass transport limitation and isolated the pure kinetics.
- The higher HOR activity is seen in the small onset potential (CV) and steeper slope (KL) compared to ORR, a sign that the ORR reaction is the limiting factor.
- However, the system that was tested was rather an individualized investigation of the two half cell reactions, useful to easily compare different catalytic materials and is not directly comparable to a fuel cell.

Resources and Citations: Gerard Montserrat Siso. “Electrocatalyst materials for low-temperature hydrogen fuel cells”. Chalmers, Physics, Chemical Physics, https://research.chalmers.se/en/publication/523045; Linnéa Strandberg. “ Electrode Degradation in Polymer Electrolyte Fuel Cells”. Chalmers, Physics, Chemical Physics; [1] PEMFC Cutaway and MEA image, Igor Zoric, Chalmers, Applied Physics; Laboratory Images, Chalmers, Chemical Physics.; [2] Rotating Head Electrode Setup image, https://www.researchgate.net/figure/Sketch-of-typical-rotating-disk-electrode-setup-Pine-Research-PHYCHEMi-US-for-ORR_fig1_354096593; **[3]** Typical CV of Polycrystalline Pt image, Linnéa Strandberg. “ Electrode Degradation in Polymer Electrolyte Fuel Cells”. Chalmers, Physics, Chemical Physics; [4] Triple Phase Pt-C image, https://www.researchgate.net/figure/Schematic-representation-of-the-triple-phase-boundary-at-the-anode-side-PEM-proton_fig7_350688294.