EFFECT OF INTERFACIAL MASS TRANSPORT LOSSES AT THE ULTRATHIN FILM CATALYST LAYER TO DIFFUSION LAYER OF A PEMFC AT SUB-ZERO CONDITIONS.

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Introduction

The cost of catalyst in polymer electrolyte membrane fuel cell (PEMFC) is being reduced by increasing the activity and reducing the loading from 0.4 mg^{Pt}/cm^2 to below 0.1 mg^{Pt}/cm^2. This results in nominal operational mass transport losses at the diffusion media/catalyst layer interface[1]. Mass transport of dilute O_2 at the interface between cathode catalyst layer (CCL) and gas diffusion layer (GDL).

At -20° C, O_2 concentration dependent voltages and hydration dependent ionic conductivity will be assessed. In this work, the interfacial losses at the interface of the ultra-thin film catalyst layers will be investigated. We wish to establish the relationship between different carrier gasses and diffusivity of O_2 at the gas diffusion layer. This work is on understanding ice formation mechanism in PEMFC at sub-zero temperature.

Fixture and Experimental

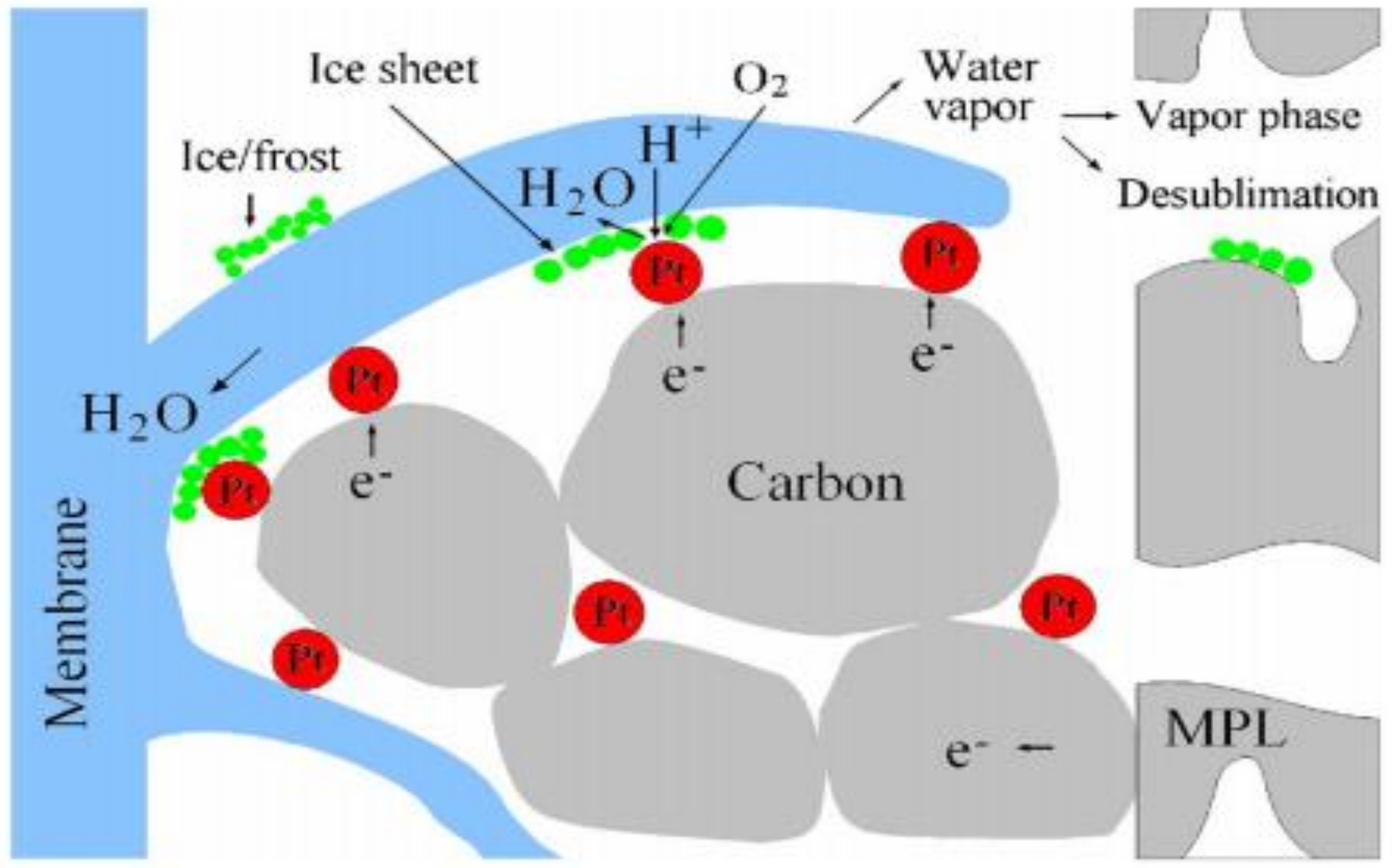
Fuel Cell Fixture

1. 16cm^2 triple pass serpentine flow fields (3/16" thick).
2. Catalyst: 0.3mg^{pt}/cm^2, 1.2ionomer-carbon ratio, Nafion 212 membrane. Ion Power SGL25BC.

Isothermal Water Fill Test

- Operate the cell at $T_{cell} = 80^0$C, 42% relative humidity (%RH) for 10 polarization curves.
- %RH condition to 75% with inert gas at $T_{cell} = 80^0$C.
- Freeze cell to -20^0C.
- Cold start: $T_{cell} = -20^0$C, I = 10mA/cm^2. Flowrate = 0.05lpm| 0.1lpm at the anode (H_2) and cathode (O_2) respectively.

Schematic of ice formation and microscale distribution in the cathode catalyst layer.[2]



Freeze pre-conditioning

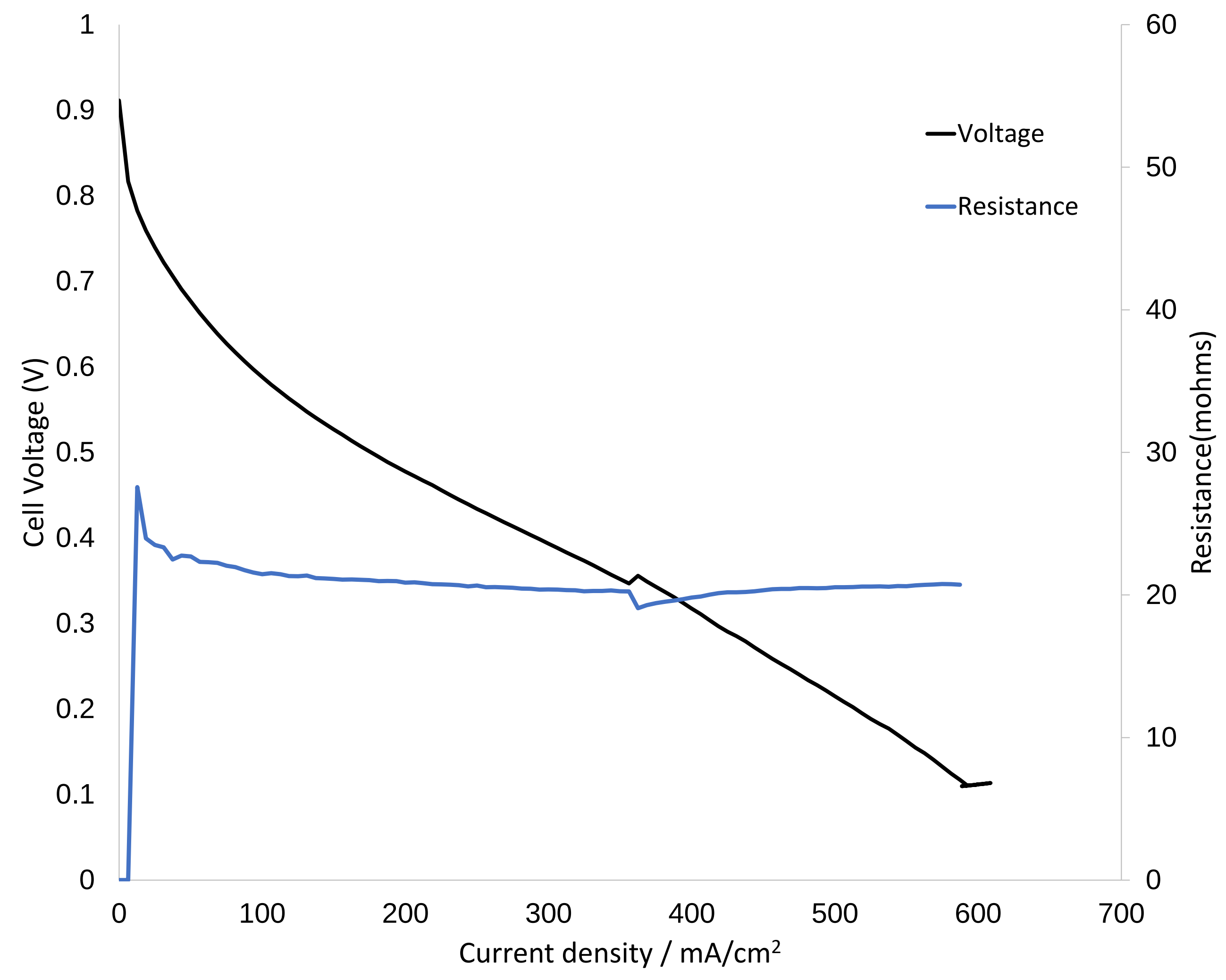


Fig 1 : Polarization at $T_{cell} = 80^0$C, 42% RH, stoichiometry = 2

- Preconditioning cell to stable performance by polarization.
- Resistance is low indicating good cell performance.
- Minimal mass transport losses.
- Activation losses impacts the performance of fuel cell.

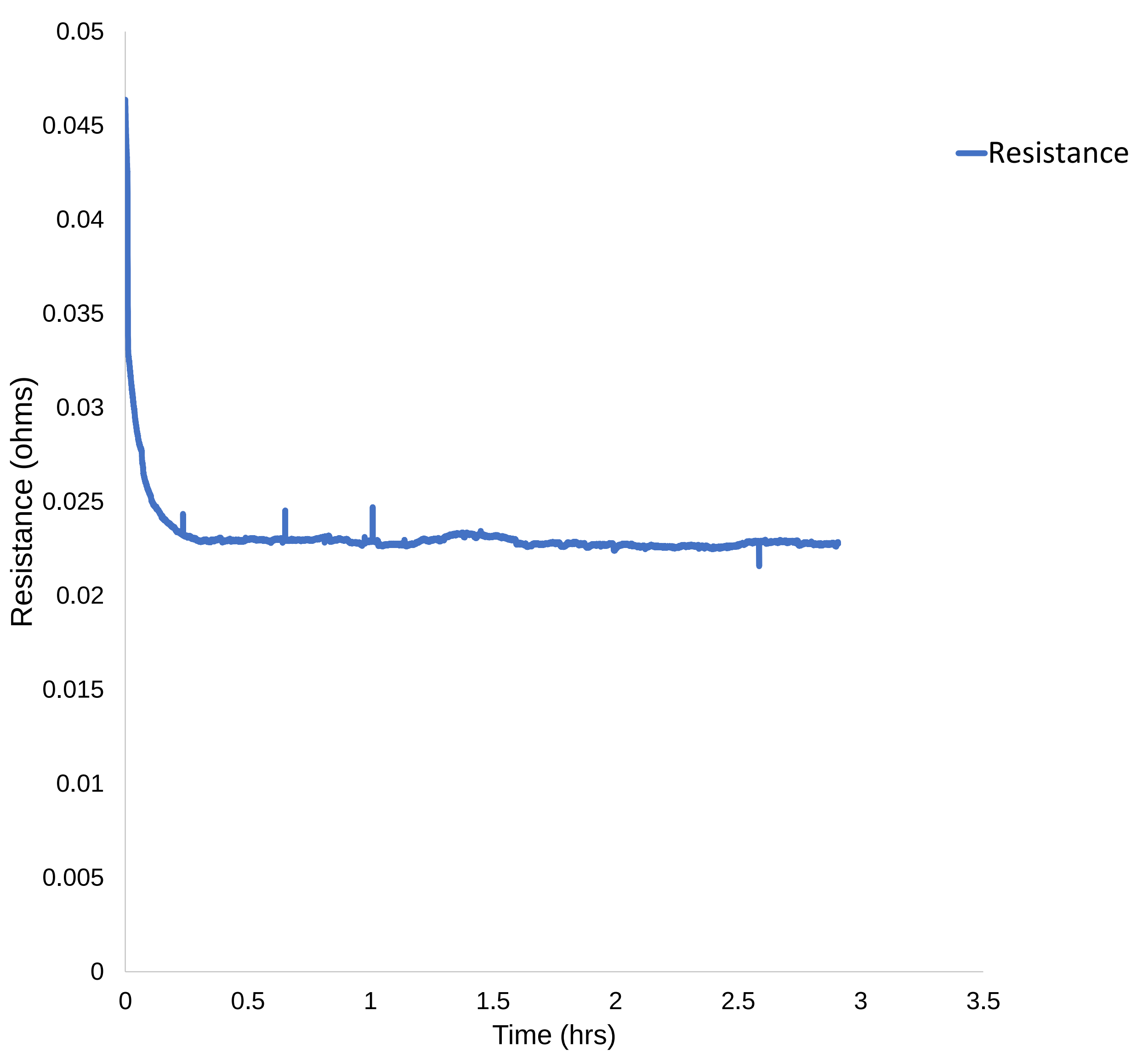


Fig 2 : Cell equilibrium conditioning $T_{cell} = 80^0$C, 73% RH.

- Water removed from GDL and flow channels.
- Water removed from open pores in the agglomerates
- MEA initial water content conditioned to 6 (ionomeric).
- Anode and cathode ionomer water content at equilibrium.

Isothermal Water Fill Test at -20^0C

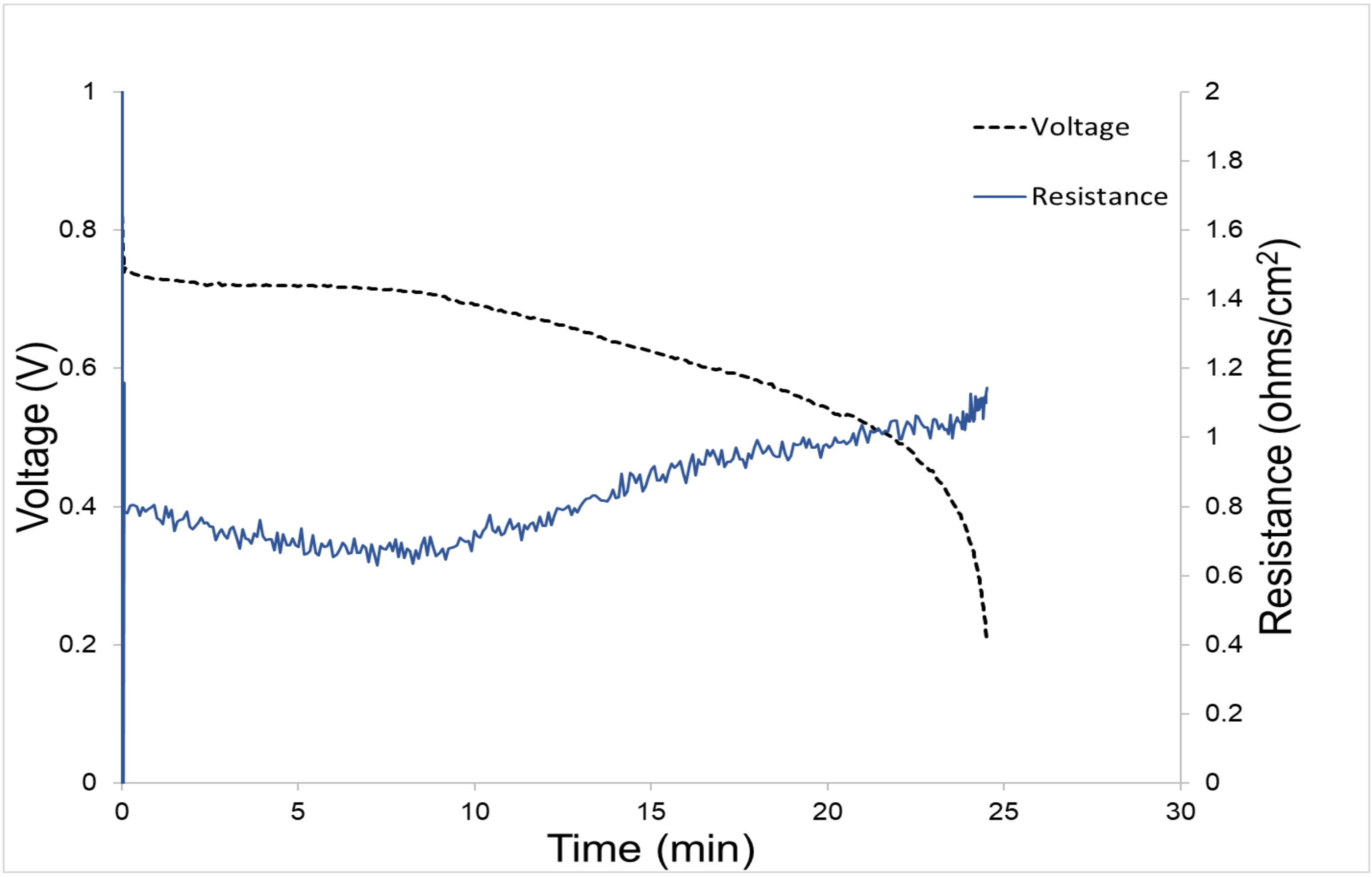


Fig 3 : Isothermal cold start at 10mA/cm^2 at $T_{cell} = -20^0$C.

- Membrane rehydration absent due to saturation of ionomers before cold start.
- Cell shut down due to ice accumulation in open pores.
- High mass transport resistance results from ice accumulation in open pores.
- Extended time onload due to water redistribution at low current density[3].

Conclusion and Future Work

Conclusion:

- %RH removes water from the pores, GDL and flow channels allowing only water in the ionomers of the MEA.
- Ice accumulation leads to mass transport resistance which ultimately shuts down the cell at subzero temperature.

Future Work:

- Cyclic voltammogram for active area measurements.
- Electrochemical impedence spectroscopy to quantify the resistance at the thin film interface between the CL and GDL.
- Fuel Cell testing with different diluents and different oxidant concentration.

References

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