Study on freezing phenomena in PEFC below freezing

research report

M1, Ryosuke ICHIKAWA
Technical problems

Dry-out: Increasing membrane resistance due to dehydration in MEA
Flooding: Obstructing gas supply by condensed water
Freezing: Obstructing gas supply by freezing produced water
High cost: Using platinum catalyst and exhaustion of resources
Infrastructure improvement: Building the hydrogen station
We want to clarify the freezing mechanism in PEFC
  ・ In particular, relationship between freezing point or timing, amount & cell performance

PEFC operation starts at below freezing
PEFC shuts down due to freezing produced water
Freezing induces extreme deterioration of cell performance
Experimental method

- Investigate the effect of freeze damage on the normal operation
- Observe the surface of Catalyst Layer by Optical Microscope
- Observe the cross section of Catalyst Layer by Cryo-SEM
Effect of cold start-up temp.

-10°C start
-20°C start

Current density = 0.04 A/cm²
Cell temp. = -10, -20°C
non-humidified gas
Anode H₂: 140sccm
Cathode Air: 330sccm

Current density = 0.5 A/cm²
Cell temp. = 30°C
humidified gas (RH=75%)
Anode H₂: 500sccm
Cathode Air: 2000sccm

Freezing mechanism & the normal operation after cold start are affected by cold start-up temp.
Factors of affecting normal operation

We concluded that ice between CL & MPL affects the normal operation after cold start. However, we found some results that could defeat our hypothesis.
We have to investigate the factors that can affect the normal operation after cold start with MPL group.
Effect of cold-start cycle

- **Drop-in** deterioration: *Flooding* induced by retention of melt ice
- **Permanent** deterioration: *Collapse* of CL formation

I am noting that the relation may exists

![Graphs showing voltage and resistance changes over time during cold-start cycle.](image)

- Regular Operation
- Deteriorate
- Expand of CL/MPL interface?
- Cracks of CL surface?
- Contingency?

-10°C start
To clarify the factors of drop-in deterioration with MPL group
To consider the novel observation method
To make new model for current density distribution in CL to estimate the regions where the water produces in detail with Nishino-san
Observation by Cryo-SEM
To clarify the relationship between drop-in & permanent deterioration