

Complex Coolant Fluid for PEM Fuel Cell Systems

Satish C. Mohapatra

Advanced Fluid Technologies, Inc.
dba Dynalene Heat Transfer Fluids

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**Project ID #
FCP 21**

Overview

Timeline

For SBIR Phase I Project

- Project start date: 07-14-2004
- Project end date: 04-13-2005
- Percent complete: 100%

Budget

- Total project funding
 - DOE share: \$97,390
 - Contractor share: in-kind
- Funding received in FY04: \$51,114.75
- Funding received in FY05: \$46,275.25

Barriers

- Barriers addressed
 - Technical Barriers (stability of the coolant at high temperatures and over a period of time)
 - Cost Barriers (preliminary cost estimates)

Partners

- Interactions/
collaborations:
Lehigh University

Objectives

- **Prove that we can fully develop and validate a fuel cell coolant based on glycol/water mixtures and an additive package (with nanoparticles) that will exhibit less than 2.0 $\mu\text{S}/\text{cm}$ of electrical conductivity for more than 3000 hours in an actual PEM Fuel Cell System.**
- **Demonstrate the potential for commercializing such a coolant at a price that is acceptable for a majority of fuel cell applications (i.e., < \$8.0/gallon).**

Key Technical and Economic Questions to be Answered

- **How is the electrical conductivity of the coolant related to the properties of the additives?**
- **Will the additives influence the heat transfer and pressure drop characteristics of the coolant?**
- **Is the coolant and its additives compatible with the fuel cell cooling system components?**
- **What is the raw material and production cost for the proposed 'Complex Coolant Fluid'?**

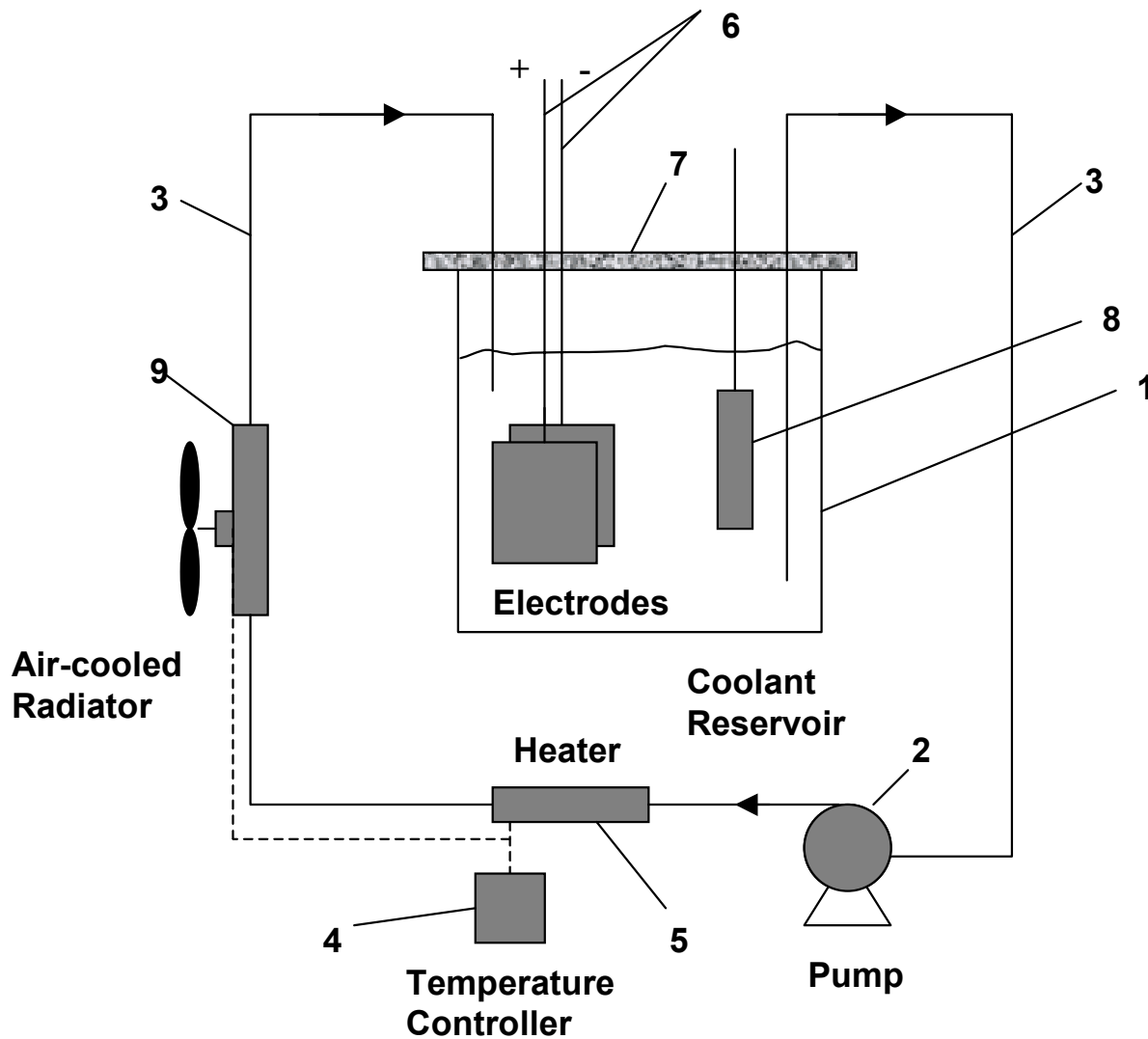
Approach

- **The proposed Complex Coolant Fluid consists of a base compound (glycol/water mixtures) and an additive package.**
- **The base compound mixture has a freezing point less than -40°C , is non-flammable, and can be used at temperatures up to 122°C .**
- **The additive package consists of non-ionic corrosion inhibitors and ion-suppressing compounds (nanoparticles) to maintain the electrical conductivity of the coolant at a low level.**

Technical Approach in Phase I

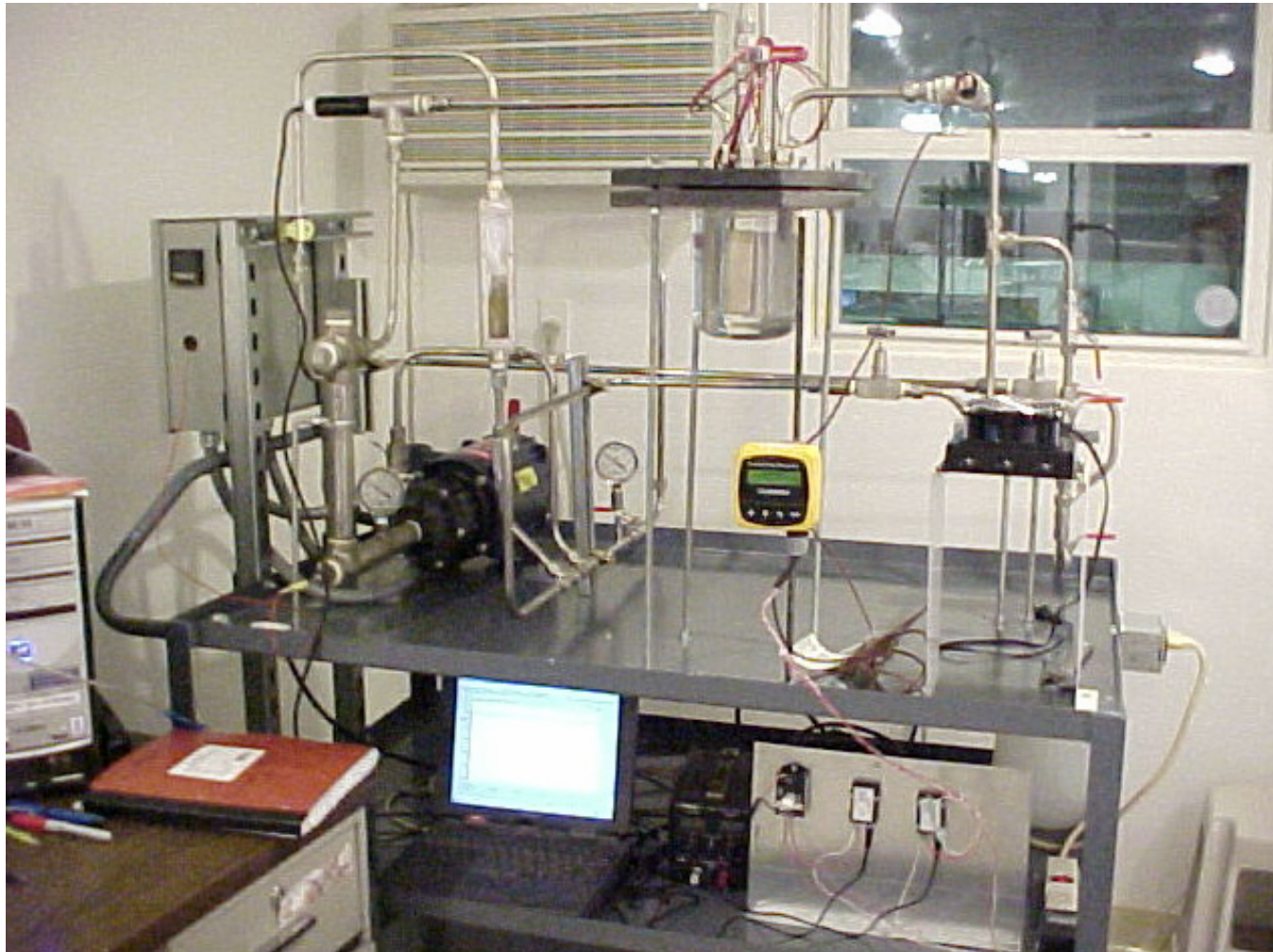
- Development of the ion-suppressant (nanoparticles)
 - Effect of preparation recipe on the electrical conductivity of the final coolant formulation
 - Study dispersion behavior in the coolant
- Building a dynamic test loop (4 L)
 - Short-term tests (electrical cond. Vs. time)

Dynamic Test Loop for Coolant Testing

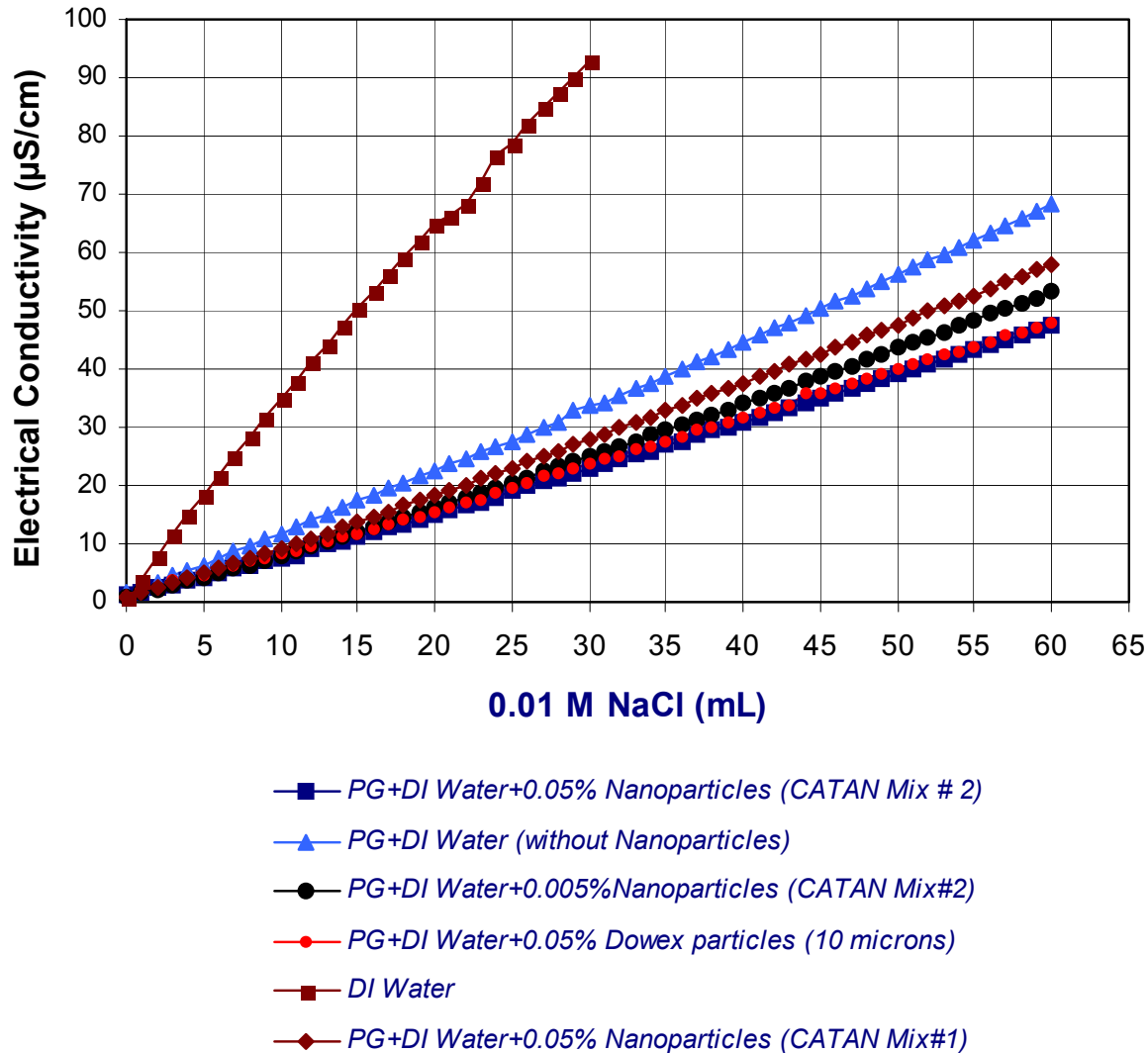


- 1: Coolant Reservoir
 - 2: Pump
 - 3: Piping
 - 4: Temperature Controller
 - 5: Heater
 - 6: Electrodes
 - 7: Head
 - 8: Probes for pH and cond.
 - 9: Radiator
- (total system volume: 4 L)

Dynamic Test Loop for Coolant Testing

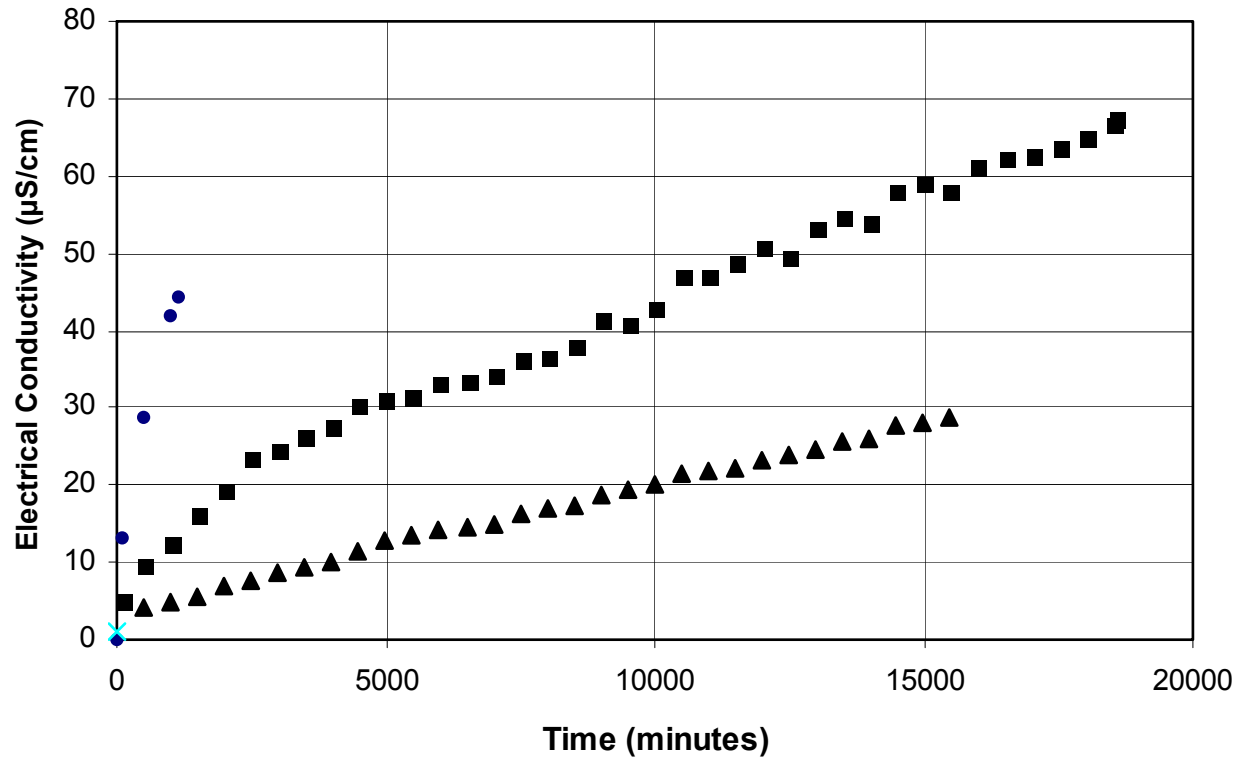


Results from Phase I



- Titration tests were conducted with 0.01 molar NaCl solution.
- Electrical conductivity increased with the addition of NaCl solution for all the formulations.
- The coolant formulation with nanoparticles showed much lower increase than DI water or glycol/water.

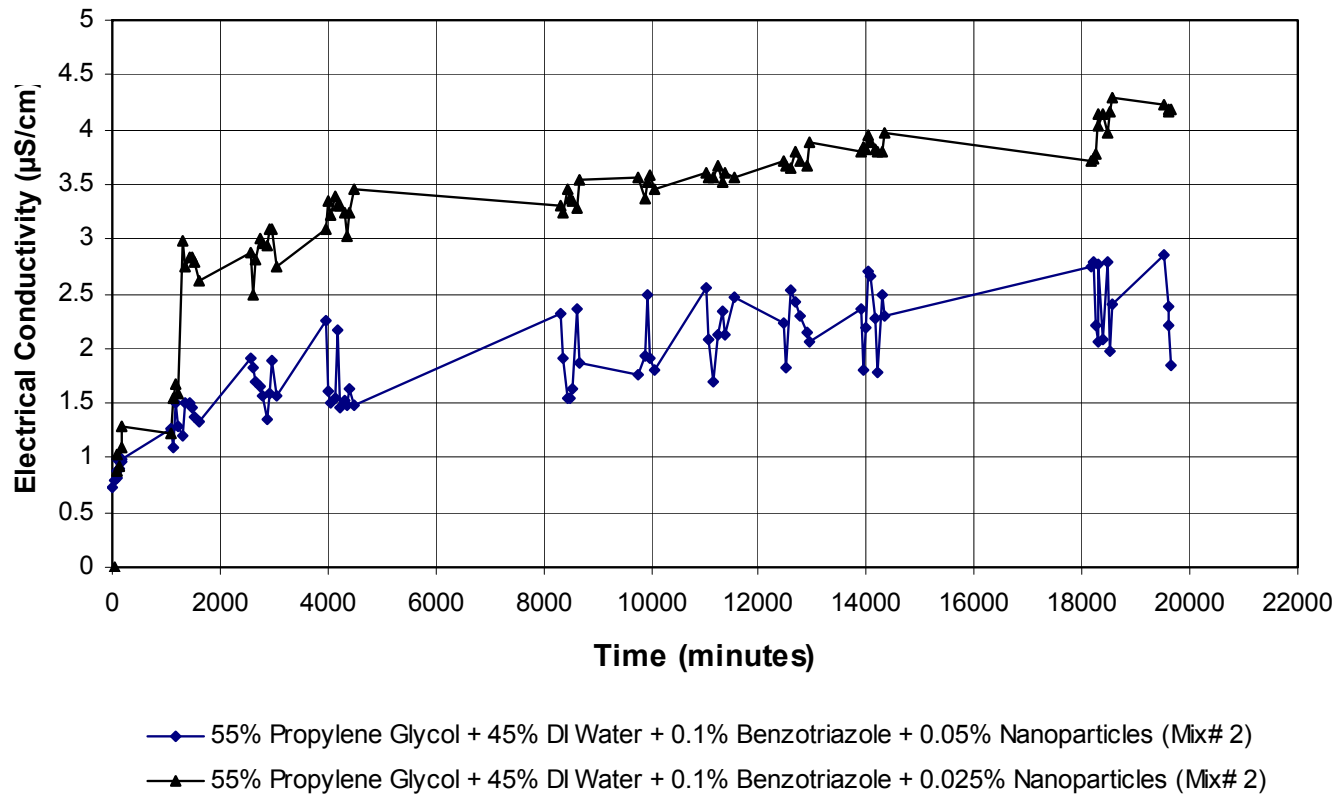
Results from Phase I



Tested in the Dynamic Test Loop (4 L volume) At 55 °C.

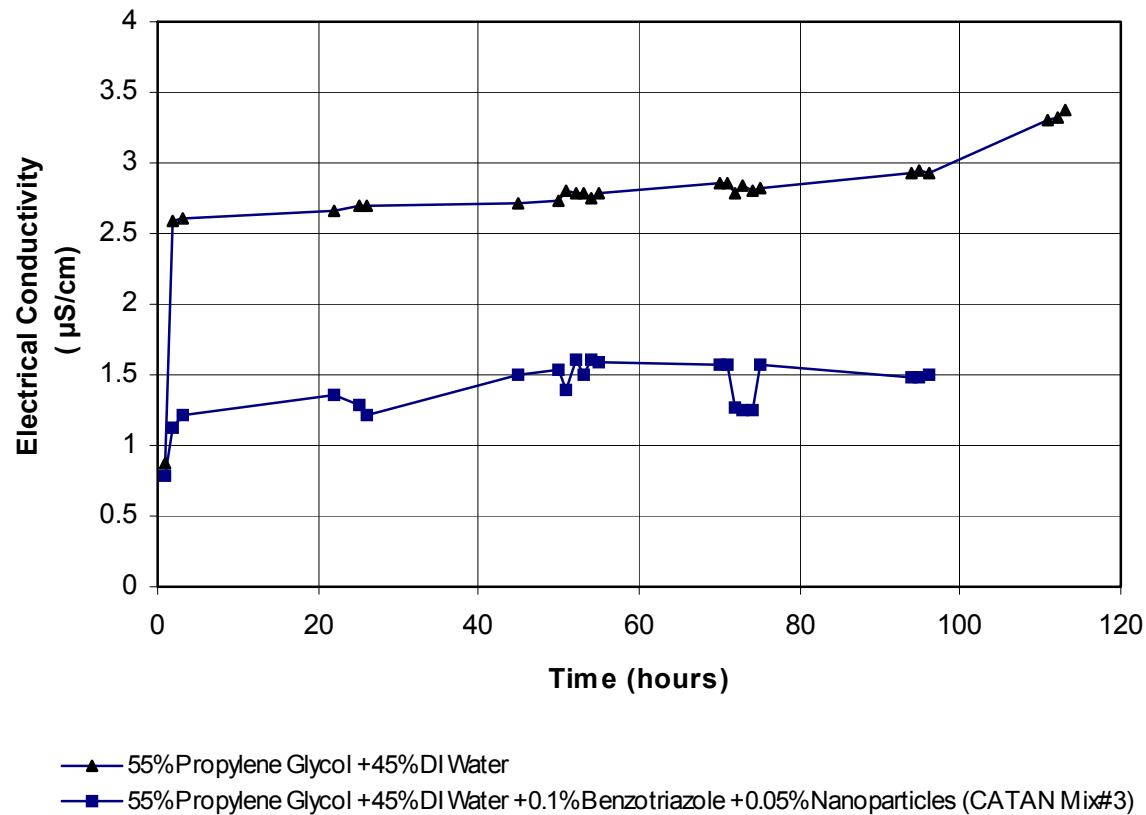
- 55% Propylene Glycol + 45% DI Water
- ▲ 55% Propylene Glycol + 45% DI Water + 0.1% Benzotriazole + 0.025% Nanoparticles (CATAN Mix# 2)
- DI Water

Results from Phase I



Electrical Conductivity vs. Time for the Coolant Formulations in a 1 L Dynamic Test Loop at 70°C

Results from Phase I



Electrical Conductivity vs. Time for the Coolant Formulations in a 1 L Dynamic Test Loop at 70°C

Discussion

- **With CATAN Mix # 1, the nanoparticles remained dispersed, making a uniform colloidal suspension. But the electrical conductivity was high ($> 3.0 \mu\text{S/cm}$)**
- **With CATAN Mix # 2, the nanoparticles coagulated. But the electrical conductivity was lower than $1.0 \mu\text{S/cm}$.**
- **With CATAN Mix # 3, the nanoparticles could be dispersed in the coolant with the help of a sonicator, and the conductivity stayed lower than $1.0 \mu\text{S/cm}$.**

Conclusions

- **The Phase I research demonstrated the feasibility of utilizing nanoparticles in a glycol/water coolant mixture.**
- **The electrical conductivity of a complex coolant formulation stayed below 2.0 $\mu\text{S}/\text{cm}$ for more than 300 hours in short-term tests in a dynamic loop.**
- **Preliminary economic evaluation suggests that the cost of the coolant could meet the target selling price of < \$8.0/gallon.**

Future Work

- **In Phase II of the SBIR project, the additive package will be optimized**
- **Several non-ionic corrosion inhibitors will be evaluated**
- **Electrodeposition rate of additives on the electrode surfaces will be determined**
- **Material compatibility tests will be carried out**
- **Optimized coolant will be tested in real fuel cell systems**
- **Cost of the coolant will be evaluated**

Publications and Presentations

- None during SBIR Phase I
- Before the SBIR Project
 - “Electrically Resistive Coolants for PEM Fuel Cells”, S. Mohapatra, presented at the Fuel Cell Seminar, Palm Springs, CA, Nov 16-19 (2002)
 - “Fuel Cell and Fuel Cell Coolant Compositions”, US, Canada and EU Patent Application pending (2002).

Hydrogen Safety

The most significant hydrogen hazard associated with this project is:

N/A (Complex Coolant Fluid development project does not use hydrogen)

Hydrogen Safety

Our approach to deal with this hazard is:

N/A

Questions?

- Contact: Dr. Satish Mohapatra (PI)
 - (610) 262-9686, satishm@dynalene.com
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