Complex Coolant Fluid for PEM Fuel Cell Systems

Satish C. Mohapatra

Advanced Fluid Technologies, Inc.
dba Dynalene Heat Transfer Fluids

05-24-2005

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 μS/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

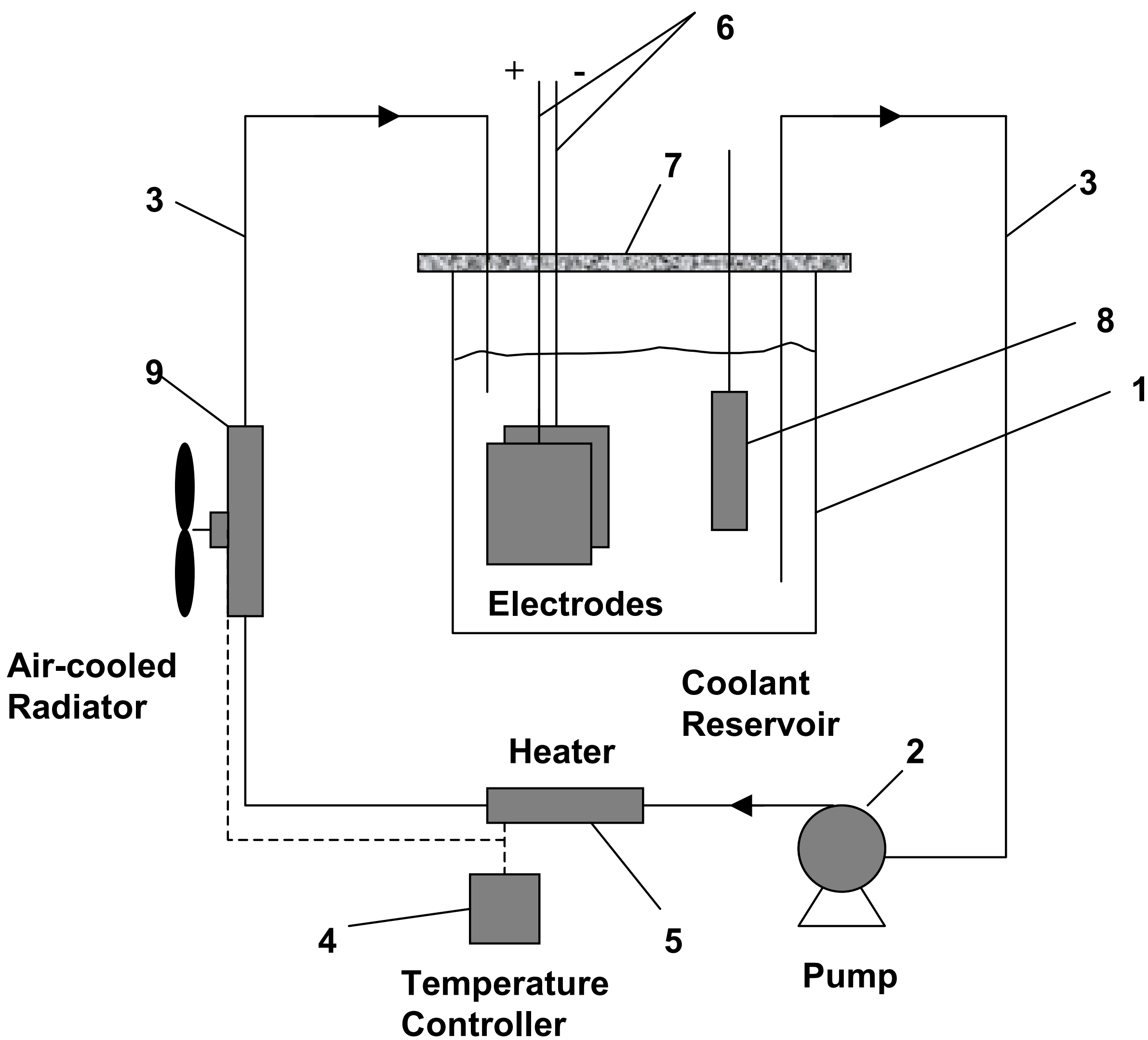
- The proposed Complex Coolant Fluid consists of a base compound (glycol/water mixtures) and an additive package.
- The base compound mixture has a freezing point less than –40^{o}C, is non-flammable, and can be used at temperatures up to 122^{o}C.
- The additive package consists of non-ionic corrosion 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)

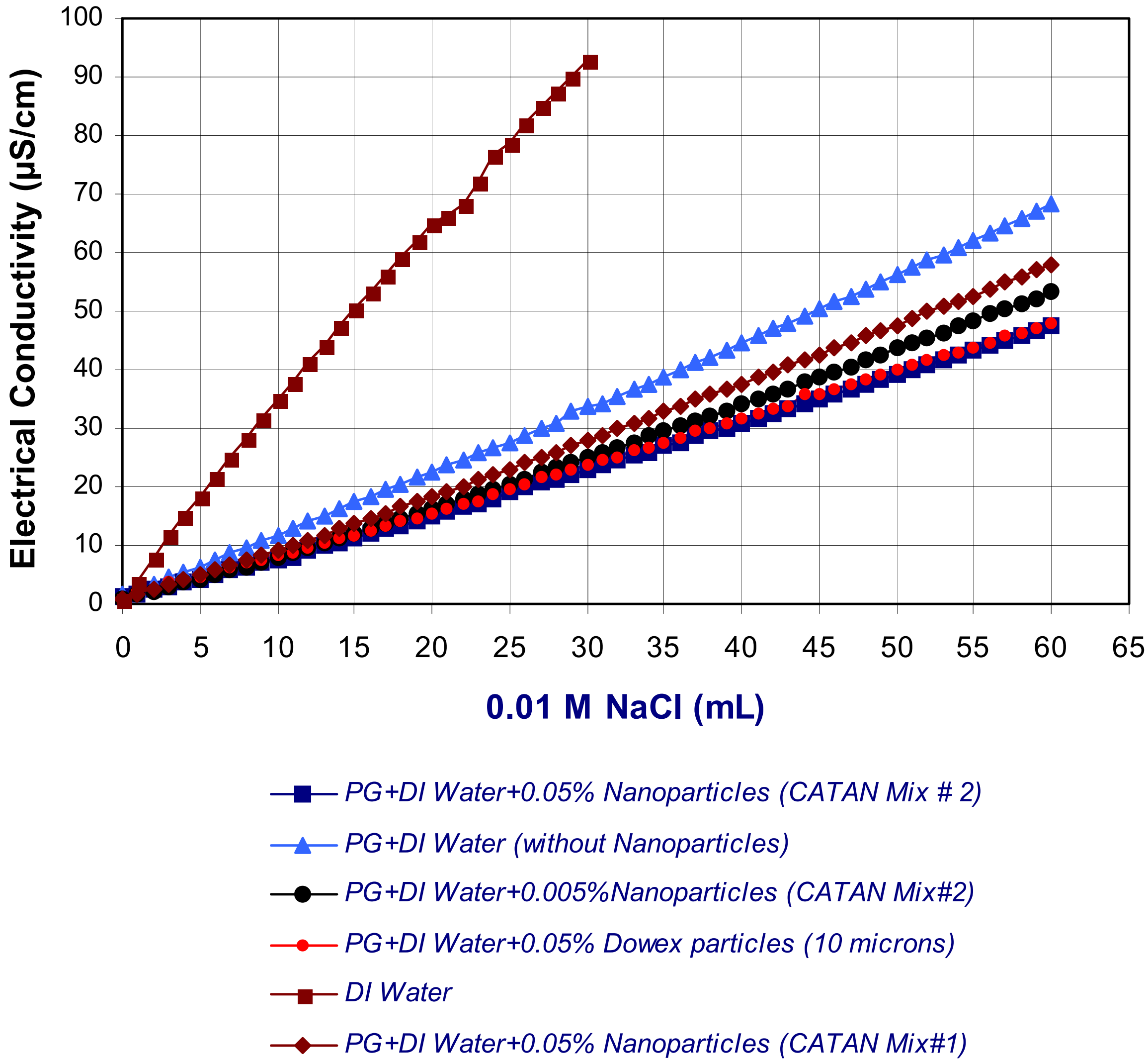
Dynamic Test Loop for Coolant Testing



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)

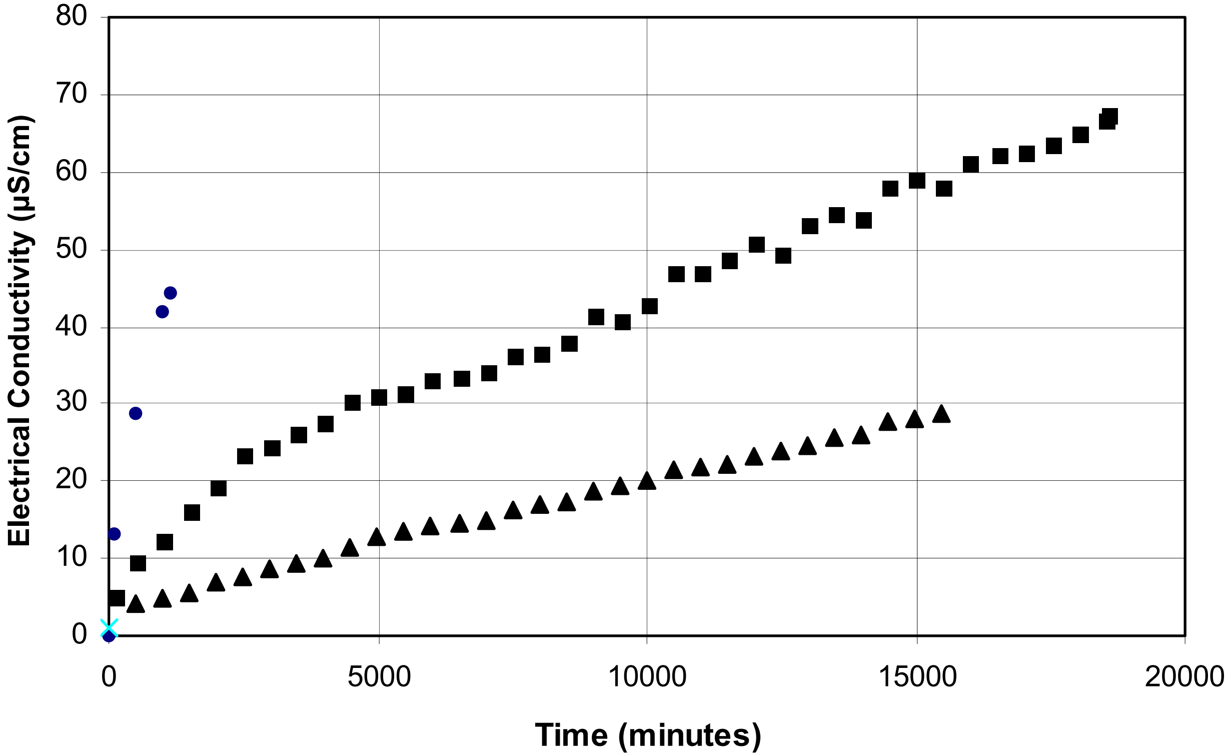
Dynamic Test Loop for Coolant Testing

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



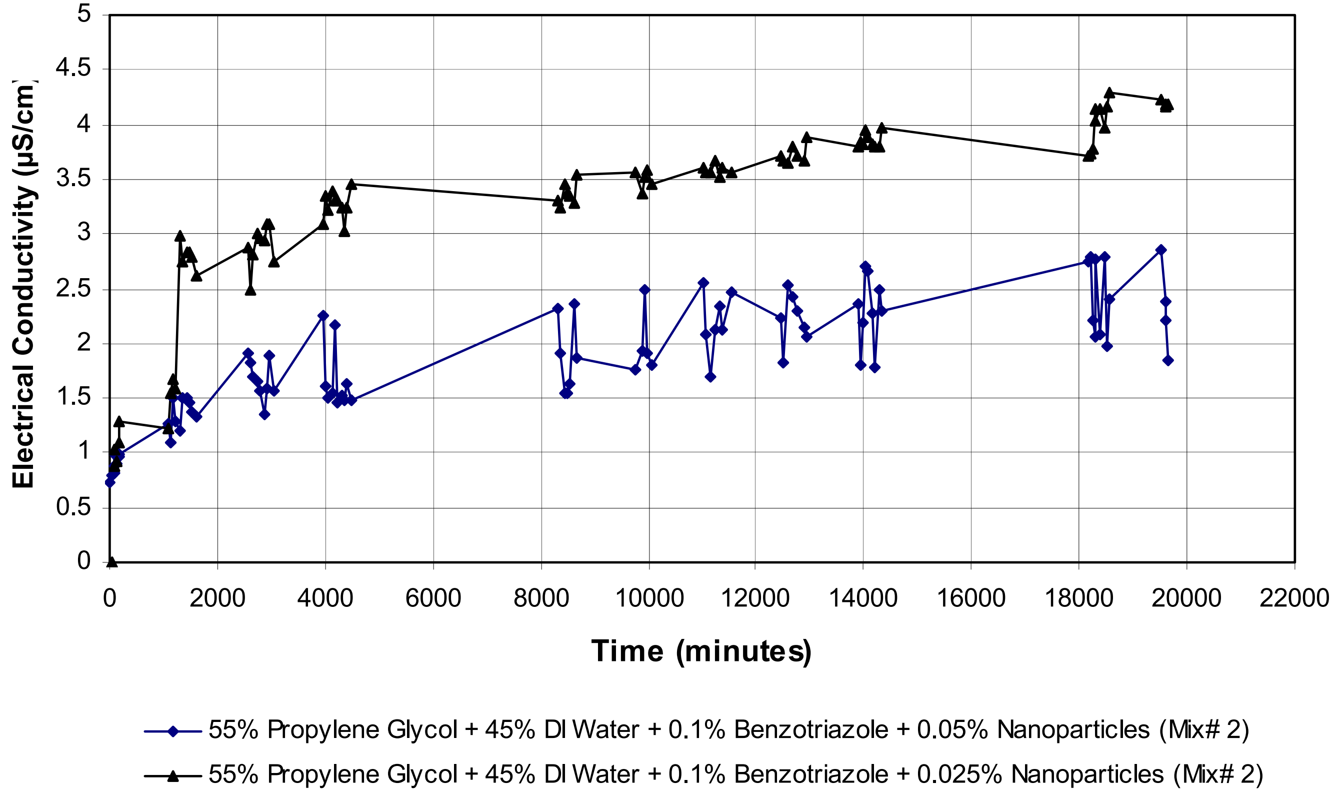
■ 55% Propylene Glycol + 45% DI Water

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

● DI Water

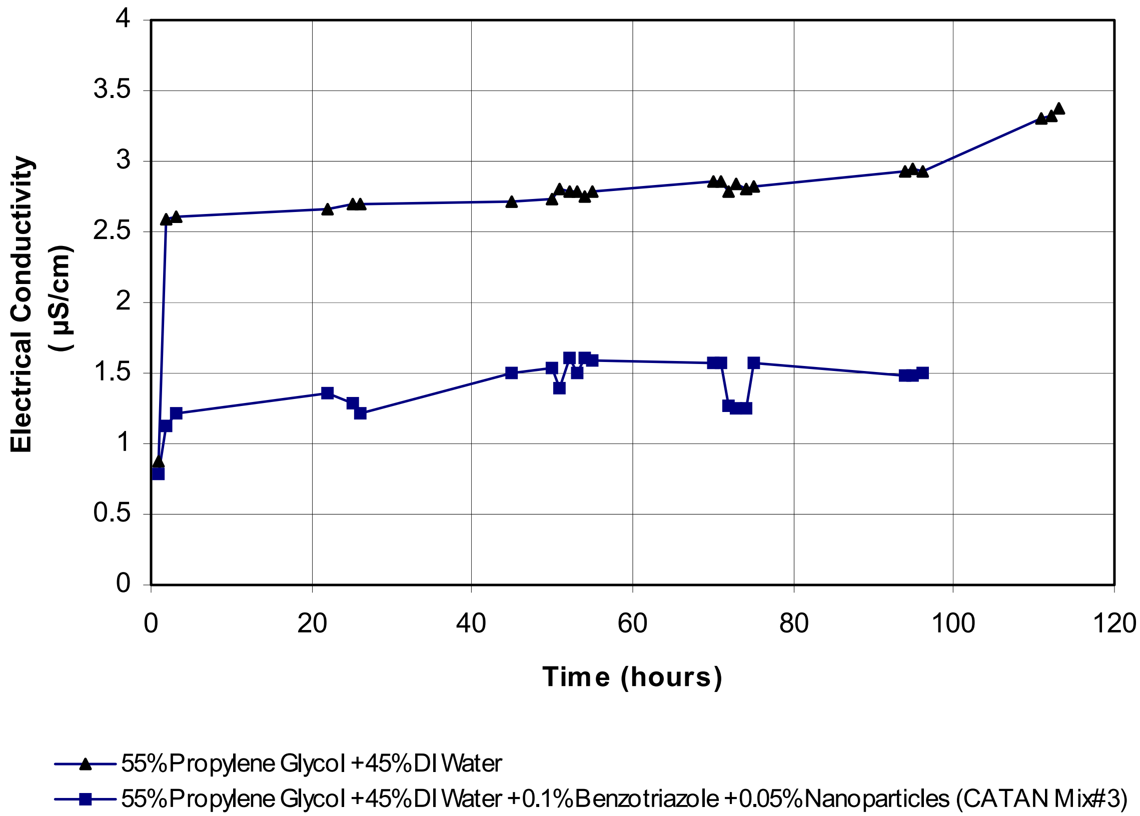
Tested in the Dynamic Test Loop (4 L volume) At 55 °C.

Results from Phase I



Electrical Conductivity vs. Time for the Coolant Formulations in a 1 L Dynamic Test Loop at 70^{o}C

Results from Phase I



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

Discussion

- **With CATAN Mix # 1, the nanoparticles remained dispersed, making a uniform colloidal suspension. But the electrical conductivity was high (> 3.0 μS/cm)**

- **With CATAN Mix # 2, the nanoparticles coagulated. But the electrical conductivity was lower than 1.0 μS/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 μS/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 μS/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

- Acknowledgement:
  - Daniel Loikits (Program Manager), Stephen Dunn, Magaly Quessada, Larry Chiang, Dr. Eric Daniels, Dr. Victoria Dimonie, Dr. David Sudol, and Prof. Andrew Klein