Complex Coolant Fluid for PEM Fuel Cell Systems

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This presentation does not contain any proprietary or confidential information
Overview

Timeline
For SBIR Phase I Project

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

Barriers

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

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

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 \(-40^\circ C\), is non-flammable, and can be used at temperatures up to \(122^\circ C\).

• 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 $\mu$S/cm)

• With CATAN Mix # 2, the nanoparticles coagulated. But the electrical conductivity was lower than 1.0 $\mu$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 $\mu$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 $\mu$S/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

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?

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