

Complex Coolant Fluid for PEM Fuel Cell Systems

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FCP 6

This presentation does not contain any proprietary or confidential information

Overview

Timeline

For SBIR Phase I & II Project

- Project start date: 07-14-2004 (Phase I)
- Project end date: 07-12-2007
- Percent complete: 83% (Phase II)

Budget

- Total project funding
 - DOE share: \$847K (Phase I & II)
 - Contractor share: \$100K (to Lehigh Univ.)
- Funding received in FY06: \$415K (Phase II)
- Funding for FY07: \$242K (expected)

Barriers

- Barriers addressed
 - System thermal management

Partners

- Interactions/
collaborations:

Lehigh University (Subcontractor)
Penn State University (Subcontractor)
Plug Power (Supporting Activities)

Objectives

Overall

To develop and validate a fuel cell coolant based on glycol/water mixtures and an additive package (with corrosion inhibitors and 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).

2006

Optimize nanoparticle chemistry (size, surface charge, stability)
Optimize corrosion inhibitors (type, concentration, combination)
Long-term tests (1000 hours tests)

2007

Optimize nanoparticle chemistry (dispersion and thermal stability)
Long-term tests (3000 hours)
Tests in Real Fuel Cells (3000 hours)

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'?**

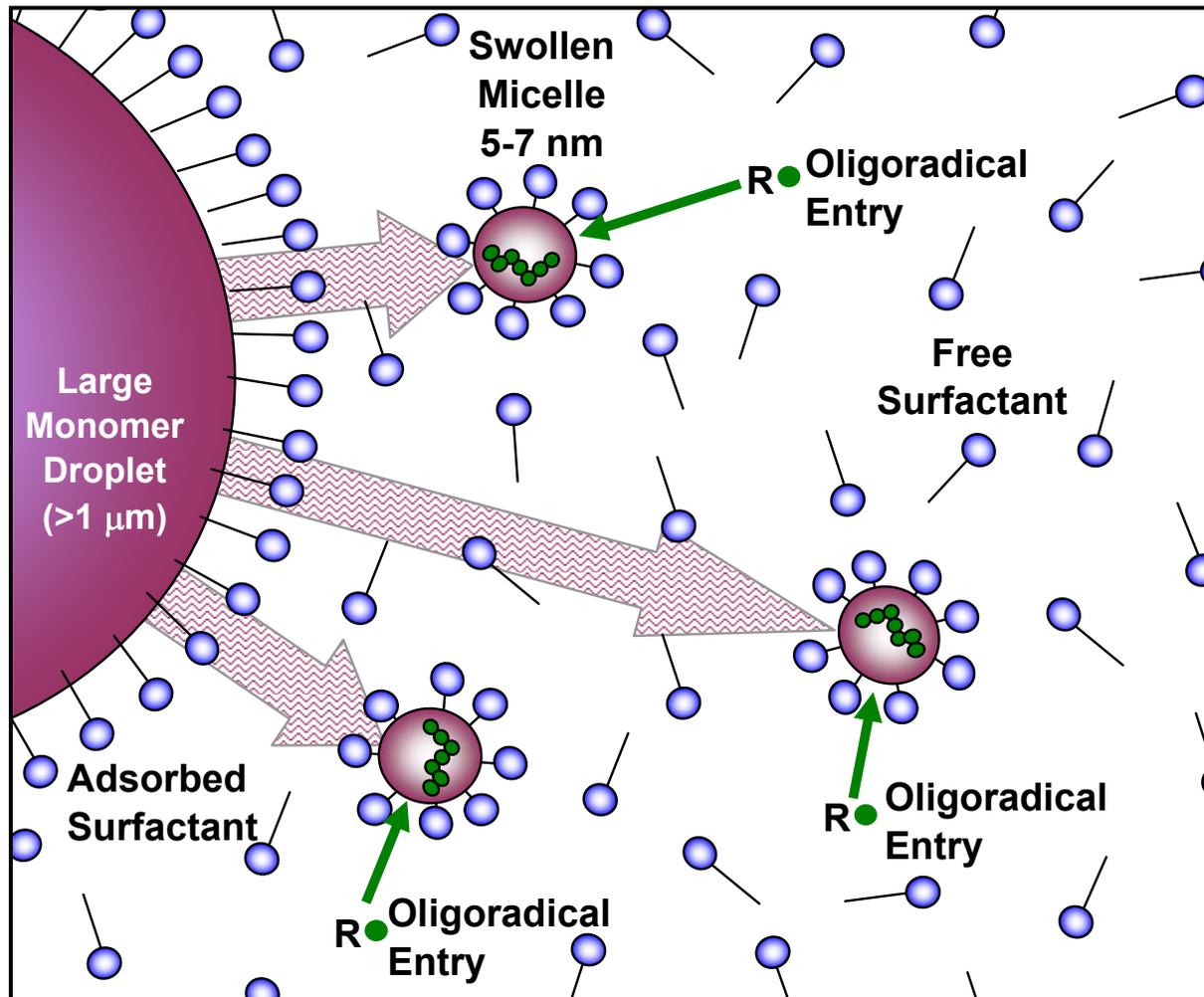
Approach

- **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 (ion-exchange nanoparticles) to maintain the electrical conductivity of the coolant at a low level.**

Technical Approach in Phase I

- **Development of the nanoparticles by emulsion polymerization**
 - 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 and long-term tests (electrical cond. vs. time and pH vs. time)

Emulsion Polymerization



Technical Approach in Phase II

- **Optimization of the ion-exchange nanoparticles**
 - Effect of preparation recipe on the particle size, surface charge and dispersion behavior
 - Study dispersion behavior in the final coolant formulation
- **Short-term and long-term tests**
 - Electrical conductivity and pH vs. time

Characterization of Nanoparticles

- Conversion
 - Gravimetric Analysis
- Particle Size
 - Dynamic Light Scattering (Nicomp)
 - Capillary Hydrodynamic Fractionation
 - TEM
- Cleaning
 - Serum replacement
 - Ion exchange resin (mixed bed)
- Surface Charge Density
 - Conductometric titration

Dynamic Test Loop for Coolant Testing

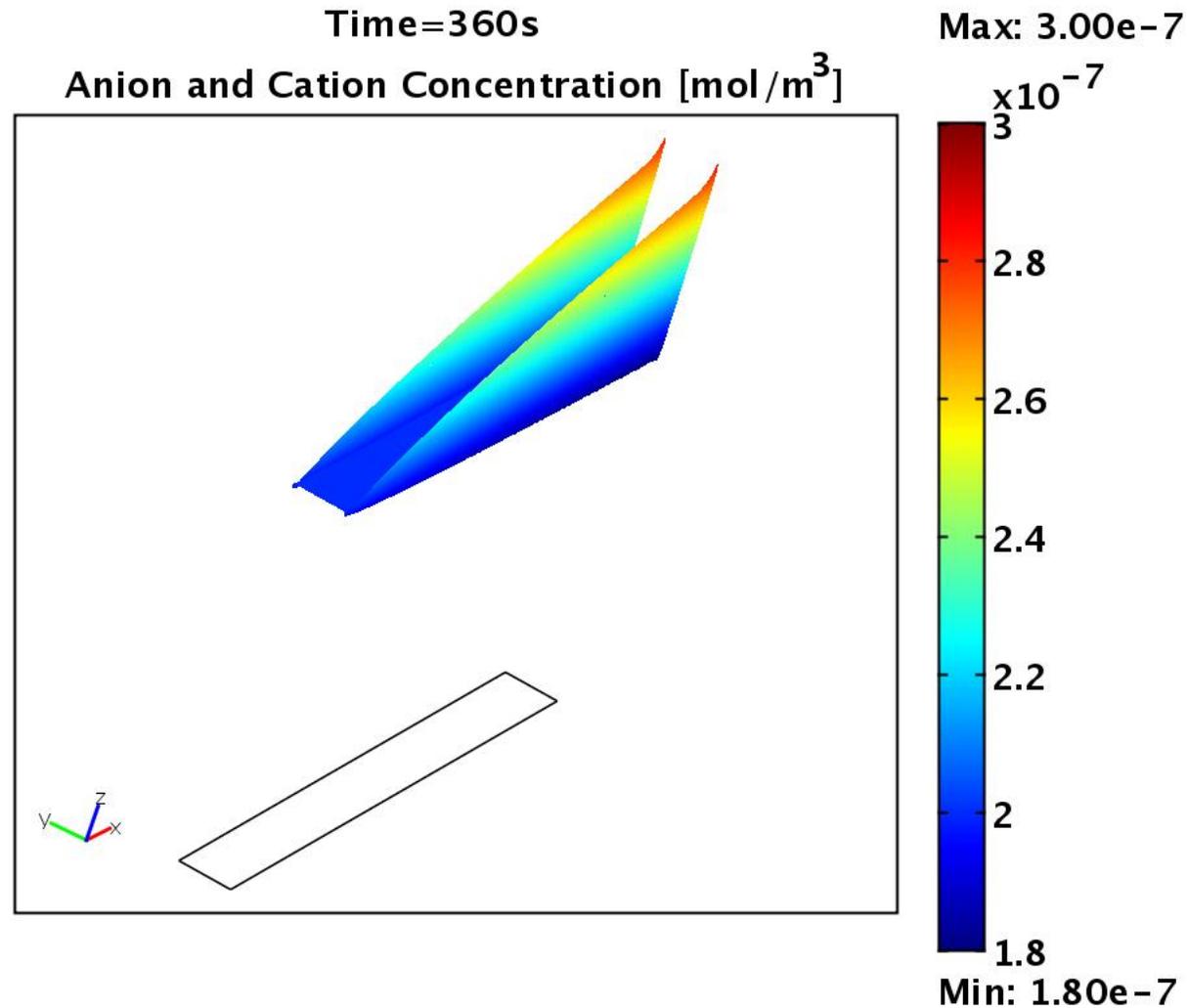


Results from Phase II

Table 1: Particle size and surface charge for both anionic and cationic nanoparticles

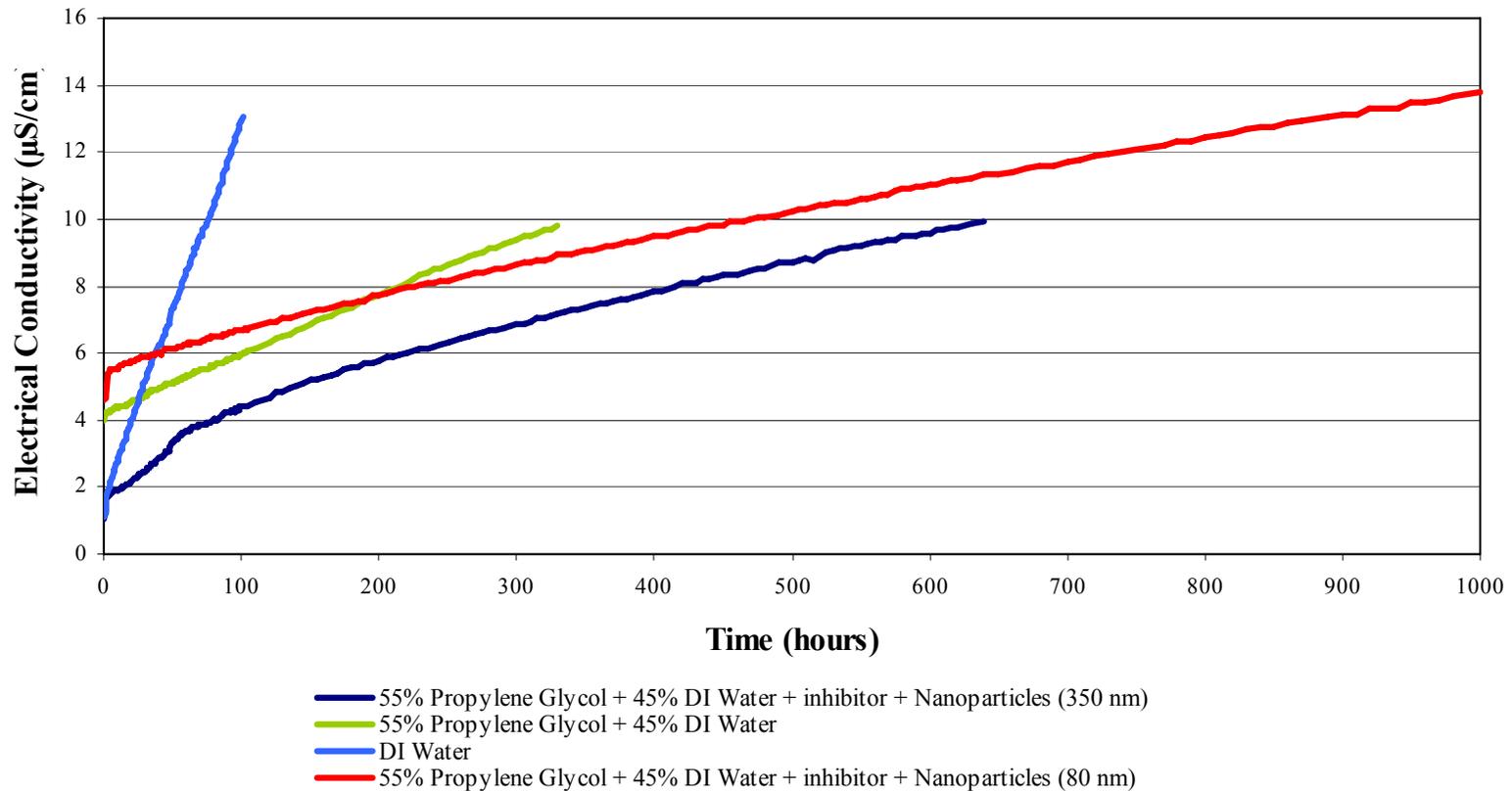
Nanoparticles	Average Size (nm)	Surface Charge by Titration ($\mu\text{eq/g}$)
ANPS 30403	80	454
CATPS 60211		743
CATPS 6	350	956
ANPS 6		28

Results from Phase II



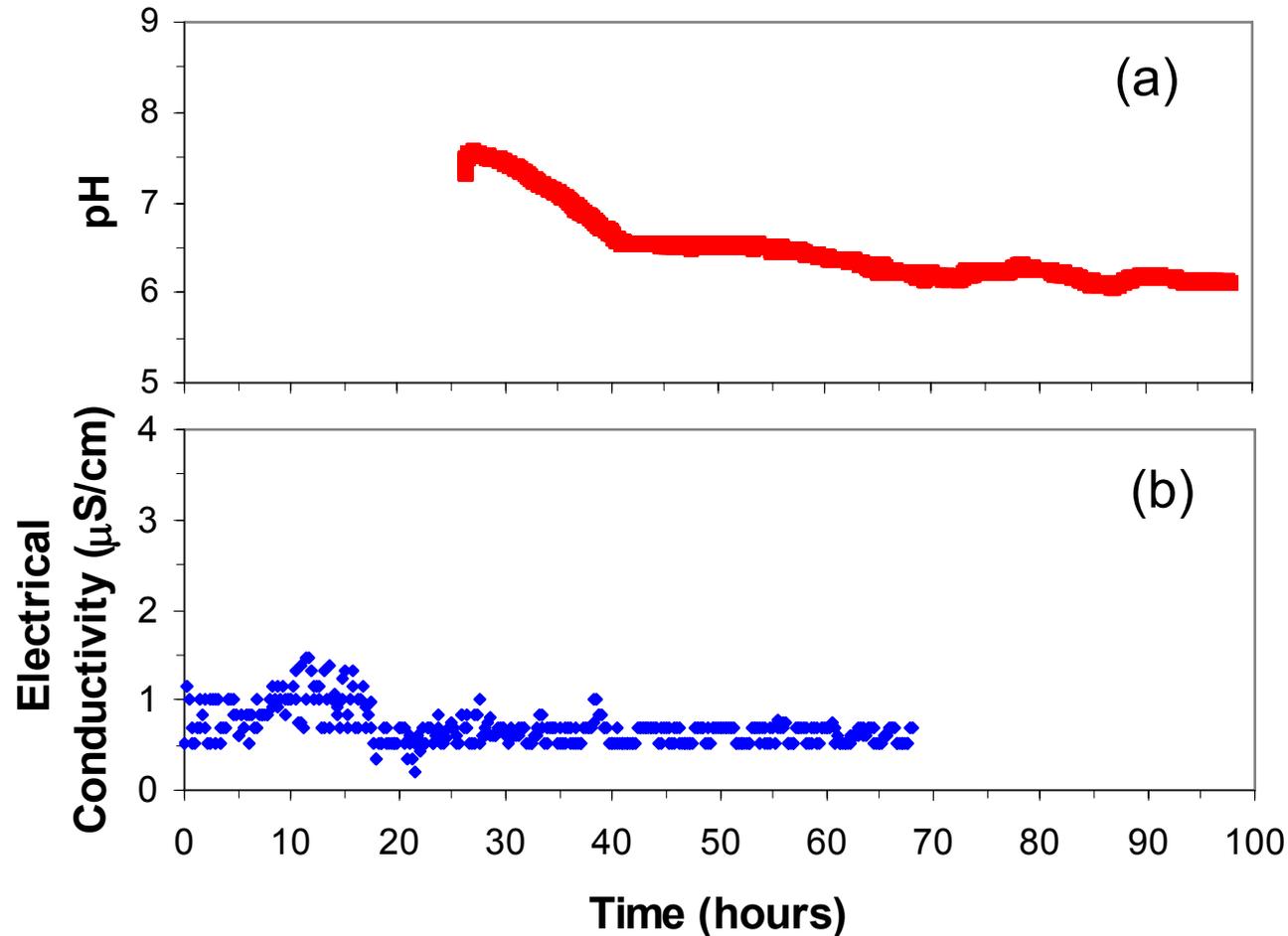
Particle deposition on channel walls due to electrostatic attraction

Results from Phase II



**Electrical conductivity of coolant formulations as a function of time
in the 4 L dynamic test system at 70 °C**

Results from Phase II



(a) pH and (b) electrical conductivity of an optimized coolant formulations as a function of time in the dynamic test system

Discussion and Conclusions

- **Uniform particle size distribution of the nanoparticles has been obtained by optimizing the recipe.**
- **High surface charge density ($> 700 \mu\text{eq./g}$) can be obtained with cationic particles. More optimization needed for anionic particles.**
- **Coolant formulations with non-ionic corrosion inhibitor and nanoparticles have lower rate of increase in electrical conductivity than DI water, glycol/water, and glycol/water/inhibitor mixtures.**

Future Work

- **In 2007, the nanoparticles will be optimized further to reduce coagulation**
- **Electrodeposition rate of additives on the electrode surfaces will be determined experimentally**
- **Material compatibility tests will be carried out**
- **Optimized coolant will be tested in real fuel cell systems**
- **Cost of the coolant will be evaluated**

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