Thermal Stability of Low Electrical Conductivity Glycol-Water Fuel Cell Coolants in Presence of Metallic Components

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Introduction

- **Low electrical conductivity (EC) glycol-water coolants are desirable for fuel cell operation**
  - Minimal ion concentration prevents leakage currents, coolant electrolysis, and system corrosion
- **Metals enhance glycol degradation [1]**
  - Metallic components in fuel cells operating at 90°C can catalyze thermal oxidative breakdown of glycol into acidic degradation products
- **Degraded coolant corrodes the fuel cell system**
  - Acidifying coolant will corrode the fuel cell stack (FCS), reducing coolant performance and lifetime of the FCS and deionizer
- **Can inhibitors prevent glycol breakdown?**
  - Inhibited coolants protect metals from corrosion, but it is unknown if they suppress metals' catalytic effects on glycol breakdown

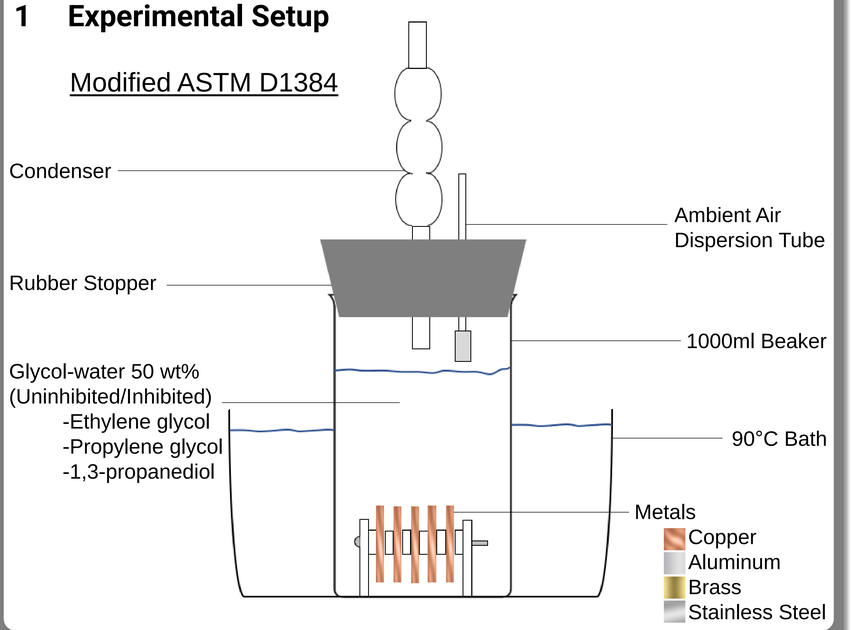
Objectives

1) Investigate the catalytic effects of common metal alloys (copper 110, aluminum 3003, brass 260, and stainless steel 316) in fuel cells on the breakdown of low-conductivity glycol-water at 90°C for 2 weeks and 4 weeks
2) Measure the difference in suppression of glycol breakdown between three inhibited and uninhibited fluids: ethylene glycol (EG), propylene glycol (PG), and 1,3-propanediol (Bio)

Materials and Methods

1 Experimental Setup

Modified ASTM D1384



Materials and Methods

2 Analysis

a

Organic Acid Quantification with Ion Chromatography

b

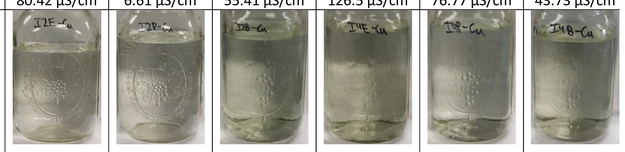
Leached Metals (Spectrophotometry)

c

Fluid Properties (visual, pH, EC)

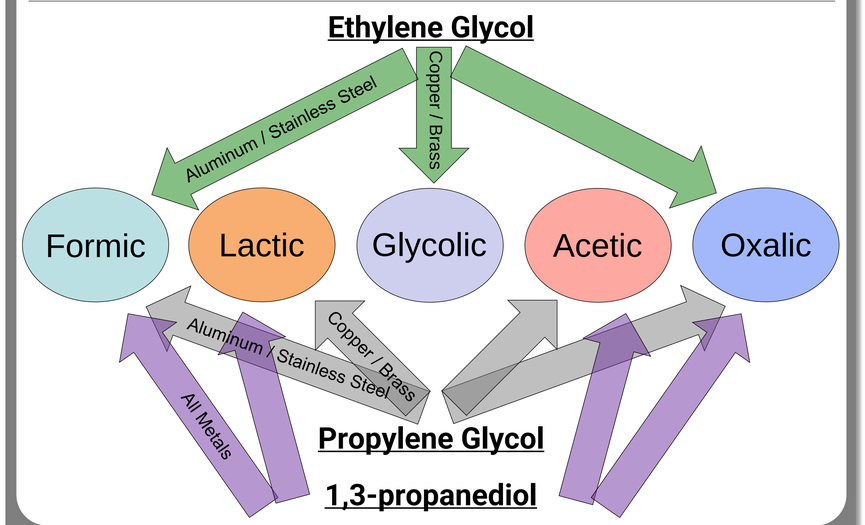
Metal Leaching Results

Copper Content in Inhibited and Uninhibited Fluids at 90°C

	2 weeks EG	2 weeks PG	2 weeks Bio	4 weeks EG	4 weeks PG	4 weeks Bio
Uninhibited						
Concentration	162 ppm	51.5 ppm	92.5 ppm	443 ppm	577.5 ppm	100.5 ppm
EC	80.42 µS/cm	6.61 µS/cm	55.41 µS/cm	126.5 µS/cm	76.77 µS/cm	43.73 µS/cm
Inhibited						
Concentration	3.9 ppm	3 ppm	2.1 ppm	3.2 ppm	2.9 ppm	4.6 ppm
EC	5.11 µS/cm	1.9 µS/cm	3.45 µS/cm	12.58 µS/cm	2.81 µS/cm	8.40 µS/cm

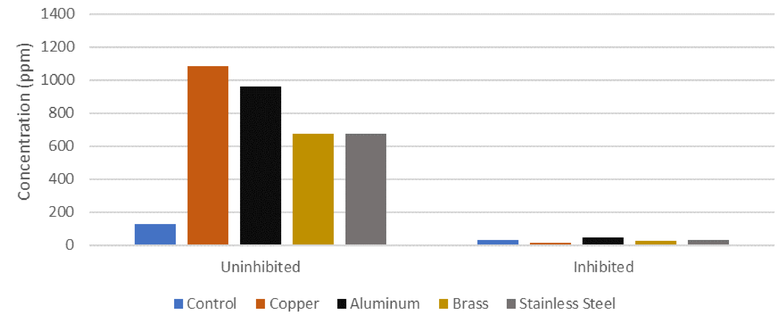
EG – Ethylene Glycol PG – Propylene Glycol Bio – 1,3-propanediol

Major Breakdown Acids

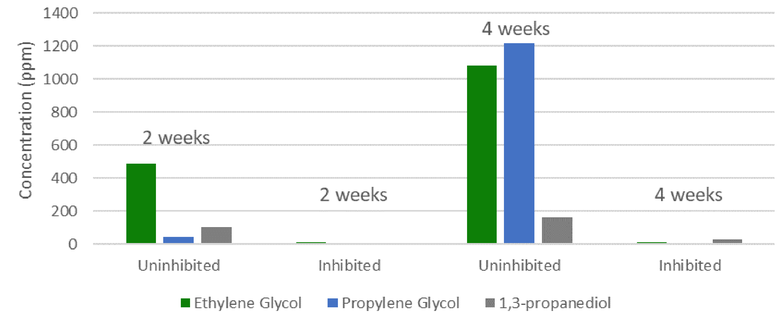


Glycol Concentration Results

Acid Formation in Ethylene Glycol for 4 Weeks at 90°C



Acid Formation in Glycols with Copper Metal at 90°C



Discussion & Conclusion

Low Electrical Conductivity Inhibited Glycol-Water Helps Prevent:

- **Increase in EC**
  - EC of inhibited coolants were consistently less than 10 µS/cm while uninhibited coolants reached as high as 126 µS/cm
- **Glycol Degradation**
  - Inhibitors suppress the catalytic effects of metals on glycol degradation by 86% on average over uninhibited glycol-water
- **Corrosion of Metals**
  - Copper and brass corrosion, which showed the highest rate in uninhibited coolant, was suppressed by the inhibitor
  - Stainless steel had the lowest corrosion rate of all coolants

The thermal oxidation of uninhibited glycol is catalyzed by metals, a process dependent on fluid type and metal type

- e.g., aluminum caused significantly more formic acid production in uninhibited EG at longer times (4 weeks)

References

[1] Rossiter, Walter J., Brown, Paul W., & Godette, McClure. (1983). The Determination of Acidic Degradation Products in Aqueous Ethylene Glycol and Propylene Glycol Solutions using Ion Chromatography. *Solar Energy Materials*, *9*(3), 267-279.