Impurity Effects on Membrane-Electrode Assembly Components

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May 16-19, 2006

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Project ID: FCP28

Overview

Timeline

- Start date: October 2005
- Project end date: open
- Percent complete: n/a

Barriers

- This project addresses the following DOE Fuel Cell Component barriers:
    - A. Component Durability
    - C. Electrode Performance

Budget

- FY'06 first year of project
- Funding for FY '06: $250 K

Interactions

- Regularly providing updates to, and soliciting feedback from, the FreedomCAR Fuel Cell Technical Team

Objectives

- Determine the mechanisms for the degradation of PEFC performance by impurities in hydrogen and in air

- Predict the long-term effects of impurities on PEFC stack performance

- Predict the effect of operating conditions and impurity concentration on PEFC stack performance

- Develop strategies to mitigate performance degradation and enhance stack durability

- Develop strategies to recover stack performance after the impurity is removed from the fuel or air streams

Approach

- ■ Determine the mechanisms of the degradation of stack performance for anticipated air and fuel impurities by determining
  - – the effects of anticipated air and fuel impurities on the
    - • *Electrocatalyst activity*
    - • *Proton conductivity of electrode layer*
    - • *Electronic conductivity of electrode layer*
    - • *Membrane conductivity*
  - – the type of poisoning (irreversible or reversible)
  - – the effect of temperature (10 to 120°C)

- ■ Develop models of contaminant interaction with stack materials to predict the long-term performance degradation caused by air and fuel impurities

Progress vs. FY'06 Milestones

- Determine effects of chloride and chloride-containing organics (07/06)
    - Established the capability to determine the effect of impurities on the reaction kinetics of high surface area carbon-supported catalysts as a function of temperature
    - Determined the effects of millimolar concentrations of hydrogen chloride and methylene chloride on the oxygen reduction kinetics of Pt_3Co/C catalyst, at 60°C

- Determine effects of selected paraffinic / aromatic hydrocarbons (09/06)
    - To be initiated shortly

Hydrogen chloride has a dramatic effect on oxygen reduction kinetics of Pt$_3$Co/C
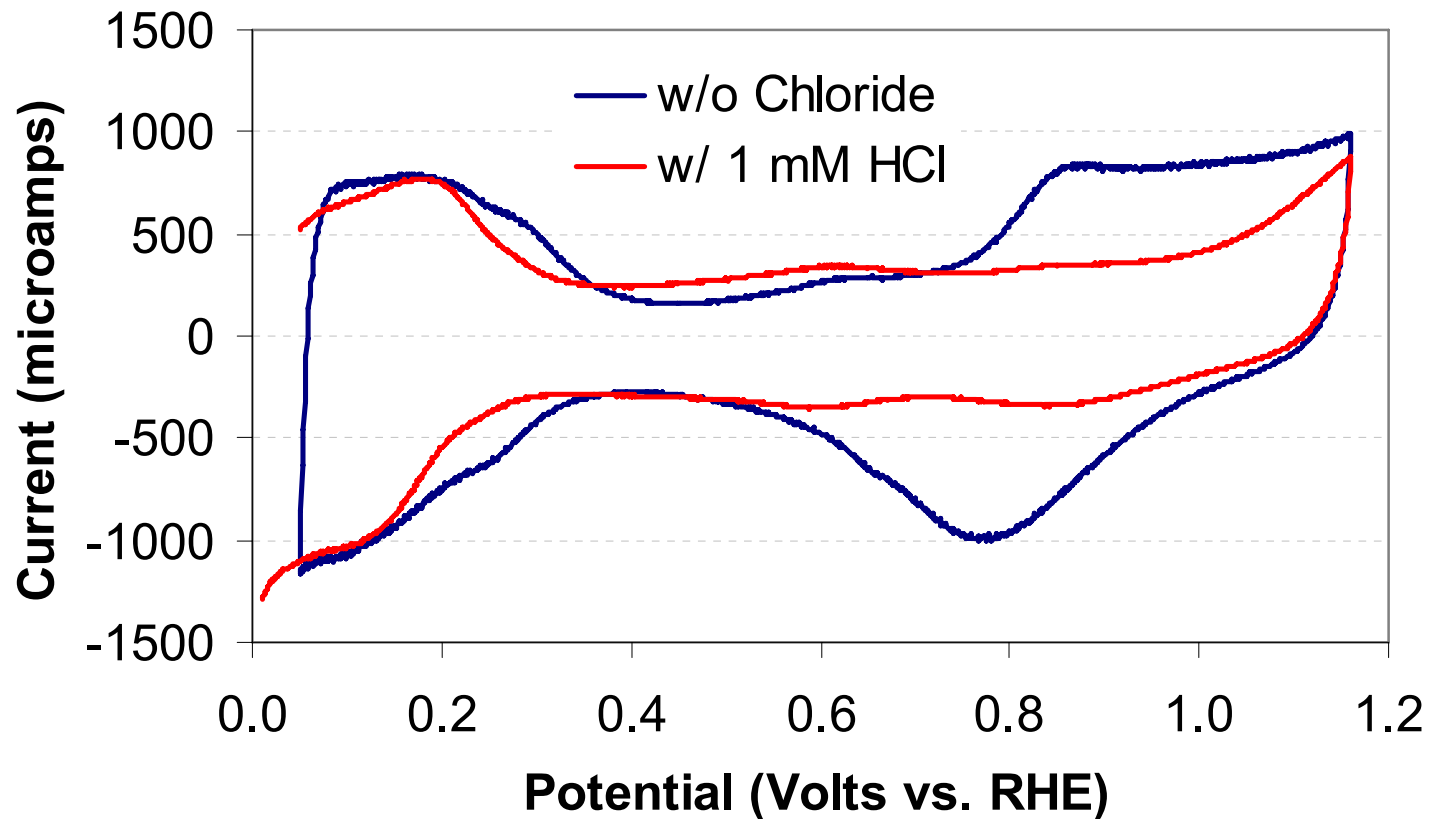
- Half-wave potential for ORR reaction is shifted by >100 mV by 1 m$\underline{M}$ chloride
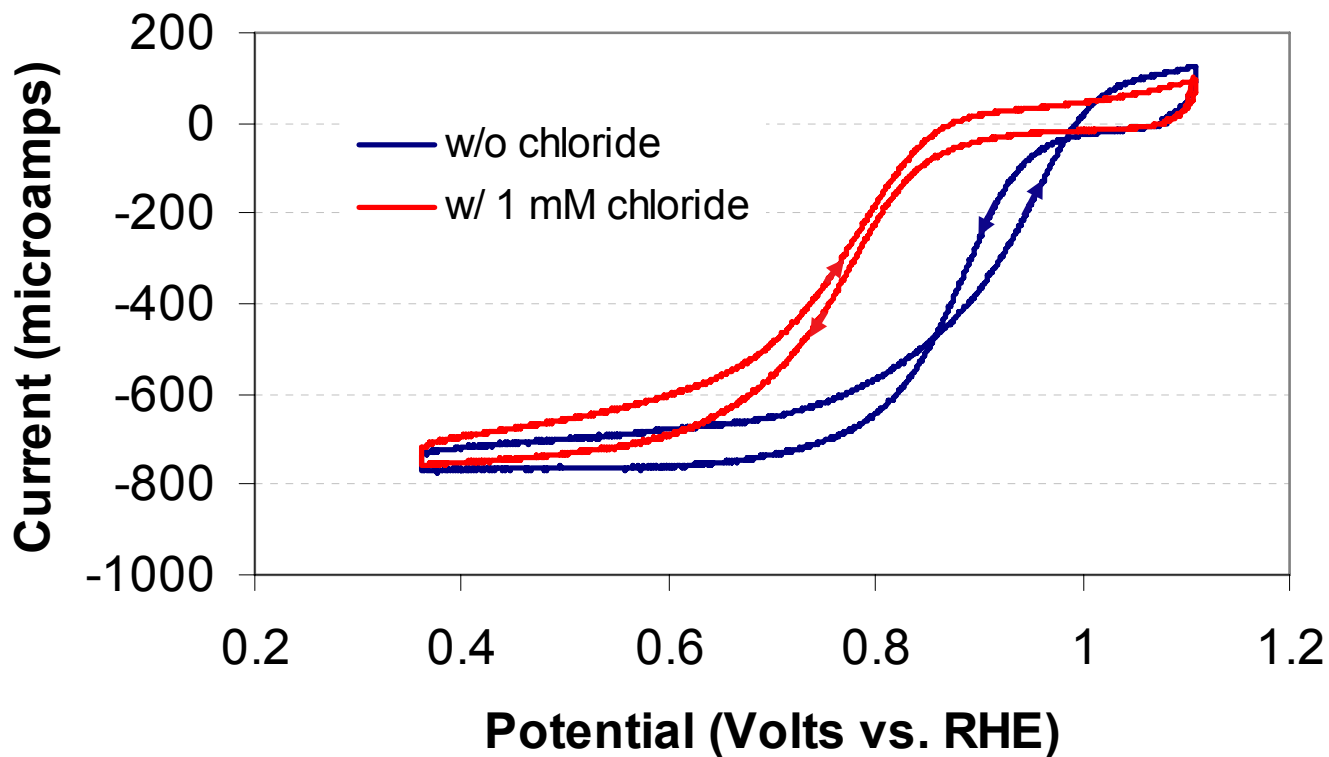
- Catalyst-coated glassy carbon rotating-disk electrode, 0.5 $\underline{M}$ HClO$_4$, 60°C, 1600 rpm, 5 mV/s, curves not corrected for double layer charging

- In agreement with published data on Pt/C (T.J. Schmidt et al., J. Electroanal. Chem., 508 (2001) 41-47.)
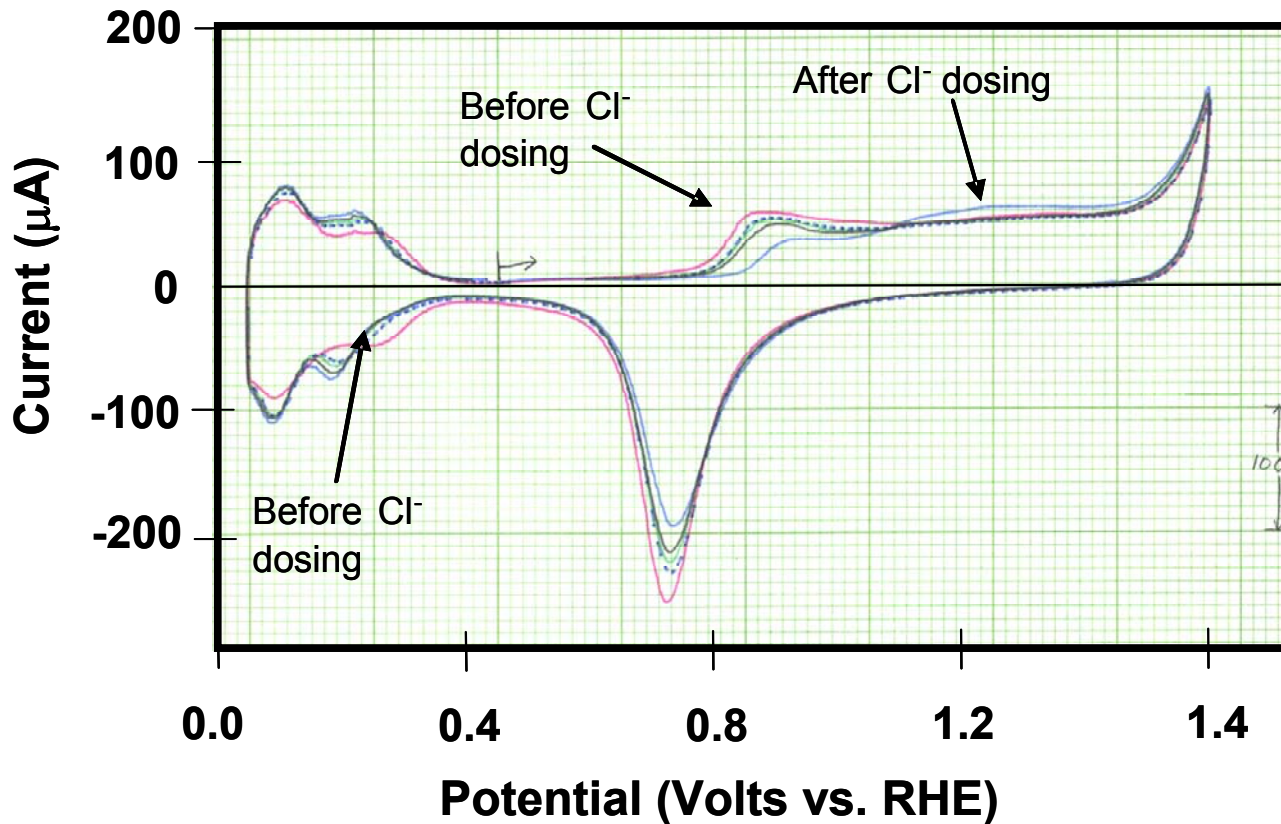
Chloride blocks the adsorption of hydrogen and the formation of oxide on Pt$_3$Co

- 60°C, 50 mV/s, 900 rpm, 0.5 $\underline{M}$ HClO$_4$, steady-state voltammograms

Multiple potential cycles are necessary to remove adsorbed chloride from Pt

- Cyclic voltammogram of Pt wire does not return to pre-chloride trace after four potential cycles between 0.05 and 1.4 V
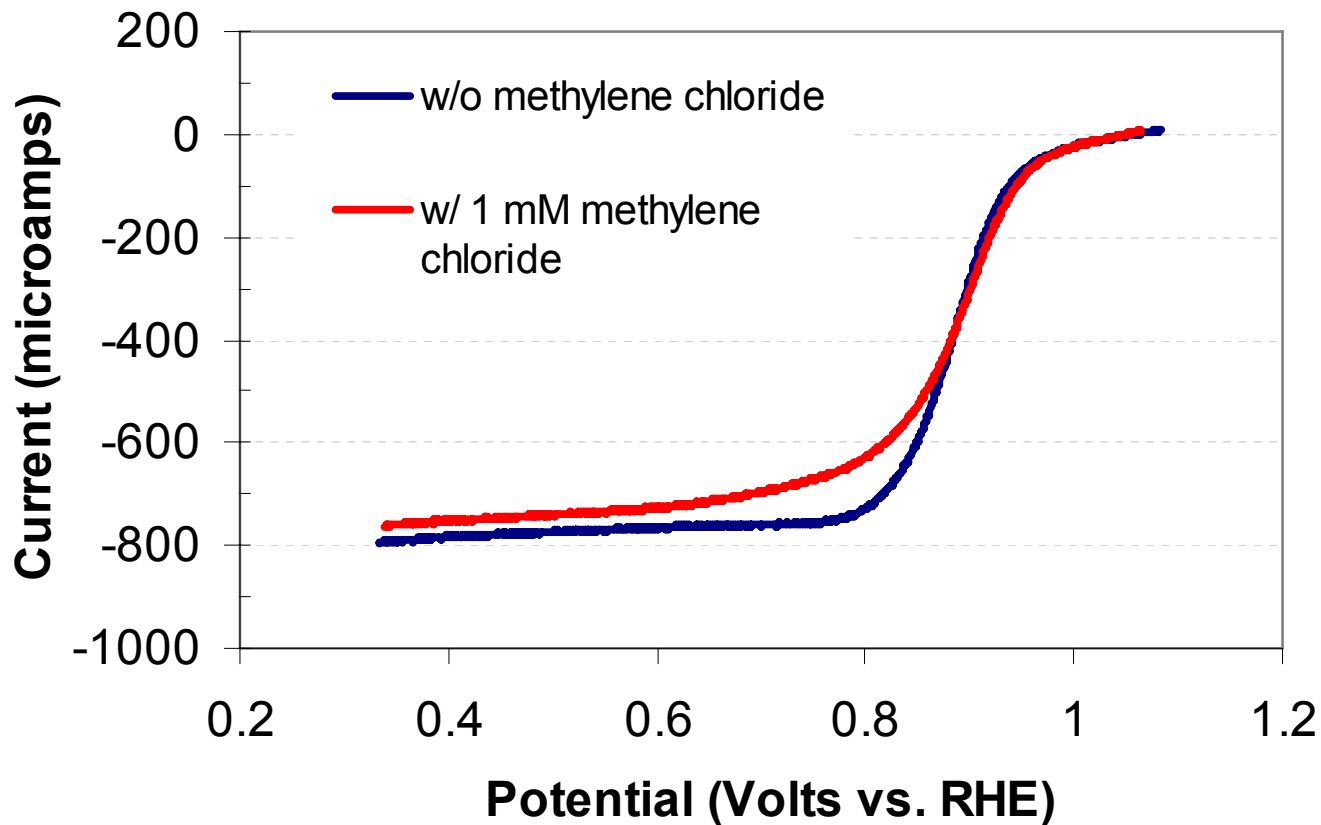

- Chloride dosed from 1 m$\underline{M}$ HCl onto polycrystalline Pt wire at 0.46 V, scans taken in clean 1 $\underline{M}$ HClO$_4$ at 50 mV/s, stagnant solution

# *Methylene chloride impurity has minimal effect on ORR on Pt₃Co/C*

■ Kinetic current of ORR at 0.9 V is unaffected by 1 mM methylene chloride

■ Catalyst-coated glassy carbon rotating-disk electrode, 0.5 M $HClO_4$, 60°C, 1600 rpm, 5 mV/s, traces not corrected for double layer charging

Methylene chloride slightly inhibits oxide formation on Pt$_3$Co/C

- 50 mV/s, 900 rpm, deaerated 0.5 $\underline{M}$ HClO$_4$, steady-state voltammograms
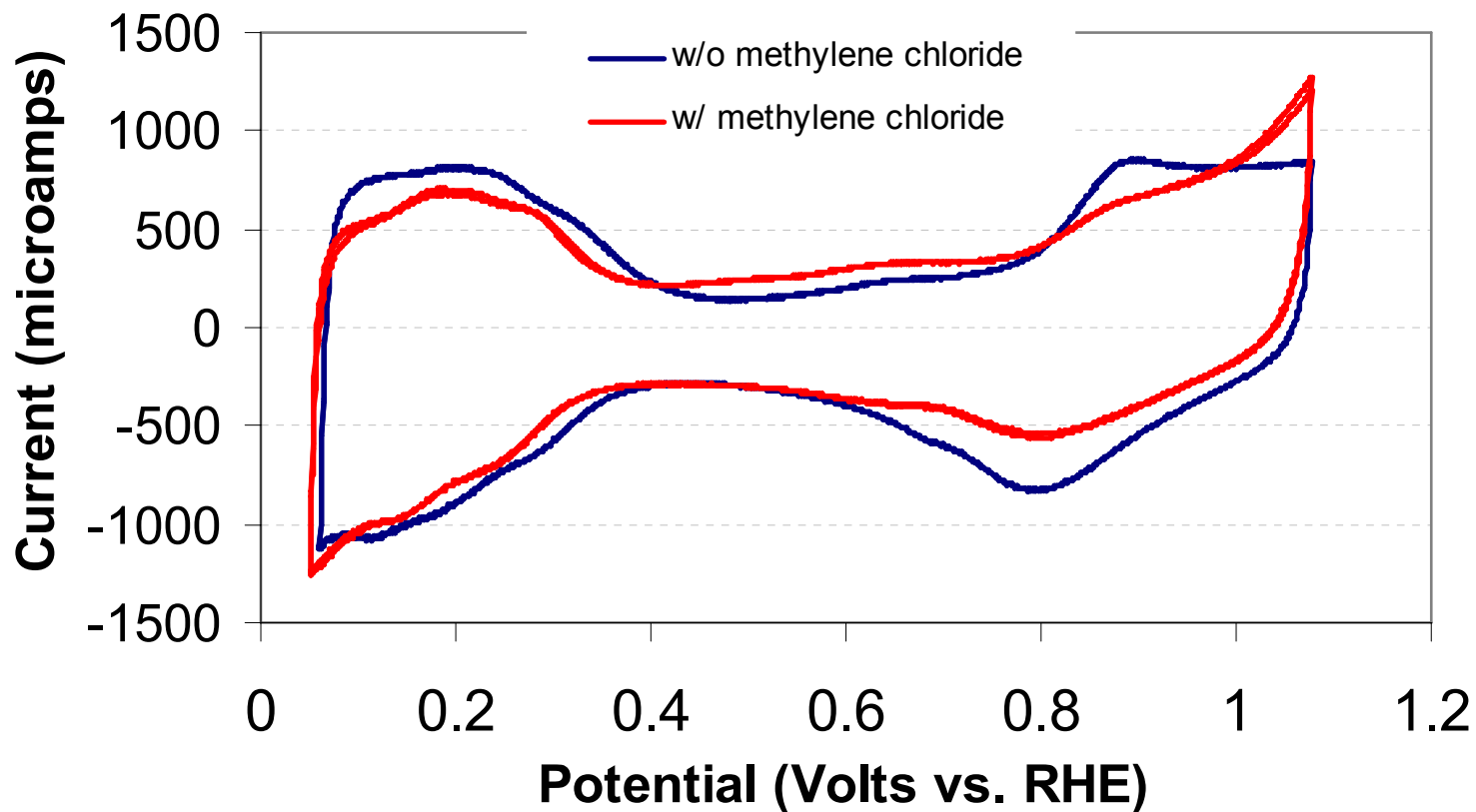
Future Work

- **Remainder of FY'06:**

  - Effect of temperature and concentration of chloride, chloride-containing organic, C_7 aliphatic, C_7 aromatic on

    - *Oxygen reduction reaction kinetics and selectivity*

    - *Hydrogen oxidation reaction kinetics*

    - *Electrode layer conductivity*

    - *Membrane conductivity*

  - Incorporate effect of chloride into Argonne's stack performance model

Summary

- The potential for oxygen reduction on Pt_3Co/C is shifted by >100 mV in the presence of 1 m$\underline{M}$ chloride, at 60°C

- Multiple oxidation-reduction cycles are necessary to remove adsorbed chloride from platinum

- Kinetic current at 0.9 V of oxygen reduction on Pt_3Co/C is unaffected by 1 m$\underline{M}$ methylene chloride, at 60°C

- A stack performance model is being developed and validated with measured stack performance data