DOE Hydrogen,Fuel Cells and Infrastructure Technologies 2007 Kickoff Meeting

Effects of Fuel and Air Impurities on PEM Fuel Cell Performance

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Project Objectives

Overall Objective: Contribute to the understanding of the effects of fuel and air impurities on fuel cell performance

Specific Objectives:

•Test fuel cell performance under simulated multi-component hydrogen impurity gas mixtures

•Investigate effects of impurities on catalysts and other FC components

•Understand the effect of catalyst loadings on impurity tolerance

• Investigate the impacts of impurities on catalyst durability

•Develop methods to mitigate negative effects of impurities

•Develop models of fuel cell-impurity interactions

•Collaboration with USFCC, Fuel Cell Tech Team, Industry and other National Laboratories to foster a better understanding of impurity effects

Technical Targets/Barriers

Near Term Targets:

- 5000 hrs durability
- 30$/kW by 2010
- 55% energy conversion efficiency
- 0.3g/kW Pt loading

Barriers:

- Electrode performance decreased by impurities(fuel cell efficiency decreases)
- Higher Pt loading required to maintain performance in presence of impurities increases cost
- Durability may decrease in the presence of impurities

Approach

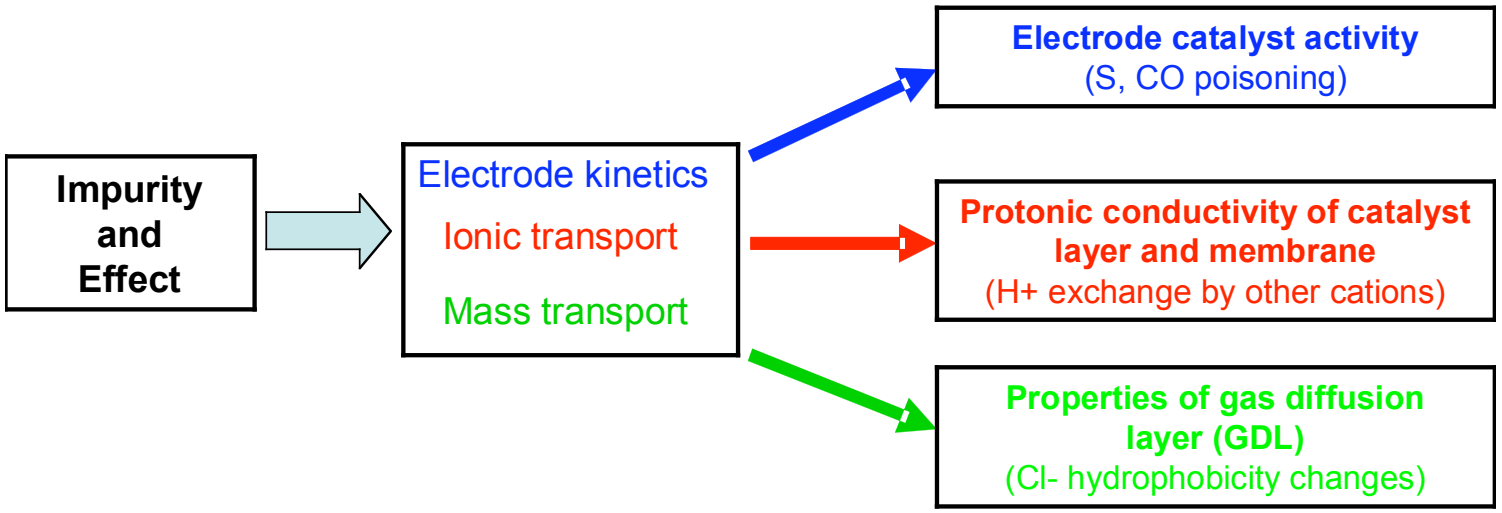
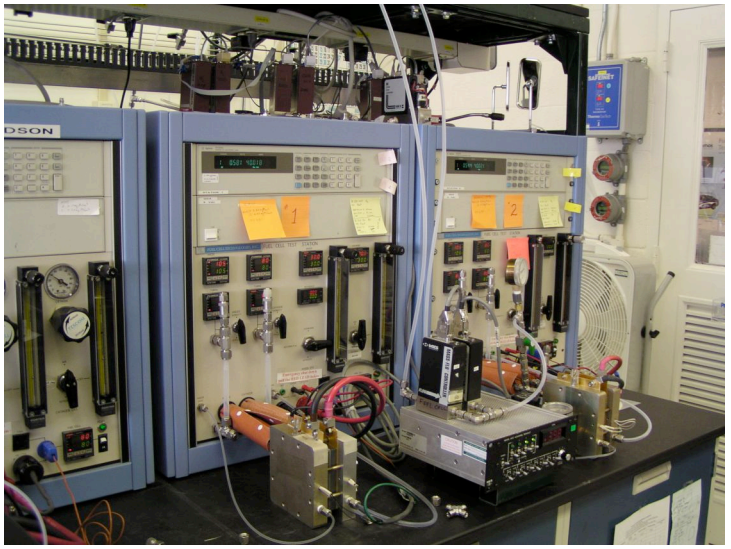
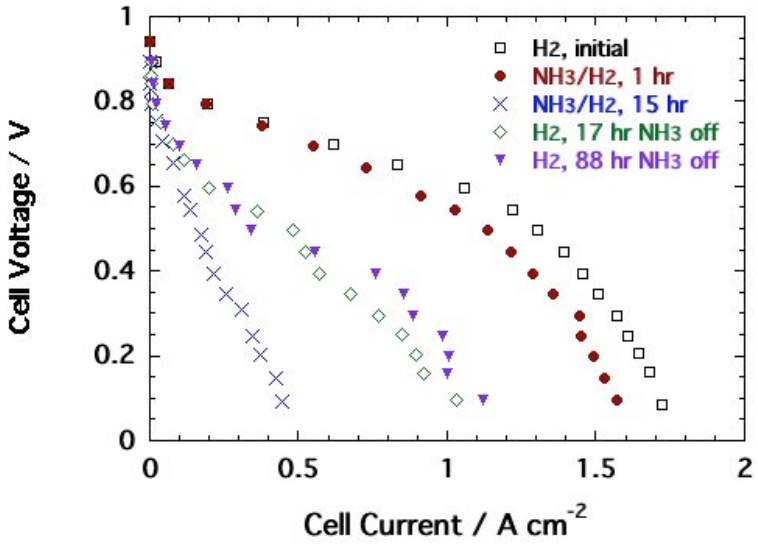


Table II. Possible mechanisms of action of impurities

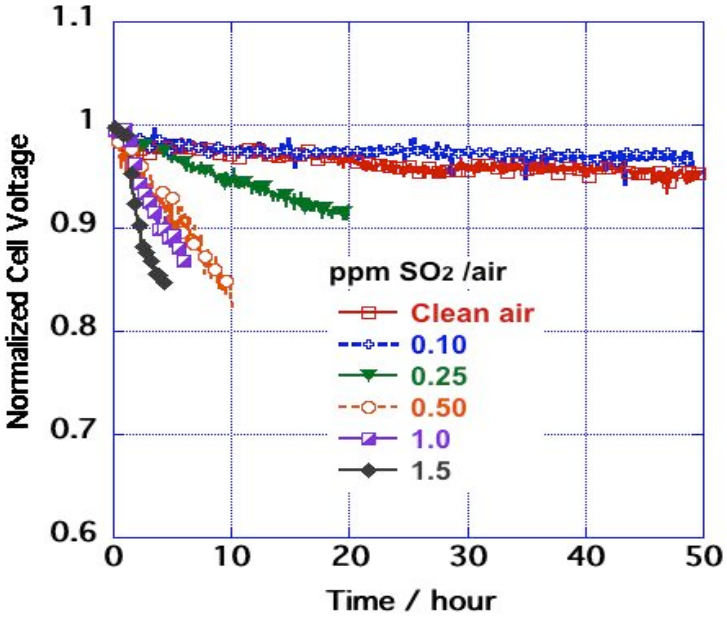
Approach

- Fabricate and operate fuel cells under controlled impurity gases
  - Multi-gas mixing manifolds and FC test stations
  - Pre-blend impurity gases
  - Measure performance
    - Understand degradation mechanisms
    - Study mitigation approaches
- Develop analytical tools for studies
  - Electroanalytical methods
  - *In situ* diagnostics
  - Sub PPM gas analysis
- Analyze and model data

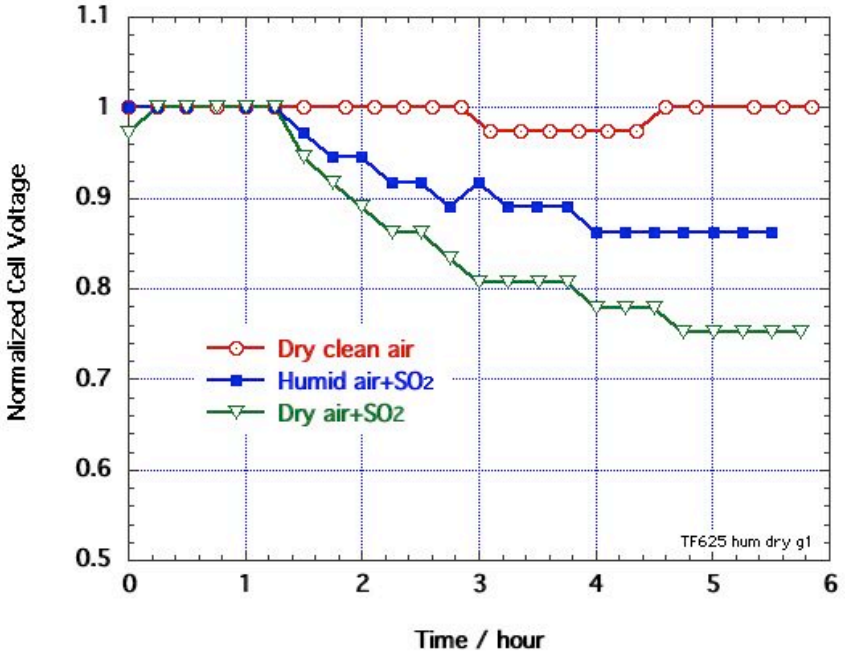




Prior Work Air Impurities: Sulfur Dioxide Injection At The Cathode



- Constant current 0.6A/cm^2
- 0.01mmols total injected for each run after humidification
- 50cm^2 cells 80°C



• The negative effect of 1.5 ppm SO_2 is more acute in dry air:
  •SO_2 very soluble in H_2O
• Dry clean air does not affect performance at these conditions.

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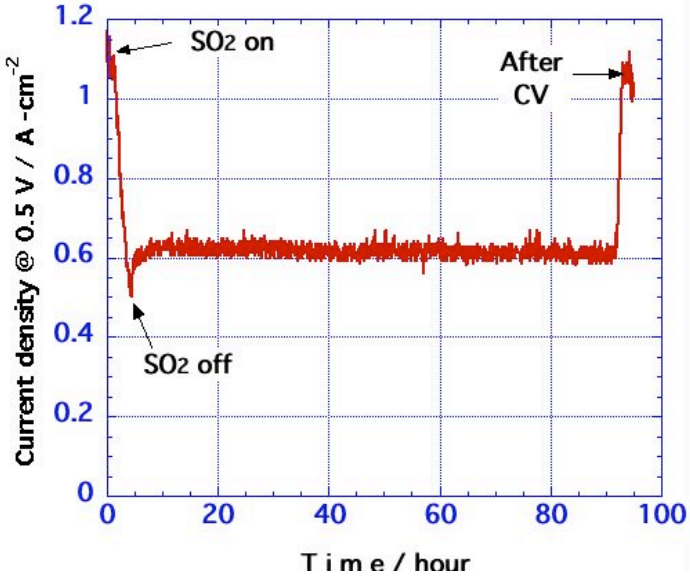
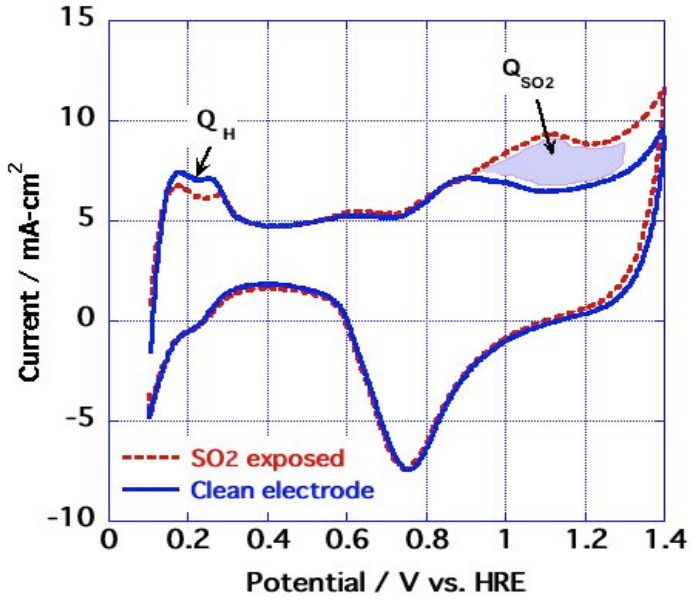
Sulfur Dioxide Injection At The Cathode

- Fuel cell operated in constant voltage mode of 0.5V
- 5 ppm of SO_2 injected after gas humidification
- CV to 1.4 V restores performance





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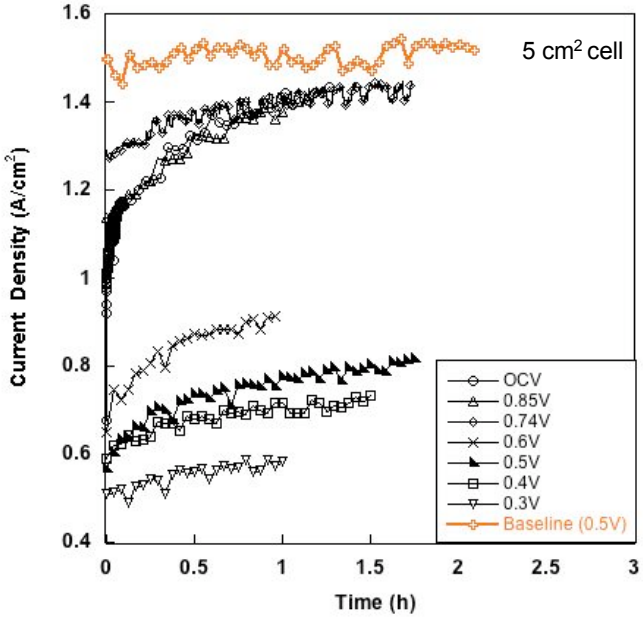
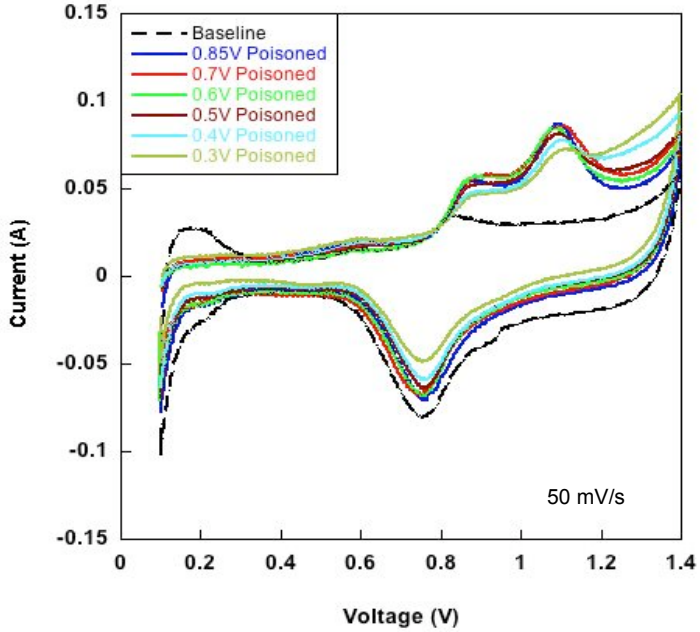
Prior Work: Effect Of Cell Voltage on H_2S Anode Poisoning

Cell performance recovery (at 0.5 V) after anode exposure to H_2S at different voltages



CV's for H_2S poisoned anodes at different cell voltages



- *Fuel Cell anode exposed to 2ppm H_2S for 1 hr*
- *H_2S exposure occurs influences amount of performance loss and recovery rate*
- *More poisoning at low cell voltages*
- *More than a monolayer of S (2-3 layers) at low cell voltages*

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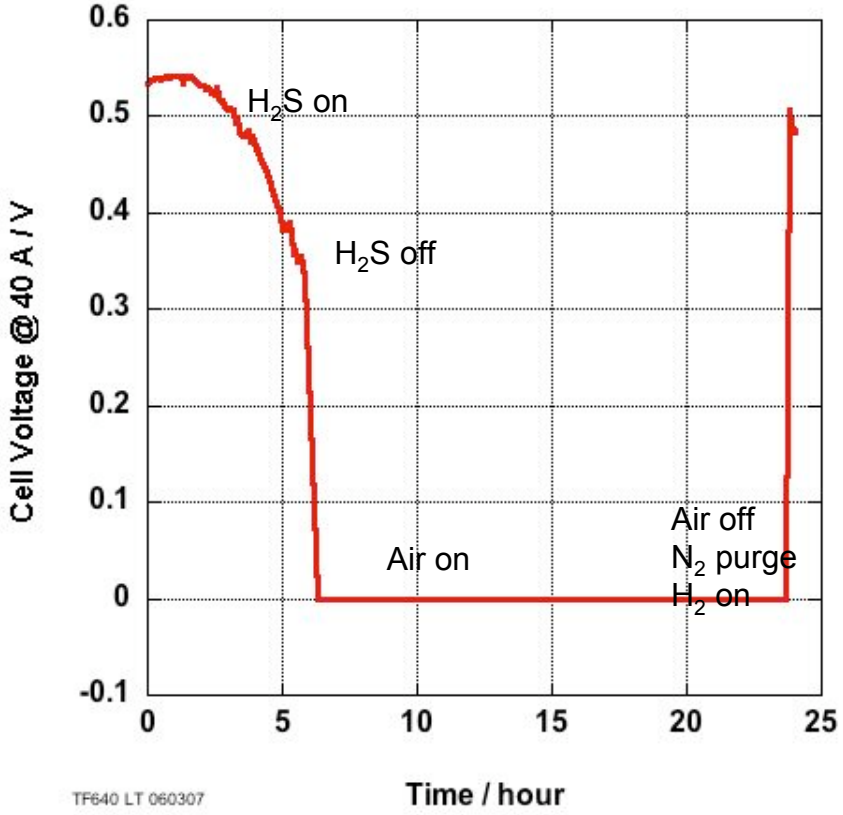
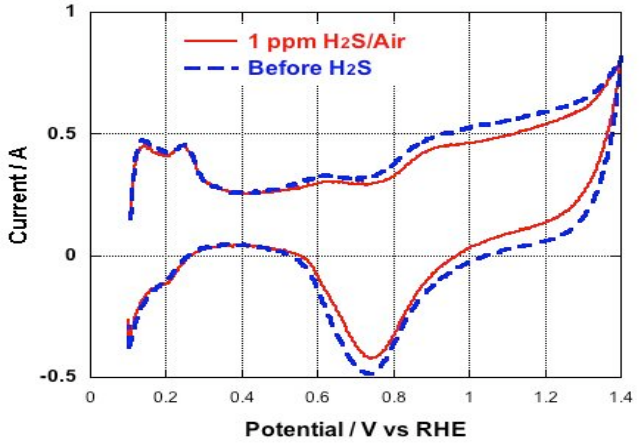
Air Effect on Anode Due To Shut-down





- **Anode poisoned with 1 ppm H_2S**
- **Anode is at OCV before air exposure**
- **Air bled overnight**
- ***Cell recovered almost fully***

Possible mechanisms?

$$S_{Pt} + H_2 \rightarrow H_2S_{gas} \uparrow$$

$$S_{Pt} + 3/2O_2 + H_2O \rightarrow HSO^-_{4\ aq} + H^+_{aq}$$

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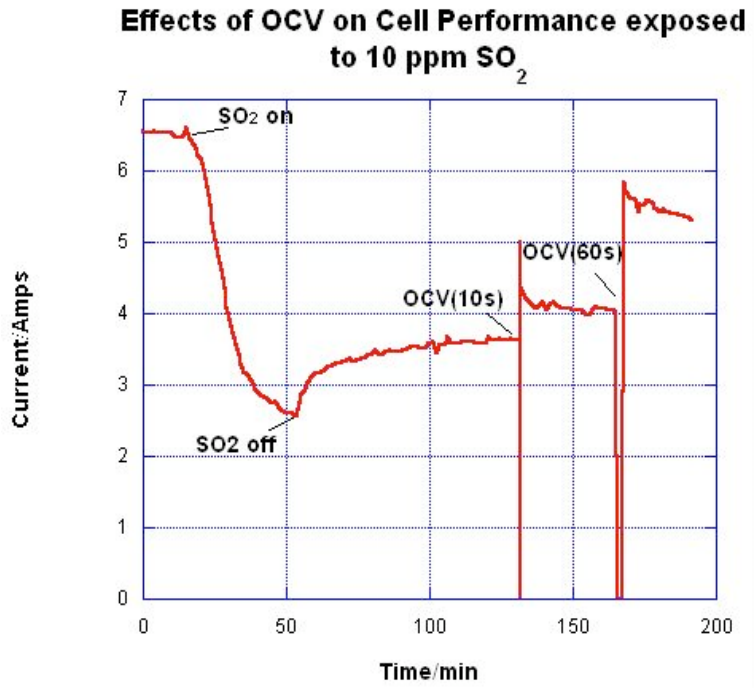
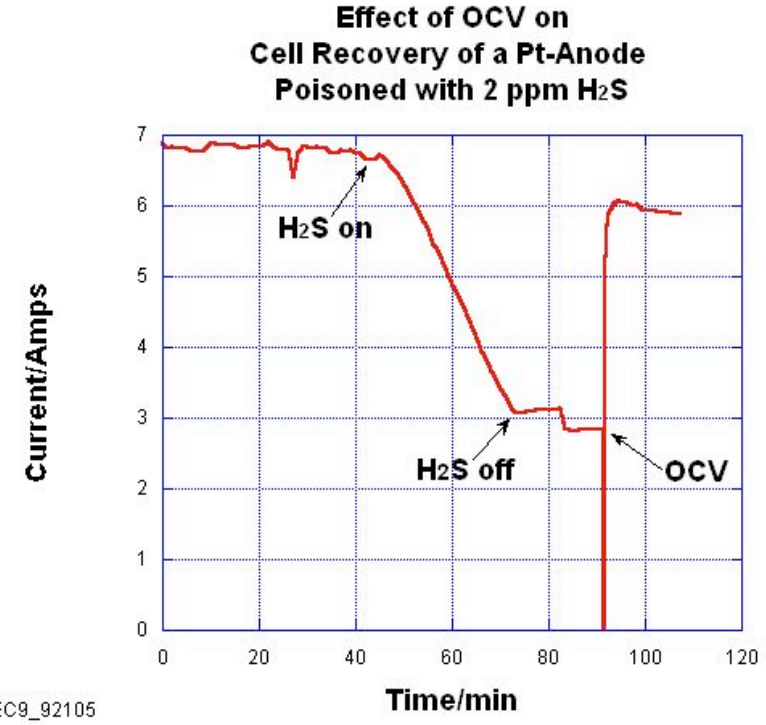
Cleaning Impurities:
Effect of OCV on Sulfur Poisoned Cathodes and Anodes





$$anode: S_{Pt} + H_2 \rightarrow H_2S_{gas} \uparrow \quad ?$$

- *Cells are poisoned for 50 min (2X amount of H_2S needed for full poisoning at 100% adsorption efficiency)*
- *The application of Open Circuit Voltage on S-poisoned electrodes indicates partial recovery*

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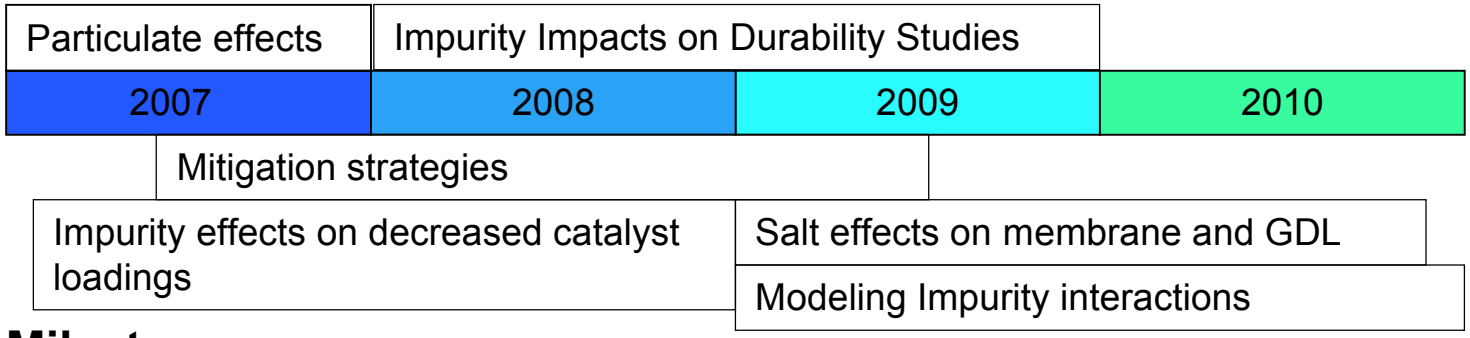
Impurity Studies

Project initiated in FY2007 for 4 years



Milestones:

Q4-Report effects of aerosols on FC performance
Q8- Report effects of impurities on 2010 Pt loading targets
Q10-Develop mitigation strategies for impurities
Q12-Report effects of impurities on 2015 Pt loading targets
Q16-Develop fuel cell impurity model
Q16-Disseminate results of salt effects studies

Go No Go's:

Q4- If aerosol effects small then terminate research
Q8- If impurity tolerance for 2010 loadings are lower than current develop new level specifications
Q12- If salt effects on FC's are small then terminate research

Organization/Partners

- USFCC
- ASME
- ASTM
- SAE
- ISO
- FCTesQA
- OEMs
- Fuel Providers

Budget

DOE Cost Share	Recipient Cost Share	TOTAL
$3,600,000	$0	$3,600,000
100%	0%	100%

- Duration – 4 years beginning in FY07
- Subcontractors
  - None