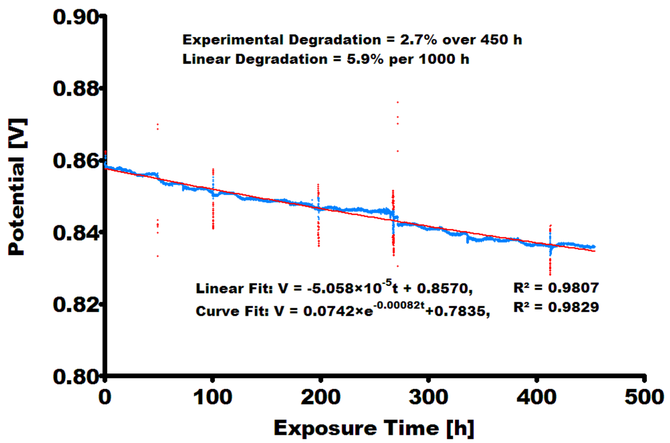
Impact of Trace Hydrocarbons from Coal Syngas on SOFC Long-term Operation

NETL-RUA Regional University Alliance

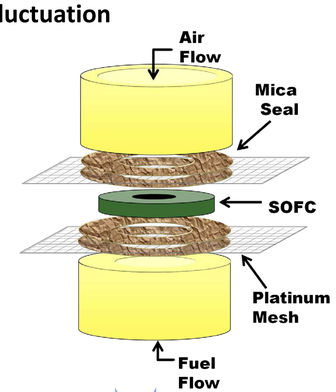
U.S. DEPARTMENT OF ENERGY

PROJECT GOAL: To determine the minimum resources required to clean coal syngas impurities to a concentration that allows continuous electrical power to be generated via solid oxide fuel cell for 40,000 hours.

Cell performance on syngas doped with 1000 ppm Ethylene at 0.25 A/cm²



- Potential loss over time is used to predict extended behavior over the cell's lifetime. Trends in the degradation data show that exponential decay curves describe the data more accurately as the majority of the potential degradation is over the first 1000 hours of operation
- The HC species ethylene (in progress), benzene, and naphthalene have been tested
- Improvements to the steam generation system has greatly improved system noise to less than 1 mV instantaneous potential fluctuation



Fuel Composition

H_2	29.1%
CO	28.6%
H_2O	27.1%
CO_2	12.0%
N_2	3.2%
CH_4	0.0%

Results

With information obtained from this research, detailed physical degradation mechanisms can be proposed from broad classes of degradation models, which are degradation caused by:

1. Physical blocking of fuel feed channels.
2. Physical blocking of SOFC active triple-phase boundary sites.
3. Chemical changes within the anode structure including secondary phase formation and the formation of metal solutions, both of which corrupt the percolation structure.

In this case, there is clear degradation caused by exposure to HCs. The best fit of the data is an exponential decay model, indicating that carbon interaction is a Class III attack mechanism because some reversibility is predicted. Assuming a 0.25% / 1000 h baseline cell degradation, rate the cleanup required to operate a cell with trace benzene and naphthalene are as follows:

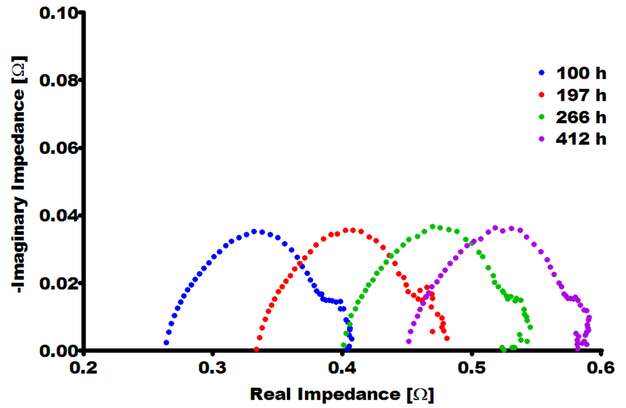
Hydrocarbon Cleanup Targets

BENZENE: < 150 ppm

NAPHTHALENE: ≈110 ppm

ETHYLENE: In progress

EIS data obtained during cell operation to syngas doped w/ 1000 ppm ethylene



- Electrochemical impedance spectra provide additional details of the degradation that is occurring over time. Post-trial analysis by XPS, SEM/EDS, and TEM provide physical details of degradation with the SOFC anode

- On-site capability to analyze real-time trace metal concentration of fuel using a coupled GC-ICP/MS. Species of interest include Hg, Se, As, and P. This method verifies that the desired contaminant concentration is reaching the SOFC

Linear Degradation Comparison (per 1000 h):

BENZENE
15 ppm = 2.9%
150 ppm = 2.7 %

NAPHTHALENE
100 ppm = 4.4%
500 ppm = 7.7 %

ETHYLENE
1000 ppm = 5.9%

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