SOFC Anode Interaction with Trace Coal Syngas

the ENERGY lab

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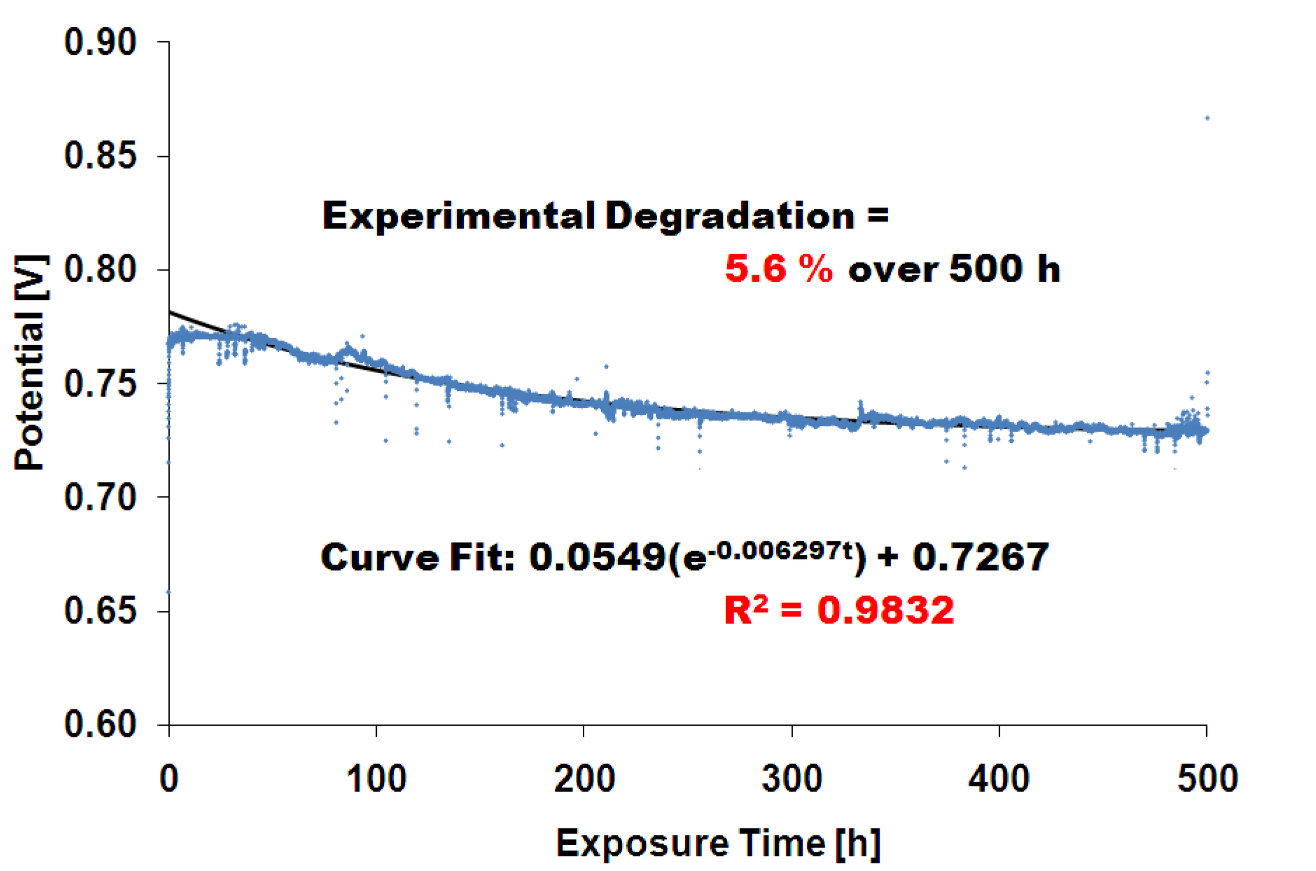
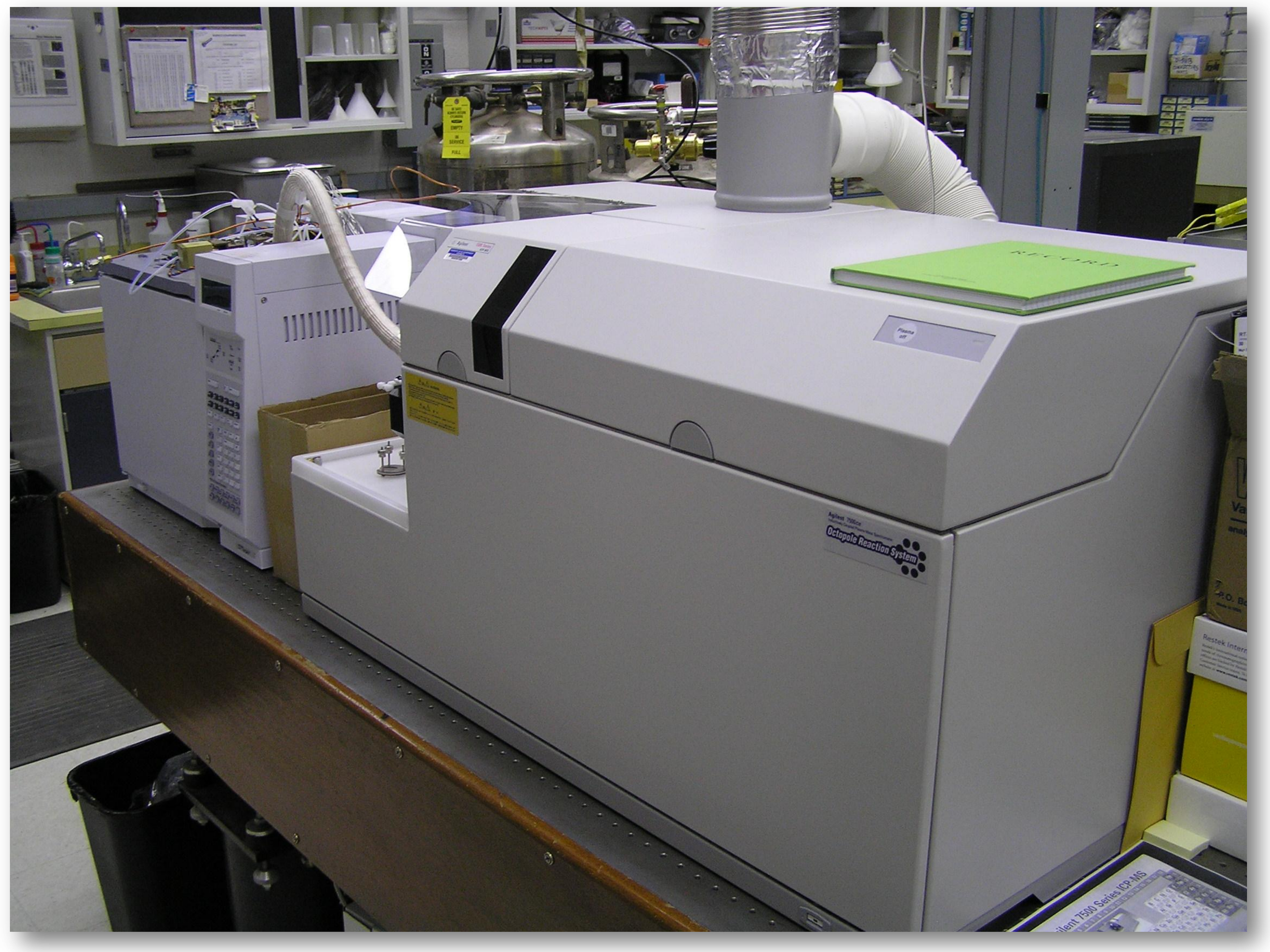
PROJECT GOAL: **To determine the minimum resources required to clean coal syngas impurities to a concentration that allows continuous electrical power to be generated via solid oxide fuel cell for 40,000 hours.**

Cell performance on syngas doped with 500 ppm naphthalene at 0.25 A/cm²

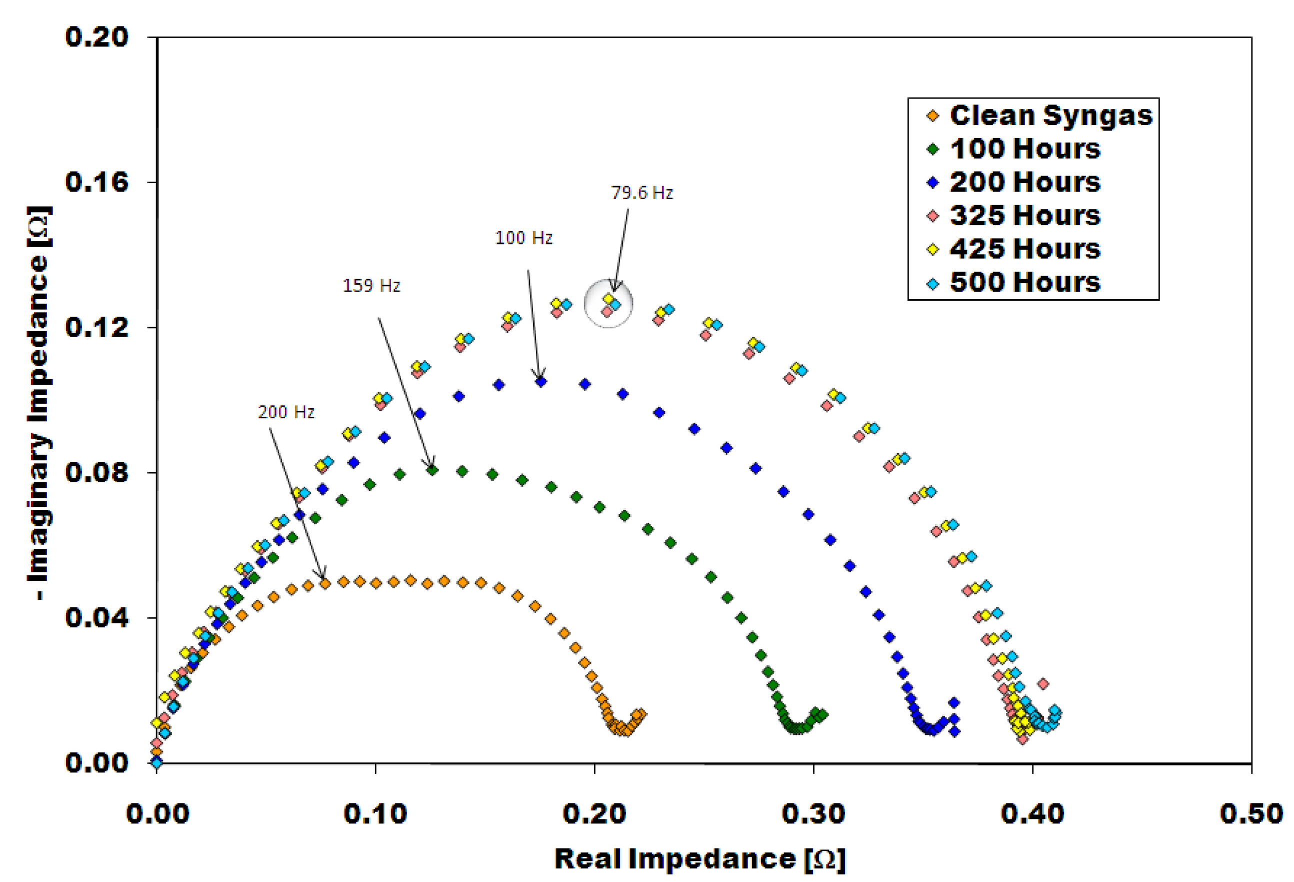


• Potential loss over time is used to predict extended behavior over the cell's lifetime. Hydrocarbon (HC) degradation fits to an exponential decay model that levels out to a linear, base-cell degradation (~0.25 -0.50 % / 1000 h). The HC species benzene and naphthalene have been tested.



GC-ICP/MS System installed at NETL

EIS data obtained during cell exposure to syngas doped w/ 500 ppm naphthalene



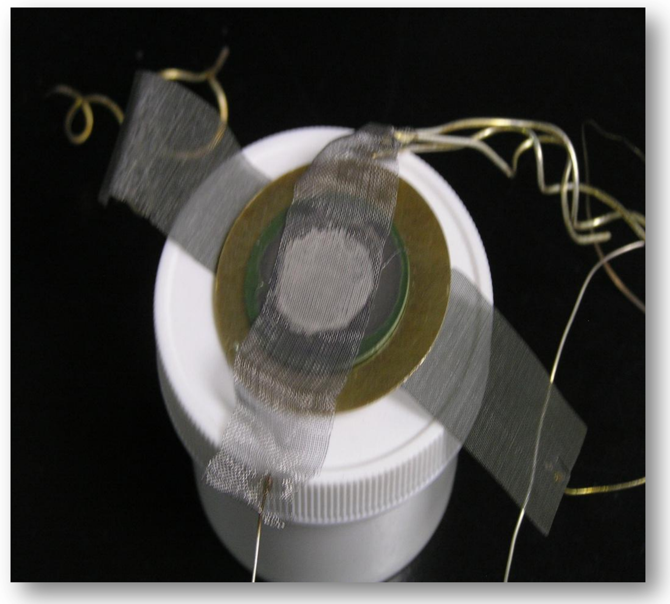
• Electrochemical impedance spectra provide additional details of the degradation that is occurring over time. Post-trial analysis by XPS, SEM/EDS, and TEM provide physical details of degradation with the SOFC anode.

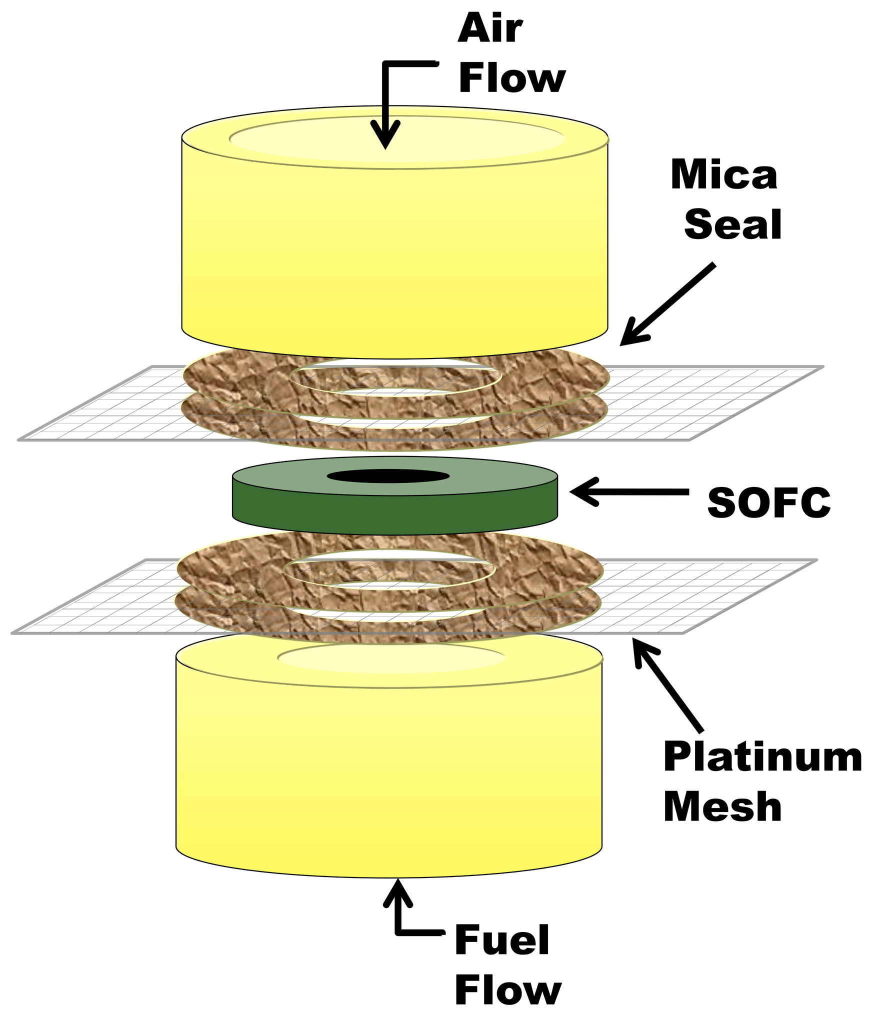
• On-site capability to analyze real-time trace metal concentration of fuel using a coupled GC-ICP/MS. Species of interest include Hg, Se, As, and P. This method verifies that the desired contaminant concentration is reaching the SOFC.

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%

Prepared Cell





Test Facilities

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 from exposure to hydrocarbons. The best fit of the data is an exponential decay model, indicating that carbon attack is a Class III attack mechanism because there must be some reversibility. Assuming a 1% / 1000 h BCD* rate, the average degradation over 40,000 h operation is (per 1000 h):

Benzene: 1.01% @ 15 and 150 ppm
Naphthalene: 1.02% @ 100 ppm, 1.09% @ 500 ppm

Because most of the degradation is predicted to occur within the first 1000 h of testing, it is useful to show the total degradation over the first 1000 h as well:

Benzene: 2.9% @ 15 ppm, 2.7% @ 150 ppm
Naphthalene: 4.4% @ 100 ppm, 7.7% at 500 ppm

Cleanup Targets @ 0.25% BCD*
Benzene: < 150 ppm
Naphthalene: ~ 110 ppm

***BCD = Base Cell Degradation (per 1000 h)**

Research Associates

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