Fuel Processing R&D at NETL

**Primary Goal**

Identify, evaluate and/or develop viable hydrocarbon fuel processing technologies for high temperature solid oxide fuel cells being supported in the NETL SECA program through fundamental understanding, research, and technology demonstration.

**Oxide-based Catalyst Systems (ABO)**

Doping the lattice of certain oxide-based compounds with catalytic metallic results in a structural catalytic surface with nano-sized metallic crystallites that serves as a template to control metallic crystallites size and dispersion.

**Doped ABO**

- High chemical and thermal stability.
- Monoclinic structure to accommodate substitutions.
- Active metal can be substituted into B-site to improve catalytic activity.
- B-site-active metallic clusters in A-site and B-site can oxidize oxygen vacancies, which may increase lattice oxygen stoichiometry to reduce carbon formation.

**Pyrochlore (A1O2B4O12)**

- Are viable reforming catalysts because they exhibit:
  - High chemical and thermal stability.
  - Monoclinic structure to accommodate substitutions.
  - Active metal can be substituted into B-site to improve catalytic activity.

**Fabrication of Catalyst into a Commercially Viable Structure**

- Powder Catalyst Oxidation
  - Activity tests: TP0 (surface formation)
  - Bulk characterization: XRD, ICP
- Surface characterization: AES, XPS, X-ray absorption
- Preliminary Tests on Oxidized Catalyst

**Diesel Fuel Reforming using Pyrochlore Catalyst**

Collaboration with Industrial Partner

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**Graded-Bed Approach**

- Partial oxidation of methanol (TPD) in presence of sulfur and oxygen.
- 150 g methanol.
- 0.1 g TPD.
- 2.0 g La2O3.
- 0.2 g Al2O3.
- 1.0 g CeO2.
- 150 g methanol.
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**Monolith Characterization**

- In situ microstructure analysis (XRD, XPS).
- Characterization of reforming reactor.
- Understanding of reforming reactor.
- Development of reforming reactor.

**Integrating SOFCs with Catalytic Coal Gasifier**

Anode Tail Gas Recycling

- Catalytic gasifier creates a syngas stream with ~28% methane.
- Methane reduces the amount of syngas heat generated in the IGFC.
- Pyrolysis of char or mixed alkali carbonates.
- CO2 removed from IGFC, free oxygen streams at ambient pressure.
- No oxygen separation from air.
- Syngas efficiency: 65%.
- IGFC: 500 °C.
- SOFC: 900 °C

**Conclusions**

- SOFC-based APUs for commercial diesel trucks is an excellent market entry technology.
- Reforming catalyzed with long-term stability and performance is critical for successful demonstration of transportation application.
- Pyrolysis catalyst has high thermal stability and other enhanced properties that make it effective reforming catalyst.
- Pyrolysis catalyst on oxygen-conducting support successfully reformed pump diesel for 1000-hr.
- Optimized pyrolysis catalyst applied to commercially representative structured supports.
- Preliminary performance of catalyst monolith demonstrated on pump diesel and biodiesel fuels under oxidative steam reforming.
- Preliminary experiments have shown some evidence of reduced carbon formation, however a detailed analysis is currently underway to repeat these findings and understand the mechanisms of RF-assisted reforming at various frequencies and power levels.
- Non-thermal plasma reforming technology has shown promising results for reforming of complex fuels such as diesel.
- Evaluating molten salt coal gasifier to generate high methane content syngas at lower pressures and temperatures.

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**Low-temperature plasma capability at NETL**

- Low temperature plasma creates high energy free electrons that can excite thermal energy states of reactants (thermal, electronic) and stimulate non-thermodynamically favorable reactions at low gas temperatures.
- Plasma also creates a significant number of ions and charged species that can accelerate the kinetics of a chemical reaction while reducing the activation energy of the reaction to proceed.
- NETL catalysts, 51-20K/AC/DC, 20-50kV AC/DC, 0.5-5kHz, 20-50kW, 10-50kA, with more work to be done at the pilot scale.

**Monolith Cutting**

- Corner coating thickness: 53 ± 13 microns

**Dot Map Analysis**

- Dot map analysis of coated monoliths.

**Pyrochlore Synthesis Methods**

- High chemical and thermal stability.
- Monoclinic structure to accommodate substitutions.
- Active metal can be substituted into B-site to improve catalytic activity.

**Monolith Technology by PC (top)**

- Microstructure and activity analysis.
- Understanding of reforming reactor.
- Development of reforming reactor.

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**Total bed carbon (TPC) formation study**

- Temperature Programmed Oxidation (TPO)
- 200 °C to 900 °C at ramp of 1 °C/min.

**Wet Gas Analysis**

- Water - pump off Water - pump on

**Areas of Future Research Include**

- Process stability to optimize small-scale efficiency.
- Use of protonic electrolyte for concentrated hydrogen and carbon dioxide capture, with regeneration of KOH.
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