Perovskite Adsorbents for Warm-Gas Arsenic and Phosphorus Removal

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Project Objectives

- Formulate and synthesize perovskite-based adsorbents containing elements that very strongly bind arsenic and phosphorus, two elements known to irreversibly poison nickel catalysts in SOFCs.
- Demonstrate rapid uptake of arsenic and phosphorus by the adsorbents.
- Demonstrate retention of arsenic and phosphorus by the adsorbents under high-pressure steam at temperatures ranging from 250-400°C.

Project Goals

- Reduce arsenic and phosphorus in gas streams from ppmv to low ppbv quantities.
- Employ synthetic water gas shift mixtures during testing.
- Operate reactor at pressures between ambient and 5 Bar.
- Operate reactor at temperatures between 250-450°C.

Key Results

- Preferred sorbents demonstrated As and P adsorption efficiencies as high as 73% versus 47% for a commercial Cu/ZnO material.
- Preferred sorbents demonstrated As and P adsorption capacities as high as 4.5% versus 1.0% for a commercial Cu/ZnO material.
- Preferred sorbents contain no Noble metals and are projected to cost <$5/lb.

*All data acquired at ambient pressure and 300°C using an argon sweep stream containing 300-800 ppm As and 30–250 ppm P flowing at 2,000 hr^{-1}.

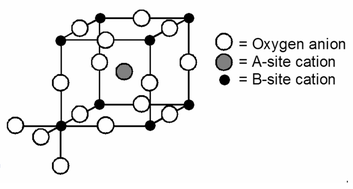
General Background

1. Why Arsenic and Phosphorus?

- **Affect ability of Ni in SOFCs to promote electrochemical reactions.**
  - Binding on Ni surface reduces active sites for H_2 and CO adsorption and inhibits dissociation of H_2.
- **Affect the electrical conductivity in SOFCs**
  - As and P form irreversible Ni-As and Ni-P solid phases which leads to a loss of electrical percolation in anode support.
- **DOE Polishing Filter Technical Targets**
  - Arsenic and Phosphorus - <20 ppbv
  - Sulfur - <60 ppbv

2. What's Eltron's Answer?

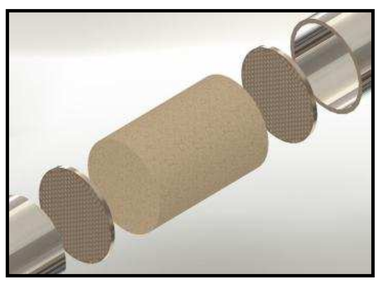
- **Focus on incorporating metals which form stable arsenides and phosphides into Perovskite (ABO_3) based materials.**

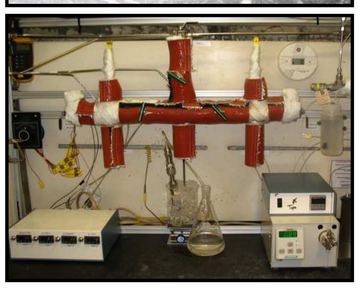


- **Multiple A-site (large metal cation) and/or B-site (small) atoms leading to ordered and disordered variants and some**
- **High oxygen mobility, and thus the lower stability of oxides, within Perovskite structures increases driving force for formation of M-As and M-P solid phases on adsorbents.**

Reactor Designs and Construction

- **Breakthrough Reactor**
  - **Employ Elemental Elemental Arsenic and Phosphorus.**
  - **Vaporize Elements, Use Inert Sweep Gas.**
  - **Ni-coated Coupons both Pre and Post-Sorbent Bed.**





- **High Pressure/Synthesis Gas Reactor**
  - **Same Testing Strategy as Breakthrough Reactor**
  - **Capable of Handling 1-5 Atm Pressure**
  - **Capable of Employing Simulated Syn-Gas Stream w/**

Testing Results and Issues

- **Successes**
  - **Synthesized and Characterized 16 Perovskite and Perovskite-like Adsorbents.**
  - **Preferred Sorbents Left No Trace of Ni on Post-Reactor Coupon.**
  - **Preferred Sorbents Out-Performed Commercial Cu/ZnO Sorbent.**
- **Primary Issues to Be Resolved**
  - **Contaminant Control – Difficulty in Generating Consistent Concentrations of As and P.**
  - **Quantifiable Data – Refining Techniques for Quantifying Post-Reactor As and P Concentrations Possible.**

Solutions and Future Plans

- **Reactor and Instrumentation Upgrades**
  - **More Precise Flow Control with Arsine and Phosphine Gas**
  - **Novel Detection System Capable of Measuring As and P Below 20ppbv**
  - **Arsenic Sensor Installed Post-Reactor**
- **Phase II Focus**
  - **Simulated Syn-Gas Stream w/Steam Addition**
  - **Sulfur Addition (H_2S)**
  - **Independent Testing for SOFC Protection by Leading SOFC Company**
  - **Pilot Plant Sorbent Scale-Up and Evaluation by Commercial Sorbent Production Company**

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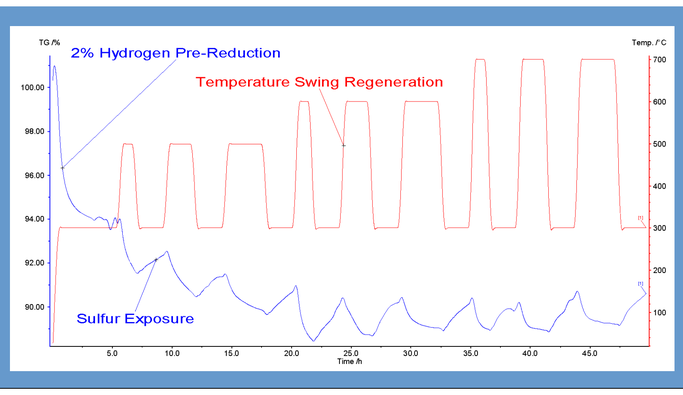

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