Title:	High Temperature Removal of H_2S from Coal Gasification Process Streams using an Electrochemical Membrane System
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ABSTRACT

OBJECTIVE

An advanced process for the separation of hydrogen sulfide from coal gasification product streams through an electrochemical membrane is presently being perfected. Hydrogen sulfide is removed from the syn-gas stream, split into hydrogen, enriching the exiting syn-gas, and sulfur, condensed from an inert sweep gas stream. The process allows removal of H_2S at temperatures of 850º C with no pressure loss through the separator. The membrane is composed of an inert ceramic saturated with a sulfide electrolyte. The process is economically attractive because typical removal options are process intensive, requiring absorbents and Claus plant conversion for sulfur recovery.

ACCOMPLISHMENTS TO DATE

Furnace Progress

Ample lab space has been provided to begin building a bench-scale furnace that will maintain operating cell temperatures of 650-900° C. A temperature controller will be employed to ensure a steady temperature profile in the furnace. In addition, a pneumatic piston will compress the cell housing blocks of the cell to ensure good contact between the cell components and to avoid cell shorting or leakage.

Electrochemical Cell Materials

Cell materials have all been chosen thus far save the cathode, which may consist of Co_8S_9, $LiCoO_2$, or $Ca_{(0.8)}Li_{(0.2)}FeO_3$. These materials will be tested to see which performs best. The other cell materials are as follows:

Component	Material
Anode	Lithiated Nickel
Membrane	Yittria-stabilized Zirconia
Electrolyte	$(Li_{0.62}K_{0.38})CO_3$
Cell Housing	316 Stainless Steel passivated by Alumina layer

Gas Inlet Composition

Water-gas shift equilibrium calculations have determined gas inlet to be a mixture of 36% carbon monoxide, 24% carbon dioxide, 2500 ppm or less H_2S, and balance hydrogen. This stream, upon hydration and elevation to furnace temperatures, will resemble typical gas streams encountered in industry via coal gasification. In addition, diluting the inlet with a similar stream that contains no H_2S will test various H_2S levels. Mass flow meters will be used on each stream so that the inlet H_2S concentration can be accurately measured. Gas chromatography analysis will also be used to verify H_2S levels at the inlet and measure them at the outlet. The GC can also be used for CO_2 concentration. Air-blown processes containing N_2 will be studied later.

Activity of Carbon diminished by H_2O

The hydration of the gasified coal stream diminishes the activity of elemental carbon to avoid build-up of carbon in the shift reactor and electrochemical cell. A spreadsheet has been developed that can predict the hydration needed at a given temperature to ensure that carbon activity $<< 1$. Water vapor is introduced to the system by a hydrator, and Raoult's law is used to estimate the fraction of water vapor in the process stream.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAMS

Hydrogen sulfide is the predominant gaseous contaminant in raw coal gas. Coal, depending on the type and area of extraction, can contain up to 5 wt% sulfur, which is converted to gaseous H_2S during gasification. Problems arise due to the corrosive nature of H_2S on metal components in these cycles. Because of this, H_2S concentrations must be reduced to low levels corresponding to certain power applications. For example, an integrated coal gasification-combined cycle (IGCC) process producing electricity from coal at nearly 50% overall efficiency, incorporates gas turbines which cannot tolerate H_2S concentrations above 100 ppm. Coal gasification/MCFC or SOFC systems, achieving conversion efficiencies around 60%, function properly only if H_2S is below 1 ppm. To achieve the highest energy efficiencies in these processes, removal must take place above temperatures of 800º C, avoiding cooling and reheating of the fuel gas stream. Absorbers are the norm in the industry now, and these require heat exchangers and intensive process systems to remove hydrogen sulfide.

PLANS FOR UPCOMING YEAR

- Finish constructing laboratory set-up
- Begin testing cathode materials, varying porosity and composition
- Determine efficiencies/limitations of cells

Student Supported under this Grant

- Alan Burke, graduate (Ph.D.) student in chemical engineering, GA Tech