IV.C.3 Single Membrane Reactor Configuration for Separation of Hydrogen, Carbon Dioxide, and Hydrogen Sulfide

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Objectives

- Develop a novel membrane process concept that would combine hydrogen sulfide removal, water-gas-shift (WGS) reaction, hydrogen separation and carbon dioxide separation in a single membrane configuration.
- Characterize, develop, and test a new class of dense/microporous membranes for hydrogen sulfide removal and carbon dioxide separation for high-temperature application feasibility.
- Test proton-conducting membranes for chemical stability under hydrogen sulfide and carbon dioxide atmospheres.
- Evaluate the performance of hydrogen production from gasification systems based on the complementary membrane water-gas-shift reactor process.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Production section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- L. Durability
- M. Impurities
- O. Selectivity
- P. Operating Temperature
- Q. Flux
- S. Cost

The project also addresses one or more of the barriers described in Section 5.1.5.1., Technical Barriers – Central Production Pathway in the Hydrogen from Coal – Research, Development, and Demonstration Plan of the DOE Office of Fossil Energy.

Technical Targets

Table 1 lists the targets that the project will attempt to meet during its implementation.

Table 1. Technical Targets for CO_2 Separation Membranes

Performance Criteria	Units	2007 target	2010 target
Flux	cc STP/cm^2/min	0.5	5
Temp	°C	600-900	700-850
ΔP operating capability	psi	100	200
H_2S tolerance		yes	yes
CO_2 purity	%	95-99	99.5
WGS activity		no	yes

Approach

- Initiate task to develop a membrane based on Ca-based nanoparticles for increased permeation rate of CO_2.
- Initiate task to prepare and test a Ca-based membrane.
- Complete construction of a permeation unit capable of operations up to 10 atm with the capability to handle H_2S-containing gas streams.
- Conduct CO_2 permeation testing on selected Ca-based membranes.
- Conduct hydrogen permeation testing with proton-conducting membranes under CO_2/H_2S-containing gas streams.

Introduction

The project objective is to develop a novel membrane process concept that would combine hydrogen sulfide removal, water-gas-shift reaction, hydrogen separation and carbon dioxide separation in a single membrane configuration. A new class of dense/microporous membranes for hydrogen sulfide removal and carbon dioxide separation will be developed, characterized and tested for high-temperature application feasibility. Proton-conducting membranes will be tested for chemical stability under hydrogen sulfide and carbon dioxide atmospheres. Theoretical models for permeation will be developed, and simulation will be performed to evaluate the performance of hydrogen production from gasification systems based on the complementary membrane WGS reactor process.

Approach

The first step is to develop a membrane based on Ca-based nanoparticles for an increased permeation rate of CO_2. Then, a test of the Ca-based membrane will be designed and conducted. The construction of a permeation unit capable of operations up to 10 atm with the capability to handle H_2S-containing gas streams will then be completed. Finally, CO_2 permeation testing on selected Ca-based membranes and hydrogen permeation testing with proton-conducting membranes under CO_2/H_2S-containing gas streams will be conducted.

Accomplishments

This project is newly initiated and no there are no accomplishments to report to date.