



## CO<sub>2</sub> SELECTIVE CERAMIC MEMBRANE FOR WATER-GAS-SHIFT REACTION WITH SIMULTANEOUS RECOVERY OF CO<sub>2</sub>

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### Background

The water-gas-shift (WGS) reaction,  $\text{CO} + \text{H}_2\text{O} \leftrightarrow \text{H}_2 + \text{CO}_2$ , is used to increase the hydrogen content of synthesis gas. However, this reaction is equilibrium limited. One approach for overcoming this limitation is to carry out the reaction in a reactor with walls that are CO<sub>2</sub> permeable. This continuously removes CO<sub>2</sub> from the system and allows the reaction to continue.

This project involves the development of a technique for depositing hydrotalcite onto a ceramic membrane suitable for implementing the reactive separation concept with the WGS reaction in integrated gasification combined cycle (IGCC) systems. The membranes are being developed using available sol gel and chemical vapor deposition (CVD) preparation techniques. The hydrotalcite is permeable to CO<sub>2</sub> but plugs the pores, preventing passage of other gases. The hydrothermal and chemical stability in a simulated WGS reaction environment will be evaluated to confirm the inert material properties of the ceramic membrane. Then, a membrane reactor (MR) study will be conducted to demonstrate the benefit offered by this membrane. Finally, process feasibility will be demonstrated in a test module, and an economic evaluation will be performed to estimate the positive effect of using a WGS-MR in IGCC coal-fired power plants.

### Primary Project Goal

The primary objective of this program is to develop a defect-free hydrotalcite membrane for selective CO<sub>2</sub> removal that will be effective in the water-gas-shift reaction environment, i.e., 300 to 600°C and in the presence of steam.

### Objectives

- Conduct a screening study to select an optimal material for developing a membrane and determine the optimum operating conditions in terms of temperature and steam content of the gas for selective CO<sub>2</sub> removal (good thermal, hydrothermal and chemical stability).
- Fabrication of the desired membrane in tubular geometry and verification of the feasibility of CO<sub>2</sub> separation along with the conversion enhancement.

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## PROJECT PARTNERS

Media and Process  
Technology Inc.

University of Southern  
California

## COST

Total Project Value: \$900,000  
DOE: \$720,000  
Non-DOE Share: \$180,000

## Accomplishments

Results from the TGA/MS studies show that the hydrotalcite material exhibits a high degree of CO<sub>2</sub> reversibility. Insignificant adsorption of water has been observed at higher temperatures (greater than 200°C). Based on these results, the conclusion is that the hydrotalcite is an ideal candidate material for high temperature gas separations requiring hydrothermal stability.

## Benefits

This combined shift reaction and CO<sub>2</sub> separation system project will produce a hydrogen rich gas which is at high pressure, high temperature and contains significant quantities of steam making it highly suitable for direct firing in a gas turbine with high efficiency. The use of an improved WGS-MR with CO<sub>2</sub> recovery capability is ideally suited to integration into the IGCC power generation system. Thus, the hydrogen (high pressure and CO<sub>2</sub> - free) produced from the IGCC can be used either as a product for power generation via a turbine or a fuel cell, or as a reactant for fuels and chemicals production.