



## PROJECT FACTS

### Existing Plants, Emissions & Capture

# Carbon Dioxide Capture by Absorption with Potassium Carbonate

## Background

Although alkanolamine solvents, such as monoethanolamine (MEA), and solvent blends have been developed as commercially-viable options for the absorption of carbon dioxide (CO<sub>2</sub>) from waste gases, natural gas, and hydrogen streams, further process improvements are required to cost-effectively capture CO<sub>2</sub> from power plant flue gas. The promotion of potassium carbonate (K<sub>2</sub>CO<sub>3</sub>) with amines appears to be a particularly effective way to improve overall solvent performance. K<sub>2</sub>CO<sub>3</sub> in solution with catalytic amounts of piperazine (PZ) has been shown to exhibit a fast absorption rate, comparable to 30 weight percent MEA. Equilibrium characteristics are also favorable, and the heat of absorption (10-15 kcal/mol CO<sub>2</sub>) is significantly lower than that for aqueous amine systems. Studies also indicate that PZ has a significant rate of reaction advantage over other amines as additives.

## Description

The University of Texas at Austin will investigate an improved process for CO<sub>2</sub> capture by alkanolamine absorption/stripping that uses an alternative solvent, aqueous K<sub>2</sub>CO<sub>3</sub> promoted by PZ. If successful, this process would use less energy for CO<sub>2</sub> capture than the conventional MEA scrubbing process. An improved capture system would mean a relative improvement in overall plant efficiency.

The project will include the development of models to predict performance of absorption/stripping of CO<sub>2</sub> using the improved solvent and performing a pilot plant (see figure) study to validate the process models and to define the range of feasible process operations. As part of the pilot plant study, a test with MEA will be conducted as a baseline to compare CO<sub>2</sub> absorption and stripping performance with tests using the K<sub>2</sub>CO<sub>3</sub>/PZ solvent. Researchers will also investigate key issues such as solvent degradation, solvent reclamation, corrosion, and alternative stripper

## Primary Project Goal

The primary goal of this work is to improve the process for CO<sub>2</sub> capture by alkanolamine absorption/stripping by developing an alternative solvent, aqueous K<sub>2</sub>CO<sub>3</sub> promoted by PZ.

## Objectives

- To improve the process for CO<sub>2</sub> capture by developing aqueous K<sub>2</sub>CO<sub>3</sub> promoted by PZ as an alternative solvent to MEA.
- To develop a system model based on data from bench-scale operations.

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## PERFORMANCE PERIOD

### Start Date End Date

07/09/02 08/31/07

COMPLETED

## COST

### Total Project Value

\$2,262,325

### DOE/Non-DOE Share

\$1,565,275 / \$697,050

## PARTNERS

University of Texas at Austin



U.S. DEPARTMENT OF  
**ENERGY**

- To perform pilot-scale experiments to validate the process model and define the range of feasible process operations.
- To optimize process variables, such as operating temperature, solvent rate, stripper pressure, and other parameters.
- To quantify the effectiveness of the promoter.

## Benefits

The major benefit of this project would be the ability to decrease the energy requirement for CO<sub>2</sub> capture from fuel gas or flue gas streams. Should CO<sub>2</sub> capture and sequestration become necessary, an improved capture process would significantly improve overall plant efficiency. The capital and operating costs for CO<sub>2</sub> capture could also be reduced.

## Accomplishments

- Three solvents (7 molal (m) MEA, 5 m K<sub>2</sub>CO<sub>3</sub>/2.5 m PZ, and 6.4 m K<sub>2</sub>CO<sub>3</sub>/1.6 m PZ) were evaluated in four pilot-scale testing campaigns with three different absorber packings (two structured and one random).
- To achieve equivalent absorber performance, 5 m K<sub>2</sub>CO<sub>3</sub>/2.5 m PZ requires two times less packing than 7 m MEA and three times less packing than 6.4 m K<sub>2</sub>CO<sub>3</sub>/1.6 m PZ.
- The effective wetted area of two structured packings, Flexipak AQ Style 20 (213 m<sup>2</sup>/m<sup>3</sup> dry area) and Flexipak 1Y (410 m<sup>2</sup>/m<sup>3</sup>), is 50 to 60 percent and 80 percent of that measured by CO<sub>2</sub> absorption from air by 0.1 N and NaOH, respectively.

- A rate-based model of absorber performance was developed in AspenPlus® with the RateSep™ block. This model was used to interpret pilot plant data and to predict performance at design conditions with and without intercooling.
- The effective working capacity of 4 m K<sub>2</sub>CO<sub>3</sub>/4 m PZ is about 60 percent greater than 7 m MEA, and the heats of absorption are nearly equivalent.
- The rate of CO<sub>2</sub> absorption in 4 m K<sub>2</sub>CO<sub>3</sub>/4 m PZ is 20 to 50 percent faster than in 7 m MEA.
- Absorber intercooling is effective at enhancing system performance when the temperature bulge is in the middle or lower end of the column, at moderate liquid-to-gas ratios, and typically with higher capacity solvents.
- Three stripper models were developed: one in Aspen Custom Modeler (ACM) based on equilibrium stages, a rate-based model in ACM, and an equilibrium model in AspenPlus®. These models were used to estimate and compare energy requirements of alternative solvents and process configurations.
- The double matrix stripper configuration is effective and produces some of the CO<sub>2</sub> at higher pressure.
- Studies of solvent loss, degradation, and reclamation have been completed.
- PZ loaded with CO<sub>2</sub> shows less than 3 percent loss of PZ when heated at 135 °C for 8 weeks, compared to 60 percent loss of 11 m MEA at the same conditions.
- The rate of oxidative degradation for PZ is low in the absence of dissolved copper.



*Pilot Plant at the University of Texas.*

