Solvents for CO_2 Capture

Background

Large point sources from power generation systems, both conventional and advanced, are key locations for CO_2 capture. With respect to advanced systems, such as Integrated Gasification Combined Cycle (IGCC), precombustion capture is advantageous because of the high partial pressure of CO_2. Additionally, CO_2 removal at higher temperatures, as compared to cooler conventional scrubbing temperatures, provides a thermal efficiency advantage. If improved, one capture technique that may provide additional benefits is higher temperature solvent scrubbing for CO_2.

The most attractive physical solvents for CO_2 capture are those having such properties as high thermal stability, extremely low vapor pressures, nonflammability, and nontoxicity. Such materials not only have the potential to capture CO_2 with minimal solvent loss in the gas stream but are expected to be environmentally benign. NETL is conducting a study involving one general type of solvent—ionic liquids—with these physical properties. The results of that study will serve as the basis for development of a new CO_2 capture technology.

Objective

The overall objective of this research is to develop and test physical solvents to selectively capture CO_2 from high temperature fuel gas streams, containing CO_2, CO, H_2S, H_2O, and H_2 like those found in IGCC systems after the low temperature water-gas shift reactor. Having established that ionic liquids currently available in large quantities do not meet performance needs, combined experimental and computational approaches will be used to screen large numbers of candidate materials both existing and novel.

Accomplishments

In past work, three fully commercialized ionic liquids (ILs) were evaluated as potential solvents for CO_2 capture. The evaluation process consisted of a parametric study including the measurement of gas solubility, mass transfer coefficient (k_La) and other hydrodynamic parameters in the solvent as a

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function of temperature, pressure, liquid height, and mixing speed in a 1-gallon agitated autoclave. The study was conducted with a multi-component synthetic fuel gas mixture consisting of CO_2, H_2, Ar, CH_4, and CO. Preliminary results from this study were published in a peer-reviewed journal. Additionally, experiments designed to determine the effects of H_2S on the ability of ionic liquids to capture CO_2 from fuel gas were conducted. The data collected from the parametric study were used to determine the potential effectiveness of this class of ionic liquids as capture solvents. The most significant accomplishments were the determination that quaternary ammonium ionic liquids are not competitive with existing commercial solvents for CO_2 capture and the development of a comprehensive understanding of the physical requirements for CO_2 capture solvents in these systems.

Benefits

One goal of the carbon sequestration program is to develop capture/sequestration systems that capture at least 90 percent of emissions and result in a small increase in the cost of energy services for gasification-based processes. To attain such benefits, NETL's CO_2 separation and capture research is aimed at developing technologies that have low capital cost, low parasitic load, high percent reduction in emissions, and the capability to integrate with pollutant controls. Additionally, its gasification technology area is focusing on achieving greater acid-gas removal, improved hydrogen economy, zero emissions, and integrated systems with lower costs due to fewer subsystems, lower parasitic losses, and smaller plant footprints. The successful development of a higher-temperature physical solvent process will produce a capture technology able to fulfill the goals of the Carbon Sequestration Program.

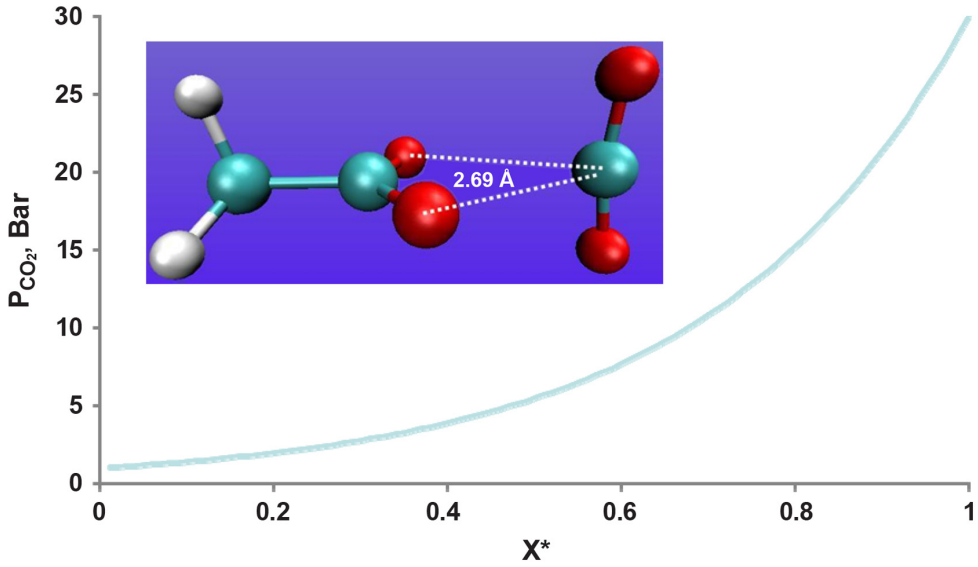

Figure 1. CO_2 solubility isotherm from molecular modeling

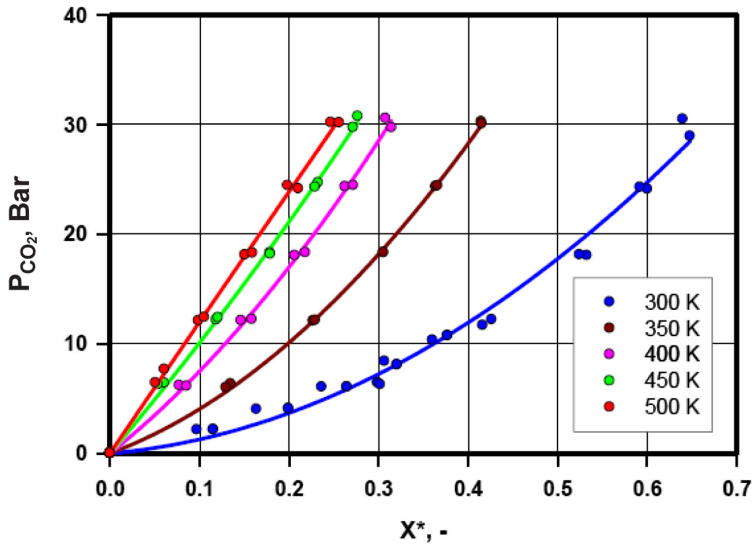

Figure 2. Experimental CO_2 solubility isotherms