R & D facts

Carbon Sequestration

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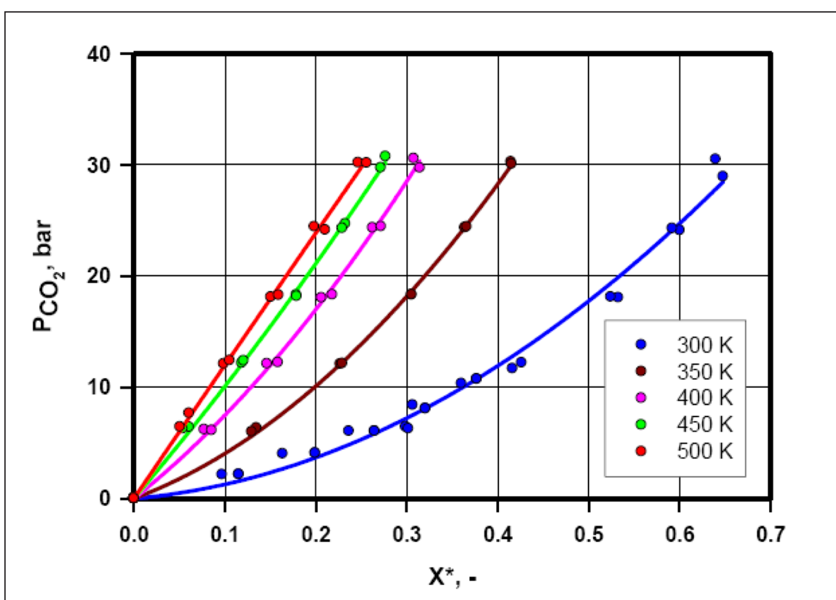
U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

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. In collaboration with the University of Pittsburgh, NETL conducted 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 a conceptual design and system analysis of a new CO_2 capture technique.



CO_2 Solubility in Candidate Ionic Liquid

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Objective

The overall objective of this research is to test and develop physical solvents to selectively capture CO_2 from fuel gas streams, particularly those containing CO_2, CO, H_2S, H_2O, and H_2 in amounts typically produced after the water-gas shift reaction. Ultimately, the technical and economic feasibility of using physical solvents for CO_2 capture from synthesis gas produced in a post-shift reaction IGCC context will be determined. A comparison between the ability of these solvents to selectively capture CO_2 from fuel gas and those of existing processes, will be performed.

Accomplishments

Three ionic liquids (ILs) were screened as potential solvents for CO_2 capture. The screening process involved measuring the viscosity and density of these materials at various temperatures and pressures, as well as determining their abilities to dissolve CO_2.

The most significant accomplishment was the identification of a CO_2 capture solvent (a commercially available ionic liquid) that contains molecular constituents that give it a strong affinity toward CO_2, is thermally stable, is environmentally benign, and has a very low vapor pressure. During the screening process, it was found to be a fairly good CO_2 solvent at 500 K, an IGCC-like temperature, while, surprisingly, being a significantly better CO_2 solvent than the existing solvent benchmark at 300 K.

Following the screening measurements, the best-performing ionic liquid solvent was advanced to the next phase of experimental work, which involved the completion of a Central Composite Statistical Design matrix, a parametric study involving the measurement of CO_2 solubility and mass transfer coefficient (k_La) and other hydrodynamic parameters in the solvent as a function of temperature, pressure, liquid height, and mixing speed in a 1-gallon agitated autoclave. This study involved the ability of the solvent to capture CO_2 from a multi-component synthetic fuel gas mixture consisting of CO_2, H_2, Ar, CH_4, and CO. The data collected from this study, after the effects of H_2O and H_2S are determined, will be used as input parameters for a future system analysis.

Benefits

One goal of the carbon sequestration program is to develop capture/sequestration systems that capture at least 90% 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, 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 technique that can certainly make it possible for the Department of Energy to fulfill the goals of its various technology areas.