the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Ionic Liquids: Breakthrough Absorption Technology for Post-Combustion CO_2 Capture

Background

Development of innovative environmental control technologies is key to maintaining coal as an affordable and environmentally sound energy source. Carbon dioxide (CO_2) emissions control technologies, specifically post-combustion CO_2 capture, for coal-fired power plants is a major focus area in addressing climate change concerns. Post-combustion CO_2 capture from flue gas is technically challenging as large volumes of gas at atmospheric pressure and with low CO_2 concentrations (10 to 15 volume percent) need to be treated. In spite of this difficulty, post-combustion CO_2 capture offers the greatest near-term potential for reducing greenhouse gas emissions as the technology can be retrofitted to existing units and tuned for various capture levels.

One area of interest in post-combustion CO_2 capture is the use of solvent-based systems, which involves chemical or physical sorption of CO_2 from flue gas into a liquid carrier. Solvent-based systems are currently being used for scrubbing CO_2 from industrial flue and process gases; however, these CO_2 capture systems have not yet been scaled to the size required for processing the large volumes of flue gas produced by a pulverized coal (PC) plant. DOE is funding research to develop low-cost, efficient, solvent-based CO_2 capture technologies that can significantly reduce CO_2 emissions from existing PC power plants.

Project Description

The University of Notre Dame (Notre Dame) and its partners are continuing development of novel ionic liquid absorbents and an associated process to remove CO_2 from coal-fired power plant flue gas. Ionic liquids (ILs) are salts that are liquid in their pure state at near ambient conditions. In a previous National Energy Technology Laboratory (NETL)-funded project, Notre Dame demonstrated that ionic liquids can be engineered to have very high physical solubilities and also be made to form chemical complexes with CO_2. Ionic liquids have great chemical diversity, which should present researchers with ample opportunities to tailor and optimize their properties for CO_2 capture. Having shown their potential in the previous project, researchers will work in this project to take the next step in the development process.

In Phase I, Notre Dame will perform atomistic-level computer simulations of a series of ionic liquids and functional groups along with flue gas species. This will give researchers insight into chemical and structural features that will lead to favorable properties. Simultaneously, researchers will investigate known CO_2 - philic moieties, synthesize new ionic liquids, and make preliminary measurements of physical properties and phase

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PARTNERS

Trimeric Corporation
The Babcock and Wilcox Company
DTE Energy
Merck KGaA
Koei Chemical Company

PERFORMANCE PERIOD

Start Date	End Date
03/01/2007	09/30/2012

COST

Total Project Value
$4,153,048

DOE/Non-DOE Share
$2,741,784 / $1,411,264

AWARD NUMBER

FC26-07NT43091

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behavior. They will also begin to set up the process model for the system. In Phase II, researchers will refine development efforts for the "optimal" absorbent, exhaustively measure or estimate all relevant properties, and use this information to complete a detailed systems and economic analysis. In Phase III, researchers will finalize the optimal ionic liquid(s), design a laboratory-scale test system, and continue to refine systems and economic analyses. During Phase IV, Notre Dame will construct and operate the lab-scale test system, finalize systems and economic analyses, and develop a path forward for pilot-scale testing and commercialization.

Primary Project Goal

The overall goal of the project is to develop a new ionic liquid absorbent and an accompanying process for post-combustion capture of CO_2 from coal-fired power plants with 90 percent capture efficiency and less than a 35 percent increase in the cost of energy services.

Objectives

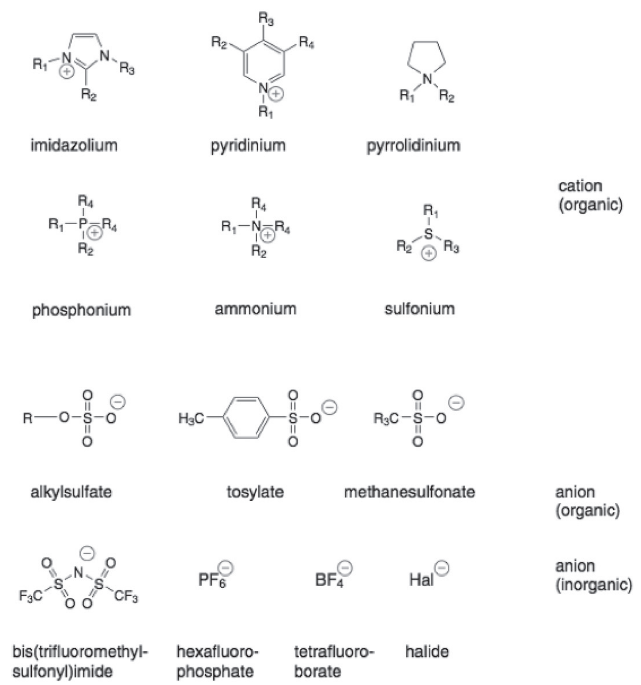
- Design and synthesize one or more ionic liquid absorbents having physical properties tailored for post-combustion CO_2 capture.
- Perform atomistic-level classical and quantum calculations to engineer ionic liquid structures that maximize CO_2 carrying capacity while minimizing regeneration costs.
- Measure or accurately estimate all physical properties of the ionic liquid that are essential for a detailed engineering and design calculation.
- Complete a detailed systems and economic analysis.
- Demonstrate the CO_2 capture process with a continuous laboratory-scale unit.
- Develop a path forward for commercialization.

Benefits

Improved capture processes are needed to make CO_2 capture economically feasible. The use of ionic liquids as CO_2 absorbents holds promise for reducing costs by enabling higher CO_2 loading in the circulating liquid and lower heat requirements for regeneration. Both of these effects would lower process costs.

Accomplishments

- Synthesized and tested a total of 17 new "Generation 1" ionic liquids during the first year of the project; synthesized a total of seven "Generation 2" ionic liquids during the second year of the project.
- Developed molecular modeling techniques that have enabled Notre Dame researchers to compute key properties of ionic liquids from first principles.
- Developed a way to tune the binding strength of CO_2 to optimize the ILs using process modeling as a guide.
- Developed unique experimental techniques, including the ability to monitor the infrared spectrum of the ionic liquid as it absorbs CO_2, and then use this information to determine reaction rates and mechanisms.
- Evaluated alternative process configurations; selected a viscosity modified absorber stripper process for continued study.
- Acquired a detailed understanding of the mechanism responsible for the large viscosity increase observed upon complexing CO_2, and designed new molecules that do not show viscosity increases.
- Synthesized several "Generation 3" ILs that exhibit low viscosity and do not demonstrate a significant increase in viscosity upon reaction with CO_2, unlike the case with "Generation 2" ILs.
- Designed and assembled a laboratory-scale absorption/desorption unit; demonstrated continuous operation with a "Generation 2" IL.



Examples of commercially available ionic liquids.