the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Molecular Design and Evaluation of CO_2 Sorbents

Background

The capture and separation of carbon dioxide (CO_2) has been identified as a high-priority topic within DOE's Carbon Sequestration Program. The costs of separation and capture, including compression to the required pressure for the storage step, are generally estimated to be a significant percentage of the total cost of the sequestration process. Improvement in CO_2 separation and capture is necessary to reduce the total cost required for sequestration.

Description

The objective of this project is to develop novel amine-enriched sorbents for the capture of CO_2 from flue gas streams generated by the utility industry. These novel CO_2 capture sorbents will be prepared by chemical treatment of the high surface area materials with various amine compounds.

The implanting of amine groups on a high surface area material will increase the needed contact area between CO_2 and amine by several magnitudes. Therefore, only a small amount of sorbent used in the typical amine process is needed for capturing the same amount of CO_2. A significant improvement in the efficiency of the process is due to the increased contact area and therefore less energy consumption in regenerating the sorbents.

Primary Project Goal

This research is aimed to incorporate and graft the amino-functionality onto various high-surface substrates for the capture of CO_2 from flue gas streams produced by the combustion of coal. These sorbents must be regenerable, durable, and cost-effective to create a CO_2 capture system that can be used in the utility industry.

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U.S. DEPARTMENT OF ENERGY

Objectives

- Design a sorbent that will bind CO_2 at greater than 3 moles CO_2 per kg of sorbent and ideally greater than 5 moles CO_2 per kg of sorbent.
- Allow for adsorption temperatures between 55 and 75 °C.
- Allow for CO_2 release at temperatures less than 120 °C, and with release complete in a short period of time.
- Provide for a low pressure drop across the adsorbent bed.
- Allow for adsorption at gas flow rates and with gas mixtures (up to 8 percent water, 14 percent CO_2, 50 ppm SO_x, 25 ppm NO_x) that are industrially realistic.
- Provide the information to develop a new environmental control technology for the reduction of CO_2, a greenhouse gas emission.

Benefits

The cost of CO_2 capture should be significantly reduced as a result of decreasing the amount of amine required to recover the CO_2. Ease of regeneration of the amine will also help to lower costs. The application of this, or similar CO_2 capture units, to older pulverized coal- (PC) fired power plants will also be very useful in reducing the total amount of CO_2 to the atmosphere. Retrofitting of capture units in the 5- to 10-thousand ton range with older PC-fired power plant units will lower costs for the removal and reduction of CO_2.

Accomplishments

The atmospheric pressure performance of these amino-sorbents was obtained in a temperature swing adsorption (TSA) system after exposure to a 10 percent CO_2 and 2 percent H_2O and He experimental gas stream. Their ability to capture CO_2 over the temperature range of 25–65 °C was detailed.

After the adsorption stage, desorption of CO_2 from these sorbents was determined at 90 °C, and the sorbents were regenerated for additional cycles. According to TSA/mass spectrometer analysis, all of the sorbents were successful in the capture of CO_2 from the moist experimental gas streams. The best performing sorbents are summarized in the table below.

Sorbent Type	Researchers	Temperature °C	Mole CO_2/kg Adsorbent
Immobilized	NETL	25-65	2.0-3.5
Polymeric	NETL/ Georgia Tech	25-65	2.5-3.0