the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Metal Monolithic Amine-Grafted Zeolites for CO_2 Capture

Background

The mission of the U.S. Department of Energy's (DOE) Existing Plants, Emissions & Capture (EPEC) Research and Development (R&D) Program is to develop innovative environmental control technologies to enable full use of the nation's vast coal reserves, while allowing the current fleet of coal-fired power plants to comply with existing and emerging environmental regulations. The EPEC R&D Program portfolio of post- and oxy-combustion carbon dioxide (CO_2) emissions control technologies and CO_2 compression and reuse is focused on advancing technological options for the existing fleet of coal-fired power plants in the event of carbon constraints.

Current aqueous amine and membrane technologies are cost-effective for separation of CO_2 as applied in natural gas liquefaction processes and ammonia synthesis processes due to the high value of the resulting end products. Application of these current technologies for CO_2 capture from coal-fired power plants results in significant increases in the cost of electricity produced. The cost of CO_2 capture and storage can be reduced if an effective CO_2 capture sorbent is developed with:

- High CO_2 adsorption capacity.
- Long-term regeneration capacity in power plant flue gas environment.
- Low energy requirement for regeneration compared to large amount of energy required for aqueous amine process.

Description

This project is investigating a CO_2 capture system that involves the novel integration of a metal monolith with amine-grafted zeolites. Key features of this system are the use of metal monoliths coated with a low cost amine-grafted zeolite which eliminates the use of corrosive liquid amine and decreases the energy required for sorbent regeneration. The metal monoliths consist of straight channels: one row of channels coated with amine-grated zeolite and one used for heat transfer media for either cooling for adsorption or heating for regeneration. The alternative arrangement of CO_2 adsorption and cooling media (i.e., water or air) channels will allow effective removal of adsorption heat.

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PROJECT DURATION

Start Date
02/21/2007

End Date
03/31/2011

COST

Total Project Value
$957,833

DOE/Non-DOE Share
$764,995 / $192,838

Primary Project Goal

The primary goal of this project is to develop a highly efficient and low-cost CO_2 capture system consisting of metal monoliths with parallel square channels of which the surface is coated with a nanostructured/hydrophobic zeolite-grafted amine.

Objectives

- Prepare and test the performance of various amine-grafted zeolite sorbents. Performance testing will evaluate CO_2 and SO_2 capacity along with long-term stability.
- Develop an optimized amine-grafted zeolite based on stability and capture capacity.
- Design, fabricate, and test a metal monolithic absorber coated with the optimal sorbent.
- Determine the performance capabilities of the final CO_2 capture system through the development of an engineering system model and economic analysis of a large scale system.

Accomplishments

- Three types of sorbent supports for the immobilized amines were tested.
- More than 15 samples of alkyl amine-grafted zeolite/oxide for CO_2 capture and 10 samples of aryl amine-grafted oxides for SO_2 capture were prepared and tested.
- More than 50 sorbents have been tested with thermal degradation under oven heating at 100 °C for more than 16 hours; more than 5 sorbents were tested with CO_2 adsorption at 55 °C and desorption at 90 °C cycling.
- A metal monolith CO_2 absorber was designed and fabricated.
- Testing concluded that the CO_2 capture capacity of the sorbents exceeds the goal of 1500 μmol/g.
- Degradation testing achieved the goal of 500 regeneration cycles with less than 10% overall degradation.

Benefits

The low cost of raw materials for the synthesis of zeolite-grafted amine sorbents combined with the innovative application of metal monoliths as an adsorber structure may lead to a breakthrough technology for the effective capture of CO_2 from flue gas of coal-fired power plants.

Planned Activities

- Complete performance testing of the CO_2 capture system.
- Develop a material and energy balance model that will be used to perform an economic analysis for scale-up of this CO_2 capture system.