the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

High Performance Polymer Composite Coated Hollow Fiber Membranes for Post Combustion CO_2 Capture and Separation From Coal-fired Power Plants

Background

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

Pulverized coal (PC) plants burn coal in air to produce steam, and comprise 99 percent of all coal-fired power plants in the United States. Carbon dioxide is present in the flue gas exhaust at atmospheric pressure and a concentration of 10–15 volume percent. Post-combustion separation and capture of CO_2 is a challenging application due to the low pressure and dilute concentration of CO_2 in the waste stream, trace impurities in the flue gas that affect removal processes, and the parasitic energy cost associated with the capture and compression of CO_2. Polymeric membrane-based CO_2 capture technologies are a potentially promising alternative to existing liquid sorbent-based options. Membrane-based CO_2 capture technologies have the potential to impact both the cost of electricity (COE) by reducing parasitic loads and operating costs, and the additional water demand, by eliminating the need to continuously cool the solvent stream.

Project Description

General Electric Global Research (GE) and partners will develop high performance, thin film polymer composite hollow fiber membranes and advanced processes for economical post-combustion CO_2 capture from coal-fired flue gas. The project will utilize novel phosphazene polymeric materials to develop economical and scalable composite hollow fiber membrane modules capable of efficiently separating CO_2 from coal-based flue gas. The membranes will be optimized at bench scale, including tuning the properties of the phosphazene polymer in a coating solution and fabricating highly engineered porous hollow fiber supports. The project will also define the processes for coating the fiber support to manufacture ultra-thin, defect-free composite hollow fiber membranes. The physical, chemical, and mechanical stability of the materials (individual and composite) to coal-based flue gas components will be evaluated using exposure and performance tests. Membrane fouling and cleanability studies will define long-term performance.

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PARTNERS

Idaho National Laboratory
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PROJECT DURATION

Start Date	End Date
10/01/2011	09/30/2014

COST

Total Project Value
$2,948,123

DOE/Non-DOE Share
$2,358,498/$589,625

AWARD NUMBER

DE-FE0007514

U.S. DEPARTMENT OF ENERGY

GE and the Georgia Institute of Technology (Georgia Tech) will work together on developing processes to apply the ultra-thin layer coating formulations onto the hollow fiber supports. GE will leverage the knowledge gained from using its flat sheet film coating apparatus to enable development of the continuous dip process for coating of hollow fiber membrane supports. Georgia Tech will use the in situ process developed to coat porous cellulose acetate hollow fibers with defect-free layers as a benchmark, which will be further adapted to obtain thin, defect-free coated layers. Both the continuous dip coating and batch in situ processes will be optimized to provide economical and scalable coated composite hollow fiber membranes. Working with Idaho National Laboratory (INL), Georgia Tech will characterize phosphazene material properties in films cast on porous polymer supports to elucidate polymer properties including aging, membrane fouling, and cleanability. The characterization techniques will enable a better understanding of polymer and composite membrane performance. Membrane performance validation testing in coal-fired flue-gas will be performed at Western Research Institute's coal combustion test facility in the final budget period. Module design and technical and economic feasibility analyses will be conducted to evaluate the overall performance and impact of the process on the COE.

Primary Project Goal

The overall goal of this project is to develop high performance, thin film polymer composite hollow fiber membranes and advanced processes for economical post-combustion CO_2 capture from pulverized coal flue gas at temperatures typically found in existing flue gas cleanup processes.

Objectives

The project goal will be attained by achieving the following objectives: (1) fabricating an engineered, highly porous, hollow fiber support for the novel phosphazene polymer, (2) optimizing robust coating processes to coat defect-free thin films of high performance phosphazene polymer on the hollow fiber supports, (3) fabricating a composite hollow fiber membrane that meets permeability and selectivity targets set by system modeling requirements, and (4) achieving the projected COE impact and CO_2 recovery that meets or exceeds DOE goals.

Planned Activities

- Conduct preliminary technical and economic feasibility studies to refine performance targets.
- Characterize and optimize phosphazene polymer separation performance on actual flue gas.
- Modify the phosphazene material into easily-processed coating solutions.
- Produce highly porous hollow fiber supports with controlled surface porosity.
- Optimize both the continuous dip and batch coating processes to provide economical and scalable coated composite hollow fiber membranes.
- Conduct preliminary membrane fouling and aging studies.
- Test membranes at bench-scale in coal flue gas.
- Conduct technical and economic feasibility analyses and an environmental, health, and safety assessment.

Accomplishments

- Kick-off meeting conducted in January 2012.

Benefits

Membranes based on coupling this novel phosphazene-based polymer with an engineered hollow fiber support could offer a higher efficiency CO_2 capture process able to be retrofit to existing coal-fired power plants. The several specific process and material optimizations to be performed in this project have the potential to significantly improve the economics of CO_2 capture, and to achieve the DOE performance criteria of capturing greater than 90 percent of the CO_2 in coal-fired flue gas with less than a 35 percent increase in the COE.

NETL

WRI coal combustion test facility.