PROJECT facts

Sequestration

03/2005

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

NOVEL DUAL FUNCTIONAL MEMBRANE FOR CONTROLLING CARBON DIOXIDE EMISSIONS FROM FOSSIL FUELED POWER PLANTS

CONTACTS

Scott M. Klara
Sequestration Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4864
scott.klara@netl.doe.gov

José D. Figueroa
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4966
jose.figueroa@netl.doe.gov

C. Jeffrey Brinker
Sandia Fellow, Sandia National Laboratories
Professor of Chemical & Nuclear Engineering
The University of New Mexico
Advanced Materials Laboratory
1001 University Blvd. SE, Suite 100
Albuquerque, NM 87106
505-272-7627
cjbrink@sandia.gov

Background

There is growing concern among climate scientists that the buildup of greenhouse gases (GHG), particularly carbon dioxide, in the atmosphere is affecting the global climate in ways that could have serious consequences. One approach to reducing GHG emissions is to scrub CO_2 from the flue gas of power plants and sequester it in geologic formations. Although it is technically feasible to remove CO_2 from flue gas, current processes are too expensive. Therefore, new, less expensive processes are needed. This project is investigating the feasibility of developing a novel, dual-functional silica-based membrane for controlling carbon dioxide emissions from fossil-fuel fired power plants.

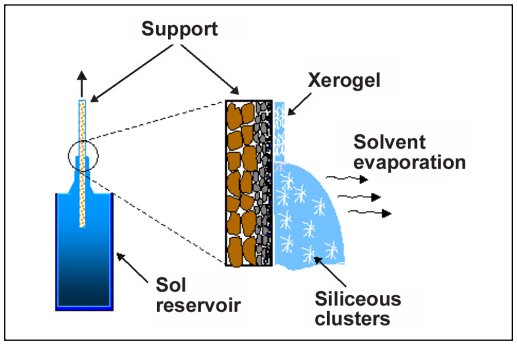

Fig. 1. Schematic representation of the sol-gel dip-coating process for depositing a microporous aminosilicate membrane on a porous tubular ceramic support.

The membrane will be prepared by a sol-gel dip-coating process on a porous support (see Fig. 1) and will consist of a microporous inorganic siliceous matrix with amine functional groups physically immobilized or covalently bonded on the membrane pore walls. It is anticipated that strong interactions between the permeating CO_2 molecules and the amine functional membrane pores will enhance surface diffusion of CO_2 on the pore wall of the membrane with subsequent blocking of the transport of other gases, such as O_2, N_2, and SO_2 (see Fig. 2). In this way, the new membrane is expected to exhibit higher CO_2 selectivity compared to prior, purely siliceous membranes that perform separations based on difference in molecular size only. The pore size of the new membranes will be controlled in the range of 4-10 Å by adjusting the precursor sol composition.

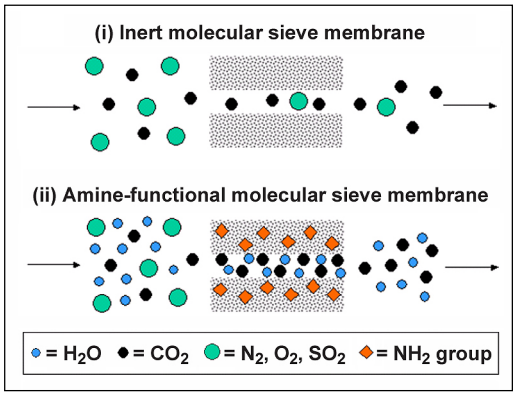

Fig. 2. Gas transport mechanism through: (i) a pure siliceous microporous membrane where separation is mainly based on size differences of permeating molecules, and (ii) a microporous aminosilicate membrane where pore blocking can be achieved by strong interactions of CO_2 and H_2O vapor with the amine groups introduced in the silica matrix.

The amount of solvent (H_2O), the type and amount of surfactant additive, and the sol aging time and their effect on membrane permeability and selectivity will be studied experimentally. The incorporation of the amine functional groups in the silica matrix will be implemented by various techniques: (1) mixing of silica sol with aqueous solution of amines; (2) using aminosilanes as a silicon source for the membrane matrix; and (3) post-grafting terminal amine groups on the pore walls of surfactant-templated membranes, using aminosilanes. The membrane microstructure (see Fig. 3) will be optimized in order to meet a targeted CO_2 permeance as high as $1x10^{-3}$ $cm^3(STP)/cm^2.sec.cmHg$, combined with a CO_2/N_2 separation factor of over 100.

The group at the University of New Mexico will be primarily responsible for laboratory-scale synthesis and testing of the proposed novel membranes, while the team at T3 Scientific will be responsible for commercialization of the technology and design/ economic evaluation of an industrial-scale membrane process for CO_2 removal from power plant flue gas.

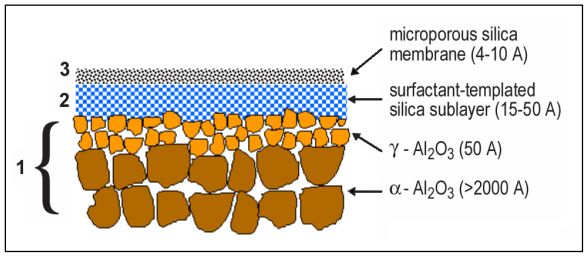

Fig. 3. Overview of the microstructure of the composite membrane comprising of: (1) a commercially available tubular or hollow fiber ceramic support; (2) a mesoporous surfactant-templated silica sub-layer with pore size 15-50 Å; and (3) a microporous aminosilicate gas separation membrane layer with pore size 4-10 Å.

Primary Project Goal

The primary goal of this project is to develop a dual functional membrane capable of removing CO_2 emissions from the flue gas of coal-fired power plants efficiently and inexpensively.

Objectives

The objectives of this project are to:

- Prepare and characterize amine functional membrane materials with a CO_2/N_2 selectivity of 100 and a CO_2 permeance of $1x10^{-3}$ $cm^3(STP)/cm^2{\cdot}sec{\cdot}cmHg$ or greater.
- Conduct small-scale parametric testing, using a simulated multi-component gas, to determine optimum performance conditions.
- Optimize thin membrane deposition.
- Perform a preliminary systems analysis for integration of a membrane system into a 500 MW power plant.
- Perform a long-term test to estimate membrane life.
- Conduct a pilot-scale test.

Benefits

If CO_2 capture from flue gas is ever to become economically feasible, improved capture processes are needed. The use of an amine modified membrane with high CO_2 permeance and selectivity holds promise for reducing costs by avoiding the expensive absorber/ stripper system required with amine based systems.

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

PARTNERS

University of New Mexico

T3 Scientific

COST

Total Project Value
$886,827

DOE/Non-DOE Share
$886,827 / $0