PROJECT facts

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

Hydrogen and Clean Fuels from Coal

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CARBON MOLECULAR SIEVE MEMBRANE AS A TRUE ONE BOX UNIT FOR LARGE-SCALE HYDROGEN PRODUCTION

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Description

A potential approach to U.S. energy independence is the use of its abundant coal reserves. These coal reserves may be converted to liquid fuels, chemical feedstocks, and hydrogen using gasification technology. Syngas generated during coal gasification is a logical source for hydrogen. However, the required sale price (RSP) of hydrogen from coal gasification is ~$8.18/MMBtu hydrogen, much higher than the RSP of $5.8/MMBtu hydrogen obtained from catalytic steam reforming of methane (SRM). Thus, to make hydrogen production from coal economically competitive with SRM, significant reductions are needed in the capital and operating costs of hydrogen production from coal. The “one-box” approach may offer the solution.

The objective of this project is to integrate hydrogen separation, carbon dioxide capture, and contaminant removal into a single unit. Building on past work with carbon molecular sieves (CMS), this project will integrate the water-gas shift reaction membrane reactor (WGS MR) with carbon dioxide separation using the CMS membrane in the reactor. The one box process will first be demonstrated at bench scale after, followed by a slipstream field test to confirm the material and performance stability of the one box reactor. Next, field tests with a pilot-scale test unit will be conducted. The mathematical model developed during earlier work will be calibrated and verified to match the laboratory and field test results. The model will now be used to optimize the process and obtain production economics. The ceramic substrate on which the CMS membrane is deposited will be compared with a stainless steel substrate to help select the optimal substrate for a future full scale demonstration.

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Primary Project Goals

- Demonstrate the proposed one-box process with a bench-scale unit.
- Conduct a slip-stream test in the field to confirm the material and performance stability of the bench scale unit over the short term.
- Design and construct a pilot scale test unit.
- Conduct a pilot test in the field to demonstrate the one-box hydrogen production process.
- Verify laboratory and field test results with the existing mathematical model.
- Utilize the model to ascertain process optimization parameters and production economics.
- Compare performance of CMS membrane deposited on a ceramic substrate versus that on a stainless steel substrate.
- Select optimal membrane parameters for future full scale demonstration.

Accomplishments

None at present – New project initiated in FY-2007

Benefits

This approach maximizes hydrogen production by reducing the unit operations of the WGS reaction, hydrogen separation, and carbon dioxide capture into a single unit. Reducing the capital and operating cost of producing hydrogen from coalcan make it competitive with the current cost of producing hydrogen from a more costly resource, i.e., natural gas. Successful field tests at pilot scale, combined with process optimization using mathematical modeling, should yield an optimized design for a full scale plant.