R & D facts

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National Energy Technology Laboratory

Gasification Technologies

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Oxygen Carrier Development for Chemical Looping Combustion

Background

Chemical looping combustion (CLC) is a flameless combustion technology where there is no direct contact between air and fuel. The CLC process utilizes oxygen from metal oxide oxygen carrier for fuel combustion. The products of CLC and are CO_2 and H_2O. Thus, once the steam is condensed, a relatively pure steam of CO_2 is produced ready for sequestration. The combustion process does not produce NO_x. The production of a sequestration ready CO_2 stream does not require any additional separation units and there is no energy penalty or reduction in power plant efficiency.

The majority of the work performed to date on CLC has been performed using methane as the fuel. There are only limited studies with oxygen carriers used to combust coal-derived synthesis gas. Those few studies that have been performed using coal-derived fuel gas suggest that more experimental information is needed. Development of oxygen carriers that have stable performance during multiple cycles is critical for the success of the CLC process.

Accomplishments

A comprehensive literature search was performed to identify those chemical looping processes that involve coal gasification. Various oxygen carriers, including NiO on bentonite and CuO on bentonite have been prepared and evaluated as oxygen carriers at 700, 800 and 900 °C using thermal gravimetric analysis (TGA). Stable reactivity was observed over 10 cycles of oxidation with air and reduction with synthesis gas. Rate information was computed for reactions over both oxygen carriers. Particle size, temperature and pressure affected the rate. Performance of these oxygen carriers were evaluated in a high pressure flow reactor at 150 psi with synthesis gas at 700, 800 and 900 °C. Stable reactivity was observed over 3 high pressure cycles, and complete combustion of hydrogen and complete utilization of the metal oxide were observed. Novel nano-composite oxygen carriers were also developed in collaboration with University of Pittsburgh to improve the rates. The rate information will be utilized for reactor design for CLC.

CONTACTS

Ranjani Siriwardane
Separations and Fuel Processing Division
National Energy Technology Laboratory
3610 Collins Ferry Road
P. O. Box 880
Morgantown, MV 26507
304-285-4513
ranjani.siriwardane@netl.doe.gov

Dan C. Cicero
Technology Manager
Hydrogen & Syngas
Office of Coal & Power R&D
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4826 or 412-386-6152
daniel.cicero@netl.doe.gov

PARTNER

University of Pittsburgh

ADDRESS

National Energy Technology Laboratory
1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street, Suite 1400
Tulsa, OK 74103-3519
918-699-2000

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

Benefits

Chemical looping combustion (CLC) can lead to increased power efficiency. CLC produces a stream of combustion products that primarily consist of CO_2 and steam. A relatively pure stream of CO_2 that is sequestration ready can be produced by simply condensing the steam. This avoids the energy penalty traditional fossil fuel fired combustors must pay to produce a pure stream of CO_2. Additionally, CLC avoids production of NO_X that is produced in almost all other combustion processes.

Development of improved oxygen carriers could increase their mechanical strength leading to increased service life, improve the rate of oxidation and reduction steps, avoid carbon deposition, and improve the stability during multi cycle tests. These improvements could significantly improve the economics of CLC.