

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



OXYGEN CARRIER DEVELOPMENT FOR CHEMICAL LOOPING COMBUSTION

Background

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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 are CO_2 and H_2O . Thus, once the steam is condensed, a relatively pure stream 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.

PARTNER

University of Pittsburgh



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.

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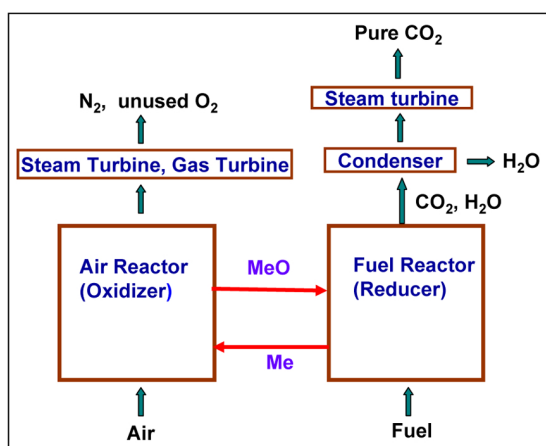
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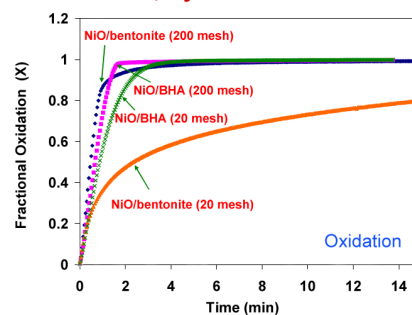
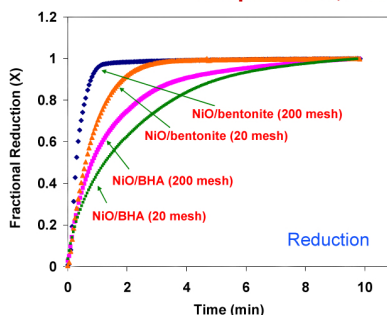
Chemical Looping Combustion Process



- Air is not mixed up with fuel
- CO_2 is not diluted with N_2 of flue gas
- Reduced NO_x problems
- Sequestration ready CO_2
- No additional energy penalty for the separation

TGA Data: NiO/Bentonite and NiO Nano Composites (NiO/BHA)

Temp.: 800°C, Particle size: 200 mesh, Cycle: 5



- Both materials ~100% metal utilization
- Reduction is faster with NiO/bentonite, while oxidation is faster with NiO/BHA
- NiO/bentonite: Rate of Oxidation is dependent of particle size
 - Smaller the particle size, faster is the oxidation
- NiO/BHA: Rate of oxidation is independent of the particle size