TECHNOLOGY OPPORTUNITY

NOVEL TRI-METALLIC FERRITE OXYGEN CARRIERS ENHANCE CHEMICAL LOOPING COMBUSTION

OPPORTUNITY:

A patented technology invented at the U.S. Department of Energy's National Energy Technology Laboratory enhances chemical looping combustion by providing tri-metallic ferrite oxygen carriers that offer greater durability and better reactivity than traditional oxygen carriers. Tri-metallic ferrite oxygen carriers also eliminate agglomeration issues, improve reduction rates, and offer similar costs when compared to traditional oxygen carriers, with convenient preparation using readily available materials. This technology is available for licensing and/or further collaborative research from NETL.

CHALLENGE:

Chemical looping combustion (CLC) is a promising technology for coal-derived energy production that involves combusting fuel in nearly pure oxygen to simplify carbon capture. In CLC systems, oxygen is introduced to the system via oxidation-reduction cycling of an oxygen carrier. Traditional oxygen carriers such as CuO, Fe_2O_3, NiO, and CoO have disadvantages including low reactivity (Fe_2O_3), low melting point and high agglomeration (CuO), and health and environmental concerns (NiO). The development of new oxygen carriers with enhanced performance characteristics is required for successful deployment of coal CLC processes.

OVERVIEW:

Oxy-combustion power generation provides oxygen to the combustion process by separating oxygen from air. Chemical looping systems take advantage of oxygen internal to the process, cutting the large capital, operating, and energy costs associated with oxygen generation. However, the development of robust oxygen carriers is critical for the efficient operation and adoption of CLC technology.

NETL researchers have developed novel tri-metallic ferrite oxygen carriers that comprise $Cu_xFe_yMn_zO_{4-8}$ - where $Cu_xFe_yMn_zO_{4-8}$ is a chemical composition with generally $0.5 \leq x \leq 2.0$, $0.2 \leq y \leq 2.5$, and $0.2 \leq z \leq 2.5$ - for CLC of solid fuels such as coal, pet coke, and biomass. The tri-metallic ferrite oxygen carrier is used by delivering it to a fuel reactor and mixing it with a carbon-based fuel at a reducing temperature, which reduces a portion of the carrier and oxidizes a portion of the fuel. Within the fuel reactor, the tri-metallic ferrite carrier interacts with the fuel and generates a reduced carrier. The reduced carrier subsequently enters an oxidation reactor, where it is infused with oxidizing gas to produce a re-oxidized carrier through an oxidizing reaction. The re-oxidized carrier, which comprises comprise $Cu_xFe_yMn_zO_{4-8}$, may then be returned to the fuel reactor for a cyclic operation.

CLC offers a major advantage over conventional coal combustion by directly producing a concentrated stream of CO_2 without expending the significant energy required for CO_2 separation. This NETL technology offers numerous advantages over traditional oxygen carriers for coal CLC. Tri-metallic ferrites perform better when compared to Fe_2O_3, demonstrating high and stable reactivity over multiple reduction/oxidation cycles and high attrition resistance. Ferrite-based oxygen carriers also display a low tendency to agglomerate at high temperatures, as with CuO. These metal ferrites can be produced using readily available materials at a cost comparable to Fe_2O_3 and CuO oxygen carriers.

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ADVANTAGES:

- Improved reduction/oxidation rates, durability and reactivity compared to Fe_2O_3
- Eliminates agglomeration issues associated with CuO
- Stable at high temperatures and over multiple oxidation-reduction cycles
- Can be produced using readily available materials at comparable cost to standard oxygen carriers
- Carriers are environmentally benign

APPLICATIONS:

- Chemical looping combustion of coal
- Chemical looping gasification of coal to produce synthesis gas
- Combustion/gasification processes using biomass, pet coke, and other solid fuels

RELATED PATENTS:

U.S. Patent No: 9,797,594

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Title: Tri-metallic Ferrite Oxygen Carriers for Chemical Looping Combustion

Inventors: Ranjani Siriwardane, Yueying Fan

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NETL researchers used the Lab's Chemical Looping Reactor to invent a patented technology that enhances chemical looping combustion by providing tri-metallic ferrite oxygen carriers that offer greater durability and better reactivity than traditional oxygen carriers.

NATIONAL ENERGY TECHNOLOGY LABORATORY

FOR MORE INFORMATION:

Customer Service:
1.800.553.7681

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412.386.4687

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304.285.4764

1450 Queen Avenue SW
Albany, OR 97321-2198
541.967.5892