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CREATING DESULFURIZED FUEL FOR FUEL CELLS

Introduction

This invention represents a substantial advance toward the goal of providing clean, sulfur-free fuel to solid oxide fuel cells (SOFCs). Researchers at the Sensors and Electron Devices Directorate of the U.S. Army Research Laboratory (ARL), Adelphi, Maryland, successfully tested a new method and apparatus that removes performance-killing sulfur compounds from petroleum-based fuels converted for use in SOFCs. Desulfurization is a critical step in SOFC operation, and ARL's invention offers a significant advantage over current methods and can undoubtedly enable wider application of this new green energy technology.

The U.S. Army Corps of Engineers is working to supply more fuel cells to military and federal facilities to reduce power costs. The ARL innovation could enable wider adoption of fuel cell technology in home, commercial, and industrial settings (Image source: U.S. Army ERDC-CERL)

Concept

The new U.S. economy continually searches for power generation that is more efficient, versatile, and sustainable. Fuel cells are one of the core technologies that can meet these challenges. They represent a more efficient way to generate electricity from fossil fuels. Moreover, they are capable of using existing fuels and distribution networks—a big plus that is bringing these devices to the market sooner than other next-generation energy technologies. However, naturally occurring sulfur in fossil fuels is a known problem for fuel cells; it harms key components and affects operations. Ideal sorbent materials would remove sulfur quickly with high holding capacity. They should also function at typical SOFC (and fuel reformer) operating temperatures (600 to 1000°C). Unfortunately, most sorbents to date have been deficient in one or more of these properties.

The ARL approach uses a combined metal oxide sorbent system in which two different metal oxides are assembled in a specific way to make best use of each of them. Tests demonstrate that this system achieves *both* high sulfur capacity *and* high reactivity while maintaining material stability above 600°C.

Invention Overview

- *Novel design simplifies process for removing sulfur impurities from fuel cell gas feedstock*
- *Does not require special equipment or processing techniques to create sorbent apparatus*
- *Industrial, home, and military fuel cell applications*
- *TRL 3 – Fully functioning bench-scale apparatus and test data available*
- *Additional information – "Desulfurization of Logistics Fuel Reformate for Fuel Cell Applications," 10th Electrochemical Power Sources R&D Symposium (2007)*
- *"Investigation of Metal Oxide for High Temperature Desulfurization", Proceedings of the 44th Power Sources Conference, June 14-18, 2010*
- *U.S. Patent Application Publication: US2011/0110836 A1*

Doing Business with ARL

- *ARL is a leader in partnering with domestic firms in a wide range of technology areas*
- *Successfully developed and implemented innovative tools to ease the technology transfer process*
- *Tools include Patent License Agreements (PLAs); Cooperative Research and Development Agreements (CRADAs); Test Services Agreement (TSA); and others*
- *Visit www.arl.army.mil for more information*

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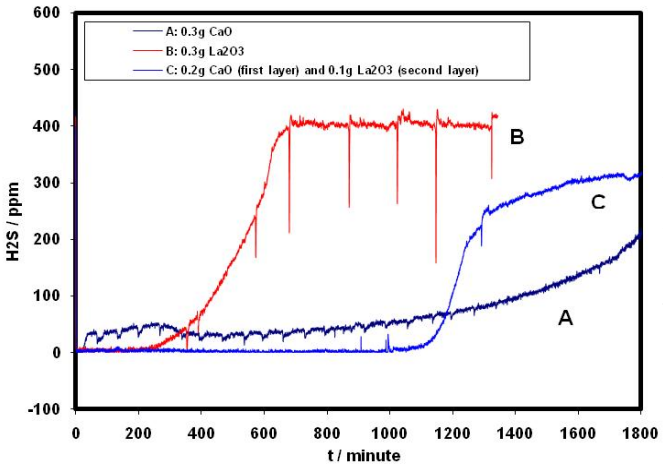
Features/Capabilities/Intellectual Property

Fuels cells combine hydrogen and oxygen to produce electricity quietly and efficiently. The hydrogen feedstock may come from a process known as fuel reforming. Reforming is an industry-standard way to disassemble hydrocarbons in gasoline, diesel, military logistics fuel, natural gas, and even gasified coal. The process, which takes place between 600 and 1000°C, produces a "reformate" gas comprising mostly hydrogen and some useful carbon compounds. The problem is that reformate also retains sulfur found in fossil fuels. These sulfur compounds in the reformate, mainly hydrogen sulfide (H_2S), can poison the anode and damage the fuel cell stack.

The ARL invention is an adsorption method and assembly that prevents sulfur-fouling. The sorbent, a combination of calcium and lanthanum oxides, reversibly adsorbs H_2S from the flow of reformate gas before it enters the fuel cell. The sorbents work at temperatures up to 800°C, well within reformer and SOFC operating range. This is a significant feature—an option to design a system that closely couples operations at higher temperatures.

A summary of features/capabilities/intellectual property offered by this invention includes the following:

- Combination of metal oxides achieves at least 3x better H_2S removal level and 4x greater removal capacity than single sorbent systems
- Practice of cooling hot reformate to below 500ºC for sulfur removal and then reheating to above 600ºC for fuel cell operation is avoided
- Construction materials are known to industry and widely available
- Sorbent apparatus can be fabricated using common practices
- IP includes novel method and apparatus



Desulfurization results comparing two single sorbent systems (A and B) and ARL invention (C). Data illustrate that with 420 ppmv starting concentration, the ARL system maintains low ppmv levels of H_2S far longer and more consistently than single sorbent systems (Image source: ARL)

Potential Markets/Applications

The ARL innovation will also be applicable to commercial advanced energy production such as coal-based Integrated Gasification Combined Cycle with Fuel Cell (IGCC-FC) power plants in which all contaminants, including sulfur, have to be cleaned from the gasified fuel stream before flowing to the fuel cell for electricity generation.

Key Advantages & Benefits

- *Designed to handle reformate from liquid fuels containing up to 3,000 ppmw sulfur*
- *Features both disposable and regenerable components*
- *No undesirable side reactions or changes in reformate properties*
- *Construction materials well known in industry and widely available*
- *Design adaptable to different fuel cell configurations*
- *Inventor team available to work with commercialization partner*

Contact Information

This technology was developed by ARL. It is now available for licensing and CRADA opportunities.

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