Project status: Ongoing

P R O J E C T   F A C T   S H E E T

Selective Adsorption for Removing Sulfur for Making Ultra-Clean Transportation Fuels & for Fuel Cell Applications

Goal

The objectives are to develop a novel desulfurization process called selective adsorption for removing sulfur (SARS) and to explore selective and high-capacity adsorbent materials for SARS to produce ultra-low-sulfur (<1 ppm) gasoline, diesel fuels and jet fuels. SARS can be tailored for on-site and on-board sulfur removal for fuel cell and refinery applications.

Team

A partial list of organizations that work with The Energy Institute in adsorption desulfurization research include: U.S. Department of Energy (DOE), National Energy Technology Laboratory (NETL), and U.S. Department of Defense (DOD).

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Background

Desulfurization research has become increasingly more important due to heightened public interest worldwide for cleaner air. US Environmental Protection Agency has issued regulations that will require the refineries to reduce the sulfur content of gasoline from a current average of 300 parts per million by weight (ppmw) to 30 ppmw by 2006, and the sulfur content of highway diesel fuel from a current limit of 500 ppmw to 15 ppmw by 2006. In order to reduce the sulfur content in transport fuels for environmental protection purpose, development of more effective methods for sulfur removal is highly desired for both refinery and non-refinery applications including on-site and on-board sulfur removal for fuel cell applications.

For diesel fuel, it is very difficult for the current hydrotreating technology to reduce the sulfur content to less than 50 ppmw, because the remaining sulfur compounds in current diesel fuel with 500 ppmw S level are the more refractory sulfur compounds. In terms of technology availability, the sulfur content in gasoline can be reduced to less than 30 ppmw by current hydrotreating processes. The major problem for deep desulfurization of gasoline is that the current hydrotreating technology results in high hydrogen consumption and significant reduction of octane number due to olefin saturation.

Project Discussion

One problem in the current industrial desulfurization processes is that in order to carry out deep removal of the sulfur compounds that account for only less than 1 percent of the fuel, 100 percent of the fuel will need to be processed at high temperatures (>300 °C) under elevated pressures using hydrogen gas. The idea behind our SARS approach is to selectively remove the sulfur compounds from the fuels by adsorption at room temperatures under atmospheric pressure without using hydrogen, and leave behind the saturate and aromatic components of the fuel which can be used directly as ultra-clean fuels. Such a system, if successfully developed, can be used not only in future refinery operations, but also in various small stationary and mobile applications for on-site or on-board sulfur removal.

SARS System for Adsorption Desulfurization

Results

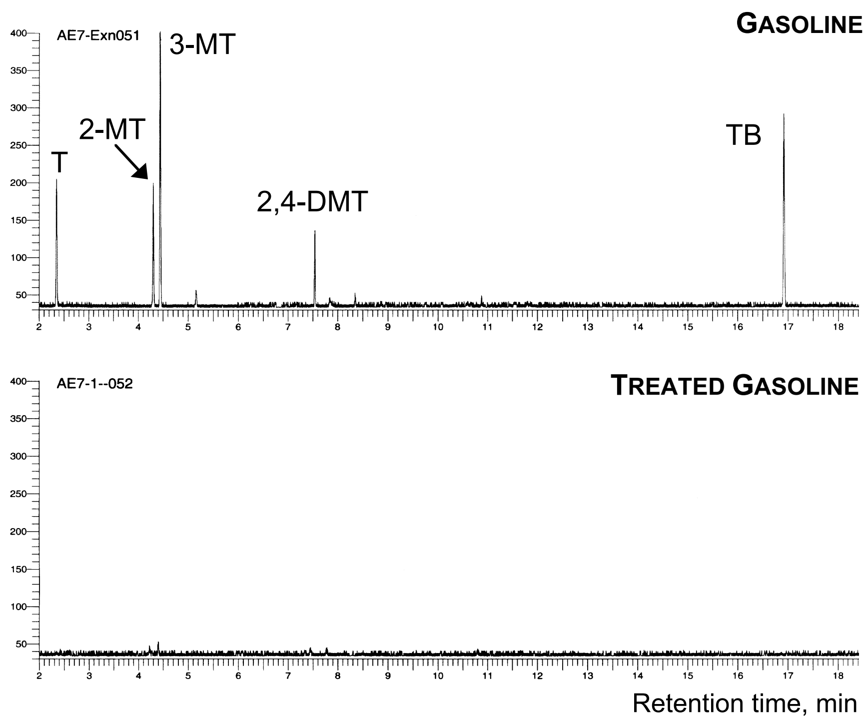
The Energy Institute has developed a novel desulfurization process called selective adsorption for removing sulfur (SARS) from gasoline, diesel and jet fuels using adsorbent at room temperature (e.g., 30°C) without using hydrogen. One hindrance to extricating sulfur from hydrocarbon fuels is the presence of aromatics. The trick is to remove only the sulfur, which comprises less than 1 percent of the fuel, while leaving the more prevalent aromatics behind. The key to SARS is the design of adsorbents possessing surface sites that selectively interacts with sulfur in the presence of aromatics. The adsorbents designed and prepared have been shown to be selective and effective for sulfur removal. This is a major advance in desulfurization research.

The SARS concept has been demonstrated in laboratory scale for making ultra-low-sulfur (<1 ppm) gasoline and diesel fuels as well as JP-8 jet fuels. SARS works for making ultra-clean fuels using solid adsorbent that selectively interacts with sulfur compounds in the presence of aromatic compounds at room temperature (e.g., 30 °C), and does not use hydrogen or other reactive gases.

SARS can lead to new and substantially more efficient ways to remove sulfur for producing near-zero-sulfur fuels for fuel cells and for making ultra-low-sulfur fuels in a future refinery. SARS could change the future of desulfurization.

SARS for Gasoline Desulfurization of by Using PSU A-1

- **Feed: Gasoline**
  Adsorbent: A-1
  5 wt % loading of a metal compound on silica gel, 70-230 mesh, ~500m2/g
- **Conditions:**
  Ambient temperature and pressure,Glass Column, 11 mm i.d.
- **Almost no sulfur signal (<1 ppmw)**



Key Publications

C. Song. Keynote: Catalysis and Chemistry for Deep Desulfurization of Gasoline and Diesel Fuels. An Overview. Proceedings of 5th International Conference on Refinery processing, AIChE 2002 Spring National Meeting, New Orleans, March 11-14, 2002, pp.3-12.

X. Ma, L. Sun, Z. Yin and C. Song. New Approaches to Deep Desulfurization of Diesel Fuel, Jet Fuel, and Gasoline by Adsorption for Ultra-Clean Fuels and for Fuel Cell Applications. Am. Chem. Soc. Div. Fuel Chem. Prepr., 2001, 46 (2), 648-649.

X. Ma, M. Sprague, L. Sun, and C. Song. Deep Desulfurization of Liquid Hydrocarbons by Selective Adsorption for Fuel Cell Applications. Am. Chem. Soc. Div. Petrol. Chem. Prep., 2002, 47 (1), 48-49.

M. Sprague, J. Zheng,, and C. Song. Effect of Sulfur Removal from Naphthalene on Its Hydrogenation over Mordenite-Supported Pd Catalyst. Am. Chem. Soc. Div. Petrol. Chem. Prep., 2002, 47 (2), 103-105.

I. Novochinskii, X. Ma, C. Song, J. Lambert, L. Shore, and R. Farrauto. A ZnO-Based Sulfur Trap for H2S Removal from Reformate of Hydrocarbons for Fuel Cell Applications. Proceedings of Topical Conference on Fuel Cell Technology: Opportunities and Challenges. AIChE 2002 Spring National Meeting, New Orleans, March 11-14, 2002, pp. 98-105.