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MAKING SYNTHETIC CHEMICAL PRECURSORS

(Lee, Behrens)

Introduction

This invention represents one in a progression of advancements aimed at transforming biomass into specialty feedstock materials. Researchers at the Sensors and Electron Devices Directorate of the U.S. Army Research Laboratory (ARL), Adelphi, Maryland, designed, fabricated and tested a new process that uses a specifically engineered catalyst and flow reactor to convert butanol into butylene. Butylene is an important starting point for synthesizing a wide range of fuels and value-added chemicals. Perhaps even more importantly, the flexibility of the ARL technology enables a growing trend toward distributed energy systems, a more efficient energy lifecycle model where production and consumption are located closer to sustainable fuel feedstock sources.

In March 2008, a B-1B from Dyess AFB became the first aircraft to fly supersonic speeds using a 50/50 blend of synthetic and petroleum fuel. The ARL invention could make synfuels less expensive and easier to produce (Image source: U.S. Air Force)

Concept

The rationale for renewable energy sources is expanding rapidly, whether to enable security of supply, reduce environmental impacts or simply find cheaper alternatives to rising oil prices. Synthetic fuels, or more commonly "synfuels," are emerging as a leading candidate to fulfill a share of this growing demand. Synfuels have chemical properties similar to petroleum-based fuels and can be comingled readily in the distribution system. The main difference is that they derive from non-petroleum sources such as coal, natural gas and biomass.

Biomass (i.e., food and non-food crops and agricultural byproducts) is an abundant resource that is the focus of intensive research worldwide. Butanol, a short-chained hydrocarbon alcohol, can be produced by fermentation of biomass, and, by itself, can power gasoline engines without modification. Butanol can also be "dehydrated" to produce butylene isomers, building blocks for the production of transportation fuels and blendstocks, lubricants, plastics, solvent and coatings. The main problems with current dehydration methods are low product yield and process scalability.

The ARL approach overcomes these problems using a new heterogeneous catalyst, flow cell and an optimized operating scheme. Tests show that a mixture of butanols converts to butylene isomers very efficiently (greater than 90%). Plus, the flow-through nature of the ARL system lends itself to scale-up to commercial production.

Invention Overview

- *New catalyst, flow cell and process optimization to convert butanol into butylene, a starting material for synthesizing a variety of fuels and specialty chemicals*
- *Does not require special equipment or processing techniques to create catalyst*
- *A conversion process scalable to commercial production*
- *TRL 5 – Fully functioning manufacturing catalyst prototypes and test data available for inspection by commercialization partner*
- *U.S. Patent Application filed, SN 12/870,888*
- *"Catalytic Oxidative Dehydration of Butanol Isomers: 1-Butanol, 2-Butanol and Isobutanol," ARL-TR-5721 (2011)*

Doing Business with ARL

- *ARL is a leader in partnering with domestic firms*
- *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

Butylene is a chemically reactive hydrocarbon molecule that has four carbon atoms. Its small size and reactivity make butylene an ideal starting point to synthesize larger hydrocarbons, including fuels and fuel additives such as isooctane (an important component of gasoline), diesel, kerosene and aviation fuels. To synthesize these products, butylene strands are linked together via well-established industrial processes, resulting in nearly infinite combinations of hydrocarbon size and degree of branching. Plus, with the addition of other organics and metals, it can create high-value specialty chemicals.

There major are hurdles, however, to overcome in converting butanol to butylene: low fuel conversion; formation of smaller hydrocarbons (i.e., 2 and 3 carbons); formation of butane, which is not a good precursor and difficult to separate from butylene; use of homogenous catalyst, complicating separation of catalyst and products; and batch processing, which limits production speed.

The ARL invention offers a number of advantages over existing conversion processes:

• Can be tuned to produce a mixture of butylenes (1-butylene, cis-2-butylene and trans-2-butylene) with a yield as high as 93%
• Continuous operation, with a short contact time of between 145 and 550 ms
• Catalyst designed to employ a smaller amount of rhodium (less than 5%, by weight) than competing technologies

Intellectual property of this invention includes a new catalyst, flow-through cell and optimized operating conditions

Substantial scientific research is focused on turning sustainable cellulosic materials into biochemicals. For example, the University of Arkansas has developed a method to transform common algae into butanol. The ARL technology can process this product into fuels consumed regionally as part of a nationwide distributed energy system strategy (Image source: Univ. of Arkansas)

Potential Markets/Applications

The U.S. aviation community has taken a leadership role in establishing a major market for synthetic fuel. For example, the U.S. Air Force has publicly stated their intention to fuel half their domestic flights with synthetic fuel by 2016. The commercial aviation industry, working with potential suppliers, is also pushing hard to secure sources of synfuel. Substantial interest has also been shown from municipal and commercial vehicle fleet operators, railroads and even refineries looking to use synfuel as blendstock. Future production of synfuel is highly dependent upon the availability and price of crude oil. Still, the potential market is substantial. Import of petroleum to the U.S. alone set records each year from 2005 through 2008, totaling $1.27 trillion for the four-year period. The ARL technology can help capture a portion of this market.

Key Advantages & Benefits

- *Highly efficient in converting butanol (>95%) and producing butylene (up to 93%)*
- *Continuous operation, with a short contact time*
- *Catalyst employs a smaller amount of rhodium (less than 5%, by weight) than competing technologies*
- *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.

For further information please contact:

Mike Rausa, ARL-ORTA,
410-278-5028, mrausa@arl.army.mil.

Julio Suarez, SAIC,
717-398-2365, julio.suarez@saic.com

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