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Butanol An Energy Alternative?

By Kristin Brekke

Though ethanol and biodiesel are driving America’s progress on the road of renewable fuels, some attention is being generated by butanol, a fuel whose promoters believe can become a real player in the world of energy alternatives.

What is butanol? How is it produced? And how should the ethanol community feel about this potential alternative fuel?

Butanol defined

Butanol is a 4-carbon alcohol. Other chemicals in the alcohol family include methanol (1-carbon), ethanol (2-carbon), and propanol (3-carbon). Today butanol is typically produced from petroleum sources, but that has not always been the case. During the first half of the 20th century, the production of butanol from biological sources was a commercial reality - and this is what today’s butanol supporters are hoping can happen again.

According to the National Renewable Energy Laboratory (NREL), “biobutanol” had previously been produced through a fermentation process known as “ABE,” named such because it produced Acetone, Butanol, and Ethanol in roughly 6:3:1 ratios. Clostridium strains were the fermenting organisms to create the chemicals from molasses-type feedstocks. This ABE process nearly disappeared in the 1960s because it could not compete on a cost basis with the economical creation of solvents from cheap, plentiful petroleum.

The current market for butanol is largely industrial, for use as a plasticizer or solvent. The world market for butanol is estimated at 350 million gallons per year, with the U.S. accounting for about 220 million of that. The average cost for a gallon of butanol is between three and four dollars.

New partnership believes in “next generation” of biofuels

Butanol has been generating some attention as a potential alternative fuel, akin to ethanol but with added benefits, its promoters argue. A heavy-hitting partnership between energy giant BP and science innovator DuPont to bring “the next generation of biofuels” to the marketplace, the first being biobutanol.

In June 2006, BP and DuPont announced a creation to develop, produce, and market “a next generation of biofuels to help meet increasing global demand for renewable transportation fuels.” In their statement to the press, the companies say they have been working together since 2003 to “develop advanced biofuels with properties that can help overcome the limitations of existing biofuels.”

They acknowledge existing biofuels as an “excellent starting point” and that these fuels will “continue to play a major role in the future.” However, BP and DuPont identify these points of opportunity in order to increase market penetration: compatibility with existing fuel supply and distribution systems, the ability to blend in higher concentrations without vehicle modifications, and fuel economy.

The first product on their agenda - biobutanol - which they believe will address each of these issues.

BP and DuPont report they are targeting biobutanol for introduction this year in the United Kingdom, where the companies are working with British Sugar, a subsidiary of Associated British Foods, to convert the country’s first ethanol facility to one that produces biobutanol.

“Initial production of biobutanol will be based on an existing technology, enabling early commercial market introduction,” the companies said in a statement. “In a second phase, development work on a new biotechnology process using a higher conversion technology is already under way.”

They report that in this second phase, feedstocks for biobutanol will include sugar cane or sugar beets, corn, wheat, cassava, and - in the future - cellulosic sources much like what the ethanol industry is striving for: energy crops like perennial grasses and agricultural byproducts like grain straw and corn stover. The companies say they plan for this second phase, the “improved conversion technology,” to support broader commercialization before 2010.

Butanol’s benefits

What are the properties of butanol that make BP and DuPont convinced that it’s a fuel worthy of development?

One of those qualities is butanol’s low Reid vapor pressure (RVP), a rating of .33 psi versus ethanol’s 2 psi and gasoline’s 4.5 psi, meaning butanol has lower evaporative emissions.

Another property touted by butanol developers is its British Thermal Unit (BTU) content.

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Butanol contains 110,000 BTUs per gallon, closer to gasoline's 115,000 BTUs, meaning there may be little compromise on fuel economy.

BP and DuPont also report that butanol can be blended at higher concentrations in gasoline than existing biofuels without modifications to auto engines. Butanol is considered "substantially similar" to gasoline for blending purposes and is certified by the U.S. Environmental Protection Agency as a blending agent up to 11 percent. Environmental Energy, Inc., a U.S. company with a patent for biobutanol production, maintains that butanol can be used as a total replacement for gasoline - 100 percent, gallon for gallon.

Also, according to NREL, butanol is more "hydrophobic" than ethanol, meaning it has a higher tendency to repel water. This quality allows it to blend well with gasoline, could be used to improve ethanol / gasoline blending, and might mean it's potentially suitable for transport in pipelines.

Production breakthrough reported

Environmental Energy, Inc.(EEI), an Ohio company led by David E. Ramey, reports on its website www.butanol.com that it has developed a process which makes "fermentation-derived butanol more economically viable and competitive with current petrochemical processes and with the production of ethanol."

EEI's website says recent technology advances have made it possible for corn and other biomass feedstocks to be cost-effective sources of butanol derived from fermentation. Prior to its work, the company says, butanol production from corn and other biomass feedstocks had been hindered by low yields and low concentrations.

"EEI's patent changes everything," the company reports. "We are now able to produce yields of 2.5 gallons of butanol per bushel of corn."

The company says its new process creates biobutanol from corn without also producing Acetone or Ethanol, as in the former "ABE"

For more information:
Environmental Energy, Inc.
www.butanol.com

BP-DuPont biobutanol partnership
http://www2.dupont.com/Biofuels/en_US/index.html

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process. In addition, its process generates hydrogen which the company believes will receive future attention as an alternative fuel in and of itself.

The cost? "Our preliminary cost estimates suggest that we can produce biobutanol from corn for about \$1.20 per gallon, not including a credit for the hydrogen produced."

Between July 14 and August 15, 2005, EEI's David Ramey took to the road to promote butanol as an alternative fuel, driving from Ohio to California and back on 100 percent butanol fuel.

A July 2005 Green Car Congress article notes that in his butanol production method, Ramey takes the approach of using two types of microbes in two separate process steps. The first pass optimizes the production of hydrogen and butyric acid, while the second pass converts this acid into butanol. Each step utilizes a different *Clostridium* strain. The article reports that other processes had also tried the use of multiple bacteria strains, but within the same slurry, making Ramey's separation approach unique.

The patent EEI holds is U.S. No. 5,753,474: "Continuous Two Stage, Dual Path Anaerobic Fermentation of Butanol and Other Organic Solvents Using Two Different Strains of Bacteria."

Some of the EEI work has been done through a U.S. Department of Energy research grant, a collaboration between Ramey and Shang-Tian Yang, Department of Chemical and Biomolecular Engineering at Ohio State University.

As BP and DuPont report intending to use existing butanol production technologies first before moving into the next phase of biomass butanol production, EEI's plan initially calls for selling butanol into the existing commercial solvents marketplace to provide a revenue stream before moving into butanol for the transportation sector.

The unknowns

According to analysis done by the National Renewable Energy Lab, most of the advantages of butanol come from its properties as a fuel, not from current production technology. Traditionally, low yields - in the 15 to 25 percent range - have plagued butanol production. Toxicity is also a problem, with butanol being toxic at the rate of 20 grams per liter. With dilute product concentrations of 1 to 2 percent, the distillation technology has traditionally been quite costly.

Another question relates to the fuel certification process that may be necessary through the EPA. According to NREL, it is uncertain whether higher concentrations of butanol or a dedicated butanol fuel would need to undergo Tier 1 and Tier 2 health effects testing, which can be a costly and time-consuming processes.

In addition, it seems that biobutanol production is largely unproven, especially in any substantive quantities. EEI's website reports that the company is scaling up to implement a demonstration pilot plant, then a "serious pilot plant" capable of producing 50 to 100 gallons per week is the next step forward. Even for its promotional butanol drive cross-country, EEI purchased conventional butanol from a chemical company to fuel its trip.

Many unknowns remain for the future of butanol. Certainly the work of BP and DuPont and of Environmental Energy, Inc. - and any others who enter the butanol efforts - will be observed with interest.

Will butanol production reach a cost-effective level? Will it reach commercial-scale viability? If these milestones are achieved, does it compete with or complement ethanol? At this point, it's more questions than answers on the butanol front.

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