4C-able future: Biobased butanol, butadiene and BDO are having a hot year

Jim Lane | August 21, 2013

Answers to your questions about butanol, the players, and the four-carbon market.

It's been quite a year on the four-carbon platform — also known as C4, 4C, buta-something, Fantastic Four, or what have you.

Though two-carbon fuels such as ethanol have long dominated the biofuels market — and complex, multi-carbon drop-in renewable diesel, jet fuels and biodiesel have been the expansion story for advanced biofuels in the past three years — if any platform could be described as the "hottest of the hottest" right row, four-carbon chemicals and fuels are right in the heart of the roaster right now.

Of course, Gevo and Butamax have been generating their special brand of attention all year by suing the heck out of each other — proving, with each million dropped on legal fees, just how valuable the space is believed to be by backers like Total, BP and DuPont.

But there's been far more — the attention given to "how to play cheap natural gas" has led many observers to note that more natgas sourced means less naphtha produced — and thereby a possible shortage of four-carbon butadiene and butanediol, down the line. Accordingly, giants like BASF have been moving into the market via investments in Renmatix and licenses of Genomatica's technology to expand production capacity quickly on the biobased chems side.

Rhodia's been active, too. The Brazilians, led by the likes of GranBio, have been moving on the four-carbon front.

Lately, it feels as if the world has discovered — above all molecules on a 4C platform — the joys of biobased butanol.

In today's Digest — why the four-carbon platform matters — and what Gevo, Butamax, Genomatica, GranBio, Rhodia, Cobalt Technologies, Green Biologics, Microvi, Myriant and BioAmber are up to — and more about a new technology called Optinol — via the page links below.

Why does biobutanol matter?

Unlike ethanol, bio-butanol is hydrophobic and has similar energy content to that of gasoline. As such, it can be transported in standard gasoline pipelines without the corrosion and other water-based issues generated by ethanol's hydrophilic nature, leading to lower overall cost.

Butanol is made from the same feedstocks as ethanol. As a fuel, it can be transported in existing infrastructure and does not require flex-fuel vehicle pipes and hoses. It has about 4 percent less energy density than gasoline, but that's hard to notice compared to ethanol's 27 percent drop compared to gas.

Its real beauty is in the fuel blending. Biobutanol, today, is approved for 16 percent blends (compared to ethanol's 10 percent

limit). If ethanol were approved for 15 percent blends by the EPA, biobutanol would be approved for 24 percent blends. Combined with the improved energy density, in a standard 13-gallon sedan tank you can carry up to 109,000 BTUs of E10 ethanol or 228,000 BTUs of biobutanol – a little more than double.

However, there are fewer blend wall issues. Right now, with E10 the US is right at the "blend wall" where farmers and processors will have to look for alternative, lower-margin foreign markets to market their ethanol. With biobutanol, the same amount of corn that results in 13 billion gallons of ethanol and hits the blend wall, produces 10.4 billion gallons of biobutanol. Plus, the 16 percent biobutanol blend wall is encountered not at 13 billion gallons, but at 20.8 billion gallons.

One trouble spot? Octane – biobutanol is low-octane. But of course, you can top off with ethanol if needed as an octane booster.

Who is Optinol and what are they up to?

In California, Optinol announced that the company has achieved cost parity feasibility with ethanol for the production of bio-butanol from a wide variety of sugars.

Optinol is a collaborative venture between SynGest Inc., Unitel Technologies, Inc. and Louisiana State University Agricultural Center, The development of the Optinol process was led by Donal Day PhD at LSU AgCenter in collaboration with Ravi Randhava PhD, CTO of Optinol.

Based on a preliminary engineering study to estimate the capital and operating costs for commercial scale production at 20 million gallons per year, the company has concluded that it is feasible to produce bio-butanol at cost parity with ethanol.

What does Optinol have to say about cost parity?

In this case, interim CEO Jack Oswald explains that "Cost parity is on a BTU basis — and means production cost and is based on price of sugar equivalence. If the price of blendstock drops independent of sugar equivalence prices…everyone loses."

And, to clarify, the product in question is n-butanol — vs. isobutanol — so, more like Green Biologics and Cobalt and less like Butamax and Gevo.

One of the reasons, we suspect, that the process has been tested with a wide variety of feedstocks including sugar cane juice and molasses, corn starch, sweet sorghum juice and molasses, beet molasses and cellulosic sugars. Both Cobalt and Green Biologics have also checked out with their n-butanol technologies in terms of using cellulosic feedstocks.

Optinol reports that "all forms of sugar performed equally well."

The bulk of the lab and pilot work has been conducted at Louisana State University (LSU). Final feasibility studies to be performed center on optimization of the extraction medium with the goal of further minimizing water transfer.

Why n-butanol?

Well, for one thing, you can isomerize n-butanol, but you can't normalize isobutanol.

To put it in market terms — n-butanol is generally seen as a more useful feedstock for chemical applications, while isobutanol has been favored for fuels.

In processing — why tailor a process to an organism, rather than the other way around?

‘‘Optinol has taken an alternative approach to butanol production", said Jack Oswald, Interim CEO of Optinol Inc. "In lieu of genetic modification of the organism or other hosts such as yeasts or E.coli, the Optinol process uses a patented non-GMO

clostridium strain that naturally and prolifically favors the production of butanol, and virtually no acetone or ethanol."

The Optinol team chose to engineer a production solution tailored to the organism rather than trying to tailor the organism to existing production processes. The net result is a high yield and commercially robust process to produce low cost butanol at a price competitive with ethanol.

"The Optinol process centers on continuous flow through fermentation of our organism in inexpensive immobilized cell columns", said Ravi Randhava, PhD, CTO of Optinol Inc. "Low cost fermentation combined with low cost continuous extraction and distillation processes provide the basis for a low cost commercially robust production platform".

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Who is Microvi Biotechnologies and what are they up to?

Earlier this month, the United States Department of Agriculture (USDA) awardedMicrovi Biotechnologies a grant to develop a technology that overcomes the toxic and inhibitory effects on butanol producing microorganisms, dramatically improving the yield and performance of biobutanol processes. Based on preliminary investigation Microvi's technology has shown that it substantially increase the titer concentration of butanol over its solubility limit leading to effective biobutanol production. The technology will be retrofitable in existing bioethanol processes and work with any microorganism including genetically modified organisms.

Green Biologics progress?

Last month, Green Biologics announced a collaboration and planned investment in facilities with Iowa's Easy Energy Systems. The collaboration will result in the modification of Easy Energy's ethanol demonstration plant in Emmetsburg, IA to produce renewable n-butanol and acetone. In mid-2012 GBL successfully produced butanol and acetone from corn mash at the Emmetsburg facility in Iowa at a 40,000 liter fermentation scale.

"We ran three separate batches in July 2012 which matched results in both total solvent production and n-butanol yields that were achieved in our U.K. laboratories and at our Columbus, Ohio pilot facility," says Sean Sutcliffe, CEO of Green Biologics. "From these demonstration runs we have validated fermentation performance at scale meeting our commercial targets."

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What are GranBio and Rhodia up to?

Last month, GranBio and Rhodia have signed an agreement to create a partnership to produce bio n-butanol. Bio n-butanol is made from sugar cane straw and bagasse, the same raw material that is used to manufacture second-generation ethanol and which is abundant in Brazil.

Under the partnership, the companies plan to build the world's first biomass-based n-butanol plant in Brazil, which will enter into operation in 2015. The plant will produce 100 kilotons per year of solvents.
Both companies will benefit from agreements that each of them has already made with companies that own the technology.

The project is a key step for GranBio and Rhodia in the manufacturing of chemicals made from renewable sources.

What are Cobalt and Rhodia up to?

In July, Cobalt Technologies announced a strategic relationship with two prominent, but undisclosed, Asian chemical companies for the development of butadiene from a range of biomass feedstocks. Under the terms of each strategic

agreement, technology development is expected to be completed in 2014 with construction of a first commercial-scale biorefinery in Asia, which would be expected to come onstream by 2015. In each case, the partners made an equity investment in Cobalt. Work to date has demonstrated, according to Cobalt, that the biomass-to-butadiene path can be highly competitive with petroleum-based butadiene under current market conditions.

Last summer, Cobalt Technologies and Rhodia announced they would begin joint development and operation of a biobutanol demonstration facility in Brazil. The Cobalt/Rhodia plant is planned to utilize sugarcane bagasse to make n-butanol; bagasse is used at sugar mills to provide process energy to drive the mill and to supply power to the local grid; the Cobalt project will utilize that fraction of the bagasse that generates power for the grid, or any residual biomass that is burned as waste.

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What's the latest at Gevo?

Two weeks ago, Gevo announced that it has brought its second million liter fermenter and GIFT system online at its Luverne, Minn. facility. And it is officially opening its paraxylene and renewable jet fuel plant in Texas over the next month.

"We have been successful in operating full-scale fermentations using our GIFT system – which separates the isobutanol from the fermentation broth – on a second million-liter fermenter and GIFT system," noted Patrick Gruber, Gevo's chief executive officer. "This serves to further validate our technology and plant know-how. We plan to bring the final fermenters and GIFT system online at Luverne later this year, testing run rates, then ramping up production and sales over the balance of 2013 and in 2014."

What's Butamax doing?

Lately, reports have found us from the courts more than from the labs or from the "Tell the Digest About our Commercial Timeline" Department.

But in the courts, they've been doing well this summer. At the end of last month, Butamax announced that Judge Sue Robinson granted Butamax's summary judgment motions for non-infringement of Gevo 8,017,375 ('375) and 8,017,376 ('376) patents.

This decision, issued last Month, closely follows the Court's dismissal of all claims against Butamax relating to Gevo's '808 "GIFT" patent. In a further ruling, the Court also granted Butamax's summary judgment motion for invalidity of the '375 patent stating that "Butamax has met its clear and convincing burden, sufficient to invalidate the patent for lack of enablement…". The Court stated that there are still "issues of material fact" related to the validity of the '376 patent thereby precluding an entry of summary judgment.

"With this decision, Butamax has prevailed on the first three of Gevo's cases against Butamax with the patents being found unpatentable, invalid or not-infringed. We expect a similar outcome from their remaining suits," added Paul Beckwith, Butamax's CEO. "Meanwhile, Butamax's appeal relating to our foundational '188 and '889 patents is progressing, with the Federal Circuit hearing likely to take place before the end of the year."

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Where's Genomatica in the mix?

Possibly counting all the money they are going to make.

Case in point. In June, Lanxess said has run a production campaign of bio-based PBT in Lanxess' world-scale production

plant using 20 metric tons of bio-based BDO made with Genomatica's commercially-proven process. The world-scale PBT plant, with a capacity of 80,000 tons per year, is located in Hamm-Uentrop, Germany and operated as a joint venture in which Lanxess has a share of 50 percent.

This — for Genomatica, after announcing that Toray had produced some PBT from Genomatic BDO, and that Versalis and Genomatica announced this past spring the establishment of a technology joint venture for bio-based butadiene from non-food biomass. The resulting process will be licensed across Europe, Asia and Africa by the newly-created joint venture. Versalis — the chemical subsidiary of Eni — aims at being the first to license the process and build commercial plants. It will also provide over $20 million in funding to Genomatica to support development of the integrated end-to-end process.

Are Myriant and BioAmber hot on the 4C trail?

Appears so. In June, BioAmber announced that it has partnered with Brenntag in the Americas for distribution of its Bio-SATM bio- based succinic acid and derivatives, including bio- based 1, 4-butanediol (BDO). BioAmber is currently supplying commercial Bio- SATM from a European production facility. Given growing market demand for its bio- based chemicals, BioAmber is going to expand capacity in 2014 in Sarnia, Canada with a 30,000 MT plant to serve the North American and other markets.

Last week, Myriant and Johnson Matthey – Davy Technologies announced the successful production of bio-butanediol (BDO) and tetrahydrofuran (THF) made from Myriant's bio-succinic acid at JM Davy's facility at Teesside, England. The bio-butanediol and bio tetrahydrofuran has an overall carbon efficiency of 87 percent, believed to be substantially better than the carbon efficiency achieved in the direct fermentation route to bio-butanediol.