Companies are pushing ahead with bio-based feedstocks like this sugarcane waste for chemicals such as BD

Rex Features

How sustainable are bio-based chemicals?

Ensuring that petrochemicals' bio-based replacements are better for the planet is not easy

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High crude oil prices and feedstock shortages are making chemical producers look for alternative raw materials made from biomass that can theoretically replace their dependence of petrochemicals.

"There is a striking, proven need for [bio-based chemicals]. This is especially true in the market for C4 chemicals, which face increasing – and long-term – supply pressures as the petrochemical industry moves to lighter feedstocks," says Damien Perriman, vice president of Genomatica, a US biotechnology firm.

"A shift towards lighter feedstocks is driving up prices of C4 chemicals – like butanediol (BDO) and butadiene (BD) and this is affecting availability," Perriman added.

Chemical companies say this new approach towards bio-based chemicals will help create sustainable feedstocks supply and make chemicals "greener". However, critics argue that this push for bio-based chemicals puts enormous pressures on food and feed supply and that arable land should not be used to produce feedstocks for chemicals in times of food shortages and rising prices.

Biochemical companies say that food and feed supply will not be affected by their operations because they will grow genetically modified plants that can withstand harsh conditions on marginal lands and they can also use secondary sources of biomass, such as household waste, energy crops, wood and other materials.

"Our core focus as a technology company is on production of normal butanol from non-food cellulosic feedstocks and in particular on existing feedstocks that are readily available as waste residuals, or as existing agricultural crops that require no significant change in production or agronomic processes", said Tim Staub, vice president of business development at UK-based Green Biologics.

Staub said that they use biocatalysts that can react well with both C5 and C6 sugars from a wide range of cellulosic feedstocks such as corn stover, corn cobs, corn shells, bagasse, energy grasses, municipal solid wastes (MSW) and wood residuals with similar results on yields.

Opponents argue that the burning of rainforests to create more space for plantations and a drive towards soybean, oilseeds, palm and corn production is a direct result of biofuel and biochemical production, which could lead to food shortages because farmers grow crops for fuels and chemicals instead of growing food crops.

VIABILITY CALLED IN TO QUESTION

At the ICIS Butadiene and Derivatives conference in Berlin in September, some delegates also questioned the viability of some of these products and whether there will always be enough biomass to supply the industry if biochemical production becomes large scale.

There are those who say that precious arable land and fertilizers should not be used to produce chemicals.

An alternative to using primary food and feed sources as biomass is to use secondary sources or to process municipal solid waste (MSW). Green Biologics is one company that

is actively looking at this approach to produce renewable n-butanol (NBA) and acetone.

Green Biologics is a biotech firm that focuses on biobutanol and other C4 chemicals production from various renewable feedstocks. Their primary product is normal butanol, or NBA, along with its co-product acetone.

"One of our focus areas is MSW. Over 2bn tonnes/year of MSW is generated globally, and nearly 226m tonnes of this in the US and it's growing," says Staub.

Staub estimates that between 30-50% of MSW on average is organic, cellulosic biomass capable of producing crude sugars. Green Biologics has processed MSW sugars in their UK facilities with remarkable results and with the highest yields they have seen to date on any feedstock, Staub said.

Alongside MSW, sugar, oilseeds and corn are often described as the most important bio feedstocks, especially sugar for its high yield compared with corn or other plants.

But to produce sugar cane, corn or soy, growers need vast amounts of fertilizers and gas-guzzling machinery which are not renewable, sustainable resources plus a lot of water and arable land.

"I think there will be a preference for those biogenic products that are not in direct competition with food, feed or forest," said Bernhard Kneissel, Project Manager at Stratley, a German chemical consultancy firm.

Some argue that biochemical production puts a big strain on resources. Most fertilizers are petrochemical derivatives and therefore dependent on oil and gas supply. Water is in short supply in some regions and the size of arable land globally is shrinking because of overuse of fertilizers and other practices, which cause soil erosion. To harvest any of the plants for biomass, growers need harvesting machines that also require gasoline or diesel, which are getting more expensive.

"There will be a preference for those biogenic products that are not in direct competition"

BERNHARD KNEISSEL
Project manager, Stratley

"We do not expect this [biomass supply constraints] to be an issue," says Perriman at Genomatica.

He argues that non-food biomass can be grown on so-called 'marginal' land, often with minimal use of fertilizers. The industry is developing and delivering more 'dedicated' energy crops and biomass species that offer drought-resistance and can be grown without fertilizers.

The world's first commercial-scale plant for BDO made using Genomatica's direct bio-process, owned by Novamont, is expected to start in 2013

Most sources say that in principle there are no limitations to how much traditional petrochemicals can be replaced by bio-based products, the question is whether it is economically viable to produce them.

"There is considerable doubt about the economical and ecological performance of these products," says Kneissel from Stratley.

Kneissel thinks that bio-based chemicals will most likely serve a niche market in the near term because of the competition with food, feed, fuel and forest and also because some doubt remains if enough biomass is available.

100% REPLACEMENT POSSIBLE

Biotechnology firms say that theoretically, all traditional petrochemical production could be replaced with bio-chemicals. "In theory, 100% of the global n-butanol market [could be replaced by our product]," says Staub.

For now though, their share is likely to remain a relatively small percentage until oil prices rise and shale gas production increases to displace naphtha as the feedstock of choice in ethylene crackers. Propylene prices could rise dramatically as a result of limited co-production of olefins in gas-fed ethylene crackers and petrochemical-based NBA costs would rise dramatically due to higher propylene feedstock costs, Staub adds.

This does not mean, however, that there is no interest in developing these new technologies on a larger scale. In Europe, two major synthetic rubber producers, Synthos and Versalis, have entered into partnerships with biotechnology firms such as Genomatica and Global Bioenergies to develop bio BD.

Global Bioenergies is a company developing the technology to produce BD from renewables such as molasses, a sugar waste, as well as isobutene biologically from renewable resources.

According to the company, isobutene can be converted into various materials such as synthetic rubbers, organic glass and plastics. Global Bioenergies estimates that the worldwide annual isobutene consumption is approximately 15m tonnes.

In July 2011, Global Bioenergies and Synthos formed a partnership to develop a bio-BD process in which Synthos will obtain exclusive world-wide rights on rubber applications and Blobal Bioenergies will get research and development funding and future royalty payments.

Global Bioenergies estimates that about 7.2 tonnes of molasses is needed to produce one tonne of bio-based BD. On a larger scale, to produce 100,000 tonnes of bio-BD, a plant would need 12 reactors at a size of 550 cubic meters each, which would consume about 720,000 tonnes of molasses/year.

Currently, one tonne of the cheapest molasses is about $175/tonne, and Global Bioenergies estimates that with current molasses prices and targeted process parameters, one tonne of bio-BD would cost about $1,500.

"Bio-based BD could start to replace some of the traditional BD supply within the next 10 years," Thomas Buhl, head of business development at Global Bioenergies, said.

Elastomer producer Versalis has entered into a memorandum of understanding with Genomatica and Novamont to produce bio-BD. In partnership with Versalis and Novamont, Genomatica intends to develop an economical, bio-based process for BD.

And Green Biologics is in discussions with major end users in the $85bn global paints, coatings and adhesives markets and are looking at other potential markets such as blending fuels and aviation jet fuels.

For the near future, however, sources expect that bio-chemicals will be used in niche markets that can attract consumers looking to buy items known for their presumed low-impact on the environment. ■