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Bio-Petrochemicals Special Report

From feedstocks to plastics: the rise of bio-based alternatives

Foreword

By Callum Colford

The use of bio-based material in petrochemical and plastics markets has come into ever-sharper focus this year as pressure grows from governments and wider society to plot a way from a fossil-based economy to a sustainable model with a far lower environmental impact.

As the plastics industry looks to its own role within the wider energy transition, bio-plastics are one of the main options for retaining the benefits brought by the use of plastics while addressing environmental concerns.

Although bio-plastics is a wide term which can refer either to material that is produced from a bio-based feedstock, material that is biodegradable but produced from a fossil-based feedstock, or material that is both biodegradable and produced from a bio-based source, this report will focus primarily on material that is produced from bio-based feedstocks.

The range and specifications of alternative bio-based products vary substantially, but most retain almost identical properties to fossil-based products, having the ability to be directly blended with them to serve the range of uses fossil products currently have.

Needless to say, fully formed bio-plastics don't grow on trees. Those parts of the petrochemical industry that have moved into bio-products are adopting a variety of approaches to achieve long-term, sustainable alternatives to fossil-based plastics, in order to provide further options for polymers in the circular economy.

As with traditional fossil-based petrochemicals and plastics, the route to creating bio-products begins with the feedstock, passing through phases that will sound familiar to those used to the way the fossil-based industry works; from cracker feeds to bio-olefins and bio-aromatics and ultimately to the finished bio-plastics.

S&P Global Platts here gives an overview of the industry through these critical stages, highlighting developments across the industry from bio-naphtha down to bio-based plastics, as well as newer approaches being adopted by industry such as the mass-balance concept.

Bio-feedstocks

The building block for the bio-industry

Bio-feedstocks

The building block for the bio-industry

By Evridiki Dimitriadou, Callum Colford, Luke Milner

- **Bio-naphtha demand exceeds supply**
- **Bio-feedstock allows ‘drop-in’ production**

Currently most bio-based petrochemicals are produced from what are known as “first-generation” feedstocks, typically food crops such as corn or sugar cane. According to industry association European Bioplastics, this is the most efficient production method at the moment, producing higher yields than second-generation feedstocks.

Second-generation feedstocks can be either non-food crops or waste materials from first-generation feedstock such as waste vegetable oil, while third-generation feedstocks are defined as biomass derived from algae or cellulose. Though third-generation feedstocks haves the potential for a significantly larger yield than either first- or second-generation feedstock, there are considerable technical and geographical challenges that have so far prevented industrial adoption.

The choice of feedstock also impacts the premium the product commands from end-users, with feedstocks derived from first-generation material such as palm oil attracting lower premiums than those from second-generation material, both due to lower production costs and consumer perception.

Bio-naphtha: a versatile feedstock

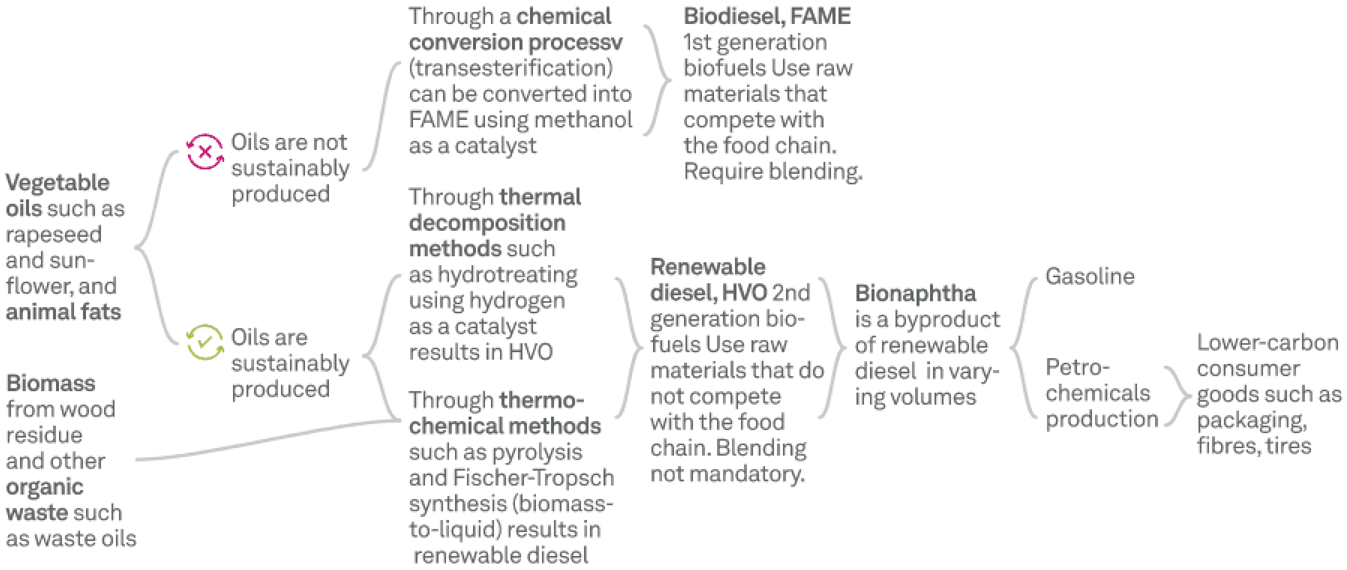
A key petrochemical feedstock for bio-production is bio-naphtha, which can be used as a direct substitute for fossil-based naphtha, either as a gasoline blending component or a petrochemical cracking feedstock.

Bio-naphtha allows the full traditional range of petrochemicals to be produced and, similarly to fossil-based products, yields can be altered depending on a product's current marketability and price.

Bio-naphtha is primarily produced as a byproduct from the manufacture of Hydrotreated Vegetable Oil (HVO), otherwise known as renewable diesel. It can be also be produced as a byproduct of Sustainable Aviation Fuel (SAF) production, or as a standalone product via gasification, although this method is typically uncompetitive on a pricing front.

European producers use a wide variety of feedstocks to produce bio-naphtha including used cooking oil, vegetable oils such as palm and rapeseed, and waste residues from sectors such as wood pulp production (known as crude tall oil, or CTO) and animal fats.

Bio-naphtha production flow



Source: S&P Global Platts

Current European bio-naphtha supply is estimated to range between 150,000-250,000 mt annually, with expectations for supply to double or even surpass 1 million mt/year in the coming years, according to the NOVA Institute. Current notable producers in Europe include Neste, Eni, Preem and UPM, while multiple plants are set to come online over the next 3-5 years including TotalEnergies' Grandpuits site, Shell's site in Pernis, and Repsol's Cartagena plant.

Available bio-naphtha supply is not sufficient to meet growing demand. Large European petrochemical producers such as BASF, Borealis, Dow and Sabic have already begun utilizing bio-naphtha for bio-based intermediates production.

On the road fuel blending front, demand also is also set to grow, alongside tightening regional regulations for transportation fuels stipulated in the EU's RED II directive. However, as supply is currently insufficient and costs significant, most bio-naphtha buyers blend a portion of bio-naphtha with fossil naphtha to produce fuels and petrochemicals.

Major bio-based petrochemical sites in Europe who purchase bio-naphtha

Buyers	Producer/buyer	Location	Status	Start of use/ production	Input/output
Dow	Petchems Buyer	Terneuzen, France	Online	2019	Bio PE
Ineos	Petchems Buyer	Koln, Germany	Online	2020	Bio Polyolefins
LyondellBasell	Petchems Buyer	Wesseling, Germany	Online	2019	Bio PP, bio LDPE
SABIC	Petchems Buyer	Geleen, Netherlands	Online	2020	Renewable Polymers
TotalEnergies	Integrated	Grandpuits, France	Planned	2024	Bio plastics
Versalis	Petchems Buyer/Integrated	Brindisi, Italy	Planned	2021	PE, Styrenics, Elastomers
Versalis	Petchems Buyer/Integrated	Porto Marghera, Italy	Planned	2021	PE, Styrenics, Elastomers
Versalis	Petchems Buyer/Integrated	Ferrara, Italy	Planned	2021	PE, Styrenics, Elastomers
Versalis	Petchems Buyer/Integrated	Mantua, Italy	Planned	2021	PE, Styrenics, Elastomers
Versalis	Petchems Buyer/Integrated	Ravenna, Italy	Planned	2021	PE, Styrenics, Elastomers
BASF	Petchems Buyer	Ludwigshafen, Germany	Online	N/A	Bio PE
Borealis	Petchems Buyer	Kallo, Belgium	Online	2020	Renewable polyolefins
Borealis	Petchems Buyer	Beringen, Belgium	Online	2020	Renewable polyolefins

Note: Entries have been updated as of 11-Aug
Source: S&P Global Platts, company reports

Bio-naphtha is commonly priced at steep premiums against its fossil alternatives, which can range between twice and three times the price of the Platts naphtha CIF NWE benchmark. The main cost component of bio-naphtha and other biofuels (commonly between 65%-80%) is feedstocks.

However, feedstock may vary significantly in price depending on source, availability and regulatory environment, and some feedstocks, notably, palm oil, are deemed by some consumers to be unsustainable and so may be priced at a discount to other bio-sources.

One example of a bio-feedstock producer responding to the public criticism of palm oil is Neste, which is aiming to increase its use of waste and residue raw materials to 100% by 2025, noting that in 2019 and 2020 palm oil accounted for under 20% of its raw material input, though demand in the market continued to exist.

The variability in bio-naphtha pricing is particularly important for blending demand. Specifically, ETBE and ethanol components can be supplemented but also substituted with bio-naphtha in the gasoline blending pool while still meeting the European gasoline EN 288 specification. Several blenders — notably Shell and Preem — are producing gasoline with such characteristics.

However, as gasoline can be composed of several substitutable components, bio-naphtha can often price itself outside the pool if blenders deem it uncompetitively priced. Demand for bio-naphtha in the cracking pool on the other hand is less price elastic due to the lack of available alternatives, although chemical recycling is an emerging possibility that could offer an alternative.

Currently demand for bio-naphtha and other biofuels is on the rise in Europe, but other regions — particularly the US — are also aggressively increasing HVO and by extension bio-naphtha capacity.

Prominent producers in the US include Marathon Petroleum and Valero Energy, while new entrants such as Gevo are coming on to the scene, adding to capacity expansions. Asian interest in bio-naphtha is increasing as well, albeit at a slower pace. One of Europe's leading biofuels producers, Neste, recently signed a deal to supply Mitsui Chemicals with 10,000 mt of bio-naphtha for its ethylene cracker in Japan between October 2021 and March 2022.

Bio-naphtha currently does not frequently flow across continents, although other bio-feedstocks such as used cooking oil often arrive in Europe from Asia and particularly South American countries such as Argentina. Within Europe, bio-naphtha commonly arrives in Northwest Europe from Scandinavia and the Mediterranean, according to industry sources, with spot market activity also developing.

Other production methods

Other traditional cracker feedstocks such as LPGs are also developing bio-based alternative petrochemical feedstocks with bio-propane a notable byproduct from HVO production.

As with bio-naphtha, market sources have noted consumer pressure in shifting from "first-generation" feedstocks such as sugarcane or corn to "second-generation" material, with research taking place into third-generation feedstocks such as cellulose and algae.

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Interview

Trinseo

Interview

Trinseo

Mass-balancing is an approach to supply chain management that has been adopted across sectors like forestry and cotton as part of the drive towards greater sustainability.

Dr. Julien Renvoise, Global Circularity Manager Plastics at US-headquartered plastics manufacturer Trinseo, spoke to S&P Global Platts to explain the mass-balance approach in petrochemicals and how it is being used by Trinseo.

Trinseo received mass-balance certification from International Sustainability and Carbon Certification (ISCC) last year. What does this mean?

Essentially it means that we're able to provide evidence of sustainable content in a final product throughout a complex value chain, in cases where it's not possible to segregate inputs. It is not a simple concept to digest for sure. If you look to a simple analogy like green electricity, it becomes easier for people to understand. But you notice when you are pushing the [idea of] mass-balance to the market, it takes some time for customers to understand the concept. There is quite a lot to it, with logistics, inventory management, and tracking. Even the financials of the product you need to have coded into your system.

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tracking. Even the financials of the product you need to have coded into your system.

Can you talk us through the mass-balance concept?

To explain the mass-balance process, it's helpful to compare it with the segregation model.

In an ideal world, if you want to include a sustainable feedstock in your product, you will keep separate streams of bio- and fossil-based material, with dedicated production lines, silos, etc. The situation now in the marketplace is that there isn't enough sustainable material available yet. Assets are not purely dedicated to bio-material as it doesn't make economic sense for all parties along the value chain to invest, and so we have to blend sustainable streams with fossil-based streams for the moment.

If you blend these two streams in a continuous process you can lose track of the precise sustainable portion at the end of the process. Hence, from segregation you move to the mass-balance principle. Mass-balance allows you to allocate the quantity of sustainable material you've added along a value chain to the final product in a virtual fashion.

The analogy is with green electricity. You buy electricity from a green supplier, which uses a renewable type of energy such as wind or solar – and once you use the electricity or switch on the button you don't know if the electricity you are using comes from wind, solar or coal. But you know when you buy from the supplier that there is a certain quantity of renewable energy being used and the more you buy from the supplier the greater the chance that the renewable energy will get developed. This is exactly the same principle in mass-balance.

What do you have to do as a company to gain the mass-balance certification?

First, a company needs to be audited by a third-party certification body, which is done once per year. You have to show that your suppliers of sustainable feedstocks are certified and the sustainable material is managed according to best practice tracking processes in order to allocate sustainable credits, which is done once per month and done per site. The process for certification, actually, is not that long, and we are trained to deal with the manufacturing, tracking and traceability process. It can take four months to be certified but it depends on how well your system is already developed and managed.

If you are certified and you aren't able to sell a certified product in the year, then normally you lose the certification. If you can explain why you were not able to sell, then it may be flexible, but there are certain rules to respect. For example, you have to have a positive balance of sustainable credits over the quarter.

Is it compulsory to have the certification in order to sell material as being mass-balanced?

Actually no, but it really is in everyone's interest to not want to break the certification chain in the sense that I, as a manufacturer, want to be certified and pass this certification along to my customers — and this means my suppliers need to be certified. I wouldn't be able to put the ISCC logo on my product if my suppliers aren't certified and my customers would be restricted in making certain claims when selling their end products or applications. Nothing prevents me from selling certified products to a non-certified customer.

To be honest, I recommend to customers to get certification as it provides them with the right level of transparency, traceability and credibility that is required for this concept and for the value chain to get familiar with.

Mass-balance still needs the value chain to become familiar with [it]. It provides a certain level of objectivity and transparency about the work that you are doing as it is the methodology required by an official external auditing body and a third-party certification and audit. There is a list of auditors you can solicit. It is quite objective as a process.

Do you see the mass-balance concept as being in competition with recycling, or is it complementary to it?

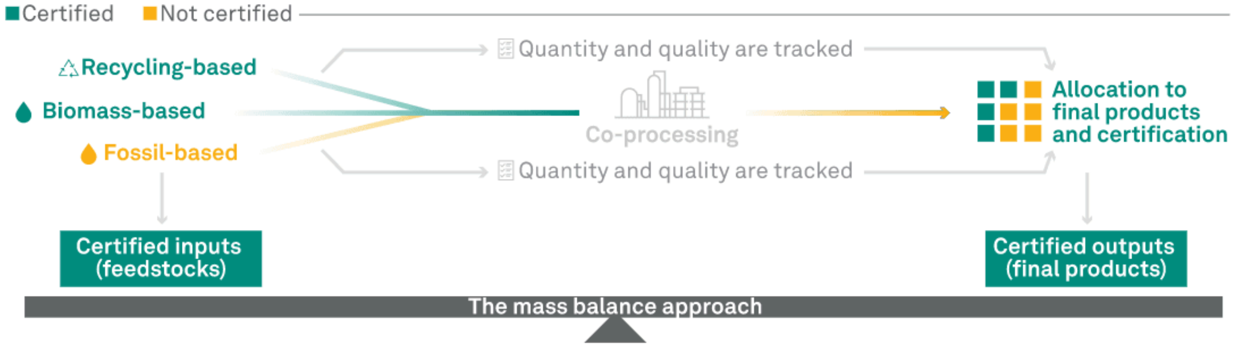
They are two different things really; mass-balance is a tracking methodology which can apply to recycled or to bio-sourced material.

For me, mass-balance competes with a segregation model. So, you have either the segregation model tracking methodology or the mass-balance tracking methodology.

Today, chemical recycling cannot happen without mass-balance. You need mass-balance to be embraced by the European Commission to support chemical recycling to achieve the ambitious 2025 [recycling] targets. It is a necessity to move on and support the circular economy.

Tracking renewable content

The mass-balance approach is used to track the allocated bio-based product share in petrochemical end products. The approach allows bio-based and fossil material to be mixed, then allocates a certification that a certain percentage of bio-based material was used to produce the finished product.



Source: S&P Global Platts, company reports

Ideally, we will, in the future, go to a segregation model where players will invest in dedicated assets and sustainable streams can be separated from the fossil-based streams.

Bio-material is a complementary element to recycling. Recycling has a yield of recycled content and you lose material during the recycling process. You then have to compensate with virgin material, and if you don't want fossil-based virgin content added, because of sustainability goals, then you will have to add bio-sourced virgin material.

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Bio-olefins

A stepping stone to bio-plastics?

A stepping stone to bio-plastics?

By Callum Colford, Sarah Trinder, Abdulaziz Ehtaiba, Luke Milner

- **Strong bio-ethylene interest from the polyethylene market**
- **Significant premiums hinder bio-butadiene market**

The olefins sector has seen strong downstream interest in bio-products, with bio-olefins a key link in the chain from bio-feedstocks through to end-products including plastics and synthetic rubber.

Production methods in the sector vary from “drop-in” production, which produces bio-based material from a mass-balanced feedstock via a steam cracker, to newer production methods which use products such as ethanol to produce bio-based ethylene via independent production methods.

Bio-ethylene

Bio-ethylene has found strong interest from downstream sectors, particularly from polyethylene applications looking to find a green solution to production methods, driven by increasing consumer interest in environmentally friendly alternatives.

Bio-ethylene, or “green ethylene”, can be produced from cracking bio-naphtha and also from the production of ethylene from ethanol.

Brazilian producer Braskem uses ethanol from sugarcane which is then processed into bio-ethylene used in the production of bio-polyethylene and ethylene vinyl acetate (EVA)

Braskem started the first sugarcane-derived ethanol-to-ethylene plant in 2010 at Rio Grande do Sul in the south of Brazil, using the bio-ethylene produced there to manufacture polyethylene. The company is expanding its green ethylene production capacity at the Rio Grande site by 60,000 mt to 260,000 mt/year with completion projected to be in the fourth quarter of 2022.

In recent years production has been gaining traction in the European market but cost remains a barrier for those considering bio-ethylene purchases, given the sizeable premium to traditional ethylene.

“There are inquiries, but the price tag is significant. There are quite a few inquiries, but they’re not interested when they see the price tag,” one European ethylene producer said.

However, in the past three years producers have continued to develop options, with both Dow and INEOS partnering with UPM Biofuels to use the latter’s bio-naphtha as a feedstock to produce renewable plastics.

In 2018 Clariant signed a deal to use Neste’s bio-ethylene (and bio-propylene) in its adhesives, plastics and coatings, and LyondellBasell followed suit in 2019, partnering with Neste to secure feedstocks for its bio-based plastic brands – Circulen and Circulen Plus.

Bio-propylene

Although the development of bio-propylene has been slower than the development of bio-ethylene, a proliferation of production methods has come to the fore in the past two years.

As companies look to on-purpose bio-propylene production to ensure the development of bio-polypropylene production, the industry is looking for alternative production routes to “drop in” cracker bio-feedstocks.

In October 2019 Austrian petrochemical and plastics producer Borealis announced plans for the first ever use of renewable propane dehydrogenation on an industrial scale for on-purpose bio-propylene to produce polypropylene with measurable bio-based content with ISCC Plus certification.

Finland’s Neste supplies Borealis with renewable propane produced in Rotterdam to feed the Austrian plastic producer’s PDH unit in Kallo, Belgium.

Production of bio-based PP, the end product of the process, began in December 2019, with bio-propylene from the Kallo PDH unit supplying both Borealis’ Kallo and Beringen production sites.

Japan’s Mitsui Chemicals is also looking to produce bio-propylene in order to produce bio-PP but via the dehydration of bio-isopropanol that comes from raw biomass materials, although the company has said that commercial production will not start until 2024 at the earliest. “There are significant hurdles associated with manufacturing polypropylene from biomass materials and the technology has yet to be demonstrated on an industrial level,” the company said in its 2020 ESG report.

Bio-butadiene

Bio-butadiene has also seen an increase in interest in recent years, both from drop-in production methods produced via a steam cracker, and novel production methods being trialed.

French tire producer Michelin is building a pilot bio-butadiene plant as part of its "biobutterfly" project, which will produce bio-butadiene to be used in the production of synthetic rubber for tires. The project uses ethanol produced from a range of biomass such as second-generation ethanol made from forestry and agricultural residues like wood chips, rice husks and corn stalks.

Other companies such as Trinseo are carrying out feasibility studies into construction of a pilot plant with Russian company ETB for bio-butadiene production. The study — expected to be completed by the end of 2021 — has a target to produce butadiene with a purification rate for the pilot plant of 99.7%, in line with fossil-based butadiene purification rates, using bio-based ethanol as a feedstock.

Similarly, Synthos has started co-operation with Lummus Green Circle to launch a feasibility study into a bio-butadiene plant with a production capacity of 20,000 mt/year, using ethanol.

While Michelin has taken a novel approach to bio-butadiene production, other companies such as Versalis produce via the drop-in method, using first- and second-generation bio-naphtha produced at two Eni bio-refineries in Italy to then produce mass-balanced butadiene.

Other major producers such as TotalEnergies also utilize this method of production via a mass-balance method, which uses existing production infrastructure rather than requiring new production methods.

This is currently the primary method of production and many market observers expect it will remain predominant for the next decade or so, until alternative methods are more thoroughly proven.

"Bio-based [alternative] projects are going to be very expensive with premiums of over $1,000/mt but can this be justified? If you are getting premiums at three times normal prices, then you can justify building the plants, but the plants are not ready yet and consumer demand at these levels is uncertain," a major European petrochemical producer said.

Major interest in bio-butadiene applications comes from the tire sector, following moves by companies to commit to using greater proportions of sustainable materials. For example, the two largest tire manufacturers globally, Bridgestone and Michelin, have stated that by 2050, their tires will be made entirely from renewable, recycled, or bio-sourced sustainable materials, with company sources saying a mixture of bio-based material and chemical recycling would be necessary to reach the targets.

Bio-aromatics

Attempts to improve polystyrene's public image drive bio-aromatics demand

Bio-aromatics

Attempts to improve polystyrene's public image drive bio-aromatics demand

By Callum Colford, Simon Price, Callum Sinclair

- **Significant demand for bio-styrene from downstream applications**
- **Bio-MTBE applications remain of interest to blenders**

The aromatics sector has also seen increasing interest in bio-polymers in recent years, with end-products including polystyrene and acrylonitrile-butadiene-styrene driving demand for bio-based styrene. The bio-based styrene route has been increasingly explored with multiple major producers offering material produced via the mass-balance approach.

Companies such as BASF produce bio-based styrene via the mass-balance approach and have entered a partnership with companies including Trinseo, which then use the bio-based styrene to produce a bio-based polystyrene and synthetic rubber products.

In addition, since 2020 Trinseo has been producing its own bio-based styrene at its ethylbenzene plant in Terneuzen. The process replaces the fossil-based benzene used in the manufacture of styrene with an oil-like substance made from waste produced during the wood-pulp manufacturing process.

The manufacture of styrene allows a mixture of bio-based material to be used with Trinseo noting its first bio-based styrene produced had 75% bio-content, from 100% bio-benzene blended with ”traditional” fossil-based ethylene.

INEOS Styrolution sources material from second-generation feedstocks and offers bio-attributed styrene-butadiene copolymer block applications where 100% of fossil material has been replaced by bio-attributed styrene alongside other mass-balanced offerings.

There is growing momentum coming from the polystyrene sector to shift to bio-based material, with the sector one of the more vocal end-applications in moving towards second-generation feedstocks in order to burnish green credentials due to the perception that it lags in recycling applications.

"The problem yesterday was that there was no technology for high-quality PS recycling — let's say food quality PS recyclates. To be used in [food] packaging you need to have this food-approved quality, and without being able to provide this, you close the door of the major retailers to PS demand," one producer said, explaining why the PS sector has had particular interest in bio-based styrene.

However, sources note that bio-based production has increasingly taken a back seat to recycling despite the ability of the sustainable methods to work hand in hand.

"Bio is a complementary element to recycling as recycling is a yield and you lose material during the recycling process. You have to compensate with virgin material, and if you don't want fossil-based virgin material then you will have to have bio-sourced virgin material," said Trinseo's Dr. Julien Renvoise.

The use of bio-based benzene extends beyond styrene production. Covestro has produced aniline which is then used to produce diphenylmethane diisocyanate (MDI) — used in the manufacture of polyurethane foams — from a bio-based sustainable benzene produced by TotalEnergies in northern France.

Benzene producers have told Platts they expect a rapid expansion in demand for bio-based products in the coming years and are looking at how to increase the bio-content of material to work alongside recycling in a circular approach.

Bio-MTBE

Although ETBE is the most widespread bio alternative to MTBE, it is not the only option. Bio-MTBE has also been gaining traction as EU policy rewards advanced biofuels. Existing infrastructure can be used to produce bio-MTBE, with the

feedstock bio-methanol used instead of conventional methanol.

"Everyone who can produce MTBE can produce bio-MTBE; they are the same molecule," a trader said. "The approach now is to use mass-balance."

Saudi producer SABIC produces bio-MTBE at its site in Geleen in the Netherlands from second-generation bio-methanol derived from sewage, manure and other organic waste.

Other companies developing bio-MTBE production include LyondellBasell, with Evonik having produced bio-MTBE at its Marl site since 2012.

Bio-MTBE product specifications are the same as MTBE, providing a direct replacement for the ether. Bio-MTBE is produced from bio-methanol which is classified for advanced biofuel production, making bio-MTBE eligible for double counting under RED II Annex IX.

Double counting encourages the use of second-generation biofuels by crediting twice the number of bio-tickets (or HBEs). These bio-tickets can be traded with biofuel producers potentially selling its ticket to non-obligated industries such as aviation and shipping. Nevertheless, the high production cost is so far limiting market adoption, according to sources.

Interview

Braskem

Interview

Braskem

Braskem is the world's largest producer of bio-polymers, producing material made from Brazilian sugarcane at sites in Brazil and Germany.

S&P Global Platts spoke to Henri Colens, external affairs lead at Braskem Netherlands, about the company's approach to biopolymer production and the challenges involved.

Do all of Braskem's bio-plastics derive from sugarcane?

In a word, yes. Braskem only produces what we call drop-in polymers. Drop-in polymers are simply bio-based versions [that] entail no substantial change in specification versus their fossil counterparts. Almost all of our drop-in bio-plastic products are derived from sugarcane.

There are four product families where the transition to bio-based feedstock is more challenging, including PP where we are assessing the use of the mass-balance approach, which would see us diversify our renewable feedstock portfolio.

How is bio-based material costed? At a premium to virgin grade fossil material or related to the sugarcane ethanol market?

The price of bio-based PE is completely decoupled from fossil-based PE. I believe Braskem is unique in its approach to move away so completely from petrochemical indexing, but this has led to several benefits for us.

Throughout our 10 years' experience marketing this material, cost has always been the biggest challenge. For our drop-in biopolymers, such as I'm green™, we have always had higher sourcing and production costs compared to conventional petrochemical production.

Which particular sectors do you see demand for biomaterial coming from?

There is demand for sustainable solutions in literally all segments, but each for different reasons. Let's take packaging as an example. When it comes to circular and sustainable alternatives, most food contact packaging will be more suited to chemically recycled or bio-based options due largely to regulatory issues and barriers to the use of mechanically recycled polyolefins. We will need, and companies will need, an arsenal of different sustainable solutions depending on segments.

In the very near future, bio-based plastic will play a crucial role in bringing circular solutions to the market. Given the loss of quality that can occur during the mechanical recycling process, virgin bio-based material can be used to restore any loss in functionality. For example, you have bio-based plastic that you can blend with potentially recycled plastic, which will bring a really circular solution. Demand for polyolefins in general is very steady as the market is very interested in mono-material solutions and bio-based polyolefins with excellent barrier and functional properties seem really well placed to deliver that.

Demand for biopolymers exists in all segments where traditional plastics play a role. Durable applications that lock in biogenic carbon for many years, applications that are hard to recycle and, in many cases, end up going to energy recovery or incineration, they are the ones demanding a lower carbon footprint, like bio-based PE. So, durables are potentially an interesting sector, alongside sectors like toys, building and construction, automotive — these sectors where there is potentially a suitable bio-based alternative could be really high-growth areas for biomaterial.

Do you see challenges to bio-polyolefins from biodegradable bio-plastics like PLA [polylactic acid]?

There has been a real uptick in PLA supply, and it is a material that can do a lot of interesting things. But there are very few applications where PE and PLA compete – as materials they just do different things. They are even quite complementary in some applications. There are some where there are real synergies such as laminated films for flexible packaging or a bio-component of non-wovens for the hygiene segment. It's interesting – PLA is often classified as a biodegradable, but in reality, for the majority of applications the end-of-life is not composting.

Potentially there may be some challenge quite far into the future in terms of competition for feedstock, but at the moment that is not a challenge we are concerned about.

Some bio-polymer producers have noted customer pressure to move from first-generation bio-production (such as sugarcane or palm oil), to second-generation production methods (such as cooking fats or animal waste). Do you notice this pressure from customers?

There has been interest in second-generation solutions for a while. In a sense, it has always been there. However, whilst second-generation may seem to be an attractive and resource-efficient concept, the energy input you need to put into the process is often considerably higher and there are also some technical challenges. It means the shift to second-gen is still some way away, because of these sustainability issues and its economic viability. Yet, we continue to look for ways to develop this concept.

Do you think first-generation production such as sugar cane or palm oil have an image problem?

Palm oil certainly has an image problem, but I'm not so sure about sugarcane. We need to ensure people understand that sugarcane is grown sustainably, and we do a lot of analysis of our feedstock situation in order to reassure customers and consumers that this is the case. The Brazilian situation is clouded by the Amazon and biodiversity loss etc. but sugarcane is grown in a different part of the country, and under conditions which have been put in place to protect natural habitats. Alongside the environmental concerns we have also put in place a code of conduct for our farmers to ensure worker welfare processes are in place – cultivation and harvesting of sugarcane employs many people, but has become highly mechanized as well.

There is not a great deal of understanding among the public of biomass and of this kind of sourcing but locally grown plastics is a great concept and one we'd like to move towards. NGOs have a role to play in highlighting the risks of unsustainable use of agricultural feedstock, but we need to show people that we have the checks and balances in place to demonstrate this kind of sourcing can contribute to the fight against climate change.

Bio-plastics

An alternative to recycled material?

Bio-plastics

An alternative to recycled material?

By Callum Colford, Miranda Zhang, Heng Hui, Abdulaziz Ehtaiba

- **Bio-based polymers driven by packaging sector**
- **Asian applications largely limited to Japan**

Bioplastics can refer to plastics that are bio-based, biodegradable or both, with bio-based polymers those that are produced from a bio-based feedstock.

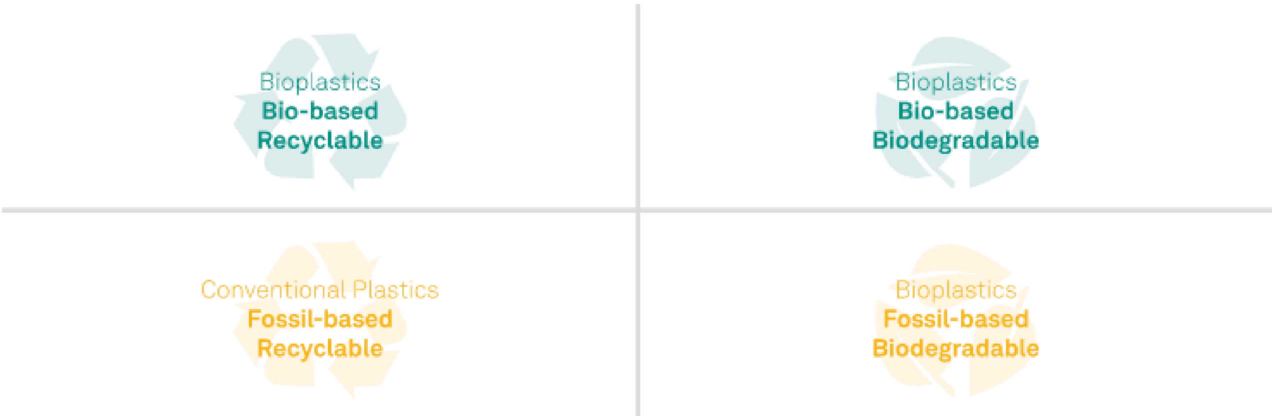
To produce one metric ton of bio-polyethylene requires 33.55 mt of sugarcane, 27.26 mt of sugar beet, 27.5 mt of potato, 10.76 mt of wheat or 7.07 mt of corn, according to the Institute of Bioplastics and Biocomposites.

In practical market applications, consumers may choose to utilize the mass-balance “drop in” approach, in which they combine bio-based material with traditional fossil-based material, producing an end-product that consists of typically 30-50% bio-based material.

Though no classification has been agreed globally regarding minimum bio-based values, the Japanese BioPlastics Association and US Department of Agriculture require a minimum of 25% bio-material to qualify for their bio-based certification.

Bio-based production of “traditional” polymers such as polyethylene, polypropylene or polyethylene terephthalate typically utilizes production of material via the drop-in method, substituting a fossil-based feedstock for one that is bio-based while producing material that has the same physical properties as the “traditional” alternative.

What are bioplastics?



Source: European Bioplastics

Biodegradables uptake limited by recycling

Polylactic acid (PLA), a biodegradable plastic made from bio-based feedstocks, is the largest bio-plastic in terms of global production capacity and PLA capacity expansion is set to continue after the two leading PLA producers, Natureworks, a Cargill and PTT Global Chemical joint venture, and Total Corbion PLA, a joint venture between Corbion and TotalEnergies, both announced plans to bring new production online in 2024.

Natureworks is to build a 75,000 mt/year PLA production facility in Thailand, while Total Corbion PLA aims to have a 100,000 mt/year PLA plant operating at Total's Grandpuits site in France by 2024.

PLA can be used in packaging, in 3D printing and as a replacement fiber in teabags. PLA is already used by brands such as Yorkshire Tea and in food packaging at tourist attractions such as the Royal Botanic Gardens at Kew in London.

While biodegradable materials such as PLA or polyhydroxyalkanoates (PHA) may have different or even improved properties compared with the range of fossil-based polymers that they can substitute, their biodegradable properties have been widely viewed as incompatible with current mechanical recycling, which may be a limiting factor on their application moving forward.

"PLA has some tough challenges to [overcome] before finding its way in the circular model and that is the problem with bio-segregated material – if you want to move to a new type of polymer or chemistry then you will have to develop the associated recycling schemes," one market source said.

Bio-based non-biodegradable materials which have a clear fossil-based equivalent with an already developed recycling stream do not face these additional hurdles.

Companies have noted the incompatibility of biodegradable material with recycling schemes and significant time periods that some biodegradable material takes to biodegrade led them to focus on other production methods. For example, Borealis has said it has no intention of producing biodegradable plastics as "we believe recycling as an end-of-life option is better sustaining the value in the plastic and we do not want to risk the littering of plastics due to biodegradable claims... Producing bio-based plastics from renewable feedstock, on the other hand, is a real opportunity for us to reduce the carbon footprint of our products and decouple plastic production from fossil-based feedstock."

Bio-based polymers

According to the European Bioplastics industry body, global bio-based polymer production capacity is expected to grow from 884,000 mt/year in 2020 to 1,081,000 mt/year in 2024 with bioplastic production estimated to be around 1% of total global polymer production annually. However, the share that bio-based material encompasses in the bioplastics market has declined in recent years as volumes of biodegradable material grow at a faster rate.

Bio-based polyethylene is the most-utilized and commercialized product in the bio-based sector, according to the body, representing around a quarter of bio-based, non-biodegradable polymers produced.

Consumption patterns were dominated by the packaging sector, consuming some 46% of bio-based production, according to European Bioplastics.

The commercialization of bio-polypropylene production has been more limited when compared to products such as bio-PE. Production routes for bio-PP have been developed by companies such as Braskem, LyondellBasell and Borealis, but details remain largely confidential.

European Bioplastics expects bio-based PP use to more than quadruple over 2019 to 2025 due to a wide range of downstream PP applications.

Although bio-based polymers should, in theory, work hand-in-hand with the recycled material, market sources said that perception among the public and brand owners meant that bio-based options were being sidelined in favor of recycled material.

"Bio will have its place but if you say today to a customer do you want recycled or bio-PS, the customer says recycled as it chimes [better] with the circularity theme," a styrenics producer said.

Limited availability and the significant cost barrier remain major impediments to bio-based material being more widely adopted by the market despite its identical properties, according to industry sources.

The outlook in Asia

In Asia, bio-based polymers, though still at much more of a preliminary development stage than in Europe, are increasingly seen as a way of complementing existing recycling solutions to control plastic pollution.

Market participants expect China to lead demand growth for biodegradable plastics in the coming years after China announced stringent plastics control and bans for single-use non-degradable plastics in 2020. The focus in China is expected to be on “degradable” plastics rather than bio-based polyolefins.

The value of China’s biodegradable plastics market will hit around Yuan 35.8-47.7 billion ($5.5-$7.4 billion) by 2025, with demand exceeding 2 million mt/year, according to estimates by China’s Huaxi Securities and HuaAn Securities.

Most of the demand comes from disposable food container and utensils, packaging for express delivery, single-use plastic bags and agricultural films.

Biodegradable products such as PLA and polybutylene adipate terephthalate (PBAT) are two of the fastest growing bio-plastic markets in China, receiving the most interest from end-users in the country.

At least 330,000 mt/year of new PLA and 120,000 mt/year of new PBAT capacity is expected to be brought online in China in the second half of 2021 to early 2022, according to annual reports and announcements by leading manufacturers in China, with more new projects expected in China in 2022 and 2023.

Despite the largely optimistic outlook for biodegradable plastics growth in China, there are concerns about the economic competitiveness of biodegradable plastics, which are priced much higher than conventional plastics.

Aside from biodegradable material, bio-based output is largely limited to Japan, where Mitsui signed an agreement with Neste to purchase bio-naphtha for its steam cracker located at Osaka, becoming the first company to produce renewable polymers on an industrial scale in the country.

For the time being, sources said neither biodegradable plastics nor bio-based polymers were immediately available in mass quantities with most schemes remaining at a pilot stage, and mechanical recycling of fossil fuel-based polymers still more prevalent in Asia.

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Bio-petrochemicals special report