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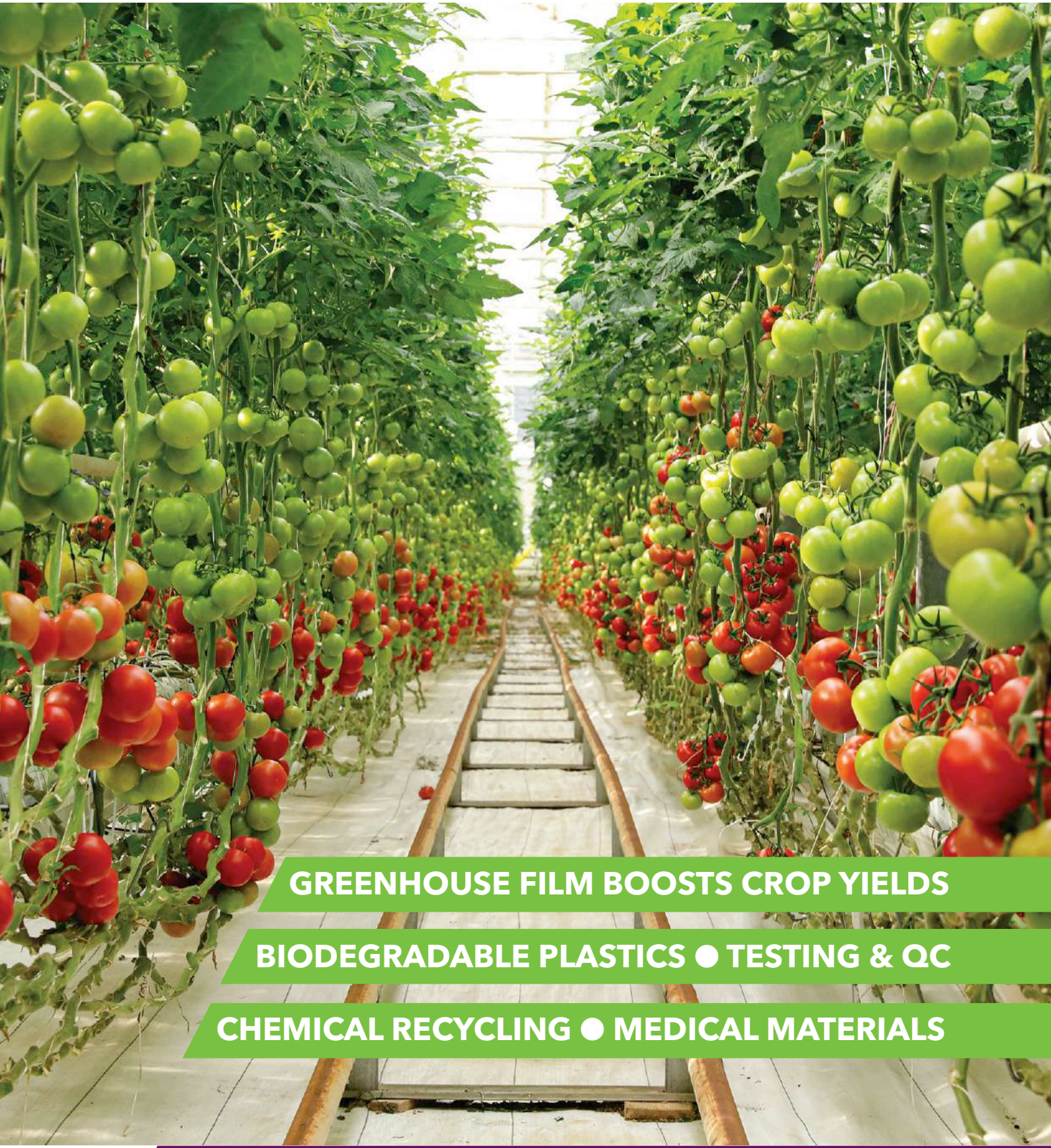

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Film and Sheet EXTRUSION

Chemical recycling presents new opportunities for dealing with plastics waste but what does the technology involve? Who are the key players? And how does it fit in the established recycling hierarchy? Produced by AMI's Magazines and Consulting teams, Chemical Recycling Global Insights 2022 presents an easy-to-digest introduction to this rapidly-evolving sector.

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› Thermoforming › Additives for film › Control/Instrumentation › Barrier film

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Alpek takes over Octal to expand in PET sheet

Alpek of Mexico is to acquire Octal – an Oman-based manufacturer of PET sheet and raw material – for US$620 million.

The deal is subject to closing conditions – including regulatory approval – and is expected to close in the first half of this year.

Octal's proprietary direct-to-sheet (DPET) technology eliminates several energy-intensive steps in converting PET into sheet.

It has customers across the Americas, Middle East, and Europe.

In Oman, Octal has a 576,000 tonnes/year PET production plant and a 400,000 tonnes/year PET sheet plant. In addition, it has an 11,000 tonnes/year PET thermoform packaging plant in Saudi Arabia and a 33,000 PET recycling plant in the USA.

Alpek says the deal will strengthen its core business – helping it move directly into PET sheet, using a process that could be expanded across the business.

"This transaction is an ideal fit for Alpek," said José de Jesús Valdez, CEO of Alpek. "Through a single acquisition, we're able to access the profitable and growing PET sheet segment and acquire differentiated technology that provides a sustainable competitive advantage."

Alpek estimates growth rates for PET sheet to be 6.4% per year until 2025.

› **www.alpek.com**
› **www.octal.com**

Custom packaging buy-out in USA

US-based Summit Plastics has expanded its custom packaging expertise by acquiring Clear View Packaging.

Clear View, based in Albany, New York, specialises in custom flexible packaging. It supplies a number of end markets, including food & beverage, healthcare, agriculture and retail. Summit says the takeover will help it to broaden its geographic presence and expand its product offerings.

"This partnership creates an industry-leading packaging platform that allows us to offer a broader suite of solutions," said Tom Nathanson, CEO of Summit Plastics.

› **www.summitplastics.com**
› **www.clearviewbag.com**

IN BRIEF...

Jindal Films Europe is to expand its Brindisi plant in Italy, adding 50,000 tonnes/year. The bulk of the expansion will be in bi-oriented polyethylene (BOPE) speciality film, including matt, sealable, coated, metallised and Alox grades. This will lift the Brindisi plant's overall capacity to 130,000 tonnes/year – making it the largest BOPE and BOPP plant in Europe, says the company.
www.jindalfilms.com

Private equity firm Rhone has acquired US-based **Paragon Films**, a manufacturer of cast stretch films. Its products are used to stabilise pallets during transit. It has three manufacturing facilities in the USA. Terms of the deal were not disclosed. Rhone says the takeover will capitalise on "favourable secular macro trends" in transit packaging.
www.paragonfilms.com

Paccor snapped up by Faerch Group

Faerch Group of Denmark has bought packaging company Paccor from its owner – New York-based investment firm Lindsay Goldberg.

The transaction is subject to closing conditions and regulatory approval and is expected to complete during the first half of the year. Paccor UK – which has two production sites – is not part of the transaction and will remain with Lindsay Goldberg.

IMAGE: PACCOR

Above: Paccor is a leading European packaging manufacturer

"With Paccor's leading position in the dairy sector, Faerch will be present in all major food packaging segments," said Lars Gade Hansen, CEO of Faerch.

Faerch employs more than 2,200 people across 16 European production sites in countries including Denmark, France, Italy and the UK. Paccor has around 3,000 employees in 15 countries.

Andreas Schütte, CEO of Paccor, added: "Faerch is the perfect partner for us. Its unique integrated recycling capabilities offer new opportunities to accelerate the transition towards circular packaging solutions."

› **www.faerch.com**
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Business calls for global UN treaty on plastics pollution

A group of multinational businesses has given support to a global treaty to tackle plastic pollution, which is set to be discussed at a meeting of the United Nations Environment Assembly (UNEA) at the end of February.

"A new UN treaty is crucial to set a high common standard of action for all countries to abide by, and to drive the transition to a circular economy for plastics globally and at scale," said the group, which includes polymer producer Borealis and several plastics packaging converters: Alpla, Amcor, Berry Global, Evertis, Flexfilm, Greiner, Minipak, Mondi and Selenis.

The group said a global plastic pollution treaty would need to include upstream and downstream policies, reduce virgin plastic production and use, and decouple plastic production from consumption of fossil resources.

At the UNEA 5.2 meeting, due to take place in Nairobi in Kenya from 28 February to 2 March, an Intergovernmental Negotiating Committee is scheduled to discuss treaty proposals from various UN member states.

A resolution from Peru seeks a treaty encompassing circular economy objectives, while another to be tabled by Japan focuses on a treaty covering plastic pollution and waste management.

Information about UNEA 5.2 proposals was presented by Tim Grabiel from UK-based NGO Environmental Investigation Agency (EIA) at AMI's Plastics Recycling Technology conference in October. He said he was optimistic there would be enough support for a treaty to move ahead.

In January, the EIA published a report in which it said that "only a robust global treaty for plastics can address the problem".

› **www.plasticpollutiontreaty.org**

IMAGE: NORNER

Above: Norner CEO Kjetil Larsen in front of the Polymer Exploration Centre

Norner opens polymer centre to extend its plastics research

Norwegian plastics research and testing firm Norner has completed its Polymer Exploration Centre at its new headquarters facility at Porsgrunn.

Covering 4,600 m^2, it describes it as a modern international research and technology centre for the plastics industry that will provide research services throughout the value chain.

The centre includes laboratories for advanced testing of chemical and mechanical performance, lab pilots for new process technology and catalyst evaluations, a variety of extreme polymer material performance testing and a high-tech plastic processing equipment, and a recycling, application and packaging centre.

› **www.norner.no**

Greif sells stake in flexpack JV

US-based Greif is to sell its 50% stake in a flexible packaging joint venture to its partner, Gulf Refined Packaging (GRP).

The stake will be sold for US$123 million, which Greif expects to use for debt repayment. The transaction is expected to close at the end of March 2022.

The sell-off happened as the partners held "different views" on the best strategy for the JV, after an 11-year partnership.

"I would like to thank our colleagues for their work over the last 11 years," said Pete Watson, president and CEO of Greif.

› **www.greif.com**

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North American machine sales grow

Sales of primary plastics machinery in North America rose in the third quarter of this year.

The Committee on Equipment Statistics (CES) at the US-based Plastics Industry Association says that sales reached nearly US$334 million in Q3 – a rise of nearly 9% compared to the same period in 2020, and 4% up on the second quarter of this year.

Sales of twin-screw extruders rose more than 61% (compared to Q3 2020) and by around 44% compared to Q2 2021. Single-screw extruder sales rose nearly 16% compared to the same period last year, and by 7% to the previous quarter.

For comparison, sales of injection moulding machines rose nearly 6% compared to Q3 2020, and by less than 2% over the previous quarter.

"Plastics equipment shipments picked up in the third quarter as the economy continued to emerge from the pandemic," said Perc Pineda, chief economist at the association. "The increase was consistent with higher plastics production – which rose 5.9% compared to a year earlier."

In the latest CES quarterly survey, three-quarters of respondents expected market conditions to improve or hold steady in the next quarter (lower than the 93% who expressed the same view in the previous quarter). For the next 12 months, 75% expect market conditions to be steady-to-better – a shade lower than the response in Q2.

"While the survey shows that growth expectations have moderated, it also reveals that plastics machinery suppliers are optimistic about market conditions four quarters ahead," said Pineda.

Exports rose to US$390m – an increase of 6% compared to the previous quarter. Mexico and Canada remained the top export markets for the USA. Combined exports to USMCA partners in the Q3 reached nearly US$173m, which was 44% of total plastics machinery exports. Imports fell 3% to US$848m, resulting in a US$458m trade deficit. The US plastics machinery trade deficit fell by almost 10% in Q3.

"The outlook for plastics machinery in the second half of 2021 is positive, though shipments will continue to fluctuate," said Pineda. "The likelihood of continuing supply-chain issues remains high."

› **www.plasticsindustry.org**

TerraVerdae expands in bioplastics takeover

Canadian bioplastics company TerraVerdae Bioworks is to acquire PolyFerm Canada – which also makes bio-based polymers.

PolyFerm produces bio-based and biodegradable elastomeric polymers known as medium chain length polyhydroxyalkanoates (mcl-PHAs).

TerraVerdae says that acquiring PolyFerm will strengthen its core capabilities and enhance its ability to produce biopolymers and resins for a wider range of applications – including films, coatings and adhesives.

"Adding PolyFerm's capabilities and know-how represents a significant opportunity for us to develop sustainable plastic solutions," said William Bardosh, CEO of TerraVerdae.

› **www.terraverdae.com**

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Piovan expands position in US with IPEG takeover

Piovan of Italy has expanded its position in ancillary equipment by acquiring US-based IPEG.

IPEG owns four ancillary brands, of which the best known are Conair and Pelletron. The deal is expected to close in the first quarter of 2022.

The new combined company will employ more than 1,800 people across 14 worldwide facilities. It is expected to have a turnover of more than €450 million (US$508m), says Piovan.

"The acquisition of such an important American player will allow us to achieve important growth opportunities on a global scale," said Filippo Zuppichin, CEO of Piovan. "It will also allow us to access a formidable customer base in North America."

Piovan's product range encompasses a range of ancillary products including conveyors, dryers, dosers, granulators and temperature control. Conair also offers a wide range of ancillaries – including blenders and control equipment – while Pelletron is known for materials handling. IPEG's other two brands are Thermal Care, which makes process cooling equipment, and Republic Machine, which makes shredders for plastic recycling.

Earlier this year, Piovan began construction of a new facility in China. The new plant, in Suzhou, will cover 10,000 sq m and be dedicated to automation systems for plastics.

› **www.piovan.com**
› **www.ipeg.net**

RKW raises MDO film production in Europe

RKW of Germany is to expand production of machine-direction oriented (MDO) film with a "mid-double-digit million Euros" investment at several European locations.

It will install a nine-layer extrusion line at its facility in Petersaurach, which is expected to reach full capacity by mid-2022. In addition, it will "renew machinery" at its Saint-Frères site in Ville le Marclet, France. It says the new machines here – planned for 2023 – are better able to handle quality fluctuations (due to using more recyclate) and can reduce production scrap.

RKW is also planning a new production line for cement packaging at its Echte site in Germany, which will also use recycled materials.

› **www.rkw-group.com**

IMAGE: RKW

Above: RKW is expanding production of MDO films in Germany and France

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IMAGE: UFZ

Consumer demand for biodegradable plastics has helped drive developments in everything from fundamental research and new grades to large-scale factory investments

Breaking down: advances in biodegradable plastics

Developments in bio-based plastics – and particularly those that will biodegrade safely in the environment – continue at a rapid pace. At the research level, scientists are trying to understand some of the mechanisms behind how these relatively new materials behave when they degrade.

German researchers have studied the mechanisms behind how biodegradable plastics break down in soil – and whether it makes sense to use the materials.

"Despite the positive image of biodegradable plastics, we still know very little about how they act in the soil – or how they are degraded," said François Buscot, a soil ecologist at the **Helmholtz Centre for Environmental Research** (UFZ).

The team investigated a number of areas, including: how quickly biodegradable plastic degrades; what micro-organisms are involved – and how they interact; and which conditions promote – and inhibit – the degradation process.

"We also wanted to know how the changing temperatures and precipitation levels – resulting from climate change – affect the degradability," added Witoon Purahong, also a soil ecologist at UFZ, and lead author of a study in *Environmental Science and Technology*.

The main focus was on mulch and horticultural films. These are typically made of polyethylene (PE), but residues of these films often remain in the soil. The team wanted to understand any effects of switching to biodegradable alternatives.

To do this, it investigated how polybutylene succinate-co-adipate (PBSA) – a bio-based mulch film – biodegrades under natural conditions in an agricultural field. The researchers distinguished between today's climate conditions and simulated conditions for Germany around the year 2070. They used modern molecular biology methods to determine which microbes had colonised both the plastic and the surrounding soil.

After around one year, 30% of the PBSA had degraded – due mainly to the effect of fungi. At the same time, an "intelligent degradation and recycling community" of microbes formed on and around the plastic. The degradation rate was hardly affected by expected changes in the climate. ›

Main image: UFZ researchers have studied the degradation of bio-based mulch film

IMAGE: BIOME BIOPLASTICS

Above: A new type of tree shelter is made from a biodegradable material

In a second study (published in *Environmental Science Europe*), the researchers examined the microbe community under more stringent conditions – such as when large amounts of PBSA enter the soil, and the effect of a high concentration of nitrogenous fertiliser. Large amounts of PBSA changed the microbial community in the soil. A 6% increase of PBSA in the soil reduced the diversity of fungal species by 45%. However, a high load of PBSA combined with fertilisation caused a widespread plant-damaging fungus to proliferate.

"When large amounts of plastic end up in the environment, it is never good – even if it is biodegradable," said Buscot.

He said it made sense to use biodegradable plastics in this type of application – but it was important to know in advance about their degradation properties.

Field testing

UK-based **Biome Bioplastics** and Suregreen have begun large-scale field testing and initial sales of their biodegradable tree shelters.

The shelters protect trees for the first five years of their lives – then biodegrade over the next two years. Shelters would typically be made from conventional plastic that would litter the landscape if not collected.

"Without the help of tree shelters, up to 90% of newly planted trees are likely to perish or be damaged – so they are of no potential commercial value," said Tim Oliver, technical sales manager at Suregreen.

The partners will now monitor the performance of around 40,000 shelters at more than 40 sites, to ensure high sapling survival rates over the next few years. In parallel, early adopting customers can buy the shelters from under the Vigilis Bio brand.

Paul Mines, CEO of Biome Bioplastics, added: "This field testing is the next step towards commercialising the novel tree shelter, and we're looking forward to seeing our lab results validated in real-life conditions."

Tomato waste

Researchers in Spain are looking to use waste from tomato processing to make a film that could be used for food packaging.

The team, from the **Institute of Subtropical and Mediterranean Horticulture** (IHSM) in Malaga, will extract various unsaturated and polyhydroxylated fatty acids from so-called 'tomato pomace' – which comprises tomato skins, seeds and other fibrous material. This is generated as waste when making products such as ketchup.

The researchers say that the resulting bioplastic would decompose in about a month in the sea. However, it may take some time before it becomes commercial – as it would need to be produced economically. The cellulose extracted can be used to make a transparent film or plastic wrap with multiple applications, said Jose Alejandro Heredia, a researcher at IHSM.

Property gains

Wacker says that two of its additives for biodegradable plastics – Vinnex and Genioplast – can enhance processing and material properties.

Recent tests show that the products are more effective when used in combination, says Wacker. It chose polylactic acid (PLA) and polybutylene succinate (PBS) for its screening. Although biopolyesters are considered alternatives to conventional thermoplastics, they can be difficult to process – and require suitable additives to achieve a suitable property profile. The tests showed that Vinnex and Genioplast complement one another in their effects – in both filled and unfilled bioplastic systems. In the samples tested, Genioplast acted as a booster and enhanced the effects achieved with the Vinnex additive that had been previously added. In several cases, it also improves properties that Vinnex has no influence on. The addition of Genioplast reduces surface friction, which increases scratch and abrasion resistance.

The additive combination helps to improve the mechanical properties of the final article. When added in the usual amounts – and depending on the individual system – the additives do not affect the degradability of biopolyesters such as PBS, PLA or or thermoplastic starch, says Wacker.

Vinnex additives were developed for modifying biopolyesters and starches – and are based on polyvinyl acetate. They are available in powder and granular form. Genioplast additives are silicone-based and available as pellets. ›

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IMAGE: BASF

Right: WPO Polymers will distribute BASF's Ecovio compostable film products in Spain and Portugal

Bigger in Japan

Kaneka is to increase production capacity of its PHBH biodegradable polymer, called Green Planet, in Japan.

The company will invest around Y15 billion (US$130 million) at its Takasago manufacturing site. This will raise annual capacity from 5,000 tonnes to 20,000 tonnes. Completion is scheduled for January 2024.

Kaneka says bioplastics demand in Japan is set to rise, as this year the country will introduce rules to cut the use of single-use plastics. The company also has plans to increase production capacity in Europe and North America, where demand is also rising.

"Green Plane has business potential on the order of hundreds of thousands of tonnes, and will be a core product in our portfolio," said the company.

The material is derived from biomass, and produced by microorganism biosynthesis of plant oils. It biodegrades in both soil and in water (salt water and fresh water) – into CO_2 and water.

It is already being used in applications such as coffee capsules, bags and films. Kaneka estimates it could replace around 25 million tonnes/year of traditional single-use plastics worldwide.

PLA plant plans

NatureWorks has received authorisation from its parent companies to build a new PLA manufacturing complex in Thailand.

The company plans to invest more than US$600 million to build the complex, which will include production of lactic acid, lactide and polymer – which NatureWorks says will be the first fully integrated PLA facility.

Below: Kaneka is expanding production of its biodegradable PHBH polymer in Japan

Work on the new manufacturing complex – at the Nakhon Sawan Biocomplex – begins in the second quarter of this. It is expected to open in 2024 and have an annual capacity of 75,000 tonnes – producing the full portfolio of Ingeo PLA grades.

"Thanks to the ongoing support of our parent companies, our plans for a second Ingeo PLA manufacturing location continue to progress," said Rich Altice, president and CEO of NatureWorks.

IMAGE: KANEKA

NatureWorks already has a 150,000 tonnes/year PLA plant in Nebraska, USA – which it is planning to expand. Its parent companies are GC International Corporation of Thailand, and US-based Cargill.

NatureWorks is also on the verge of moving into new headquarters – which includes a biopolymer research facility – in Plymouth, Minnesota.

The expanded laboratory capability will help support research into its Ingeo biopolymers. It will also help in the construction and operation of the planned Ingeo PLA manufacturing complex in Thailand.

"We've designed a space that will enable research, invention, and collaboration between us, our partners, and the market – no matter where we are located in the world," said Altice. "These new facilities will help accelerate the pace of research and innovation."

Green expansion

WPO Polymers is to distribute Ecovio compostable film products from **BASF** in Spain and Portugal. The films are used to make shopping bags, organic waste bags and fruit and vegetable bags. BASF says the films will help retailers comply with legislation – such as a Spanish law that insists on the use of compostable bags less than 50 microns thick. Ecovio is a blend of BASF's PBAT Ecoflex and renewable raw materials, meaning it is partly bio-based.

CLICK ON THE LINKS FOR MORE INFORMATION:

- **www.ufz.de**
- **www.ihsm.uma-csic.es**
- **www.biomebioplastics.com**
- **www.wacker.com**
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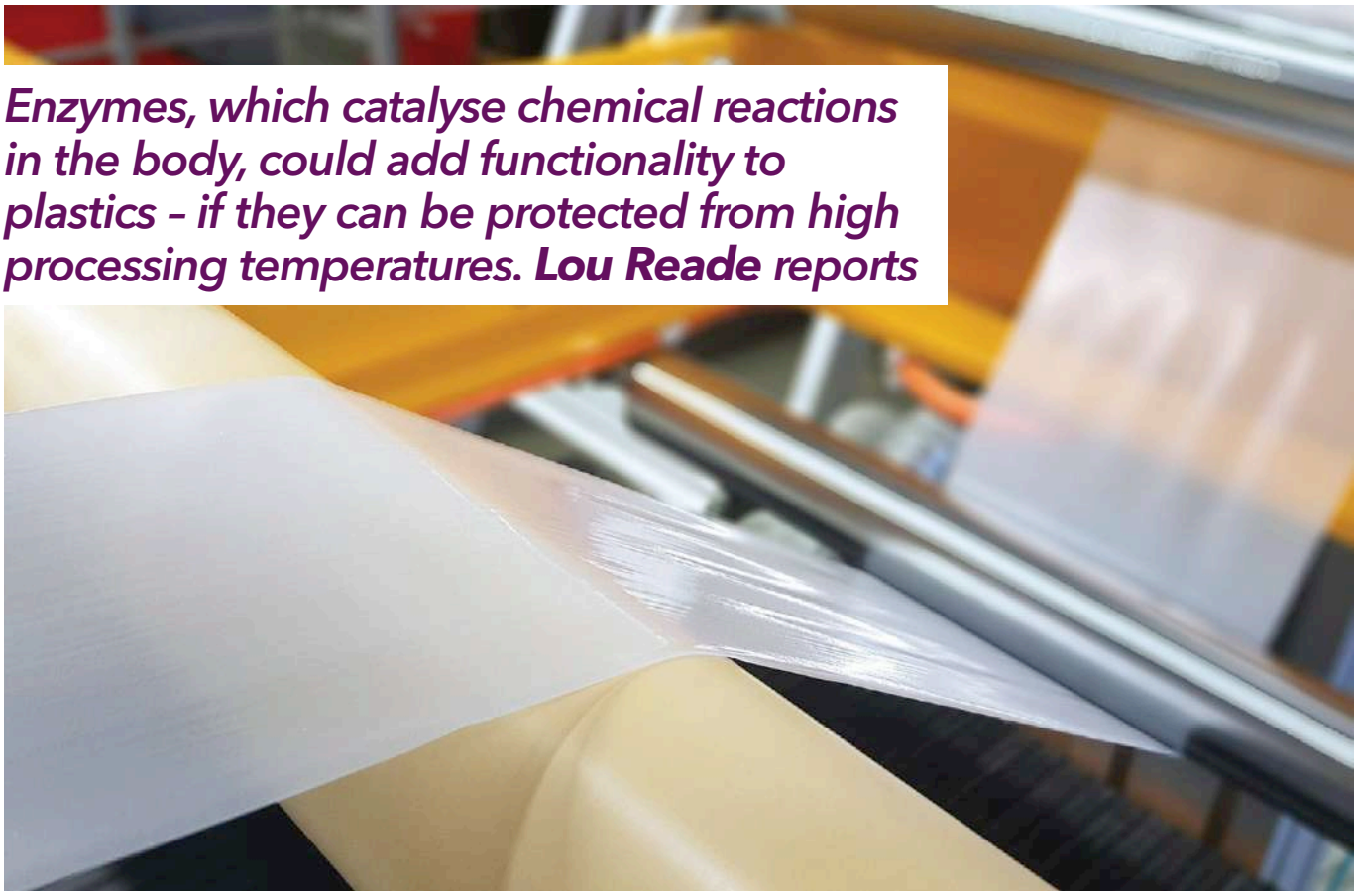

IMAGE: FRAUNHOFER IAP

Enzymes, which catalyse chemical reactions in the body, could add functionality to plastics – if they can be protected from high processing temperatures. Lou Reade reports

Enzymes add multiple properties to plastics

Enzymes are biological catalysts. They drive chemical reactions in the body – such as those involved in digestion – that would otherwise take much longer or require much higher temperatures.

Enzymes could also add functionality to plastics – such as self-cleaning, the ability to resist mould or bacteria, or even self-degradation (biodegradability). However, enzymes are not very heat-sensitive – and plastics are typically processed at high temperatures. This makes it hard to incorporate enzymes into plastics.

Now, scientists at the **Fraunhofer Institute for Applied Polymer Research** (IAP) in Germany have found a way to do this without destroying enzyme function. Their aim is to turn this into an industrial process.

"We are not looking to produce biofunctionalised plastics on a laboratory scale," said Ruben Rosencrantz, head of the biofunctionalised materials and glyco-biotechnology department at Fraunhofer IAP. "We want to show that technical production is possible."

The organisation is around halfway through a research project, which began in 2018. The researchers use highly porous inorganic carriers to stabilise and protect the enzymes. The enzymes bind to the carriers by embedding themselves in the pores.

"Although this restricts the enzymes' mobility, they remain active and are able to withstand much higher temperatures," said Rosencrantz.

However, there is not a single process that works in all cases – as the carrier must be chosen specifically for each enzyme because "no two enzymes are alike", he says.

Applying the stabilised enzyme to the bulk plastic – not just the surface – is more difficult, it is longer-lasting, prevents signs of wear on the surface. To achieve the best result in the downstream process, the stabilised enzyme must be

Main image: Fraunhofer IAP researchers have made a biofunctionalized film that contains enzymes

IMAGE: ADAM LAU/BERKELEY ENGINEERING

Above: PCL plastic has been embedded with enzymes to make it degrade more readily

distributed into the hot plastic melt quickly, so it is not exposed to excess force or high temperatures. The researchers have developed a process that can be applied to both bioplastics and conventional petroleum-based plastics such as polyethylene.

"Once embedded in the plastic, stabilised enzymes can withstand higher thermal loads than before," said Thomas Büsse, head of Fraunhofer IAP's processing pilot plant for biopolymers in Schwarzheide. "This makes the use of enzymes and all process steps much easier."

So far, the researchers have focused on enzymes called proteases, which break up proteins. Plastics embedded with proteases could have a self-cleaning effect – such as pipes that resist clogging. However, the team is also testing other enzymes. Project partners at BTU Cottbus-Senftenberg are focusing on enzymes that degrade plastics and toxic substances.

The first functionalised granulates and films have already been produced, and researchers have established that the enzymes embedded in these products remain active. They have submitted a patent application for the research.

Green research

At the same time, research into 'green' plastics is booming. As well as bio-based materials – such as Braskem's 'Green PE', made from sugar cane rather than crude oil – there is ongoing interest in biodegradable and compostable plastics. These materials are typically – but not always – made from sustainable sources.

However, biodegradable and compostable plastics typically only break down under specific

conditions, such as those of 'industrial composting'. This means that, if these materials find their way into the environment or landfill sites, they will not decompose.

This is one reason why research is continuing into how plastics can be engineered to break down more effectively. One emerging approach is to use enzymes that 'digest' plastic molecules.

Embedded approach

Researchers at the **University of California at Berkeley** have devised a way of embedding enzymes into plastics, to make them break down more quickly.

The scientists, led by Ting Xu of the department of materials science and engineering, have applied the process to polylactic acid (PLA) – a commonly used biodegradable plastic – in order to speed up its degradation. Xu says that many items made from PLA end up in landfill sites – where they do not biodegrade.

The process involves embedding a polyester-eating enzyme into the bulk polymer as it is produced. A protective polymer layer ensures that the enzyme remains dormant until it is needed. Heat and water destroy the protective shell, which then allows the enzyme to start degrading the bulk polymer. PLA, for example, is broken down into lactic acid, which can feed soil microbes in compost.

The protective shell – which degrades along with the bulk plastic – is a molecule called a random heteropolymer (RHP). It is made of four types of monomer sub-units, each with chemical properties designed to interact with chemical groups on the surface of the specific enzyme. They degrade under UV light and are present at a concentration of less than 1% of the weight of the plastic – low enough not to be a problem, says Xu.

In research published in *Nature*, the team embedded billions of the nanoparticles into plastic granules. The paper showed that the RHP-protected enzymes did not change the nature of the plastic – which could still be processed into fibres at temperatures of around 170°C.

"If you have the enzyme only on the surface it would etch down very slowly," said Xu. "You want it distributed nanoscopically everywhere – so that each molecule eats away its polymer neighbours and the whole material disintegrates."

Water and heat

Degradation is triggered by adding water and heat. At room temperature, 80% of the modified PLA fibres completely degraded within about one week. The process was faster at higher temperatures: under industrial composting conditions, the modified PLA degraded within six days at 50°C. Another polyester, PCL (polycaprolactone), degraded in two days under industrial composting conditions at 40°C. For PLA, Xu embedded an enzyme called proteinase K that converts PLA into lactic acid. For PCL, she used lipase. Both enzymes are inexpensive and commonly available.

IMAGE: TING XU/UC BERKELEY

Above: Plastic modified with enzymes breaks down in just three days in standard compost

Xu believes that higher temperatures make the protected enzyme more mobile – allowing it to find the end of a polymer chain quickly, degrade it, then move to the next chain. RHP-wrapped enzymes also tend to bind near the ends of polymer chains, keeping the enzymes near their targets.

The modified polymers do not degrade at lower temperatures or during brief periods of dampness, said Xu. A polyester shirt would withstand sweat and washing at moderate temperatures. Soaking in water at room temperature, for three months, did not cause the plastic to degrade. However, soaking in lukewarm water – such as water from the hot tap – did lead to degradation.

Xu is developing RHP-wrapped enzymes that can degrade other types of polyesters, but she also is modifying the RHPs so that the degradation can be programmed to stop at a specified point – and not totally destroy the material. This could be useful if the plastic needs to be remelted and recycled, she said.

In addition, one of the study's co-authors – former UC Berkeley doctoral student Aaron Hall – has spun off a company to further develop these materials.

It proves that, while enzymes are critical to biology, they are becoming increasingly important in developing new plastics.

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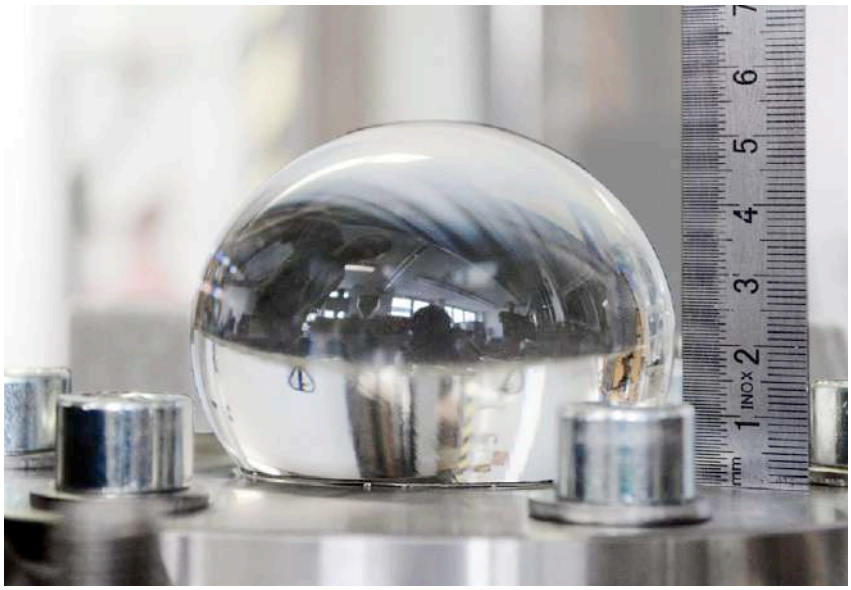

IMAGE: FRAUNHOFER LBF

Sophisticated quality checks – whether of raw materials, the production process or finished articles – helps to minimise the chance of sub-standard products leaving the factory

Testing plastic materials – for everything from thermal properties to purity – helps to ensure that the final product is of sufficient quality for the customer. In addition, quality control systems such as cameras and gauges spot defects and correct the process in order to eliminate them.

Researchers at the **Fraunhofer Institute for Structural Durability and System Reliability** (LBF) recently improved bulge testing for elastomeric sheet.

The results of virtual simulation of elastomer parts often differ from the real behaviour of components. One potential reason is that only data from unidirectional tensile tests are taken into account. LBF has now improved specifications for the biaxial tensile test.

The implemented 3D optical measurement during loading allows for precise measurement of the mechanical response of the elastomer sheets. The data from this new test improves material modelling – providing better design quality of elastomeric components.

The bulge test is the simplest way to realise biaxial tensile loadings on elastomer sheets. The Fraunhofer LBF method supplies data for reliable modelling of components. In this way, a wide variety of parts can be designed more reliably and cost-effectively, says LBF.

The test fixture comprises a circular ring, elastomer plate and base plate. The elastomer is clamped in the test fixture and inflated with water, causing it to expand as a bubble. A balanced biaxial stress occurs in the centre of the bubble. Stress is avoided by a special design of the edges of the circular ring. Evaluation of the geometry change in the elastomer bubble is performed in a post-processing step using GOM Aramis 3D software. Test results can be evaluated up to an approximate height of the bubble of 45mm.

Main image: Fraunhofer LBF has devised a test procedure for elastomeric sheet

Software updates

US-based Lloyd Instruments – part of **Ametek** – has updated its materials testing software.

NexygenPlus 4.1 – when combined with the company's LS or LD series of materials testing machines – allows testing of a wide range of plastic products, including pipes and films.

The Windows-based software holds a library of pre-defined test set-ups for a wide range of applications. These include tension, compression, three- and four-point bend, and shear tests. In addition, it can check factors such as the 'slip' of plastic wrapping film and the peel of adhesive seals. Pre-defined test setups make the software quick and easy to operate. The user can also create custom, multi-stage tests for more complex or unique requirements. Whole tests can be videoed and synchronised with the stress/strain data and replayed for detailed post-test analysis. An optional security and audit trail module provides full traceability and the software provides full capacity for automatic testing. ›

IMAGE: LLOYD INSTRUMENTS

Above: Lloyd Instruments has updated its NexygenPlus materials testing software

One new feature of the software is the intuitive user interface, which resembles that of Microsoft Office. This gives the users a familiarity when first using the software. In addition, navigation has been simplified while maintaining the original advanced functionality.

NexygenPlus 4.1 interacts with Excel and Word and alllows automatic transfer of test results directly to an organisation's own templates without user intervention. Live graphs are available during testing, SPC data is continuously monitored, and built-in export utilities assist direct connection to LIMS systems.

The software can be purchased as an upgrade to older NexygenPlus versions, or as part of a complete solution including IQ/OQ and result calculation verification. Batch files used with previous versions of the software can be imported to NexygenPlus 4.1 so existing customers can easily transition to the new version.

Thermal testing

TA Instruments has introduced its Trios Autopilot software, for use with its thermal analyser products.

The software helps laboratory staff create routine and streamlined standard operating procedures (SOPs) up to 25% faster. It also avoids transcription errors that can reduce productivity and lead to inconsistent thermal analysis measurements.

"Next to reliable and sensitive analytical instrumentation, modern, easy-to-use instrument software is key to unlocking scientific creativity and productivity," said Jianqing Bennett, senior vice president at TA Instruments.

As a premium feature on TA's thermal analysers and rheometers, the OneTouch interface guides operators – with video and text prompts – which simplifies the process of getting test results. The software includes pre-written express scripts for automating procedures such as sample loading, instrument calibration and verification.

In one polymer industry example, the R&D laboratory at Continental Reifen Deutschland in Germany develops and performs laboratory test methods to characterise new, experimental rubber compounds.

"The Trios Autopilot maximises our flexibility for addressing R&D-related questions," said Juergen Tschimmel, senior scientist for test method development at Continental. "The OneTouch feature ensures a safe, simple and operator-independent execution of our tests in a production facility."

TA says that AutoPilot is the first thermal analysis software to be based on Google's visual programming interface, Blockly. The open source software allows operators to create custom scripts and

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IMAGE: TA INSTRUMENTS

Right: Trios Autopilot software helps lab staff create thermal analyser routines

configure them for thermal analysis applications without having to learn a higher-level programming language.

Air testing

Aimplas of Spain has extended the scope of its testing capabilities – and is now accredited for emissions testing using the one cubic-metre chamber method.

This is used, among other things, to test emissions from car interior components.

Aimplas says it is the first laboratory in Spain to obtain ENAC international accreditation for odour emission tests for vehicle interiors. The number of accredited emissions tests has steadily increased to include testing for total volatile organic compounds (TVOCs), formaldehyde and other aldehydes such as ketones, fogging tests and tests for volatile organic compounds in air through thermal desorption (VOC and FOG).

The one cubic-metre chamber emission method test makes it possible to validate large parts in close to 'real' conditions, while controlling the heating time, temperature, humidity and air flow.

Converting measurement

NDC Technologies has introduced its Series 9 on-line gauge for converting applications.

The product, which builds on earlier versions, claims to offer process vision beyond that of conventional in-process measurement systems. It can be integrated with NDC's single-beam scanners – such as SlimTrak II – and Pro.Net TDi web gauging controller.

Users can perform accurate measurements of moisture, coat weight, degree of cure and film/layer thickness across a range of converting applications such as extrusion, coating and lamination.

"The Series 9 gauge is the sum of what we've learned over the past years to meet the challenges faced by the converting industry," said Mark Rainville, product manager in NDC's film extrusion and converting businesses.

Other benefits include: long-term stability – with no need for recalibration; advanced diagnostics, including features for preventative maintenance to ensure maximum uptime; and low cost of ownership.

IMAGE: NDC

Right: NDC has developed a version of its Series 9 on-line gauge for converting applications

QC showcase

At this year's ICE Europe show – scheduled to take place in March – **OCS** will present a number of quality control and assurance products that promise to reduce scrap, rework and machine downtime.

It will give a live demonstration of its FSP600 web inspection system. This can recognise irregularity in films, laminates and non-wovens in real time. It is made possible by a special high-speed camera that can recognise features such as gels, black specks, burn marks and other defects. One practical feature is that real-time results are transferred directly to production and process control.

At the same time, its Multi-Channel Evaluation (MCE) technology allows detection in reflected or transmitted light mode – as well as in dark and bright field applications – to be combined, with one piece of hardware (the camera).

This enables the simultaneous detection of defects on up to six channels. One channel could be for the reflection of surface defects, for instance, and three additional channels for transmission (red, green and blue = RGB) for better defect detection and classification.

Defect references are learned with the help of the teach-in function. A standardised classification of the film rolls (calculation of grades) can be made, says OCS.

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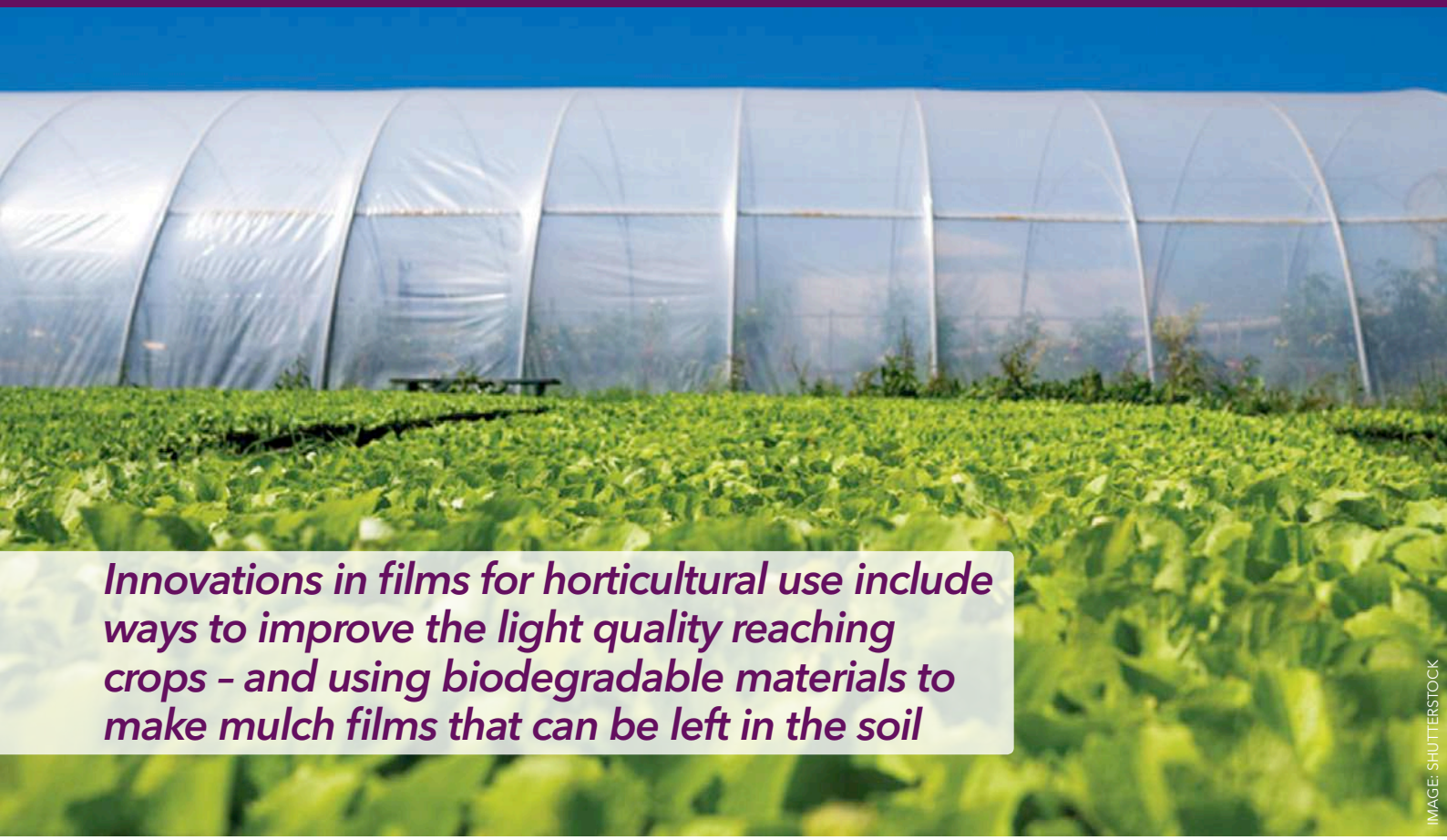

Innovations in films for horticultural use include ways to improve the light quality reaching crops – and using biodegradable materials to make mulch films that can be left in the soil

IMAGE: SHUTTERSTOCK

Field day: advances in agricultural film

Delegates at the recent *Agricultural Films* conference, organised by AMI, learnt about a wide spectrum of recent technologies – from advances in greenhouse and mulch film to new products that control light diffusion.

Michael McLaren, a research scientist at **Ingenia Polymers** in Canada, told delegates that analysis and testing can help to develop better polymer processing aid (PPA) masterbatches.

PPAs such as fluoropolymers are typically added to the melt, and coat metal surfaces of the extruder and die to reduce friction. Their performance can be affected by factors such as the presence of other additives in the mix. Adding the PPA as part of masterbatch can help to ensure the correct particle size, he said.

A typical PPA test in film processing is 'time to clear' (TtC) melt fracture testing, which measures the time from PPA introduction to total elimination of melt fracture. For agricultural film, it is also important to test potential interactions with other additives such as hindered amine light stabilisers and anti-blocks.

In a typical test, a test resin (LLDPE) is exposed to different shear rates, and PPA loading increased gradually.

"In testing, our newer PPA grades showed significant reduction in TtC over older products," said McLaren.

Its ITZ-443 formulation has been designed to match the performance of existing PPAs – and with better economics.

"TtC testing and other evaluations allowed us to develop the new PPA masterbatch," he said. "It is designed to perform similarly to our existing offerings at a better price point."

Film improvement

Amy Laird, customer and application development engineer at **ExxonMobil**, explained how improved greenhouse films can increase crop yield and expand the growing season. The market for these kinds of films is expanding fast – with China dominating consumption, she said.

Several ExxonMobil materials, including Enable and Exceed XP, can be used in agricultural film

Main image: Greenhouse film can help to boost crop yields and expand the growing season

IMAGE: SHUTTERSTOCK

Above: US-based strawberry growers say biodegradable mulch film technology is 'unproven', say researchers

formulations. Laird said that these types of film have been put through ageing performance tests – including both dry and wet ageing. Both are exposed to a temperature of 38C and humidity of 50%. In dry ageing, the film is dipped in solutions of sulphurous acid (H2SO3) and permethrin – repeated every 1,000 hours. In wet ageing, 102 minutes in dry conditions is followed by 18 minutes of water spray – for the whole ageing time.

Both wet and dry ageing tests showed superior performance for thinner films that incorporate polymers such as Enable and Exceed XP.

Novel mulch film

Kristin Taylor, CEO of **Radical Plastics**, told delegates of her company's novel technology to make biodegradable mulch film.

The company has blended conventional plastic with a mineral catalyst, which it says then renders the polymer biodegradable in the natural environment.

The catalyst is incorporated into the polymer during compounding stage, to create pellets. There are two stages to its breakdown: chemical and biological. In the chemical phase, the catalyst allows complete polymer oxidation, she said – and creates no microplastics. In the biological phase, microbes metabolise material into biomass, CO2, water and trace minerals.

Agriculture is the initial target market for the technology. It could help to ensure that mulch film can be left in the soil to rot – rather than having to be collected and recycled. At the same time, using a conventional plastic – rather than a bioplastic – would typically allow better mechanical properties such as tensile strength, she said.

It has been field tested at more than 15 locations in the USA – from east to west coast. After two months, the Radical film showed signs of chemical change – while there was none in a conventional film.

In the lab, it showed no ecotoxicity effects and passed physical property requirements.

The company plans to sell its biodegradable mulch films through **Charter Next Generation Films**.

Strawberry fields

Researchers at **Washington State University** (WSU) are also working on mulch film that biodegrades – and has assessed their attractiveness to strawberry growers.

Lisa Wasko DeVetter, associate professor in horticulture at WSU, said that soil-biodegradable mulches (BDMs) include various feedstocks and additives that typically achieve 90% biodegradation within two years. In general, they have the same benefits as PE mulches but do not need to be removed at the end of the season.

California is the leading strawberry producer in the USA – using around 32,000 acres of mulch film to grow them. This is typically PE-based mulch film. WSU surveyed 43 Californian strawberry growers: most of them used PE mulch, yet only around 30% recycled it. Although many said PE mulch film needs to be recycled more effectively, only 10% said they were 'very likely' to use BDM film in future – saying it was 'unproven'.

"Strawberry growers in California are interested in BDMs – and reducing plastic waste generation – but currently perceive BDMs as an unproven technology," said DeVetter.

Pest management

Ralf Dujardin, vice president of marketing and innovation at **Imaflex**, explained how controlled-release mulch systems can help to make pest management safer.

He said that mulch films can be used to 'contain' pesticides – targeting it exactly where it is needed. This helps to reduce the amount needed, and stop it from spreading where it is not needed.

"More than 90% of today's applied pesticides does not reach its intended target," he said.

One way around this is to use 'plastic fumigation film'. Here, an active ingredient is incorporated into a multi-layer mulch film. The ingredient – such as a herbicide – then leaches into the soil from the film.

He cited how the company's Advaseal HSM film has been used to improve weed control and drive higher crop yields – while using less fumigants. It has since developed an improved product called Advanseal HG – a broad-spectrum pesticide plastic film that releases a fungicide, nematicide and insecticide. It has been trialled in tomato production and led to a higher yield and larger fruits.

Overall, it can reduce the amount of pesticide

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Right: 'Sunlight altering' greenhouse films from UbiQD have helped to boost tomato output

needed by 99%, while also requiring less equipment and labour, said Dujardin.

Light work

Sunlight is an important factor in plant growth – but getting light from the correct part of the spectrum is critical.

Michael Burrows, vice president of business development at **UbiQD**, explained how his company's 'sunlight altering' greenhouse films can help to maximise crop yields.

One aim is to reduce the amount of blue and UV light, while maintaining green light – which penetrates deeply into leaves. Orange and red light are also important, as they help maximise photosynthesis (as long as enough blue and green is also included).

This can be achieved through various coverings, such as coloured film or netting, and luminescent film. A luminescent film, for instance, absorbs light at a certain wavelength and emits lower energy light. A similar effect can see high energy light converted into heat energy.

The company's UbiGro film was trialled on tomatoes – and was found to increase light use efficiency by 23%, and harvested weight by 6%.

"Photo selective coverings are a cost-effective option," said Burrows. "Ongoing greenhouse testing shows plant yields increasing."

Flexible tubes

Albert Zhang, technical manager at **Berry Global**, said that long plastic 'tubes' could be an answer storing silage or grain.

Storing silage and grain for feed is vital, and is typically done by wrapping them in bales or bags, for instance. Zhang said that wrapping them in an elongated 'bag' would be more efficient – as they would take up less space, better protect the contents and result in less feed loss.

He said that his company's Agflex 'rodent repellant' bags can actually protect a wide variety of wildlife – including deer, bears and birds – in contrast to typical grain bags, which are often damaged by animals as small as mice.

"Making agricultural plastic sustainable is about making it last longer – and easier to recycle and reuse," he said.

Diffused film

Luigi Pezzon, plasticulture specialist at **Pati**, presented details of a case study to make a diffused film for a polytunnel – in order to prevent heat stress in crops.

The aim of developing the film was to reduce

IMAGE: SHUTTERSTOCK

quality problems in red currant and raspberry production.

"By adding a special raw material – or using extra diffuse film – it is possible to reduce quality problems as a result of heat stress," he said.

Dutch research organisation Vlamings researched what types of films were needed to reduce heat stress, and these were supplied by various suppliers. Dataloggers were used to monitor temperature and humidity.

Films investigated included standard diffused films, a diffused cool film, and Pati's H75 super-diffused film. In one example – for red currants – Pati's film kept the temperature within a greenhouse to 42C (the heat stress limit) for more than 10 hours. Only the diffused cool film had a better performance.

For raspberries, the Pati film and the diffused cool film kept a similar maximum temperature in the greenhouse – but Pati's film heated up less quickly in the morning, while the competitor film heated up less quickly in the afternoon. These two films also led to the lowest number of damaged fruits.

■ The next *Agricultural Film* conference is held in Barcelona, Spain on 28-30 March 2022. For more details, contact Angelina Ruocco on +44 (0)117 314 8111 (**angelina.ruocco@ami.international**).

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Health alert: new medical materials and applications

Material developments for medical applications have boomed in the pandemic – including a large focus on materials that can naturally fight microbes and pathogens

IMAGE: USP

Above: USP has developed a latex-free medical TPE film for use in wound-healing applications

Materials for medical applications have been thrust into the spotlight with the advent of the global pandemic – though not all developments are directly related to Covid-19.

United Soft Plastics (USP) has developed a medical TPE film for use in wound-healing applications.

Wound dressings are typically kept clean and dry by covering them with a protective film or protective bag (polybag), which is attached to the skin with an adhesive tape and sealed. However, it is painful to remove (by tearing the tape off the skin).

The new film is a latex-free alternative and does not have to be torn off because it is permanently welded to the polybag as a sealing strip. As a result, adhesive tape can be eliminated. It was developed in conjunction with Danish start-up **Nomeco**.

The TPE grade has a low Shore A hardness (25-35), high tear strength in connection with demanding transverse and longitudinal strain loads, and is 0.2-0.4mm thick. The TPE can also be produced cost-effectively, according to Michael Bodmann, general manager for Europe at USP.

The year-long joint development project is in a pre-commercialisation phase and undergoing clinical trials. After initial commercialisation in Europe, the new film will be made available globally.

Medical demand

The company has seen a surge of interest in the use of TPEs for Covid-19 related medical applications. It says several customers have requested materials to convert non-medical manufacturing facilities, so they can make medical items.

TPEs have been used in applications such as face masks and face shields, as well as ventilator parts.

"We are pleased to be an important contributor in the development of medical products that will help our fellow citizens combat this awful virus," said Benedict Herbst, executive vice president at USP.

USP sees more interest in replacing current materials such as silicone with softer plastics in current applications – and in scaling these applications for the future.

"We can help prevent the spread of disease through the choice of proper materials," said Herbst.

Now, many applications that were previously not considered 'medical' – such as items in a waiting

room – will in the future need to withstand different sterilisation methods such as autoclaving, he said.

There has also been strong growth in face shields and other face coverings during the pandemic. USP says that its Unisoft special and medical series grades provide excellent elasticity, strong recovery properties and tear resistance. For instance, several million face shields have been manufactured that use USP material for the straps.

Coronavirus killer

Researchers in Spain and Japan have developed a face shield which they say deactivates a wide range of microbes – including the Coronavirus – in less than a minute.

The face shield, developed by researchers at the **Catholic University of Valencia** (UCV), relies on PET sheet that has been treated with a thin anti-microbial coating of benzalkonium chloride.

Ángel Serrano, who leads the research, says that face shields do not typically have anti-microbial activity – and only act as a physical barrier.

"A healthy person can become infected if they come into contact with the contaminated surfaces of these materials," he said.

As well as deactivating 'enveloped viruses' such as SARS-CoV-2 within a minute of coming into contact with the surface, it is effective against *Staphylococcus aureus* and *Staphylococcus epidermis* – both of which are resistant to the antibiotic methicillin.

The anti-microbial compound developed at UCV can also be used to make other types of protection such as glasses, masks and divider screens used in shops, said Serrano. Benzalkonium chloride (BAK) is commonly used as a disinfecting agent. It is applied to the PET by dip-coating the plastic into a solvent containing BAK. It forms a coating around 25 microns thick.

The development has been published in the *International Journal of Molecular Sciences*.

Pathogen free

A project carried out at a Swiss hospital has shown that anti-microbial adhesive film helped to reduce the level of pathogens on surfaces.

Right: Anti-microbial adhesive film helped reduce pathogen levels at a Swiss hospital

IMAGE: SANITIZED

The study, at University Hospital Basel, looked at how effectively a coated plastic adhesive film from **Hexis** – using additives from **Sanitized** – acted against pathogens that can cause hospital-acquired infections.

The film was applied to frequently touched surfaces – such as overbed tables and toilet seats. Half the surface was left exposed as a 'control'. Over several months, normal cleaning routines were carried out. Swabs were taken from the treated and untreated surfaces twice a week from a 25 cm² area and examined for microorganisms.

The treated film led to a reduction in total viable count of more than 98% across all surface types.

"Antimicrobial-treated surfaces can prevent the spread of multidrug-resistant pathogens in hospitals," said Andreas Widmer, who led the study. "Even daily disinfection of surfaces cannot prevent recontamination within a few hours – but antimicrobial-treated surfaces can close this gap."

The results were published in the journal *Antimicrobial Resistance & Infection Control*.

Intelligent petri dish

Greiner Assistec is helping Accensors – an expert in film sensor technology – to develop an 'intelligent petri dish' using thermoforming.

The aim of the partnership is to offer customers the option of buying thermoformed plastic parts with printed sensor systems. As part of the pilot project, an initial demo prototype has now been developed, taking the form of a smart petri dish. This involves printing two sensors on PET film before putting it through a thermoforming process. The prototype can check the pH value and the temperature of the medium in the dish, using an Accensors scanner and an app. The data obtained can be used to gain new insights in research and development.

The intelligent sensor systems can be produced and printed onto the films at an affordable cost and in high volumes. During thermoform-

Right: UVC says its coated PET face shield deactivates the Coronavirus in less than a minute

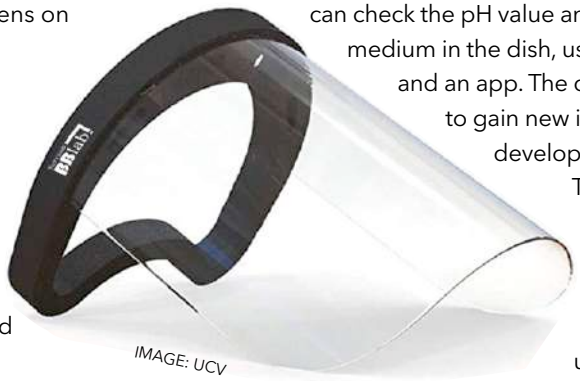

IMAGE: UCV

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- **Compounding and additives** for recycling
- The impacts of changing **legislation and regulation**
- **Feedstock security** as a growing industry challenge

Right: A thermoformed 'intelligent petri dish' can be monitored for pH and temperature

ing, the film printed with the sensor technology is formed into a three-dimensional shape while retaining sensor functionality – so the petri dishes can be monitored as effectively as possible.

"The development of this smart petri dish has yielded a promising outcome and highlights one of many different possibilities for transforming plastic parts through the use of printed electronics," said Natascha Andraschek, technology manager at Greiner Assistec.

Eike Wilhelm Kottkamp, CEO of Innome – the parent company of Accensors – added: "The implementation of thermoformed film sensors in 3D geometries is a key milestone on our roadmap. At the moment, we are holding preliminary discussions with parties interested in specific applications in the biotech, smart manufacturing, and agricultural sectors."

Medical recycling

VinylPlus has begun a European collaborative project to recycle single-use PVC medical devices.

VinylPlus Med builds on the earlier VinylPlus-funded RecoMed recycling scheme. It is developing a recycling scheme for single-use PVC medical devices in Belgium to help hospitals sort their PVC medical waste stream.

The scheme will focus on clean, REACH-compliant PVC waste that can be recycled into a wide range of products marketed across Europe. In partnership with the Europe Hospitals group, high-quality PVC waste from various departments will be collected and recycled. Most of the waste has not been in contact with patients.

"Most PVC medical waste is non-infectious and can be recycled when properly sorted and collected," said Brigitte Dero, managing director of VinylPlus. "We are keen to enhance PVC's recyclability in this critical sector."

Other partners are waste management company Renewi and recycler Raff Plastics. All Belgian VinylPlus Med partners are located in a radius of 120 km, to minimise transport distances and reduce carbon footprint.

"There are many materials that could be recycled but – due to unfavourable circumstances – are sent to landfill or incineration," said Caroline Van der Perre, co-owner of Raff Plastics. "A project like this helps towards the renewal of raw materials."

PVC medical devices are recycled in eight countries including Australia, New Zealand, UK, South Africa, Canada, Guatemala, Colombia and Thailand.

IMAGE: GREINER ASSISTEC

TPE investment

Hexpol is to invest more than €5 million (US$6m) at its site at Amal in Sweden, to make medical materials. The investment will expand TPE production capacity and support growing demand and changing market requirements, the company said.

Construction of a new production hall has already begun and should be finished in autumn 2022. The new space will be dedicated to production of materials for medical devices. Its Mediprene grades are used in applications including medical packaging and tubing.

The facility has been designed to minimise contamination risk and will house a new twin-screw compounding line with gravimetric feeders and advanced monitoring systems.

"This investment confirms our ongoing commitment to this important product area," said Georg Brunstam, president and CEO of Hexpol.

Below: Hexpol is to expand capacity of medical-grade TPEs in Sweden

IMAGE: HEXPOL

CLICK ON THE LINKS FOR MORE INFORMATION:

- **www.unitedsoftplastics.com**
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CONSTRUCTION

Multiwall sheet cuts energy in construction applications

Exolon has developed a new type of multiwall sheet for construction applications.

Hybrid X combines walls and air chambers, giving it high energy-saving potential. It offers good thermal insulation and improved light diffusion – and has strong mechanical properties with optimised weight.

Its geometry allows it to bring more daylight into interior spaces at constant temperature, says the company. The 10-20% stronger interior walls in the structure – with the same weight per unit area – improves mechanical properties. This gives greater safety, allowing for larger spans and lighter beams.

Hybrid X multiwall sheet has a low heat transfer coefficient which can produce energy savings of more than 30% compared to conventional standard sheets. There is also a solution for high levels of sunlight. The translucent plates in the IQ-Relax version reduce heat on sunny days while providing high light transmission.

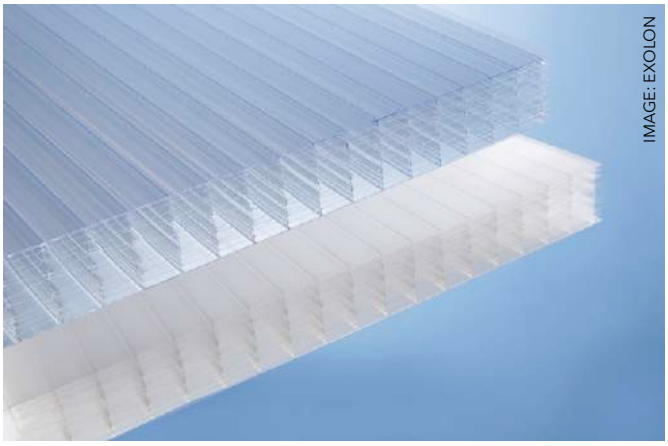


IMAGE: EXOLON

Exolon has developed a multiwall sheet called Hybrid X for construction applications

It is suitable for private and industrial applications where high thermal insulation is required. The sheet meets quality standards in terms of fire protection – with a CE mark in accordance with EN 16153, and DIN ISO 9001 for quality management. It is guaranteed for 10 years of weather and hail resistance.

› **www.exolongroup.com**

SHRINK FILM

Shrink labels easy to sort

Taghleef Industries has developed a new shrink film, which it says helps to improve the recycling of PET bottles.

The film, Shape360 TDS, is a high TD shrink clear label film. It improves PET bottle recycling by ensuring the separation of floatable printed sleeves from rigid PET flakes, says the company.

TDS is also compatible with polyolefin sorting streams so is ideal for combining with PP and HDPE containers for an all-olefin package.

The film gives up to 65% shrinkage, enabling a gradual labelling of empty and thin-wall containers. Its negligible MD shrink prevents any undesired 'smile effect' at bottle extremities.

› **www.ti-films.com**

POLYETHYLENE

PE grades boost physical performance

ExxonMobil has developed two new Exceed XP polyethylene (PE) grades that combine mechanical performance with features such as low density and fractional melt index (MI).

It says that Exceed XP 7021 and XP 7052 offers "a combination of attributes" not currently available in a single resin. These include factors such as high elasticity and holding force, puncture energy and dart impact resistance.

The grades also offer a combination of fractional MI and low density (0.911-0.912 g/cm³) not currently available, it said. This leads to films with enhanced bubble stability, while could help converters to increase output.

The materials can be used to make films for stretch hood packaging, collation shrink, primary packaging, and greenhouse applications.

"They are designed to help create innovative solutions to meet specific applications needs," said Michael Vinck, global polyethylene new products marketing manager at ExxonMobil.

Producers of stretch hood packaging films, for example, can benefit from high elastic recovery and high holding force. Collation shrink films can be made with high shrink speeds at temperatures as low as 120°C.

The films can also be sealed at low temperatures.

"The combination of fractional MI and low density helps prevent seal thinning without the addition of LDPE," said Vinck.

› **www.exxonmobilchemical.com**

ANCILLARIES

Compact roll stand with small footprint

US-based Processing Technologies International (PTI) has added a compact, configurable roll stand to its portfolio.

The eG series – aimed at processors with limited production floor space – is based largely on the existing G series of roll stands. This focuses on producing high-quality sheet by close temperature control, and incorporating design features to simplify the extrusion process – such as vertical nip height positioning.

Accurate sheet thickness and proper cooling is made possible via specifically engineered design of features that adjust temperature and positioning accordingly.

Hydraulic and linear bearing supported roll actuation, with motorised gap positioning, help to meet sheet thickness requirements. Spherical tapered roller bearings support chrome rolls for 0.0003 – 0.0005in Total Indicator Reading (TIR) runout in the stand. There is also dedicated heat and direct inject cooling for each chrome roll zone.

The eG series can be tailored to include equipment such as roll skew, servo motorised gap and an eAntiStat coater.

› **www.ptiextruders.com**

RECYCLING

From bottles to trays

Amut has extended its partnership with Erema by installing an extrusion line for food grade PET sheets at Alto Packaging in New Zealand.

The plant converts 100% washed post-consumer flakes (from bottles) into food contact grade monolayer thermoforming sheet. This is the first such application in New Zealand, said Amut.

Melt is fed straight from a Vacurema 1716 T Basic to an Amut sheet line without requiring pelletising. The recycled PET is already decontaminated and pre-dried prior to extrusion.

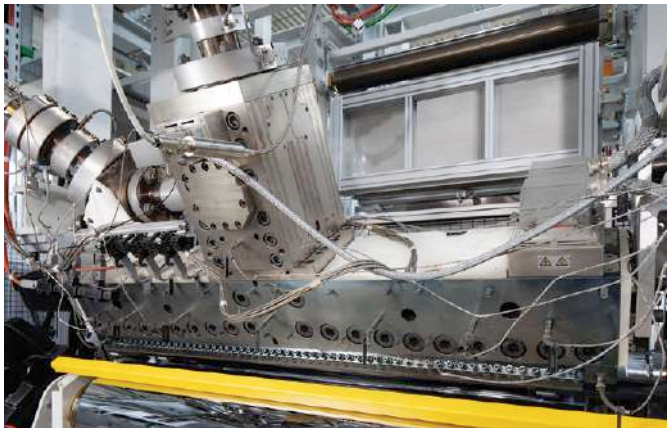
After filtration by Erema's SW-RTF backflush filter and online IV measurement, the melt is processed into sheet of 0.15-1.2mm thickness. At Alto, it is processed into trays and food containers.

› **www.amut.it**

DIES

PET extrusion die on show

At the recent Fakuma exhibition, Comelt of Austria presented a 1,400 mm PET extrusion die as well as a three-layer feedblock with fixed geometry.



It can process a PET mixture with a high proportion of recycled material, making films of 150 to 1800 microns.

"This processing unit of feedblock with slot die is used for the coextrusion of flat films or sheets," said Bernhard Winter, CEO of Comelt.

Comelt slot dies have a wide range of applications and are available from 150 to 3,000mm. Depending on the requirement, they are made of standard or chrome steel, with coatings such as chromium nitride.

For multi-layer films, Comelt has a variety of feedblock systems – for development and production of new film structures either in the technical centre or up to production scale.

› **www.comelt.at**

EXTRUDERS

Compact model for coating

Davis-Standard has developed a compact extruder for extrusion coating applications.

The CHP claims to offer a smaller footprint and lighter weight to allow for easier addition to an existing carriage or platform structure. This gives a space-saving replacement or coextrusion addition for increasing outputs and line speed.

"This design addresses profitability factors such as reduced raw material loss, improved outputs, and greater application development," said Danis Roy, vice president of sales for films and flexible packaging. "The CHP is built for improved transition times and higher processing rates than conventional extruders."

› **www.davis-standard.com**

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SCANFILL: GREENER PACKAGING

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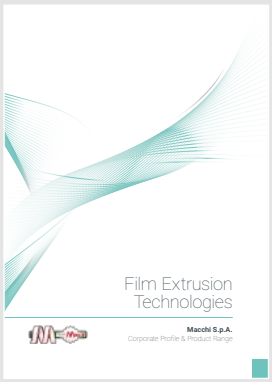
MACCHI: FILM EXTRUSION



This 28-page brochure from Macchi covers the company's wide range of film extrusion technologies including coextrusion lines, wide webs, die heads, take offs, winders, trim recovery and control systems.

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COLINES: BARRIER FILMS

This new brochure from Colines focuses on extrusion lines for the production of barrier films for vacuum and modified atmosphere packaging to preserve foodstuffs and medical products.

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CHEMOURS: PROCESSING AIDS

In this brochure, Improving the Efficiency and Quality of Polyolefin Extrusion, Chemours explains how issues including melt fracture and extrusion instabilities can be addressed with its Viton FreeFlow products, the next generation of polymer processing aids.

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POLYSTAR: BLOWN FILM LINES

Polystar's blown film technology is detailed in this brochure, including its Classic, Compact, ABA Three-Layer and AB Two-Layer machines. Also, find out how Polystar customers around the world have benefited from its technology in a series of case studies.

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GLOBAL COLORS GROUP

Find out about Global Colors Group in this brochure showcasing the group companies, their vision and focus on quality, R&D, technology and sustainability. Its portfolio includes colour, white and black masterbatches.

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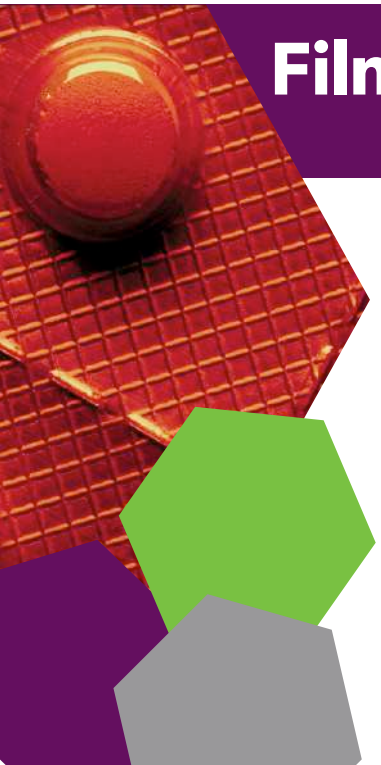
Ecolean

Head office:	Helsingborg, Sweden
CEO:	Peter Nilsson
Founded:	1996
Ownership:	Private
Employees:	Around 500
Profile:	Ecolean, established in 1996, is a specialist in flexible packaging that has grown from its base in Helsingborg, Sweden to be present in 30 countries – including China, Russia and Pakistan. The company specialises in producing packaging such as stand-up pouches for liquid products – including milk-based drinks (such as yoghurt) and various types of juice.
Product lines:	The company has a variety of brands for liquid food packaging, such as its Ecolean Air range. The basic range is highly printed and is used for a variety of products including milk, yoghurt and even fermented products such as kefir. Packages are typically available in 200ml to 1500ml sizes. Variants include a transparent version (called Clear) and an Aseptic version – allowing products such as juice to be packaged without the need for refrigeration. Snapquick is its reclosing device that is integrated into the package. The PET device allows resealing with a light pinch and adds less than 0.38g to the total weight.
Factory location:	Ecolean makes all its packaging products at its headquarters plant in Helsingborg, Sweden. However, the products are still used across a variety of markets in Europe, Asia and the Americas. Recently, for instance, Vietnamese food company Nutifood used Ecolean's aseptic packaging (in 125ml and 250ml sizes) for a new series of milk-based drinks.

To be considered for 'Extruder of the Month', contact the editor on lou@filmandsheet.com



Film and Sheet FORTHCOMING FEATURES
EXTRUSION

The next issues of Film and Sheet Extrusion magazine will have special reports on the following topics:

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Additives for film
Control/instrumentation
Barrier film

April 2022
Polyolefins
Film winders
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Chinaplas 2022 preview

Editorial submissions should be sent to Lou Reade: lou@pipeandprofile.com

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Film and Sheet
December 2021
The December edition of Film and Sheet Extrusion looks at the latest innovations in foaming technolgy. It also reviews developments in melt filtration systems, web static management, and additives for enhancing performance of recycled resins.

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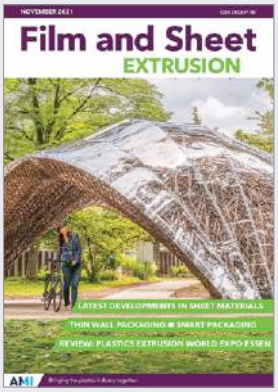

Film and Sheet
November 2021
The November 2021 edition of Film and Sheet Extrusion explores some of the latest applications for film and sheet in the construction sector. Plus, innovations in thin wall packaging, engineered sheet, and smart packaging.

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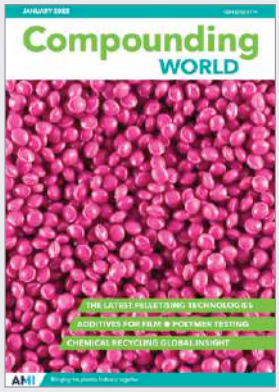

Compounding World
January 2022
The January 2022 edition of Compounding World looks at the latest developments in pelletising technology. It also explores some of the recent additions to the film additive option list and learns how new demands on compounders and end users are changing polymer testing strategies.

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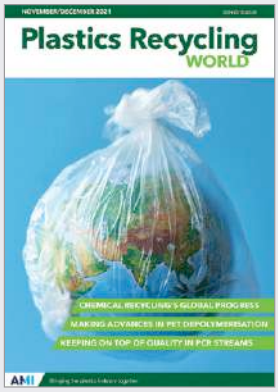

Plastics Recycling World
November/December 2021
The November-December edition of Plastics Recycling World has a lead feature on progress in chemical recycling projects around the world. Other features cover PET depolymerisation and quality measurement in mechanical plastics recycling.

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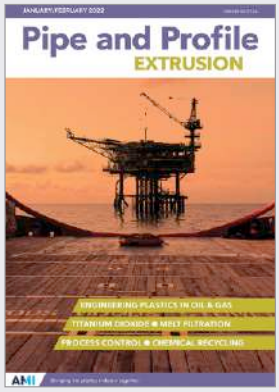

Pipe and Profile
January-February 2022
The Pipe and Profile Extrusion January-February edition looks at the success of engineering plastics and composites being used in oil and gas applications. Other features cover regulatory issues around titanium dioxide, controls and melt filtration.

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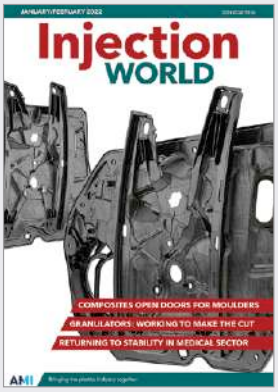

Injection World
January/February 2022
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Chemical Recycling
GLOBAL INSIGHT 2022

Letter from the Editor

Welcome to Chemical Recycling Global Insight 2022, a special publication written and produced by AMI Magazines, with support from AMI Consulting. The development of chemical recycling is a response to the global problem of waste plastics in the environment. Its advocates see chemical recycling as complementary to mechanical recycling which is itself growing in importance.

In this publication, we look at the market prospects for chemical recycling and how the industry is taking shape.

The articles cover not just the scope of the waste plastics problem, but also influencing factors such as legislation and targets for use of recycled content. There is an article on the various technologies that come under the chemical recycling umbrella term, offering a guide to their differences and relative advantages.

You will find our article on what's new in chemical recycling projects very helpful in staying up-to-date with the many facilities being built around the world. Some of the players in this fast-moving industry are featured in a series of company profiles.

We hope you find this publication informative and useful.

David Eldridge – Editor
AMI Magazines

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The need for more plastics recycling

The problem of plastics waste has come to dominate the outlook for the plastics industry. Many polymer producers and technology companies are now turning to chemical recycling as a possible solution

IMAGE: SHUTTERSTOCK

Main image: Mixed plastics waste is the source of feedstock for many plastics recycling companies

The circularity of plastics has risen rapidly up the agenda for the global plastics industry. It is now the top talking point at any conference, forum and exhibition at which industry companies gather. Campaign groups have tried to highlight the problem of plastic waste in the environment for many years, but it only cut through to the public as a mainstream issue in 2018. The blanket media coverage of plastic pollution in oceans and on beaches has receded since then, but the problem of what to do about waste plastics remains just as strong.

The European Union responded quickly with actions to tackle plastic packaging waste, including its Plastics Strategy, setting medium-term targets for reducing plastics waste, and more immediate action to ban plastics in certain single-use items. But it's not just in Europe that the issue has achieved such prominence. The challenge has been recognised in all regions of the world and many countries have implemented or are planning to implement regulations, notably China's ban on most plastic waste imports, which was followed by other Asian countries imposing similar import bans.

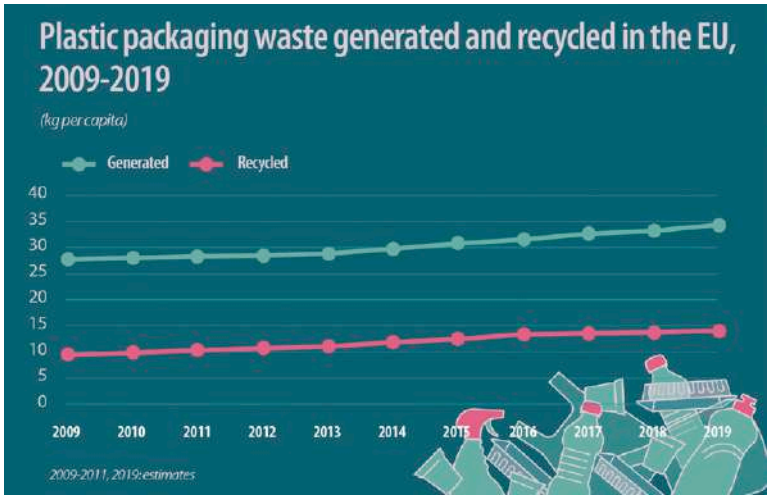
A key approach to the problem is circularity, which encompasses reduction in material usage and the recycling of materials so that loops are created in material production and use, thereby cutting the amount of waste. Multinational brand-owners have become active in reducing virgin plastics and increasing recycled plastics in packaging of their products.

Ellen MacArthur Foundation has been at the forefront of the drive towards a circular economy in plastics packaging, along with other areas such as fashion and food. In November 2021, it published the third annual progress report on its New Plastics Economy Global Commitment. It said signatory businesses, accounting for 20% of all plastic packaging produced globally, have progressed towards their 2025 targets to create a circular economy for plastics.

The report was nonetheless critical of companies in terms of reducing packaging: "There is very little evidence of ambitious efforts to reduce the need for single-use packaging in the first place."

Chemical and mechanical recycling can be used for plastics waste that arises in all sorts of industries, including automotive, electronics and others. But it is plastics packaging that is the major focus for many companies in the plastics industry, because of the huge volumes of packaging waste and because this is where social concern is the greatest.

Plastics packaging recycling has actually been increasing in the EU for more than a decade. A study published by Eurostat in October 2021 indicated a 41% EU recycling rate for plastics



SOURCE: EUROSTAT

packaging waste in 2019. Between 2009 and 2019, the recycling volume of this waste increased by 50%. However, a burgeoning plastics packaging market in the decade meant that the volume of waste generated per inhabitant over the decade increased by 24%.

Recycling of plastics packaging waste has not kept pace with the growth in the EU packaging market. So the pressure is on the plastics industry to deal with the problem and plastics producers have turned to chemical recycling as a solution.

Mechanical recycling is a more established transformation route for waste plastics, and it has the advantages of being a cheaper and less energy-intensive process than chemical recycling. But current small capacities for mechanical recycling are not enough to deliver the huge tonnage of recycled plastics that are necessary to meet regulatory and corporate targets. This is where large-scale polymer producers believe they can step in and help.

In May 2021, PlasticsEurope, the representative body for polymer producers in Europe, announced a significant increase in planned chemical recycling investment, from €2.6bn in 2025 to €7.2bn in 2030. Its member companies are aiming to increase their investment in chemical recycling to produce 1.2m tonnes of recycled plastics in 2025 and 3.4m tonnes in 2030. Advocates of chemical recycling state that this growth will not impact on the further development of mechanical recycling, as the focus would be on mixed plastics waste and other types of hard-to-recycle waste streams.

PlasticsEurope said: "Chemical recycling allows us to recycle plastic waste which is otherwise incinerated or sent to landfill. It delivers significant quantities of recycled material with virgin plastic properties. It is complementary to mechanical recycling and has a huge potential for creating quality jobs and contributing to a climate neutral and competitive Circular Economy in Europe."

The American Chemistry Council is supporting US-based polymer producers involved in projects to increase capacity for chemical recycling, or advanced recycling as it is more commonly called in the USA. A chemical recycling report from ACC in 2019 estimated the US could support investment in 260 new facilities converting plastics waste to products such as feedstocks for new plastics and chemicals.

ACC's polymer producing members have set a goal for 100% of US plastic packaging to be reused, recycled or recovered by 2040. To help reach that goal, ACC has drawn up its Roadmap to Reuse which highlights six key areas for plastics makers and the value chain to focus on to help solve plastic waste challenges.

Increased plastics recycling capacity will certainly be needed as plastics usage is set to grow over the next decade in all regions of the world. According to a forecast by AMI Consulting, China accounted for almost one-third of commodity polymer demand in the world in 2019. By 2030, China is forecast to account for 38%. This contrasts with slower virgin polymer demand growth in Europe (0.2% annually to 2030) and in North America (1.1% annually) and South America (also 1.1% annually). South East Asia and the Middle East/Africa are both forecast to grow by 3% per year. The Indian Subcontinent will be a hotspot with its polymer demand forecast to grow by 5.3% per year up to 2030.

In its *Chemical Recycling Global Status 2020* report, AMI Consulting presents its expectations for the global chemical recycling market in 2025 and 2030. It is forecasting a compound annual growth rate (CAGR) for global chemical recycling of 28.0% up to 2030. Europe is expected to grow fastest and have a lead over North America by 2030 due to the more advanced legislative agenda of the European Union. But North America will not be far behind, and Asia is likely to also experience good growth.

Of the four types of chemical recycling technologies – pyrolysis, gasification, depolymerisation and dissolution – pyrolysis will be the dominant one in terms of total waste recycled (also see separate technology article). This is due to a few factors: the greater number of pyrolysis projects currently being developed; less complexity than other processes; fewer concerns about the scale required to achieve commercial viability.

Mixed polyolefins can readily be recycled in large amounts using pyrolysis. Depolymerisation technologies will mainly be used for PET waste types, such as coloured material, that mechanical recycling is not targeting. Polystyrene waste will be recycled by different technologies, especially dissolution and depolymerisation. ■

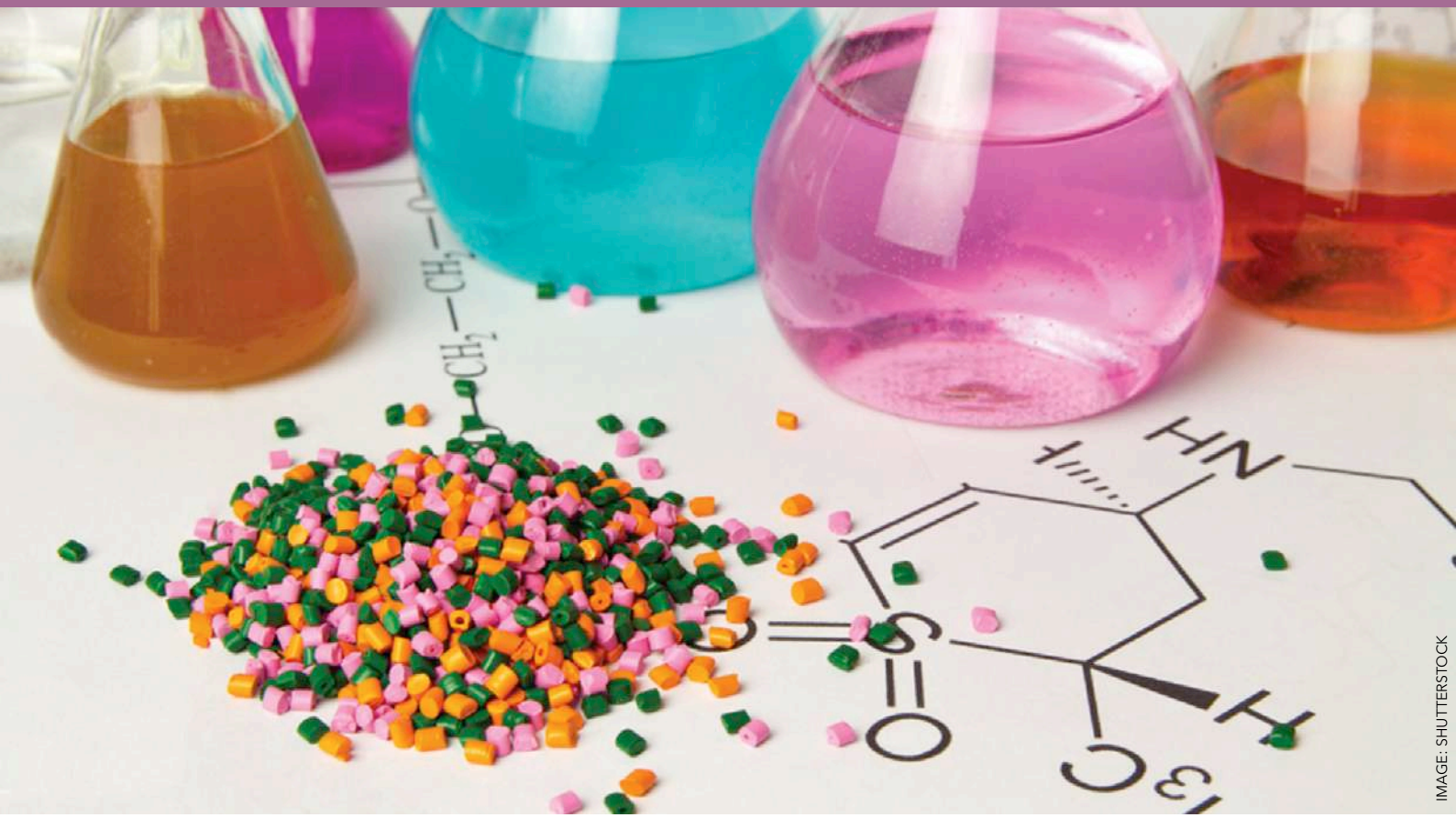


IMAGE: SHUTTERSTOCK

Explaining chemical recycling processes

Chemical recycling is an umbrella term that includes a variety of technologies, each with their own process characteristics, input requirements and outputs. We explain the technologies

Few in the plastics industry will not have heard of chemical recycling but that simple term covers a huge range of quite different technologies. Today's chemical recycling technologies can be classified into three broad concepts: dissolution, depolymerisation, and thermal cracking. These three approaches differ, at a conceptual level at least, in the type of materials they can handle, the amount of "chemistry" involved, and the product that results.

Dissolution technologies use carefully selected solvents to dissolve the polymer from the mixed waste, allowing insoluble contaminants such as fillers and pigments to be filtered out. The dissolved polymer can then be precipitated and recovered from the solvent, which is reused. This is a physical process – the chemical composition and structure of the polymer is unchanged. As a result, many of its proponents consider it to be closer to mechanical than chemical recycling and promote it accordingly, using terms such as solvent-based purification or physical or material recycling.

The key to success in dissolution is the selection of a solvent that recovers only the target polymer. This means it is best suited for use with relatively homogenous waste streams. A number of pilot projects are already well advanced – Purecycle Technologies in the US, for instance, is targeting polypropylene with a technology licensed from P&G while Canada's Polystyvert is focusing its efforts on polystyrene.

The need for a relatively homogenous waste stream does not necessarily mean that dissolution technologies are suitable only for mono-material plastic waste. Germany's APK, for example, is developing its technology to recover LDPE and PA from multi-layer films.

Main image: Some chemical recycling involves changes in chemistry, but not in the case of dissolution

In theory, at least, dissolution exposes the polymer to less thermal and physical stress during the recovery process than conventional mechanical recycling. However, the recovered polymer is likely to require compounding or pelletising to make it suitable for further use, which may mitigate that benefit to some extent. In addition, the cost of the numerous processing steps – pre-treatment, dissolution, filtration, precipitation, solvent removal and reformulation – is likely to make dissolution most attractive for processing of mono-material waste streams with a relatively high level of contaminants that would be difficult to remove mechanically otherwise.

Depolymerisation is certainly a chemical recycling process, typically using heat (and often a catalyst) to convert a polymer back to its building block monomers – for this reason it is sometimes referred to as monomer recovery. It is most suitable for use with step-growth polymers such as PET, which are polymerised by polycondensation.

A number of companies are developing various processes to depolymerise PET, with pilot projects underway at Carbios in France, CuRe Technology and Ioniqa in the Netherlands, Rittec in Germany, and BP Infinia, Eastman and Loop Industries in North America.

Depolymerisation of polycondensation polymers typically involves reintroducing the molecular component that was eliminated during the original polymerisation process. Several solvolytic processes are being investigated to do this, including hydrolysis, glycolysis, methanolysis and transesterification. These are all multi-step processes that include pre-treatment of the waste, followed by depolymerisation, monomer recovery, repolymerisation, and finally extrusion and pelletising.

Solvolytic depolymerisation techniques are not suitable for use with polymers produced by chain-growth or polyaddition reactions, such as PE, PP and PS. However, some companies – including Pyrowave in Canada and Agilyx in the US – are working with alternative thermal depolymerisation technologies that are capable of converting PS polymer back to styrene monomer.

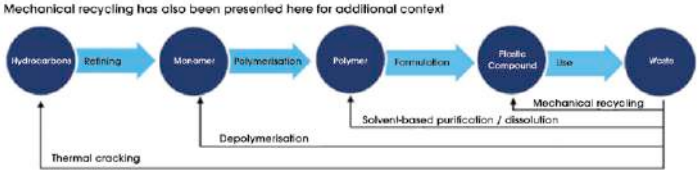
By converting polymers back to the original monomers, depolymerisation can lead to new polymers of virgin quality. However, it uses highly specific chemical processes so the incoming waste stream has to be consistent in terms of polymer composition, meaning considerable cost may be incurred in pre-sorting. Energy requirements can also be quite high.

Thermal cracking converts waste plastic – and many of the contaminants the waste may carry – back to basic feedstock components such as hydrocarbons and syngas (a gaseous mixture of CO, CO_2, H_2 and CH_4). Two processes are used to thermally crack – or feedstock recycle – polymers: pyrolysis cracks the polymer chains at high temperature in the absence of oxygen; gasification heats the polymer with a controlled but limited amount of oxygen. Both yield a different mix of end products with targeted applications ranging from fuels to chemical feedstocks.

Conventional pyrolysis thermal cracking is a relatively simple technology. Waste goes through a pre-sorting and shredding process and is then pyrolysed at high temperature – typically 400-600° – to create vapour and gas, which is then purified to create a range of hydrocarbons. These hydrocarbons can include gas, wax, oils and char. Yields of each can be controlled to some extent by adjusting temperature, pressure, and residence times, as well as through the use of particular catalysts and thermal profiles.

As pyrolysis occurs in the absence of oxygen, the process is only really suitable for polymers with a limited oxygen content, such as PE, PP and PS. Polymers containing high levels of oxygen or halogens – particularly PVC and compounds containing brominated flame retardants – must be sorted and removed from the waste input stream.

Oxygen and halogen concerns aside, pyrolysis can handle waste streams with a mixed polymer composition that would be highly challenging for either mechanical or dissolution and depolymerisation chemical recycling methods. That said, it is an energy intensive process and the quality and mix of the output materials is still dependent to some extent on the input materials. In addition, much of the gas and oil output from pyrolysis plant is likely to be burnt as fuel, either to provide energy for the process itself or because of the need for additional purification steps to upgrade it to be used as a cracker or chemical plant feedstock. Under most regulatory and accreditation regimes, the use of



	Mechanical recycling	Solvent-based purification / dissolution	Depolymerisation	Thermal cracking
Feedstock	PET, POs, PS, PVC, mixed plastics	POs, PS, PVC, PET	PET, PS	Mixed plastics, POs, PS
Output	Plastic compound	Polymer	Monomer, oligomer	Hydrocarbon mix
Status	Industrial scale	Pilot stage	Pilot stage	Pilot, industrial

Four types of plastics recycling
Source: AMI Consulting

outputs as a fuel is not recognised as recycling.

Major players in the development of pyrolysis-based technologies include Luxembourg-headquartered Clariter, Enval, Recycling Technologies, Renew ELP and Plastic Energy in the UK, Fuenix Ecogy in the Netherlands, OMV in Austria, Quantafuel in Norway, Brightmark, Encina, Nexus Fuels and Alterra Energy in the US, GreenMantra Technolgies in Canada, and Licella in Australia.

Gasification thermal cracking differs from pyrolysis in that the process takes place in the presence of a controlled but limited amount of oxygen. It can handle almost any organic material – including plastic waste and biomass – and can take on polymers containing oxygen and halogens. The end result is syngas that, depending on its composition and purity, can be used as a production feedstock.

The gasification process involves fewer steps than pyrolysis: pre-treatment of the waste (including water removal); gasification; and cleaning of the gas to remove tars and other contaminants. That final purification step is required to remove impurities such as ammonia, H_2S, alkali metals, NO_x and tars.

Gasification is not a new technology. Texaco developed and licensed its TCP (Texaco Gasification Process) technology back in the 1980s to handle hazardous waste organics. It is a non-catalytic, partial oxidation process capable of converting organics to syngas and chars. However, the TCP process does not produce feedstocks suitable for reintroduction into plastic-to-plastic or other value-added chemical synthesis chains.

A number of companies are investigating gasification processes to crack plastic waste to heavy oil and non-condensable gases and condensable gases. The non-condensable gases are used as process fuel while condensable gases and heavy oils can be gasified with oxygen and steam. These processes typically involve use of high temperature gasification at more than 900°C, which is energy intensive, followed by additional purification steps.

Gasification thermal cracking technologies are under development by a number of companies, including Enerkem in the Netherlands, Eastman in the US, and Showa Denko and Sekisui/Sumitomo in Japan.

Chemical recycling is still a very young technology. However, it seems clear from the work carried out to date that hopes that it will solve the challenge of handling mixed waste streams may be misplaced. The reality is that most of the technologies currently under development will need some level of homogeneity in waste feedstock. That means that, initially at least, chemical recycling is likely to draw on the waste sources and supply infrastructure developed for mechanical recycling.


IMAGE: BASF

Above: BASF's Andreas Kicherer holding a jar containing pyrolysis oil

Drawing on the same collection and sorting infrastructure does not necessarily mean that chemical recycled material will compete directly with mechanical recycled material. Compared to mechanical recycling, all chemical recycling processes are more complex and are likely to be more costly. So, where high quality waste streams are available, mechanical recycled polymer is likely to win out simply on economics.

Chemical recycling, on the other hand, begins to look a lot more attractive where waste streams are less homogenous than is preferred for mechanical recycling, or where volumes of recycled material exceed the capacity for reuse in new applications (either for reasons of regulation or for deterioration in material properties).

There may be some competition for feedstocks, but even that is likely to be limited. In its most recent *Chemical Recycling Global Status* report, AMI Consulting says that while the potential exists for competition to develop between the two recycling technologies in some areas – it cites the example of PET bottles and trays – it is also quite conceivable that separate markets may emerge. PET waste with the lowest levels of contamination, for example, could be sought out by mechanical recyclers while PET waste streams with higher contamination levels may be processed by depolymerisation, the report authors say.

Looking at feedstocks for the thermal cracking processes – either pyrolysis or gasification – that are expected to account for the majority of chemical recycling in volume terms, the AMI consultants say the fact that mechanical recycling can only offer a "downcycling" solution for mixed plastics waste makes it a prime stream for the chemical route. The study authors conclude that the likelihood of feedstock competition "is minimal for the vast majority of chemical recycling." ■

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IMAGE: GR3N

What's new in chemical recycling projects

The number of companies getting involved in chemical recycling of plastics waste has been growing rapidly. This article provides an update of recent developments in projects around the world involving chemical recycling of mixed waste, plus ones focussed on PS and PET

Announcements of new plastics chemical recycling projects have been coming out regularly in recent months, along with progress reports on previously announced projects. Most operations are set for the 2022/23 time frame. What follows is a non-exhaustive review of projects in various states of construction and operation around the world, mostly related to mixed plastics waste but also for individual polymer streams (PET and polystyrene).

Plastic Energy, probably the most prominent independent technology company operating in chemical recycling, already has two commercial chemical recycling plants in operation, in Almeria and Seville, Spain. They have been running since 2015 and 2017 respectively. Each has a capacity of 5,000 tonnes/yr. The technology uses a thermal anaerobic conversion (TAC) process to produce what Plastic Energy brands as Tacoil. The Spanish facilities take waste, mostly film, collected by a waste management company that would normally send the material to landfill.

Main image: Swiss company Gr3n has constructed a demonstration plant for its PET recycling technology

Plastic Energy says it is continuing to increase its portfolio of European projects, with a 20,000 tonnes/yr plant currently under construction in the Netherlands with partner **SABIC** in a joint venture called SPEAR (SABIC Plastic Energy Advanced Recycling), and a 25,000 tonnes/yr plant that has recently started construction in France, along with a collaboration offtake agreement with ExxonMobil.

The company also has a joint venture with **TotalEnergies** (previously Total) for a 15,000 tonnes/yr recycling plant at the latter's Grandpuits "zero-crude platform" site in France, with construction expected to start soon. This will be France's first chemical recycling plant using pyrolysis to produce Tacoil.

The plant in the Netherlands is expected to become operational in 2022, with SABIC building a treatment facility to purify the pyrolysis oil coming from this joint venture, before feeding the oil into its own processes. Both plants in France should be operational in 2023.

This October, Plastic Energy also announced a partnership with Freepoint Eco-systems and its first recycling project in the US, with plans to build a 33,000 tonnes/yr plant in Texas, and a collaboration offtake agreement with TotalEnergies; it should be operational by mid-2024. In addition to this, Plastic Energy has an MoU with Petronas for a recycling project in Malaysia, and says it is working towards expanding in other parts of Asia.

SABIC is also exploring opportunities in other regions. It is for example working with Saudi Investment Recycling Company (SIRC). The two companies are cooperating in Saudi Arabia to build the first chemical recycling facility in the country, producing feedstock for SABIC's local polymer units. SABIC is also doing something similar in Asia and in the Americas, but no announcements have yet been made.

In March, **BP** and SABIC signed a new agreement to work together to drive a circular economy in the petrochemical activities at the Gelsenkirchen chemical complex. The two companies have a long history of cooperation on the site, dating back to when the SABIC operations were owned by DSM.

Below: BP and SABIC are working to drive a circular economy in petrochemical activities at the Gelsenkirchen chemical complex

IMAGE: SABIC

Pyrolysis oil will be processed at BP's Gelsenkirchen refining site and then used by SABIC in its Gelsenkirchen polymer plants to produce certified circular products, which SABIC brands as Trucircle. After successful trials in December 2020, polymer production using the alternative feedstock started at the site early this year.

BP and **Brightmark**, a global waste solutions company that has proprietary chemical recycling technology, have signed a Memorandum of Understanding (MoU) to jointly evaluate opportunities for development of the next generation of plastic waste renewal plants in Germany, the Netherlands, and Belgium. BP is already the offtaker for Brightmark's 100,000 tonnes/yr pyrolysis plant in Ashley, Indiana, USA, which is currently undergoing final commissioning. The Ashley facility produces plastics-to-fuel and waxes. "Moving forward, all facilities will be designed for circular end products," says a representative.

In January, Brightmark and **SK Global Chemical**, headquartered in South Korea, signed an MoU to create a partnership to build a commercial scale pyrolysis plant in South Korea with a 100,000 tonnes/yr capacity. Both parties are currently carrying out a feasibility study. By the end of this year, they should have completed evaluation of the most optimal methods to operate, scale and develop the technology within South Korea.

In September, Shell Ventures and BlueAlp Holding announced a strategic partnership to develop, scale and deploy BlueAlp's pyrolysis technology. Shell has taken a 21.25% equity stake in BlueAlp as part of the agreement.

Shell and **BlueAlp** will form a joint-venture company to build two new conversion units in The Netherlands, which are forecast to convert more than 30,000 tonnes/yr of plastic waste. The units are planned to be operational in 2023 and will supply 100% of their pyrolysis oil as feedstock to Shell crackers in The Netherlands and Germany. Shell is exploring licensing a further two units for deployment within Asia to supply the Shell Energy and Chemicals Park Singapore.

In October Shell Chemicals Europe also announced a strategic cooperation and offtake agreement for pyrolysis oil made by Rotterdam-based company **Pryme** from recycled plastic waste. Pryme will supply Shell from its first plant located in Rotterdam. Currently under construction, the plant

is scheduled to become operational in 2022 and is forecast to convert 60,000 tonnes/yr of plastic waste into pyrolysis oil by 2023.

The agreement also includes provision for future supply to be delivered from Pryme's proposed second plant in the region. This will have an estimated annual pyrolysis oil production capacity of 350,000 tonnes.

Eastman has two chemical recycling technologies that tackle different feedstock streams. Polyester Renewal Technology processes polyester feeds (see section on PET below), while its Carbon Renewal Technology can recycle most other thermoplastics, with the exception of PVC. In late 2020, Eastman said it expected to use up to 50m pounds (close to 27,000 tonnes) of waste plastic in Carbon Renewal Technology operations in 2020, with projects underway to significantly expand that amount. No update was available at the time of writing.

In early November, **Aduro Clean Technologies**, a Canadian developer of patented water-based technologies to chemically recycle plastics and transform heavy crude and renewable oils into new resources and higher-value fuels, announced a pending partnership with Brightlands Chemelot Campus in Limburg, The Netherlands.

Aduro says the objective of this partnership is to complete an installation that applies Aduro Hydrochemolytic technology (HCT) to demonstrate, on a tonnes per day scale, the conversion of polyethylene waste to useful feedstock for chemical processes, including production of new PE.

Ofer Vicus, CEO of Aduro, says: "This year we plan on doing our proof of concept. This is nearly done and we are working on the data to submit it to a third party," says Vicus. "Our next step in the road map is to work on the pilots – this is happening now with Brightlands and possibly others."

He says: "Traditional methods rely on high temperatures from 400°C to as high as 1,100°C, and on hydrogen produced by conversion of fossil fuels at between 700°C and 1,000°C. Aduro Hydrochemolytic processes operate at only 240-390°C."

Marc van Doorn at the Brightlands Chemelot Campus says: "We are at the early stages and it still needs quite a lot of development, but lab results were quite interesting. Aduro is planning to scale the process up to pilot plant level at our campus, where we have a number of other things going on in chemical recycling."

Another chemical recycling process that relies on water – super-critical steam in this case – has been developed by **Mura** in the UK. In April, it announced a partnership with Dow Chemicals to support the rapid scaling of its HydroPRS (Hydrothermal Plastic Recycling Solution) process. Dow will also take recycled materials from the first plant, in Teesside, UK. The first of four 20,000 tonnes/yr lines is expected to be operational in 2022. Dow and Mura are looking to co-operate on offtake at a number of additional European projects, currently in Mura's development pipeline.


IMAGE: EASTMAN

Above: Eastman has two chemical recycling technologies that tackle different feedstock streams

Alongside its first plant in the UK, Mura also has four 100,000-tonnes/yr sites under development in Germany and four of the same capacity in the US – Washington State has just been announced as the first location. It also recently announced the sale of the first HydroPRS licence to Mitsubishi (MCC), which has plans to develop the process to commercial operation by 2023 at its Ibaraki site, Japan. It will have the capacity to handle 20,000 tonnes of plastic waste per year – with MCC studying the possibility of increasing capacity in the future. Initially, the project will aim to use post-industrial plastics.

"Our ambition is to have 1m tonnes of plastic recycling capacity in operation or development by 2025," says a representative.

Dow says it is actively pursuing a number of commercial partnerships with customers and brand owners to scale chemical recycling technology. Two years ago, for example, it announced its partnership with Fuenix Ecogy Group for the supply of pyrolysis oil feedstock made from recycled plastic waste, to be used in the production of new polymers at Dow's production facilities in Terneuzen, The Netherlands. It has since announced additional investments in Fuenix to help scale this advanced recycling technology further. Most recently, in October 2021, Dow and Fuenix announced the construction of a second plant in Weert, which will process 20,000 tonnes of waste plastic.

As well as its partnership with Mura Technology, Dow has also established a multi-year agreement with New Hope Energy, based in Tyler, Texas, USA to supply it with pyrolysis oil feedstocks derived from plastics recycled in North America, which Dow


IMAGE: RENASCI

Above: Renasci's ISCC PLUS-certified recycling centre in Oostende, Belgium

will use to produce circular plastics.

BASF is working with several partners to further develop pyrolysis technology. In 2019, it invested €20m in **Quantafuel**, a Norwegian company specialised in the pyrolysis of mixed post-consumer plastic waste and the purification of the resulting oil. In September 2020, Quantafuel started up its first pyrolysis plant with a capacity of approximately 20,000 tonnes/yr in Skive, Denmark. "Together, we are also working on further developing and improving the process," says BASF. "Developing suitable catalysts for the new process technology is an important aspect of this. These catalysts aim to ensure that high-purity pyrolysis oil is always produced, even when the composition of the plastic waste varies."

In late August, Quantafuel said the Skive plant would undergo upgrades before the end of the year, allowing for stable, long-term commercial production. "We are working on removing the last known obstacle," said Quantafuel's interim CEO Terje Eiken. In September, it announced plans to expand into the UK, with a plant in Sunderland that could be up and running "in a few years." Additional sites are also being considered by Quantafuel UK. The Sunderland plant will be designed to process more than 100,000 tonnes/yr of waste plastics, to be sourced from across the north of England.

In June, **Borealis** announced an exclusive agreement with **Renasci** which has enabled Borealis to offer commercial volumes of chemically recycled base chemicals and polyolefins since May. (Borealis has a10% share of Renasci.) Borealis obtains chemically recycled material from Renasci Oostende Recycling in Belgium. Projected output is 20,000 tonnes/yr. Feedstock will be subsequently processed in the Borealis steam crackers, initially at its production location in Porvoo, Finland.

Earlier, in April, Borealis announced a feasibility study for a chemical recycling unit to be established at the Borealis production location in Stenungsund, Sweden is being carried out with project partner Stena Recycling, and could lead to operations beginning in 2024. Borealis will also co-operate independently with Fortum Recycling and Waste on a project involving the sourcing of plastic waste to the chemical recycling unit.

In October, **ExxonMobil** announced plans to build its first, large-scale plastic waste advanced recycling facility in Baytown, Texas, USA, which is expected to start operations before 2023 with a planned capacity of 30,000 tonnes/yr. A smaller, temporary facility, is already operational and producing commercial volumes of certified circular polymers that will be marketed by the end of this year.

ExxonMobil's initial trial of its proprietary process recycled more than 1,000 tonnes of plastic waste and has demonstrated the capability of processing 50 tonnes per day.

The company says it is developing plans to build approximately 500,000 tonnes/yr of chemical recycling capacity globally over the next five years. As mentioned earlier, it is collaborating with Plastic Energy on a plant in Notre Dame de Gravenchon, France, which is expected to process 25,000 tonnes/yr of plastic waste when it starts up in 2023, with the potential for further expansion to 33,000 tonnes/yr. ExxonMobil is also assessing sites in The Netherlands, the US, Canada, and Singapore.

At the beginning of November, **Honeywell** announced the commercialisation of its UpCycle Process Technology, which incorporates pyrolysis. Sacyr, a Spain-based global engineering and services company with operations in more than 20 countries worldwide, will be the first to deploy the Honeywell technology. The two companies will form a joint venture to operate a facility in Andalucía, Spain, with a capacity of 30,000 tonnes/yr of mixed plastics waste. Production is expected to begin in 2023.

Arcus Greencycling uses a pyrolysis process that can handle a wide range of polymers found in mixed waste, from PP, PE, and PS to more difficult polymers like PVC and ABS. The company has a co-operation agreement regarding pyrolysis technology with Karlsruhe Institute of Technology.

Arcus is currently building a 4,000 tonnes/yr industrial-scale pilot plant in Frankfurt am Main, Germany. The company expects this to start operations in the second quarter of 2022. "This plant will offer customers a highly robust process at an industrial scale to either test the suitability of a wide variety of waste streams for chemical recycling and/or utilise the facility to produce commercially usable pyrolysis oil," it says.

Clariter says its chemical recycling technology

enables it to make end products, not a feedstock like pyrolysis oil. The company has developed a three-stage process for recycling mixed plastics waste. First it uses thermal cracking which generates a wide range of hydrocarbons. Stage two is a hydro-refining process developed to remove impurities and form naphthenic and paraffinic hydrocarbons. The third distillation stage results in three product families, waxes, solvents and oils for industrial and consumer use which are sold to its customers.

Clariter's technology has been proven through an operational pilot plant in Gliwice, Poland, and a demonstration plant in East London, South Africa. In 2021, it has announced collaborations with DSM and Mitsubishi. In addition, South African chemicals group AECI has made a €2.5m investment in Clariter and is exploring construction of full-scale plants in South Africa, Germany and USA.

Recycling Technologies, in Swindon, England, has developed thermal cracking technology that it says can be installed at existing waste sites anywhere. Its RT7000 machine produces pyrolysis oil branded Plaxx. A demonstration plant and testing facility has been operating at Swindon Borough Council's recycling facility since 2017. The first commercial-scale unit will be installed at Binn Eco Park in Perth, Scotland, in collaboration with Binn Group and Zero Waste Scotland.

Polystyrene

Chemical recycling of polystyrene is well-advanced. This April, Recycling Technologies was selected by **Ineos Styrolution** as the technology provider for commercial scale recycling of PS back to styrene monomer. Prior to building the commercial scale recycling plant, a PS recycling pilot plant will be built in Swindon, UK. It uses the same basic technology as the RT7000 but the machine to recycle polystyrene will have a different name.

Ineos Styrolution plans to build its full commercial scale recycling facility in Wingles, France, but has not given a date; capacity should be 15,000 tonnes/yr. **Trinseo** has said it plans to build a dedicated 15,000 tonnes/yr plant at its Tessenderlo, Belgium location, to come into operation in 2023.

In May, Trinseo announced that it could supply recycled polystyrene (rPS) for food contact applications with the launch of the first yogurt pot integrating rPS (again from Yoplait), now on shelves in France. Styron CO2RE CR55 contains 55% recycled content resulting from depolymerisation.

In September, Trinseo and Indaver, a leader in sustainable waste management in Europe, signed an offtake agreement for recycled styrene monomer. Trinseo said it would buy a minimum of 50% of the monomer produced at Indaver for a 10-year period, following start-up of the plant planned in 2023.

Indaver will collect post-consumer polystyrene, such as yogurt pots and single-use packaging, and produce new styrene monomer through a proprietary depolymerisation technology at its Antwerp, Belgium site, for repolymerisation at Trinseo's Tessenderlo, Belgium site.

At the end of last year, Total (now TotalEnergies), sheet extrusion company Intraplás, and yoghurt producer Yoplait said they had successfully run a pilot test aimed at using certified chemically recycled polystyrene in yogurt pots. Total said that by converting mixed plastics waste in its steam cracker in Antwerp, it can produce certified chemically recycled polystyrene.

Canadian technology company **Pyrowave** is involved in a major polystyrene chemical recycling project in a partnership with Michelin in Europe. Pyrowave manufactures modular equipment that uses microwave technology to depolymerise polystyrene and it licenses its use. Michelin will operate the equipment at a location yet to be decided. It will acquire several units from Pyrowave. Michelin will use the styrene monomer as a feedstock to make rubber for tyres.

At the end of last year, the two companies said they would work together to fast-track the industrialisation of Pyrowave technology with a view to a certification and commercial roll-out in international markets. The joint development agreement will ultimately account for an investment of more than €20m. Michelin and Pyrowave are working together to develop an industrial demonstrator, funded and operated by Michelin, by 2023.

PET

Eastman is building the world's largest polyester chemical recycling facility at its site in Kingsport, Tennessee, USA, employing its Polyester Renewal Technology (PRT) which uses methanolysis. Eastman expects the facility to be mechanically complete in late 2022. "Our goal is to recycle 250m pounds (around 113,000 tonnes) annually by 2025 and 500m pounds annually by 2050," says a representative.

"We pioneered the technology decades ago when we were formerly part of Eastman Kodak and used methanolysis to recycle polyester including Kodak films. We've retained that R&D knowledge and actually improved on it in the decades since."

Aquafil Engineering designs polyamide and polyester polymer plants based on its own patented technology and production know-how. It also offers several recycling solutions under the brand

IMAGE: CARBIOS

Abve: The Carbios demonstration plant

name EverPET for internal, industrial or post-consumer waste. It has recently been building a recycling unit to produce 100% PCR PET on a small scale for customer and test samples for different PET customer applications (bottle, film, yarn, multi-layer packaging).

In the chemical EverPET process, the raw materials (oligomers, monomers and BHET) are recovered from previously cleaned polyester wastes, which can be re-processed into a high-quality polyester by downstream polycondensation.

Carbios, which has developed an enzymatic recycling technology (C-Zyme) for depolymerising PET using hydrolysis, brought its first demonstration plant onstream in September. The plant includes a 20 m^3 depolymerisation reactor capable of processing 2 t of PET per cycle, which is the equivalent of 100,000 bottles. It is co-located with a Michelin tyre production plant in Clermont-Ferrand, France; Michelin is a major shareholder in Carbios, and is interested in using various recycled or renewable materials in its tyres.

Martin Stephan, the company's Deputy CEO, says Carbios will also build and operate a 40,000 tonnes/yr reference unit, the first industrial plant. Its intention is to start up the plant in 2025 and that the plant will be adjacent to an existing PET production line. Carbios has Expressions of Intent with at least one PET supplier.

Swiss company **Gr3n** has another technology that uses alkaline hydrolysis. A demonstration plant should be fully operational early next year. Fabio Silvestri, Head of Marketing and Business Development, says the first industrial plant, with a capacity of 30,000 tonnes/yr, could start up before the end of 2024. He says the company has had confirmation that its technology can depolymerise textiles. Gr3n has an MoU with Kolon Industries to accelerate the commercialisation and the implementation of its technology throughout Asia.

Ioniqa, a clean-tech spinoff from the Eindhoven University of Technology in The Netherlands, has a 10,000 tonnes/yr plant producing BHT monomer from bottles using glycolysis, which it currently supplies exclusively to Indorama. Maarten Stolk, the company's Business Developer, says that it plans also to use fibre as a feedstock. The company is currently in discussions with a plant engineering firm so that it can sell licensed packages.

In June, **Loop Industries** in Terrebonne, Quebec, Canada, announced a strategic partnership and equity investment from SK Global Chemical (now called SK Geo Centric); Loop and SKGC intend to form a joint venture with exclusivity to build recycled PET resin and polyester fibre manufacturing facilities using Loop's depolymerisation technology throughout Asia. SKGC currently has a 10% shareholding in Loop. In August, plans were announced for the first Infinite Loop Asian facility in Ulsan, South Korea, to begin preparation in 2022.

Loop recently completed the conversion of its Terrebonne, Québec pilot plant to a small production facility. In September of this year, together with French mineral water company Evian, Loop unveiled the Evian Loop bottle, made from Loop's 100% recycled PET coming from waste plastic and fibre. The bottles will be rolled out at commercial scale in South Korea in 2022, with the goal of launching in other markets later. ■

CLICK ON THE LINKS FOR MORE INFORMATION:

- **https://plasticenergy.com**
- **www.sabic.com**
- **https://totalenergies.com**
- **www.bp.com**
- **www.brightmark.com**
- **http://eng.skglobalchemical.com**
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- **www.trinseo.com**
- **www.pyrowave.com**
- **www.aquafileng.com**
- **www.carbios.com**
- **https://gr3n-recycling.com**
- **https://ioniqa.com**
- **www.loopindustries.com**

Aquafil

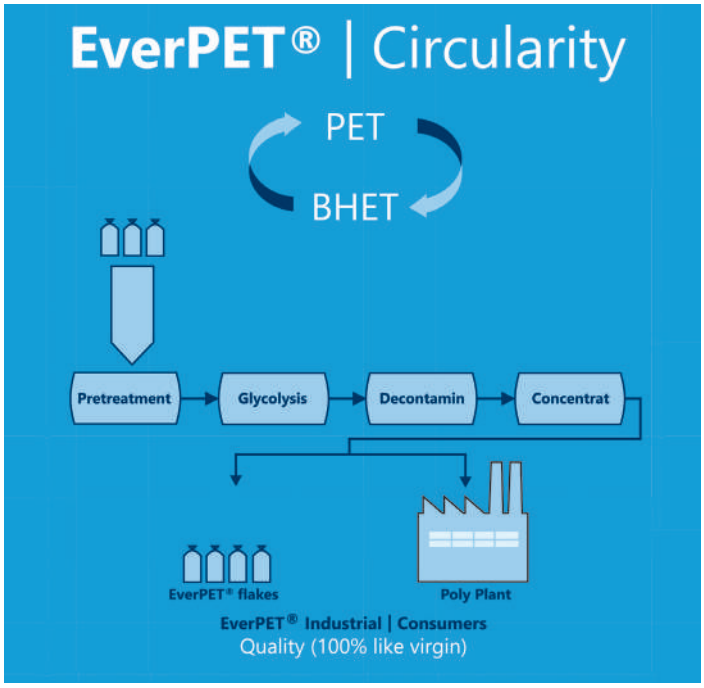
Aquafil Engineering: Experts in polyester and polyamide recycling plants

Aquafil Engineering, an independent company of Aquafil Group, is located in Germany, and is one of the worldwide leading companies in technology and equipment design for polyamide, polyester and recycling plants. The plant design is based on patented technology and production know-how which provides customers with state-of-the-art technology combined with high quality, flexibility, efficiency and sustainability.

Aquafil Engineering understands itself as provider for customised solutions for fibre, film, technical and bottle applications.

The EverPET™ technologies are the newest developments in polyester recycling. EverPET™ is the brand name for a collection of different recycling systems and includes solutions for mechanical (extrusion) as well as for chemical (glycolysis) recycling.

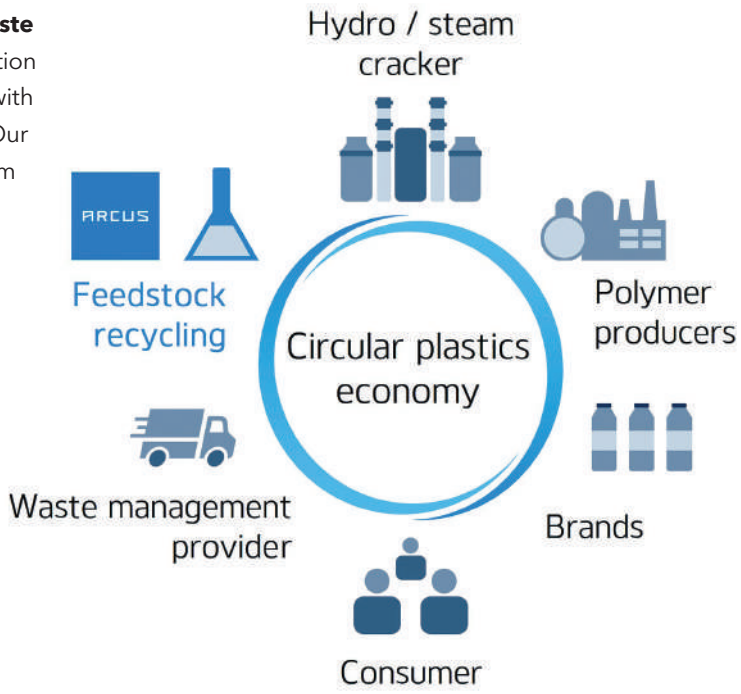
› **www.aquafileng.com**



Arcus

Leading the way to recycle mixed and dirty plastic waste
Arcus leads the way in providing a chemical recycling solution for currently non-recyclable mixed plastics waste streams with as little as possible prior sorting or cleaning of the waste. Our process successfully handles a wide range of polymers from PP, PE, and PS to difficult to process PVC, ABS, or PET.

First industrial scale plant of its kind in Germany
Arcus is currently building a fully authorised (BImSch approved, REACH registered, end-of-waste status acknowledged as well as ISCC, RedCert2, and EfbV certified) 4,000 tonnes per year industrial-scale pilot plant in Frankfurt am Main, Germany, which will go live in the second quarter of 2022. This plant will offer customers a highly robust process at an industrial scale to either test the suitability of a wide variety of waste streams for chemical recycling and/or utilise the facility to produce commercially usable pyrolysis oil.
› **www.arcus-greencycling.com**



The ARCUS Greencycling solution: Closed loops are the model for a world without plastic waste and lack of resources

- Variable and truly mixed inputs (incl. PP, PE, PS, PVC, PET, etc.)
- High-value feedstock for the petrochemical industry (incl. REACH registration)
- Longstanding operations and research track record
- Fully approved and certified testing plant in Germany

Greencycling ...

Recovers raw materials

Closes the material loop

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Preserves natural resources

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Clariter

Clariter takes plastic waste no one wants and transforms it into products everybody needs. While the recycling industry is turning plastic waste into new plastics, fuels, or intermediates that require further processing and blending, Clariter's innovative technology transforms most plastic waste streams, even those with the lowest value, into pure, ready-to-use industrial products: aliphatic solvents, mineral oils, and snow-white waxes.

According to the latest Life-Cycle Analysis, Clariter's process is preferable to landfill, incineration, and other pyrolysis-based solutions. This is a real paradigm shift and a resource efficient approach to meet circularity standards in the EU and beyond.

The company unlocks the value of the circular economy without compromising on profitability or sustainability. Clariter's short-term plan is to build and operate full-scale plants in Israel, Poland, and the Netherlands.

Each plant will recycle 60,000 tons of plastic waste and produce 50,000 tons of clean products annually.

Clariter's solution bridges the world of recycling and the petrochemical industry by replacing crude oil with upcycled plastic waste, thus saving significant amounts of CO_2, cleaning the earth of plastic waste, and making sustainable products for the market with 1000+ end applications, e.g. paints, shoe polishes, degreasers, detergents, inks and even ski waxes.

› **https://clariter.com**

Watch the video Clariter in Brief

Above: Clariter's Industrial-scale plant has been in operation in East London, South Africa since 2018

Left: Clariter's technology transform plastic waste into aliphatic solvents, mineral oils and paraffinic waxes

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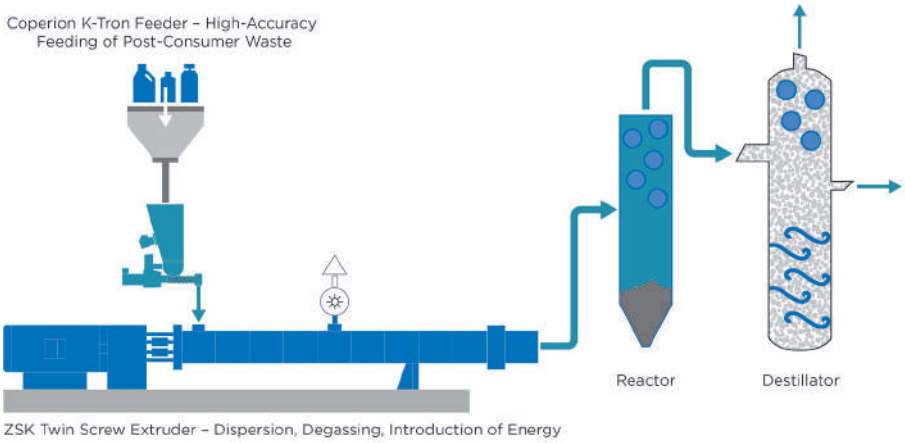
First class technology for chemical recycling

Chemical recycling is a promising process for recycling mixed plastic waste into chemicals, waxes or liquid energy carriers. Coperion provides process know-how and superior technologies for chemical recycling.

Coperion K-Tron feeders ensure high-accuracy feeding of raw materials into the extruder. Coperion's ZSK twin screw extruders enable a very efficient energy addition to the material in shortest time. Within 30 seconds, ZSK extruders produce a homogeneous, highly devolatilised melt with high temperatures. Throughputs of up to 20 tonnes per hour can be realised.

COPERION PROCESS FOR CHEMICAL RECYCLING



Next the melt is further processed to the reactor and destillator to transform it into marketable products such as oil, heavy fuel, or waxes.

Contact: Jochen Schofer
Business Segment Manager
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MAAG Group

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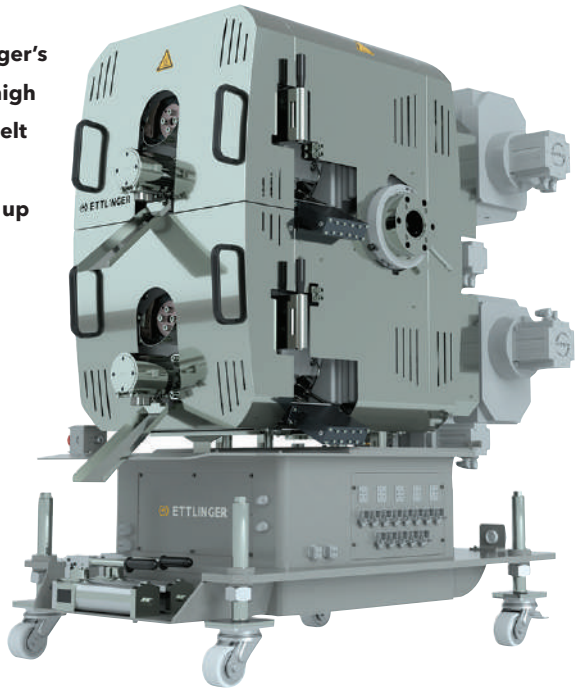
MAAG Group systems play a key role in enabling a more circular economy for plastics. Our equipment and solutions cover the entire plastics value chain and help to introduce used plastics back into high quality products.

As a specialist for polymer filtration and recycling systems, we have developed custom melt filtration and pelletising systems that meet the strict requirements of our customers. Our systems provide solutions to process the most demanding material streams and turn them into valueable resources.

Our goal is to preserve material properties and produce pellets that are equal in quality to virgin materials when processing post-consumer and post-industrial plastic materials.

› **https://maag.com**

MAAG Group company Ettlinger's new ECO 500 high performance melt filter achieves throughputs of up to 4,000 kg/h



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- High quality pellets with low residual moisture level
- Purpose-built for recycling applications and flexible options for all requirements
- Melt pump for precise and stable volumetric flow
- High performance Melt Filter for continuous operation
- Fully automated operation requiring minimal operator intervention

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Pryme

Pryme contributes to a meaningful solution to the global plastic waste problem by enabling the circularity of plastic. We convert plastic waste into valuable petrochemical products using a proven pyrolysis process that is enhanced with proprietary characteristics and has a low carbon footprint.

Our R&D team has worked long to take the pyrolysis process to a higher level, so we teamed up with a reactor manufacturer that boasts over 80 years of experience in this area. As a result, our reactor ensures a very precise and controlled application of heat at lower temperatures, which makes the recycling process more energy-efficient.

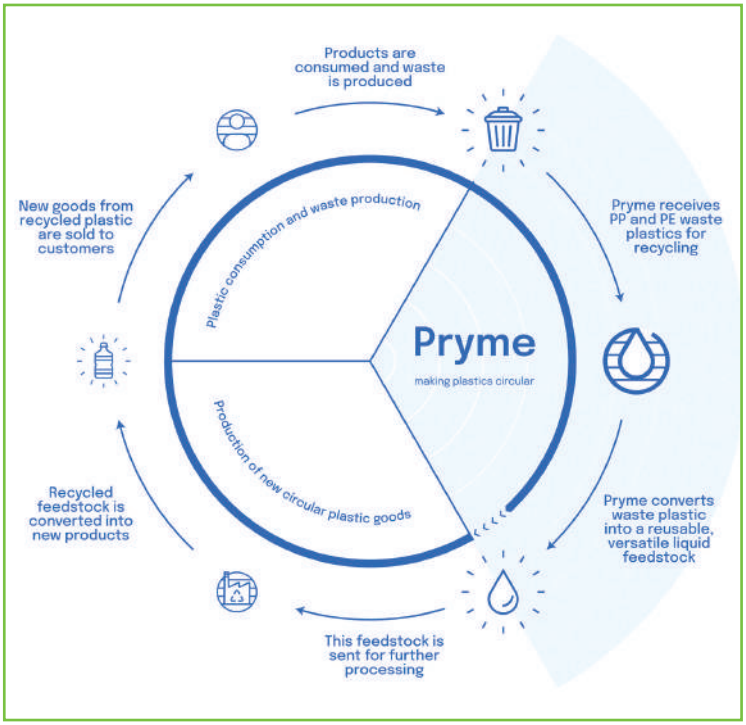
In addition, we have enhanced the process in order to remove contaminants such as chlorine, which we know oil majors don't want in recycled oil because it is highly corrosive. Moreover, we can process more waste than our competitors do, giving us an extremely high conversion rate: 100% of the plastic waste that we treat is converted to value-added streams.

Thanks to our tweaks to the process and installation, we can ensure a high input and output capacity and can rapidly scale the technology, which is key for market feasibility. Pryme's first plant will start production in 2022 in Rotterdam. This plant will have an initial intake capacity of 40,000 tons of plastic waste per year and produce 30,000 tons of feedstock in its first year. That tonnage will grow by 50% by 2023.

Pryme is an ambitious and innovative company, so if you're interested in our business, technology or job opportunities, be sure to contact us via our website.

› **https://pryme-cleantech.com/**

Above: Sander Schiereck, Michiel Kool and Joeri Dieltjens at the site of the new Pryme plant



Above: Pryme provides a sustainable, circular solution to converting waste plastics into valuable feedstock

IMAGE: SHUTTERSTOCK

Realising the opportunity

How will the chemical recycling industry develop? We look at factors that have a major influence on the industry's progress, including legislation and the mass balance concept

The chemical recycling industry has started on a growth path as the drive for greater plastics recycling volumes stimulates demand. As well as supply-demand dynamics, there are other important factors that are helping to shape the chemical recycling industry, such as legislation.

In Europe, regulatory impetus in plastics recycling comes from the European Union's Strategy for Plastics in a Circular Economy which the European Commission announced in 2018. This set out a series of targets focussed on packaging recycling: a target for recycling 65% of packaging waste by 2025 and 70% by 2030, and a specific target for plastic packaging recycling of 50% by 2025 and 55% by 2030.

Another aim is for all packaging to be recyclable by 2030, which would not only help grow mechanically recycled volumes but would also benefit chemical recycling by reducing contamination in waste feedstock.

Going hand-in-hand with legislation is funding support from the EU. Among collaborative R&D projects is Demeto, in which 13 partners are developing a PET depolymerisation process using microwave-based process intensification, and which receives funding from the EU's Horizon 2020 research and innovation programme. Other EU projects are not looking at packaging but focus on other areas, such as the Plast2BCleaned project in WEEE plastics recycling, and the Circular Flooring project which is investigating the CreaSolv process as a means for recycling PVC flooring.

Associations have been set up to provide collaborative platforms as the chemical recycling industry grows. The European Coalition for Chemical Recycling was founded in early 2019 by Cefic and PlasticsEurope, which supports the work of the EU Circular Plastics Alliance and its aim to ensure that 10 million tonnes of recycled plastics find their way into new European products by 2025. Chemical Recycling Europe's members are companies fully focused on chemical recycling technology rather than production of plastics, although it does hope to involve petrochemical companies as well.

Voluntary commitments are also acting as a focal point for mechanical and chemical recycling companies. Many polymer producers are among the corporate signatories of the Global Alliance set up by Ellen MacArthur Foundation, which has also led the way for individual countries to formulate specific recycled plastics content targets within its Plastic Pacts initiative. Sector-specific recycling is supported by Extended Producer Responsibility (EPR) schemes in different countries. But the extent to which EPR schemes proliferate remains to be seen after some poor results and scheme failures.

The chemical recycling industry in the USA is also being influenced by legislation. In the past couple of years, federal bills formulated by often cross-party sponsors have targeted aspects of plastics waste, recycling and environmental improvement. The Break Free from Plastic Pollution Act envisages a producer responsibility scheme involving a 10-cent beverage container deposit

Main image: Mass balance aims to measure the waste plastics contribution from chemical recycling in a much larger manufacturing process and allocate that to the end product

IMAGE: RECYCLING TECHNOLOGIES

Above: Recycling Technologies makes its Plaxx pyrolysis oil from waste plastics at its plant in Swindon, UK

program to operate nationally, minimum recycled content targets, phasing out some single-use plastics items, and a temporary halt to new polymer production plants being built. The RECOVER Act focuses on allocating federal grants to states and municipalities to invest in improving their recycling programs and infrastructure.

In addition to federal and state legislation, the Environmental Protection Agency has developed a National Recycling Strategy with a goal of achieving a 50% recycling rate for all materials by 2030. The American Chemistry Council, representing petrochemical and polymer producers, has been proactive and developed its own Roadmap to Reuse to support its members' aim for all US plastics packaging to be reused, recycled or recovered by 2040.

In the ACC's opinion, crucial to the US achieving its plastics sustainability ambitions is the need for official recognition of chemical recycling and its contribution to the country's efforts. Placing chemical recycling on a par with mechanical recycling is also desirable for plastics producers working in Europe. The risk for the chemical recycling industry is that its processes are not defined as recycling if the European Commission holds the position that the waste plastics input can be converted to fuel either for processing purposes or in the creation of new fuel products. After much lobbying of the European Commission, it has still not officially announced if its definition of plastics recycling includes chemical recycling processes.

Mass balance

A counter approach is being followed by chemical recycling companies with regard to the input-output of their plants and its use in the production of new plastics: it's called the mass balance approach. Tracking use of recycled material is relatively straightforward in the mechanical recycling supply chain but not so easy in chemical recycling, where outputs typically take the form of basic hydrocarbons that subsequently make their way through multiple and complex cracking and polymerisation processes. The solution for the chemical recycling industry is to follow the principles of mass balance.

Already applied in sectors as varied as electricity marketing and Fair Trade agriculture, the mass balance concept aims to determine and measure the contribution of a particular component in a much larger manufacturing process and allocate that accordingly to each unit of end product. In the case of chemical recycling, it aims to ensure that the amount of recycled feedstock entering a production plant equates to any claims made about the recycled content of a product leaving it.

While this may sound a simple task, the reality is much more complex as different approaches can be taken with regard to what and where to allocate. For instance, the entire output of a chemical recycling process could be allocated as a contributor to any polymer or chemical production process – so called free-attribution. Alternatively, it may be decided to allocate only the non-fuel components. Or, at its strictest, only those components used as a non-fuel contributor to production of a polymer.

Chemical Recycling Europe leans toward the free-attribution approach. In a recent white paper it said: "Our position is that all mass-balance interpretations should ensure that the full recycled output from chemical recycling finds a credible value and recognition though the system."

Others, however, favour more restriction. Zero Waste Europe, together with several other environmental NGOs, this year published 10 recommendations to ensure that mass balance does not undermine circularity goals. These include only allowing post-consumer waste streams, not allowing trading of recycled content credits, and ensuring allocations are restricted only to processes where there is a direct link between feedstock and final product (an approach being followed by Sweden's Perstorp with its traceable mass balance scheme).

Mass balance will be essential in the development of chemical recycling as an industrial process and to that end must be seen to be transparent and trusted – consumers, for example, must understand the claims made and, more importantly, have confidence in them. A number of organisations are already running certification programmes, of which the best known are International Sustainability and Carbon Certification (ISCC)and RedCert (both headquartered in Germany). In addition, last year the International Organisation for Standardisation (ISO) announced it had started work on a global mass balance standard. ■

AMI | Events

Plastics Recycling Technology

13-15 September 2022 | Vienna, Austria

Exploring the future of plastics recycling - new ways to boost productivity, quality and profitability

Save €300* - Book your place today!

Media supporter: Plastics Recycling WORLD

*Discounts cannot be used in conjunction with other offers. Offer valid until 11 March 2022. Price may be subject to VAT.

DEVELOP YOUR KNOWLEDGE

Themes for 2022:

- **Innovation** in machinery and processing for increased recyclet quality and throughput
- **Traceability** as a key to high value and quality supply chains
- **Compounding and additives** for recycling
- The impacts of changing **legislation and regulation**
- **Feedstock security** as a growing industry challenge

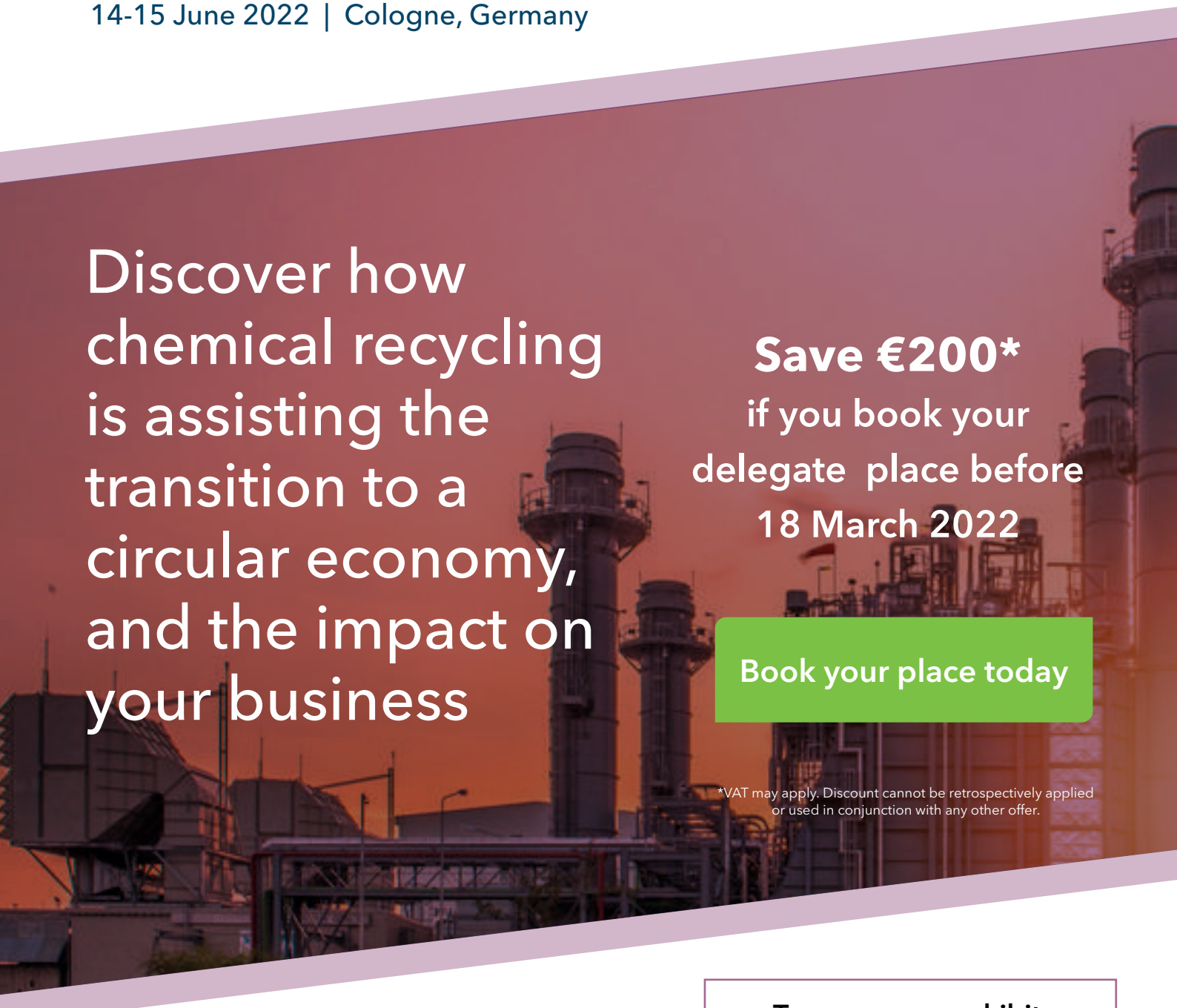
AMI | Events

Chemical Recycling

14-15 June 2022 | Cologne, Germany

Explore the potential of chemical or advanced recycling to turn waste plastics into new materials

www.ami.ltd/attend-chem-recycling



Discover how chemical recycling is assisting the transition to a circular economy, and the impact on your business

Save €200*
if you book your delegate place before 18 March 2022

Book your place today

*VAT may apply. Discount cannot be retrospectively applied or used in conjunction with any other offer.

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