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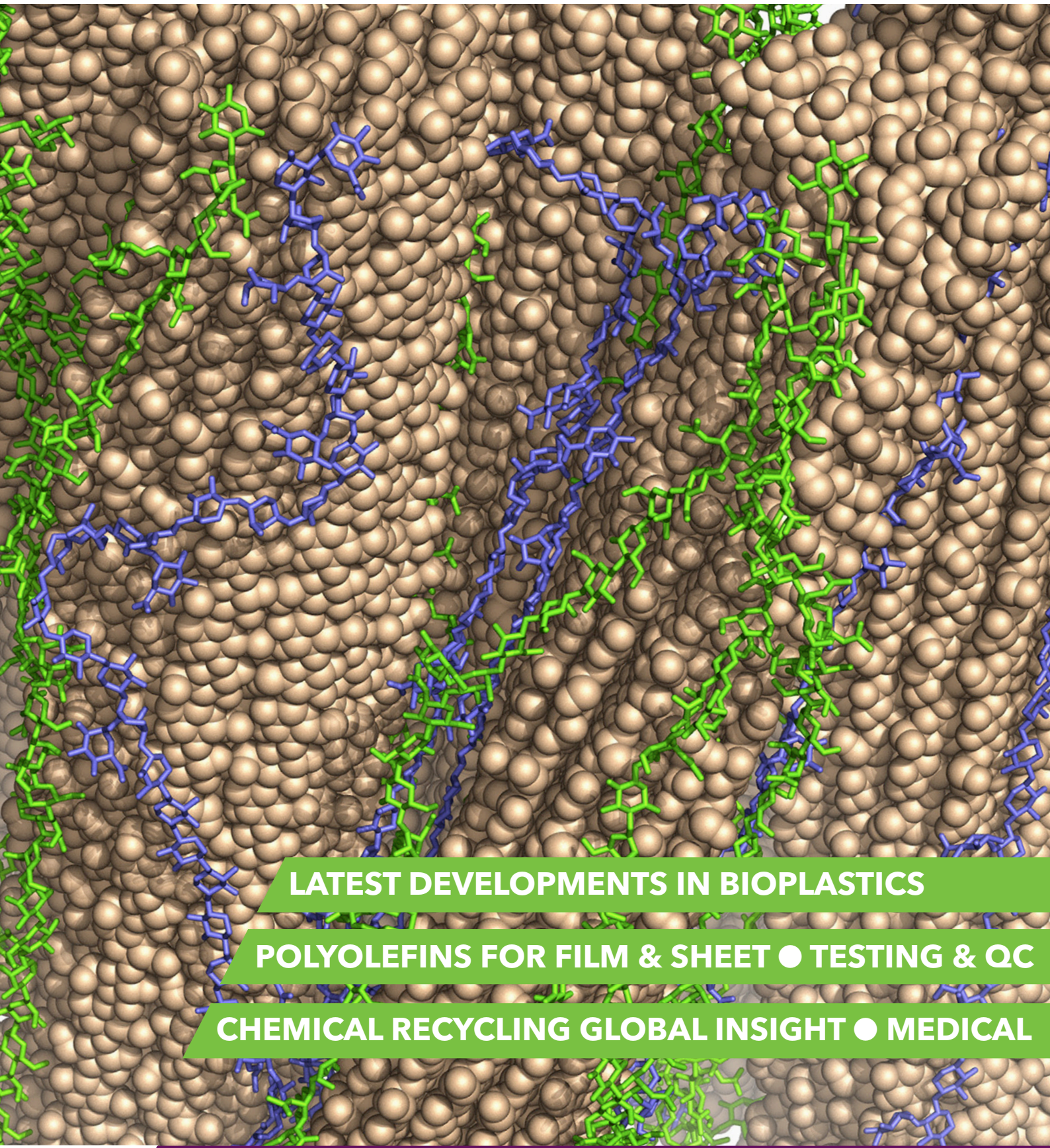

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Exxon starts Gulf PP plant

ExxonMobil has also started production of polypropylene (PP) at its new polyolefins plant at Baton Rouge in Louisiana, USA – increasing Gulf Coast PP production capacity by 450,000 tonnes/year.

The company said the new capacity will help meet demand for high-performance, lightweight, durable plastics for end-use applications including medical and food packaging.

"With the start-up of this new production unit, we are well positioned to responsibly meet the growing global demand for these high-performance polymers," said Karen McKee, president of ExxonMobil Product Solutions.

› **www.exxonmobil.com**

Huhtamaki sales and profits increase in 2022

Finnish packaging major Huhtamaki has reported a rise in both sales and profits in 2022, despite what the company called a "volatile environment".

Sales for 2022 rose by 25% to nearly €4.5 billion (US$4.9bn), while profitability (adjusted EBIT) was €395m (US$426m) – which was also 25% higher than in 2021.

In the final quarter of 2022, sales rose by 10% to just over of €1.1 billion (US$1.2bn), while profitability (adjusted EBIT) was €93m (US$100m) – which wasa a 14% increase compared to 2021.

The company's global food service business saw a gradual improvement over the course of the year, eventually reaching €1.1 billion (US$1.2bn) – a rise of 18%. This resulted in a 28% rise in profitability to around €106m (US$114m).

IMAGE: HUHTAMAKI

Héaulmé: "Trading conditions are expected to remain relatively stable in 2023"

While sales in flexible packaging rose by 34% to reach around €1.6bn (US$1.7bn), profitability in the segment rose by 36% to around €105m (US$113m).

Business in North America also improved – growing by 27% to reach almost €1.5 billion (US$1.6bn). In addition, the company divested its Russia operations in September 2022.

"Whilst demand remained solid overall, the pressure of inflation on consumers started to erode consumption growth across categories and geographies during the second half of the year," said Charles Héaulmé, president and CEO of Huhtamaki.

"Trading conditions are expected to remain relatively stable in 2023, despite the continued volatility in the operating environment. Our diversified product portfolio provides resilience and our good financial position enables us to address profitable long-term growth opportunities," he added.

› **www.huhtamaki.com**

Film production plant opens in Mexico

IMAGE: EVERTIS

Above: Film producer Evertis has opened a new production plant in Monterrey, Mexico

Portugal-based film producer Evertis has opened a new production plant in Monterrey, Mexico.

Evertis has been present in Mexico for more than 20 years. It has now invested in a new manufacturing site there, which it says will enhance its position in Mexico – and growing presence in the USA and Canada.

The Monterrey manufacturing facility will support growth in high barrier materials and – through the introduction of new products – find its way into new segments including medical and pharmaceutical packaging.

The facility has an annual capacity of over 22,000 tonnes – which it plans to expand to 36,000 tonnes this year.

The company operates facilities in Portugal, Brazil, Mexico and Italy and is part of the IMG Group – which includes sister company Selenis, a specialist in copolyester resins in high performance applications.

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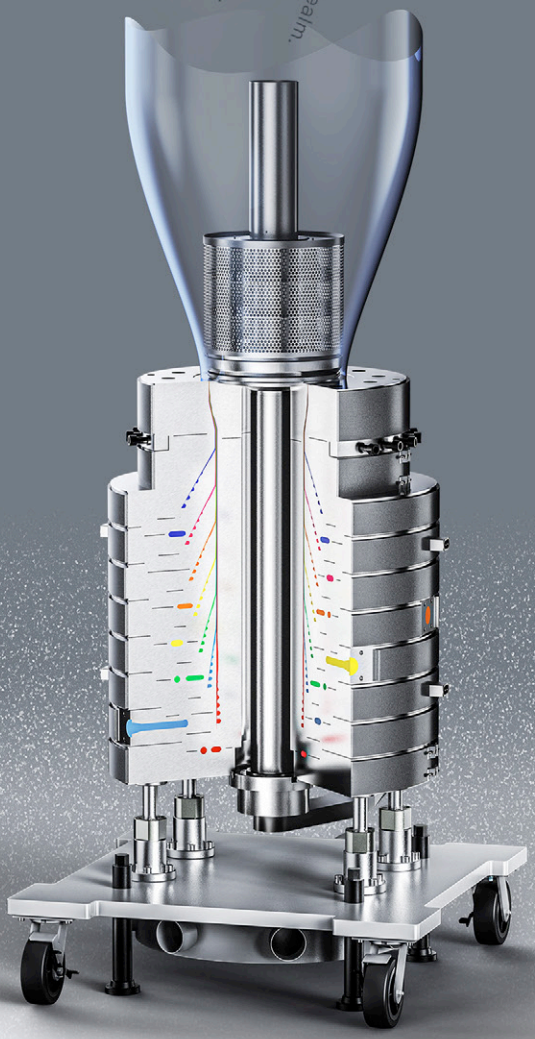

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Berry stretch hood film contains 30% recyclate

Berry Global is launching a new version of its stretch hood film – with at least 30% recycled plastic content.

It says this will help to support businesses to achieve their own sustainability objectives.

Maintaining stretch film properties can be challenging if it incorporates any recycled material. However, Berry says its Sustane polymers incorporate recycled plastic while delivering high levels of technical performance.

The new film is ideal for low- to medium-stretch applications in markets such as beverages, building and glass, says Berry. It is being manufactured in the company's factories in Belgium, Germany, Poland and the UK. Berry calculates that the recycled-content film can reduce carbon emissions by around 18% compared to a product made from virgin material.

"For all stretch wrapping applications, the focus is on ensuring that the chosen film consistently delivers the necessary levels of performance and protection – and we will continue to work with our customers to develop solutions tailored to their requirements," said Daniel Stauber, commercial director at Berry Packaging Solutions Industrial.

Read more about new polyolefin grades in our feature on **page 37**.

› **www.berryglobal.com**

IMAGE: BERRY GLOBAL

Above: Berry Global's new stretch hood film contains at least 30% recycled plastic content

Bioplastics to double by 2027

Installed capacity of biopolymers is estimated to boom in the next five years.

Nova Institute says bioplastics capacity will rise from 4.9 million tonnes now to 9.3m tonnes by 2027. This is a compound annual growth rate (CAGR) of around 14%.

Some polymers will grow at above-average rates: PHA is expected to grow by 45%, PLA by 39%, PA by 37% and PP by 34% until 2027. PE in Europe will increase by 18% until 2027.

› **www.nova-institute.eu**

PPC buys StePac of Israel

US-based PPC Flexible Packaging has acquired Israel-based StePac, which manufactures packaging for fresh produce.

StePac's patented technologies create atmosphere- and humidity-controlled packaging through roll goods, lidding and pre-made bags and pouches for bulk and retail applications. It has customers in over 40 countries.

"StePac has been a technology leader in the boutique produce market for many years," said Kevin Keneally, president & CEO of PPC.

The buy-out means that PPC – which prints and converts flexible films and pouches – now has 14 manufacturing facilities, all of them in the USA except for StePac's plant and one in Colombia.

In October last year, PPC acquired flexpack manufacturer Plastic Packaging Technologies (PPT) and its two US-based manufacturing sites.

› **https://ppcflex.com**

TeraPlast sales rise as profits fall in 2022

TeraPlast of Romania reported the "second-best year in its history" in reporting results for 2022.

The company, which produces a variety of products, including packaging, saw a 16% increase in sales for the year, reaching RON711 million (US$157m).

However, profitability (EBITDA) fell by 29% to around RON53m (US$12m). It put this down partly to volatility in raw material prices.

While turnover in its flexible packaging business rose by 139% to around RON40m (US$9m), EBITDA collapsed – and the division posted a loss of around RON11m (US$2m). The volumes produced in 2022 were half of the production capacity. Profitability of this new division "requires more time than initial estimates", it said.

"We draw the line after a difficult year, full of challenges, that tested our skills in managing complex situations," said Ioana Birta, financial director of TeraPlast.

› **www.teraplast.ro**

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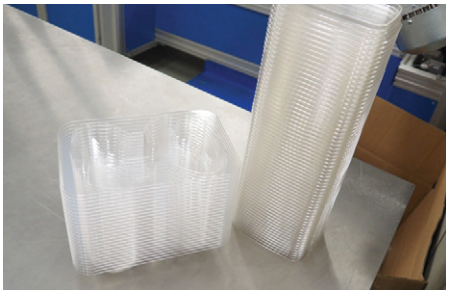
Top: Partly coated with anti-fog



Bottom: Stacked packaging, coated with anti-block

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IN BRIEF...

Constantia Flexibles has signed a joint venture (JV) agreement in India with **SB Packagings**. The JV will pursue organic and inorganic growth in higher added-value market segments. Constantia says the JV will help it strengthen its business in the region, and in market segments such as hygiene – where SB Packagings is strong. The agreement is expected to be finalised by the end of March.
www.cflex.com
https://sbpackagings.com

RKW Group has invested a "single-digit million" sum (in Euros) in a new 10-colour printing line at its Echte site in Germany. RKW says the new printing line will allow it to produce more complex product images on its packaging. The Echte site produces industrial packaging, including its ProVent sacks (to package powdery goods such as cement), as well as valve sacks and trash bags. In August 2021, the company installed a five-layer extrusion line inaugurated at the site.
www.rkw-group.com

US grants available for PVC recycling projects

The US-based Vinyl Institute, which represents PVC manufacturers, has launched a grant programme to encourage recycling of the material.

The programme, called Viability, will provide up to US$1 million per year for the next three years from four US-based resin manufacturers: Formosa, Oxy, Shintech, and Westlake.

"Each year, more than 1.1 billion pounds of vinyl material is recycled in the US and Canada," said Ned Monroe, president and CEO of the Vinyl Institute. "However, post-consumer material accounts for less than a fifth of that total."

He said the scheme should help the industry reach its goal of increasing post-consumer recycling volume to 160 million pounds by 2025.

Grants are available to organisations such as trade associations, material recovery facilities and recyclers – in amounts up to US$500,000. Funds can be used for everything from equipment and process investments to research and development or educational programmes. The first round of applications is due on 1 March 2023.

"It is our responsibility to identify pathways to grow PVC recycling," "We are eager to identify worthy vinyl recycling programmes."

› **www.vinylinfo.org**

Amaplast: Italy expects to see flat growth in machine sales for 2022

Italy expects to see a 1% growth in plastic machinery production in 2022.

Amaplast, which represents machinery manufacturers, says the figure – which amounts to sales of €4.5 billion (US$5bn) – "consolidates the recovery seen during the previous year".

In 2022, exports – which represent about 70% of production – are expected to grow by 2% (to exceed €3bn), domestic sales by 1% and imports by 5%.

In the first nine months of 2022, the main growth markets were Asia (especially India), South America (especially Colombia) and Europe. At the same time, sales to Africa declined.

However, Amaplast sees "low or negative growth" in 2023 – with an expected downturn of "a few percentage points".

"Companies will have to make significant effort to innovate in order to improve their machinery and stay abreast of increasingly specialised demand – especially as regards sustainability and energy efficiency," said Dario Previero, president of Amaplast.

› **www.amaplast.org**

Tape manufacturer buys into Malaysia

Advantek, a US-based producer of carrier tape and precision component packaging, has acquired LKTT Plastic Technology of Malaysia.

Financial terms of the transaction have not been revealed.

LKTT has more than a decade of experience in carrier tape manufacturing with a focus on complex designs for connectors, shields, and other components. It has customers across the ASEAN region.

"Customer service – including local manufacturing capabilities – is a key component of Advantek's business," said Wim Goossens, president and CEO of Advantek. "Establishing a manufacturing footprint in Malaysia is an important step in our plans."

› **www.advantek.com**

IMAGE: ADVANTEK

EPA denies call to list PVC waste as hazard

IMAGE: SHUTTERSTOCK

Above: The EPA has rejected a call to treat PVC waste as hazardous

The US Environmental Protection Agency (EPA) has published a "**tentative denial**" of a petition that waste PVC materials should be listed as hazardous waste.

The decision follows an agreement the EPA entered into with the petitioner – The Center for Biological Diversity – in May last year. It called on the EPA to "promulgate regulations governing the safe treatment, storage and disposal of PVC, vinyl chloride and associated dialkyl- and alkylarylesters of 1,2-benzenedicarboxylic acid, commonly known as phthalate plasticisers."

In its tentative denial, the EPA said: the petition did not provide sufficient evidence to suggest listing PVC as hazardous waste would have a significant impact on phthalate exposure; had not shown that exposure to phthalates resulted from current waste management practices; had not demonstrated that tighter incineration rules under RCRA would reduce emissions; and had not established proper evidence of plasticiser leaching from discarded PVC.

The EPA also said the petition conflated exposure with hazard and added that the resource-intensive process of listing PVC hazardous waste would preclude it from more pressing hazard programmes. It is requesting public comment.

› **www.epa.gov**

ACI and Ravago set up $10m Michigan film recycling plant

US-based ACI Plastics is to set up a US10 million post-consumer plastic film-recycling plant in Flint, Michigan.

ACI, in partnership with Luxembourg-based Ravago, will deliver the recycled film – in the form of pellets – to customers across the USA. The plastic film, such as shrink wrap and bags used in product packaging, comes from companies such as Meijer, Amazon, and Walmart.

At its peak – by later this year – ACI expects to process 24m lbs of post-consumer plastic film per year with the ability to double that if there is sufficient demand. It says the new plant will create 25-30 new jobs.

ACI employs about 120 people at its four locations (two in Flint and one each in South Carolina and Nebraska).

› **www.aciplastics.com**

› **www.ravago.com**

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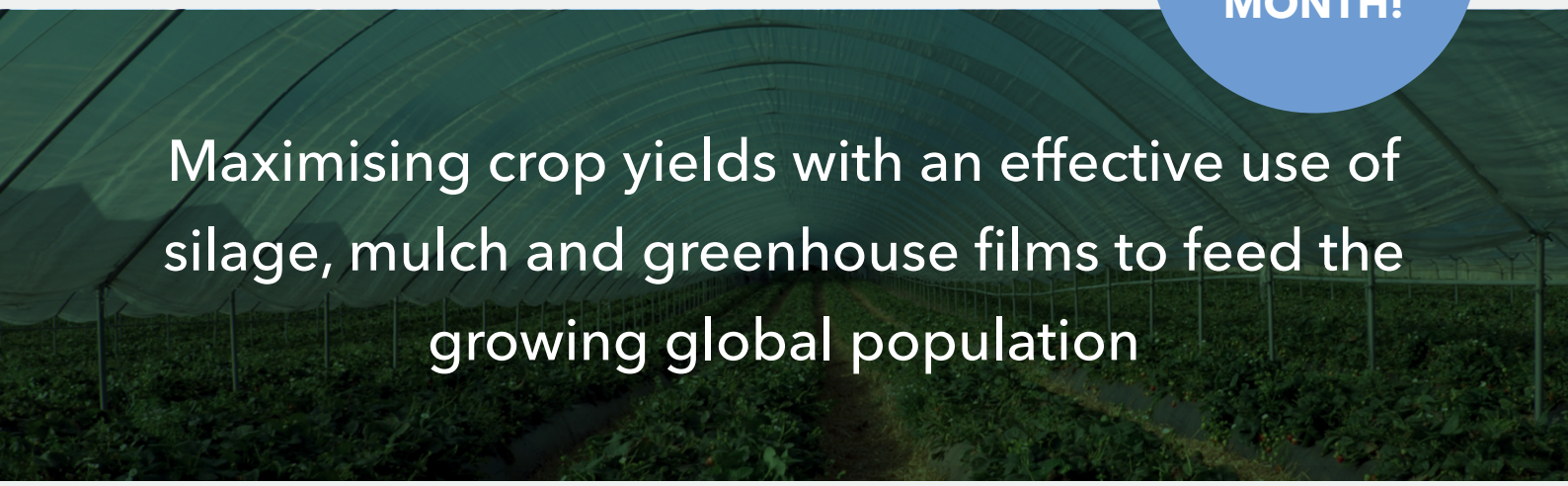

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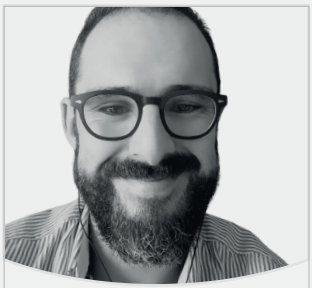

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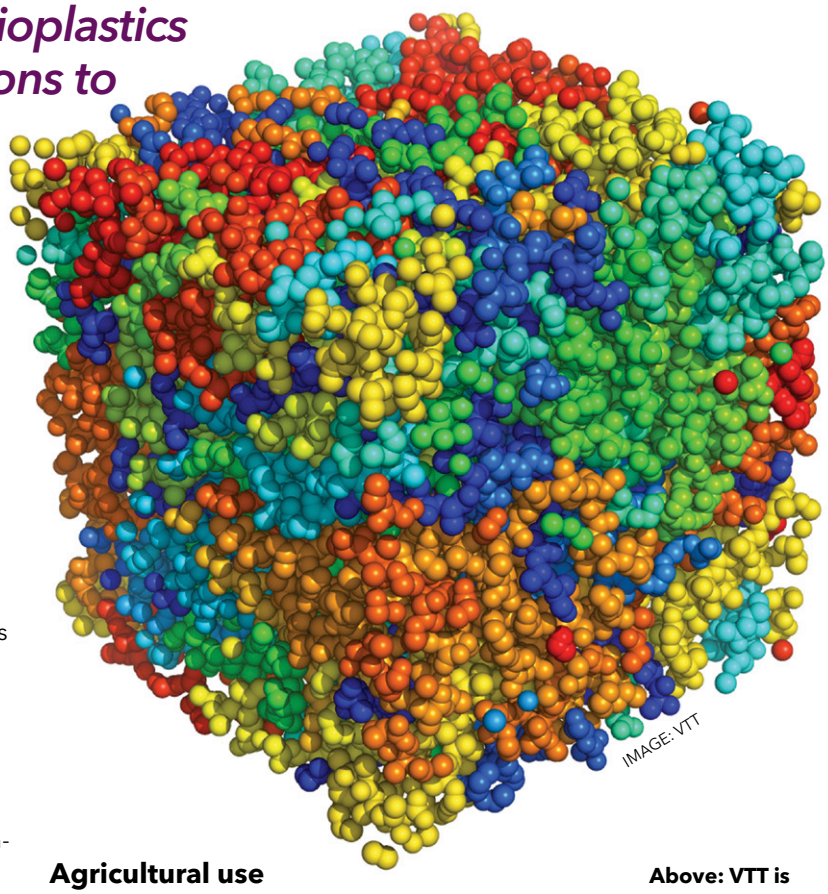
Green revolution: latest developments in bioplastics

Recent developments in bioplastics include several collaborations to move the materials further into the mainstream – as well as new ways to modify their properties



Above: VTT is using physics-based modelling to develop new plastic materials – such as this PLA

Bioplastics research has boomed as demand for more sustainable materials continues to increase. This research varies widely – encompassing everything from finding new raw material sources to developing innovative applications.

For instance, Finnish research centre **VTT** has expanded the use of its physics-based modelling and AI – to model and design soft materials such as novel bio-polymers.

VTT's virtual modelling toolbox – ProperTune – had previously been used to model hard materials such as metals. It allows companies to cut product development time in half, decrease cost elements of product development, reduce environmentally harmful materials and design new materials that perform better, says VTT.

"Developing products virtually is happening now," said Antti Puisto, research team leader at VTT. "As products are improved and new ones are created for different industries, we need to make each resource count."

He says the technique holds promise for the construction industry, as an example. Here, insulation materials in the walls of buildings are typically made of petrochemical-based polymers or mineral wool – which often end up in landfill.

"How do we create an alternative insulation material that doesn't rot between the walls – but disappears without a trace after its life cycle is over?" he said. "This is the kind of inspiring challenge that we want to tackle."

Potential examples include: building structural models of bio-composites – incorporating cellulose fibres into a polymer matrix; and designing a biodegradable material from scratch, including modelling of factors such as enzyme action.

Agricultural use

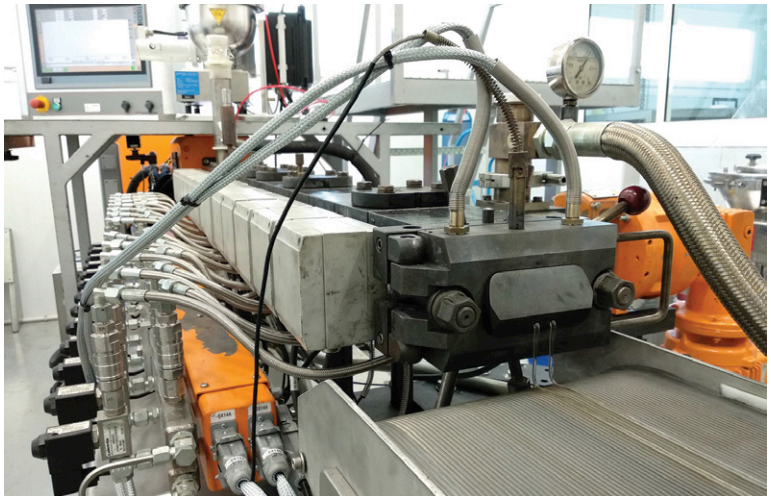
Italy-based **Sabio Materials** – a start-up that develops and produces bioplastics – has used its technology to create two material grades.

Its Biodura range has been designed to allow creation of high quality, solid, durable items, while its Terralix material is to make items easy to dispose of at the end of life – or, in case of accidental dispersion in the environment, yield a reduced impact. Applications are envisaged in the agriculture, forestry and aquaculture sectors.

"Terralix is used in agriculture to produce systems to bind and protect new plants, in particular in vineyards," said founder Alessandro Carfagnini. "At the moment, we are studying grades of Terralix to make advanced mulch systems and seasonal irrigation systems that do not need to be removed at the end of use."

Carfagnini says he believes that many traditional plastics used in agriculture could be replaced with Terralix – which is based on linear biopolyesters combined with additives of plant origin – bringing

IMAGE: AIMPLAS



Above: This reactive extrusion pilot line from Aimplas will produce PLA-based nanocomposites

"both an environmental and economic benefit due to the ease of disposal."

Small project

Pan-European research project **Biomac** is ready to offer its services to small and medium-sized enterprises.

The project has been developing nano-enabled bio-based materials (NBMs) for agricultural and food packaging solutions. As part of Biomac, Spanish research organisation **Aimplas** has developed a reactive extrusion pilot line.

The next step is to scale up applications and get them ready for commercialisation.

The Biomac Ecosystem provides access to its facilities (17 pilot lines) and services, covering the whole value chain – from biomass fractionation and intermediate chemicals to final NBMs. Aimplas is in charge of pilot line number 11 – a reactive extrusion (Rex) pilot plant for polymerisation of PLA and its copolymers and the production of PLA-based nanocomposites.

The Aimplas pilot line is working in two different test cases within Biomac. In agricultural applications, it will develop PLA-based masterbatches with nanoparticles to be used in formulations for mulching applications. In food packaging, it will develop PLA nanocomposite formulations for blown film applications.

Right: BeonNet is developing bioplastics-based active packaging for cosmetics applications

The next step is to validate the pilot lines with five internal test cases – in automotive, agriculture, food packaging, construction and printed electronics.

Aimplas is also a partner in the BeonNet project – which is developing bioplastics for active packaging for cosmetics applications.

The project relies on sourcing biomass from trees and shrubs that are grown on marginal land. It covers the cultivation and harvesting of selected species, extraction and purification of essential oils and plant extracts, and manufacturing a variety of packaging materials – including activated carbon and bioplastics.

Aimplas will produce PLA from lactic acid – produced by fermenting sugars in plant biomass waste. Essential oils with different active properties – such as antimicrobial action – will be added to the PLA, and used to make cosmetics packaging. Aimplas is collaborating with Laboratorios Maverick to produce the packaging, and with Idoasis as a supplier of active substances.

Bio-based barrier

The drive towards sustainability means that more barrier films are now bio-based. In a project called MultiBioBarrier, Aimplas has developed – with partners **Gaviplas** and **Nurel** – a material that is 70% bio-based. At the same time, it is biodegradable and has a high oxygen and moisture barrier. This makes it useful for packaging products such as cheese. As well as being biodegradable, the multi-layer film had to be easily recyclable by separating the layers.

Nurel developed the polymers, which have superior barrier properties to its existing Inzea grades, it said. The films can be processed by blown film technology – and have been used to make three- and five-layer products.

Three grades have been developed: Inzea F18C is transparent and sealable; FBH 10 has an oxygen barrier and is water-soluble; and FBT has an oxygen and water barrier.

Aimplas was tasked with developing multi-layer structures from the materials, while Gaviplas will scale up and validate the production process.

Multi-layer films – using all three grades in either three- or five-layer structures – have been produced and tested at pilot plant scale. The five-layer structure (which included tie-layers) was transparent and recyclable, while the three-layer version was compostable. ›

IMAGE: AIMPLAS

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IMAGE: BRASKEM

Right: Braskem has a 'green ethylene' plant in Triunfo, Brazil

Bio PP project

Braskem has begun a project to evaluate potential production of bio-based polypropylene (PP).

The project would use the company's proprietary technology that converts bioethanol into polypropylene. It is looking to establish several downstream project partners.

"We are actively evaluating a project to produce the world-s first bio-based PP on an industrial scale," said Mark Nikolich, CEO of Braskem America.

Braskem says that the US is home to the world's largest ethanol industry production. The bio-based PP would be a drop-in solution with the same technical properties as Braskem's current PP portfolio.

"This US-based project would serve a growing market for sustainable solutions and reduce our reliance on fossil feedstock," Nikolich added. "Expanding our portfolio to include bio-based PP supports our goal of 1 million tonnes of biopolymers capacity by 2030 and becoming carbon neutral by 2050."

Faster degradation

Teijin Frontier – the converting division of Teijin – has developed a grade of PLA with a higher rate of degradation.

By adding a new biodegradation accelerator to the polymer, Teijin Frontier has boosted its biodegradation rate without impairing strength or other properties. The grade is expected to help reduce microplastics thanks to its faster degradation rate.

"Until now, attempts to improve PLA's biodegradability have impaired its strength and other practical properties," said the company.

The company will start producing and selling pellets for applications including extrusion in fiscal 2023 (which ends in March 2024). It aims to sell "several hundred million JPY" by fiscal 2026.

When PLA polymer is hydrolysed to less than 10,000Mn (average molecular weight) it can be broken down into carbon dioxide and water by bacteria and fungi. The accelerator accelerates hydrolysis to reduce molecular weight more quickly than pure PLA.

During processing and storage, molecular weight decreases only slightly – similar to that of conventional PLA – so the resin is practical because its crystallinity and processability are not impaired, says the company.

The decomposition period – of six months to two years – can be controlled by adjusting addition conditions and the amount of biodegradation accelerator. This is useful for specific items such as agricultural film.

IMAGE: NATUREWORKS

Above: NatureWorks recently held a cornerstone-laying ceremony for the new 75,000 tonnes/year PLA plant it is building in Thailand. The factory, on the Nakhon Sawan Biocomplex (NBC), is scheduled for completion in the second half of 2024

Bioplastic tie-up

Bioplastics producers **NatureWorks** and **CJ Biomaterials** have signed an agreement that will see them collaborate on the development of new sustainable materials.

While NatureWorks is a leading producer of polylactic acid (PLA), CJ Biomaterials produces polyhydroxyalkanoate (PHA).

The companies plan to develop materials to replace fossil-fuel based plastics in applications ranging from compostable food packaging to films and other products. The initial focus will be to develop bio-based solutions for compostable rigid and flexible food packaging.

CJ Bio claims to be the only company producing amorphous PHA (aPHA). The first product under its new PHAct brand – introduced in May 2022 – is PHAct A1000P. Amorphous PHA is a softer, more rubbery version of PHA that offers different performance characteristics from crystalline or semi-crystalline forms. It is certified biodegradable

IMAGE: WACKER

Above: Wacker's new additive masterbatches are used to modify biodegradable polyesters

in industrial compost, soil (ambient), and marine environments. Modifying PLA with amorphous PHA is said to lead to improvement in mechanical properties, such as toughness, and ductility, while maintaining clarity. It also allows adjustment of the biodegradability of PLA and can potentially lead to a home compostable product.

"Plastic pollution is a major global concern," said Seung-Jin Lee, head of biomaterials at CJ CheilJedang, the parent company of CJ Biomaterials. "To successfully address this, it is critical to introduce new solutions that will have a real impact by improving the biodegradability and compostability of plastic."

Modified polyesters

Wacker showcased several new additive masterbatches for modifying biodegradable polyesters at K2022.

The products are pelletised polymer blends consisting of vinyl acetate-based polymer resins and polylactic acid. They have the same effect as pure vinyl acetate-based resins but are easier to handle – making them easy to process.

Two of the grades – Vinnex LA 2540 and 2640 – are for the production of highly transparent, biodegradable films. Both grades increase melt strength, allowing optimised extrusion. With their higher melt strength, the two grades reduce the necking – constriction of the extrudate – that is observed in many biodegradable polyesters. In blown film extrusion, they stabilise the extruded polymer bubble, making high process speeds possible.

The masterbatch carrier is a polylactic acid produced from renewable raw materials. The actual active component is the vinyl acetate-based polymer resin. The ready-to-process masterbatches have an active ingredient content of 40%, while the polylactic acid content is 60%. Grain size is around 3mm, allowing the dry blend to be smoothly dosed.

Wacker also presented results of an in-house study, showing that using a combination of silicone and polymeric additives creates more benefit – when processing bioplastics – than when using just one. Both enhance the processing and material properties of bioplastics.

The tests show that the additives can be readily combined, yielding benefits in optimally adjusted processing and product properties, and improved effectiveness.

Biopolyesters can be difficult to process without suitable additives. Wacker chose PLA and polybutylene succinate (PBS) as representatives of biodegradable plastics for the tests. The company observed that Vinnex and Genioplast comple-

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IMAGE: TOTAL ENERGIES CORBION

Above: BGF's noodle cup relies on Luminy high-heat PLA

mented each other in their effects in both filled and unfilled bioplastic systems.

When used together, the processing and performance properties of bioplastics could be optimally adapted to specific requirements.

Depending on the grade used, Vinnex showed a positive influence on polymer melt or mechanical properties. In the samples tested, Genioplast acted as a booster, enhancing the effects achieved with Vinnex. In several cases, the silicone additive also improved properties that Vinnex on its own did not influence.

Mass balance

Bio-Fed – an expert in biodegradable and bio-based plastics – showcased a number of materials at K2022, including a mass-balanced PP compound called M-Vera.

Most M-Vera bioplastics are also biodegradable, with many of them either partially or fully bio-based. They are suitable for various different processing technologies including blown film, extrusion and thermoforming. The range also includes a mulch film type that is soil degradable according to EN 17033.

If offers OK compost Industrial certified products – with different proportions of renewable content – for extrusion and thermoforming,. These have different mechanical properties that are tailored for each specific application. They can be processed with standard equipment, into sheets, films and profiles.

Circular EVOH

Kuraray introduced its Bio-Circular ethylene-vinyl alcohol (EVOH) at K2022, the latest addition to its line of Eval EVOH barrier resins for packaging applications.

The company says it is the first EVOH copolymer producer to receive ISCC Plus certification for bio-circular ethylene monomer in its supply chain. It says it covers, in principle, all EVOH variants that it produces at its plant at Antwerp in Belgium.

Kuraray also showed its Septon Bio series of TPEs, which are based on hydrogenated styrene farnesene block copolymers (HSFC) synthesised from beta-farnesene, a monomer derived from sugarcane. Bio-based content varies up to 80% depending on the specific grade.

Compared to conventional styrenic block copolymers, Septon Bio grades are claimed to reduce greenhouse gas emissions by up to 33% as well as improving properties such as oil retention, weatherability and compression set.

PLA collaboration

Total Energies Corbion has entered a long-term collaborative arrangement for application development and the supply of its Luminy PLA to South Korea-based **BGF**. Both companies are focused on the development and production of biodegradable materials and products.

BGF recently launched a single-use, noodle cup which is aesthetically pleasing, bio-based and compostable. The lightweight, foamed cup minimises the use of materials and is being produced using high heat Luminy PLA as a base resin. The cup is a joint development between the companies, with more developments to follow in future.

"Bringing more environmentally friendly products to the Korean market remains a key focus of our business," said Hong Jung-Gook, CEO of BGF.

Thomas Philipon, CEO of Total Energies Corbion, added: "The biopolymers market is experiencing strong growth – and customers are requesting innovative solutions tailor-made to their market needs."

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Check marks: latest in materials testing

IMAGE: OCS

Materials testing – whether of incoming polymer pellets or fast-moving film – helps raise product quality, using techniques as diverse as camera inspection and thermal analysis

The need for product quality is critical in plastics extrusion. Black specks in incoming raw materials – or defects such as gels on extruded film – can both lead to product being scrapped or recalled.

A variety of techniques, from visual inspection to thermal analysis, can help to ensure product quality is maintained in an efficient way.

Atlas Weathering Services Group (AWSG) says that its Virtual Inspection and Evaluation of Weathering (View) system helps companies avoid the challenges and expense of an on-site testing visit. Instead, clients can observe the effects of weathering on specimens remotely. In addition, the convenience of View allows assessments to be made more frequently.

Using secure video conferencing software, a client interacts with an AWSG technician equipped with specialised, camera-enabled glasses to observe specimens in situ in high definition. They can then focus on specific areas of interest in detail – with magnification up to 60x using View's digital microscope.

Features of the service include: live on-line meetings or recorded video/audio; screen capture and whiteboard features to note specific areas of interest; and a digital microscope, for magnification of any specific surface defect.

View is available at three US locations and will be expanded to European testing sites in future, says the company.

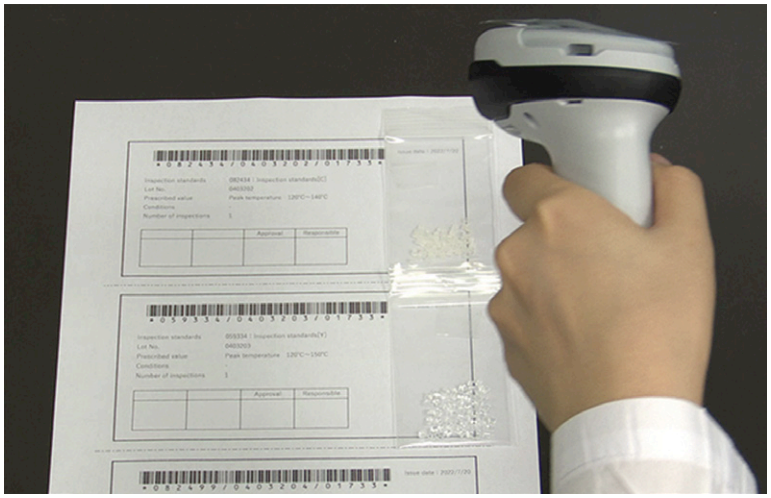
Finding fault

OCS offers a number of systems for inspection, analysis and classification of gels and contaminations.

Special camera and lighting technology – and the use of high-performance hardware and software components – helps OCS systems detect irregularities in real time. This includes gels, black specks or burn marks. ›

Main image: OCS offers a number of systems for finding contamination in plastics

IMAGE: HITACHI HIGH-TECH ANALYTICAL



Above: Hitachi High-Tech Analytical Science's latest workflow efficiency software allows users to scan bar codes to enable automatic data storage

Its FSP600 web inspection system with MCE (multi-channel evaluation) technology allows detection in reflected or transmitted light mode as well as in dark and bright field applications, using only one camera. This enables the simultaneous detection of defects on up to six channels. For instance, one channel can be used for the reflection of surface defects, and three channels for transmission (red, green and blue) for better defect detection and classification. Defect references are assimilated with a teach-in function, and a common classification of the film rolls (grade evaluation) can be carried out.

The OCS software can be integrated into systems such as Ruby (from Windmoeller & Hoelscher), to create further value for the operator.

In plastics processing, traceability is critical. For film manufacturers, film rolls can be locked by the system without an operator having to interact, thanks to OCS analysis software – which uses the material, raw material and process parameters from the PDA system in relation to the respective quality/film grade, to provide long-term statistical process control. This reduces reject quantities and saves both time and cost.

Thermal performance

Hitachi High-Tech Analytical Science has also been working on updating software tools – in this case, for its thermal analysis equipment.

"Many polymetric material manufacturers are looking for ways to improve traceability, prevent human error and increase effectiveness," said Olivier Savard, product manager for thermal analysis at the company.

Savard says that software options such as its recent input/output software update improve workflow efficiency through automatic analysis. This allows end users to scan a bar code to access the sample information, method settings and analysis method. When used with an autosampler, everything from sample information input to results export is automated – which helps to reduce costs.

Another trend is the ability to combine different technologies. "Extra information like the effect of temperature on the sample colour can now be investigated with camera systems fitted on thermal analysis," he said.

Over the last few years, it has become easier to gather more information from thermal analysis by connecting other techniques such as FTIR, MS, and GCMS. For example, the company's STA (TGA/DSC) can be connected to all these techniques from the major brands including the combination of STA, IR and GCMS for optimal evolved gas analysis, he says.

Next generation

Isra Vision introduced its next generation of camera-based inline inspection systems – with new features and intelligent software tools – at K2022. These included the latest generation of its Cloud Xperience software platform. This uses artificial intelligence (AI) for clustering during defect classification and a smart software solution for real-time process and status monitoring.

"Today, users of our systems receive comprehensive information about the condition of their products in real-time, and benefit from accelerating the ramping-up of their production – lowering costs and simplifying the operation of these high-tech systems," said Dirk Broichhausen, group vice president of surface and print inspection for advanced materials at Isra.

Isra offers two inspection systems to manufacturers of lithium-ion batteries to identify possible problems and defects. The Smash Battery system is optimised for the automatic inspection of electrode coatings, as well as separator foils and their coatings (such as PVDF). It delivers real-time information on product quality and indicates to what extent the specifications have been met. Its inline classification – the differentiation between 'black spots' and holes that appear dark – ensures maximum safety and confidence, it says. It also presented PouchStar, for inline inspection of single battery cells. The system inspects the shape, size, and sealed seam of the cells and finds surface defects, deformations, blemishes, and contamination.

Meanwhile, DualStar helps to optimise workflow in flexible packaging manufacturing and finishing. It allows the user to switch between 'surface' and 'print' inspection depending on the job. This makes it the only solution to combine inspection of unprinted foils, laminates, and coatings with that of printed material in a single system, says Isra. ›

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IMAGE: SIKORA

Above: Sikora encouraged customers to bring material samples to K2022, for inspection on its Purity Concept V

Sorting kits

Trinamix has launched an initiative to supply waste management projects with 50 starter kits – helping them to identify different plastic types instantly.

Each kit contains its mobile NIR spectroscopy solution, a smartphone, data analysis in the Trinamix spectroscopy cloud, real-time access to results via mobile app and the documentation of results in the customer portal. Use is free for one year.

The technology helps to improve waste sorting by identifying a broad range of plastic types.

"This allows users to identify plastic waste on the spot within seconds – using a mobile device," said Adrian Vogel, business development manager at Trinamix. "This could be used to train waste sorters – to improve the purity of sorted bales."

At K2022, Trinamix and its partner – the Alliance to End Plastic Waste – explained how they would bring the technology to remote areas.

Justin Wood, vice president of strategic partnerships at the Alliance, said: "We are using the handheld device to help some of our projects engage with communities and education more effectively – to improve sortation and characterisation of plastic waste and to maximise bale quality and economic value."

High purity

At K2022, **Sikora** introduced its Purity Scanner Advanced – which inspects and sorts plastic pellets according to their quality.

It is a modular system for flexible optical online inspection and sorting of plastic material, which has three optical cameras and one X-ray camera.

"Even the smallest, critical contamination is reliably detected and sorted out by the system," said Ralf Kulenkampff, head of sales for plastics at Sikora. "The detection and ejection of contaminated pellets is perfectly coordinated."

Thanks to the modular concept, different camera types can be used depending on the inspected material. As well as optical 25-micron, high-resolution cameras – which detect black specks and discolorations – an X-ray camera can detect metallic contamination.

Typical systems on the market have a maximum of two optical cameras. However, these quickly reach their limits due to relatively low coverage as soon as the contamination is outside the field of view, says Sikora.

"Our scanner uses a third black and white camera, so a significantly higher detection rate is achieved – and more contaminants are detected," said Kulenkampff.

It also showed its Purity Concept V laboratory testing device. Within a few seconds, test material can be inspected for metal contamination or optical deviations. Sikora encouraged visitors to bring material samples to K2022 for analysis.

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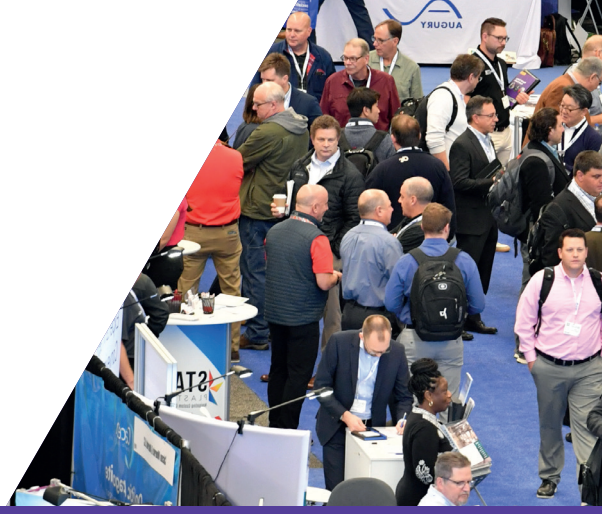

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IMAGE: AIMPLAS

Advances in medical materials and applications include new high-barrier packaging, anti-microbial masks and face shields, and several improved grades that raise performance

Health kick: advances in medical materials

Production standards for medical materials typically exceed those of other industries – including food. Despite the challenges of developing new materials in this sector, suppliers continue to find new ways to meet the needs of medical companies.

Constantia Flexibles says that its Perpetua and Perpetua Alta flexible packaging sachets offer a high barrier to keep the contents safe.

It says that, because they are a mono-material solution (all-polypropylene), they are easier to recycle. Constantia showed the sachets at the Pack Expo International show in Chicago last year.

"In our R&D department we place equal importance on the safety and sustainability of our packaging," said Pim Vervaat, CEO of Constantia Flexibles. "Our packaging is only fit for the future if it meets both our standards. With Perpetua and Perpetua Alta, we combine performance and sustainability."

Perpetua protects against oxygen, water vapour, and light – which is necessary to maintain the efficacy of medicines. In addition, it is Cyclos-HTP certified, meaning it has a recyclability of 90-96%, depending on the individual material specification.

Perpetua Alta has a high chemical resistance to pharmaceutical products, so can be used for more demanding products (in both pharmaceuticals and foods). Compared to conventional laminates, the package is lighter, with higher efficiency, and offers optimal protection, says Constantia.

Constantia also invests in counterfeit-proof packaging – because up to 30% of the world's medicines are counterfeit, it says. Many of Constantia's product lines are available with anti-counterfeiting features.

Anti-microbial masks

A collaborative Spanish research project is developing masks and face shields with antimicrobial properties – to help prevent viral and bacterial infection.

Main image: A Spanish research project is developing antimicrobial masks and face shields

IMAGE: CONSTANTIA FLEXIBLES

Right: Constantia's Perpetua Alta boasts a high barrier to protect pharmaceuticals

The project, called Dotmask, looks at new coatings and plastics obtained from plant extracts that improve the performance of personal protective equipment (PPE).

The initiative is coordinated by chemical company Lamberti. Partners include **Aimplas**, the Medical Research Institute of La Fe Hospital in Valencia, biotech company ADM Biopolis and mask manufacturer Airnatech.

The materials are being developed to reduce infection from pathogens – which are frequently transmitted by air. Viruses and bacteria can be particularly hazardous in hospital environments, where they can become resistant to drugs.

Existing coatings typically use inorganic, metal-based additives. However, has some disadvantages, such as a tendency to corrode in some environments and the possible release of active ions – with potential toxic effect. Plant-based compounds could help to overcome these problems. Dotmask is developing materials based on bio-based phenolic compounds with strong antimicrobial activity for integration into PPE. The coatings will be applied to plastic sheet that is used to make protective face shields.

Lamberti and ADM will analyse the antimicrobial capacity of the additives, Aimplas will develop new antimicrobial plastic materials and Airnatech will use the new additives for masks – which will be tested at La Fe Hospital in Valencia.

Medical sheets

Eastman and **Exolon** have begun a collaboration to extrude solid sheet materials for medical use.

Exolon's Vivak Med solid sheets for rigid medical packaging are extruded using Eastman's Eastar 6763 medical copolyester resin. The sheet is available in thicknesses from 0.6 to 8mm.

"Eastar 6763 has been the standard for decades in rigid medical packaging applications," said Michael Burkardt, business development manager for speciality plastics at Eastman.

As well as meeting an increasing demand for thermoplastic solid sheet products, Vivak Med meets ISO 10993/USP Class VI biocompatibility requirements, says Exolon.

Wim Van Eynde, head of product management at Exolon Group, added: "The medical packaging industry will now have access to thicker and wider sheet material. Eastman medical-grade materials offer advantages such as reduced material usage and freedom from substances of concern compared to other materials like high- impact polystyrene."

Last year, at K2022, Exolon presented its entire medical range – Exolon Med, Vivak Med and Inspria Med.

All products consist of 100% virgin material, meeting the requirements of ISO 10993 for the biological evaluation of medical devices. Sheets are produced in accordance with good manufacturing practices (GMP).

These are used to make a wide range of medical products, including dental splints, rigid medical packaging, containers and trays for medical devices, said Exolon.

Elastomer film

Gel-Pak showcased its custom silicone, TPU, and TPE film extrusion and coating capabilities – along with biocompatible carriers for the medical device industry – at the recent MD&M West show in California, USA.

The company manufactures customised elastomer films for medical and electronics applications. The engineered films are made in a cleanroom environment and offer optical clarity, chemical resistance, low hysteresis, and tight process control, says Gel-Pak.

Gel-Pack also supplies biocompatible trays, slides and films that hold medical components in place during transport, processing, and storage. An example is its new BTXF Jedec tray: a micro-textured film is laminated to the bottom of a flat tray, which immobilises medical devices using non-adhesive holding forces – yet allowing easy removal. The product is ideal as a handling medium during manufacturing processes or shipping, says the company. The products are manufactured in an ISO-certified, class 10,000 cleanroom.

Acrylic grades

Roehm added two new medical products to its Cyrolite portfolio at the recent MD&M West show.

Cyrolite acrylic-based copolymer compounds provide a superior balance of properties that helps

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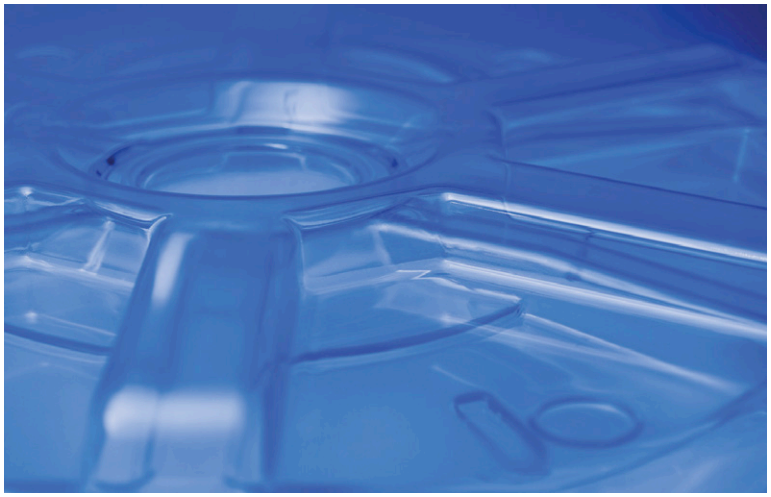
IMAGE: EXOLON



Above: Exolon's Vivak Med solid sheet uses Eastman's Eastar 6763 medical copolyester resin

designers create medical devices, says the company.

The first product, Cyrolite G-20 CP, is a PMMA-based copolymer for injection moulding and extrusion of UV-light protective medical applications. It ensures integrity of photosensitive substances such as oncology drugs, antibiotics, and antifungal agents that require superior UV-light protection, says the company.

Roehm says it has five times the impact resistance of unmodified acrylics and high resistance to body fluids and other chemicals. It has a UV-light transmission of <1.0% (260 - 480nm) and high transmittance between 500 and 780nm.

"Cyrolite G-20 CP allows designers the flexibility to create medical devices that offer dynamic properties which are crucial to innovation," said Thomas Spagnuolo, vice president and general manager of moulding compounds at Roehm America.

The second grade, Cyrolite MD zk6, offers enhanced impact resistance. It is an amorphous, impact-modified acrylic polymer for injection moulding and extrusion applications, based on PMMA.

DEHP alternative

Citroflex B-6, from **Vertellus**, is partially derived from bio-based raw materials and is said to demonstrate biodegradability. It is marketed as a phthalate-free plasticiser solution for flexible PVC blood storage and transfusion systems that can provide an alternative to di-2-ethylhexyl phthalate(DEHP).

The company says DEHP has long been the predominant plasticiser used in PVC medical devices. While questions about its safety in blood bag systems have been raised since the 1970s, it says it has only recently been labelled as a reproductive toxin.

"With the recent changes in the European Union's Medical Device Regulation (MDR; EU 2017/745), as well as Amendment Annex XIV per ECHA REACH mandates, use of DEHP will require authorisation based on Benefit Risk assessment, complicating supply and prolonging the path to product commercialisation," the company said. "Medical PVC compounders and blood transfusion product brand owners are now preparing for next-generation products, fast-tracking the development of alternative, phthalate-free technologies."

Citroflex B-6 is a butyryl trihexyl citrate (BTHC), listed in the European pharmacopoeia as an approved alternative to DEHP for medical products.

Vertellus says it enables brand owners to comply with various regulatory mandates – not only the MDR and REACH Regulations but also RoHS EU Directive 2015/863 (RoHS 3).

PVC films plasticised with Citroflex B-6 are said to display similar physical properties to those containing DEHP, says Vertellus.

Medical conversion

US-based **Delta ModTech** recently supplied a custom-designed converting press to ATL Corp – a specialist in printing, material converting, and contract manufacturing – to create a new medical device for a new customer.

KelCor, a medical start-up, proposed a new product concept: single-use adhesive tape that could be removed from sterile packaging. The tape would be used to secure an airway tube to an intubated patient. The tape, called a drape support, can be subject to airborne particulates and splash – and could become a source of healthcare-acquired infection.

KelCor developed a general concept of the securing device but needed a methodology to manufacture the product in cost-effectively – and in adherence with regulatory guidelines. ATL helped create a prototype of the securing device. The drape support was a die-cut, multi-layer lamination with adhesive. It would be made on the Delta ModTech Crusader converting machine. Once the prototype proved viable, ATL could make the first 5,000 parts.

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Circling around: polyolefin materials and applications

The demands of sustainability mean that new polyolefin grades – or packaging designs – must incorporate some form of circularity, such as using recyclate or being more recyclable

Polyolefins are the most widely used materials in plastics extrusion – and account for the largest volume in extruded film.

Recently, film extruders in particular have wrestled with the challenge of recyclability. As a consequence, a key trend within polyolefin extrusion is that of developing mono-material packaging that has equivalent properties to multi-layered structures.

In addition, there is a greater focus on incorporating more recyclate into packaging.

IMAGE: NOVA

Kind packaging

Many brand owners have been increasing the amount of post-consumer recycled content in their plastic packaging.

Mars recently began wrapping its Kind snack bars in this way – with help from **Taghleef Industries** and others.

The packaging is a new flexible BOPP structure made with certified circular food grade PP. The mono-material packaging helps end-of-life recycling in existing collection and sorting operations without affecting quality or processability.

"Our mission is to ensure that our products are aligned with Circular Economy principles and meet our important needs such as product protection, performance, and sustainability," according to Monica Battistella, group sustainability manager at Taghleef.

Other partners in the project include Landbell – which co-ordinated collection of mixed used plastics – and Plastic Energy, which converted the materials into pyrolysis oil before its conversion back into plastic.

PCR in sacks

Borouge has developed a method to incorporate post-consumer recycled (PCR) content into PE-based heavy duty shipping sacks. New sacks are made from 30% PCR content – originally used in the same type of product – together with Borouge's Borstar and Anteo PE grades.

Borouge worked with partners Han King Plastic Machinery, Kunshan Golden Alliance, Shanghai Longstone and Shanghai Tianqiang to develop the closed-loop PE for heavy-duty sacks, with the aim of developing a sustainable solution with a lower carbon footprint.

Material from used sacks is recovered through waste collection streams, then mechanically recycled.

The recycled resins are then incorporated – with virgin PE – to the end application.

"This circular solution enables multiple recycling cycles within the same application, which takes us a step closer towards a circular economy," said Eddie Wang, senior vice president for Asia North at Borouge.

Main image: Nova Chemicals says its EX-PCR-NC4 grade, made from mechanically recycled PE, helps meet sustainability goals

IMAGE: SAPERATEC

Right: Saperatec says its mechanical recycling process for thin-layer composites creates "virgin-similar recyclates"

Recovered resin

Nova Chemicals has developed a new, mechanically recycled polyethylene resin. The grade, EX-PCR-NC4, allows converters and brand owners to meet sustainability goals without compromising package performance – in applications such as shrink film,heavy-duty sacks and protective packaging.

The material is made completely from post-consumer recycled polyethylene (rPE). It is sourced from distribution centre flexible film, which includes a blend of back-of-store stretch and front-of-store consumer drop-off. Source materials are processed to have a low odour and be consistent and stable.

"Through customer trials and applications development, we have successfully incorporated our new rPE resin into various end-use formats," said Anna Rajkovic, circular economy market manager at Nova.

Commercial quantities of the grade are already available.

Alan Schrob, mechanical recycling director at Nova, added: "By utilising rPE, we're diverting plastic waste from landfills while enabling a fully-recyclable new product. We aim to deliver commercial quantities of consistent high-quality rPE products to meet the needs of our customers."

Partner prototype

Three German manufacturing partners used K2022 to showcase a prototype packaging design – which relies on a multi-layer delamination technique.

The detergent packaging relies in part on a mechanical recycling process for thin-layer composite materials – which creates "virgin-similar recyclates" – from **Saperatec**.

The two-layer packaging, made from polyethylene (PE), includes an inner sealing layer with more than 50% PCR rLDPE from beverage carton waste. The outer layer is laminated with a **Henkel** adhesive. Overall, the packaging contains at least 35% PCR rLDPE, which meets goals proposed for the pending EU Directive on Packaging & Packaging Waste for non-food packaging. The film was produced by packaging film supplier **Wentus**.

Saperatec is building its first recycling plant for composite packaging in Dessau, Germany, which will begin operations in 2023 – with an initial goal of processing around 18,000 tonnes/year of packaging waste. In the process, hot-wash separation fluids are water-based and solvent-free and reused more than 30 times.

Initially, Saperatec will focus on composite flexible packaging materials and tube packaging with aluminium foil barriers, as well as plastics and aluminium from beverage cartons.

Recycled solutions

Chase Plastics has developed the Recothene range of recycled-content solutions for polyethylene film manufacturers.

"Recothene rPE can help PE film manufacturers contribute to the circular economy and reduce the carbon footprint of their products," comments Johnstone Smith, managing director of Chase Plastics.

The company saw demand for Recothene rise in the run-up to the introduction of the UK Plastics Packaging Tax in April last year. Customers have incorporated it into transit packaging applications at addition rates above 30%.

"Many businesses can ensure their used PE is sent for recycling, while PE film manufacturers can move towards a circular model by reformulating their products to incorporate Recothene," he added.

Better blends

Baerlocher has applied its Baeropol T-Blends technology to a number of plastics recycling projects.

The technology uses a family of customisable additive blends that can replace traditional antacids. It works with primary and secondary antioxidants to stabilise polyolefin resins more effectively than standard binary antioxidant blends, says the company.

"Collaboration is fundamental in achieving our industry recycling objectives," said Ed Hall, CEO of Baerlocher USA. "Our industry-leading solutions facilitate the increased use of recycled content without sacrificing quality and performance."

In one example, it has worked with Revolution, a recycler based in Little Rock, Arkansas. Here, Baerlocher's expertise in stabilising PCR content

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IMAGE: DOW

Right: Dow, W&H and B&B have developed a recyclable MDO-PE bag for pet food packaging

and the use of its Baeropol T-Blends were used during the development phase of new higher-performing PCR resins for film applications.

In another project, with Cascades Flexible Packaging, the technology helps the company to achieve higher-quality recycled content and increase its use in film applications.

"We are committed to developing films with a high percentage of recycled content, to improve our carbon footprint and provide higher quality to our customers," said Fabricio Smillo, technical manager of Cascade Flexible Packaging. "We are collaborating closely with Baerlocher team and using T-Blends to increase the oxidative induction time (OIT), melt stability and physical characteristics of various PCR/PIR resin sources."

Pet projects

Mondi has developed recyclable, high-barrier packaging for Norwegian pet food manufacturer Felleskjøpet, that keeps material in circulation and avoids waste.

Felleskjøpet is using Mondi's FlexiBag Recyclable, a pre-made mono-material polyethylene (PE) bag, for the relaunch of its Appetitt range of dry cat and dog foods. It will replace the previous multi-layer solution – and is recyclable in existing Norwegian plastic recycling streams.

Below: Felleskjøpet is using Mondi's FlexiBag Recyclable for its Appetitt range of pet foods

"This partnership was about designing appealing packaging, meeting the consumer need for convenience and product protection, and helping Felleskjøpet meet its sustainability goals," said Pal Wikstrom, sales manager for Nordic consumer flexibles at Mondi.

A slider enables easy opening and closing for bigger bags, while a handle allows for convenient transportation.

IMAGE: MONDI

Hege Rosenhaug, product and development manager for pet food at Felleskjøpet, added: "The pet food is protected and kept fresh by the new packaging. This is an important step in our journey towards being a more environmentally responsible organisation."

Similarly, **Dow** – with machine manufacturers **W&H** and **B&B** – has developed a recyclable, wide-format MDO-PE bag – which uses only polyethylene (PE) and a minimal layer of EVOH.

The product is aimed at pet food packaging. The challenge for recycling pet food packaging has been finding ways to maintain the efficiency of packaging production and its final qualities – while relying only a single material.

"Packaging recyclability is a challenge that no one company can do alone," said Romain Cazenave, packaging EMEA marketing director at Dow Packaging & Specialty Plastics. "Our Elite, Innate and Affinity resins and sealants have helped realise the next generation of recyclable packaging."

The film was produced on a W&H Varex II machine with inline MDO. It has a final web width of 2 x 1260 mm and is optimised to reduce material wastage during production. It was then laminated at industrial scale before being made into bags on B&B's side-gusseted SFB bag machine. This produced 80 bags per minute, which is comparable to multi-material PET/PE structures.

PP extension

Borealis has launched the first polypropylene (PP) grades based on its Borstar Nextension technology, which it says have superior properties for cast and blown film.

The two BorPure film grades – RB787MF and RE539MF – are designed for eco-efficiency and recyclability, says the company.

"Borstar Nextension technology will enable the development of novel and more circular solutions for a wide range of applications, especially in the packaging industry," said Erik Van Praet, vice president of innovation & technology at Borealis.

BorPure RB787MF and RE539MF are the first resins made using the technology, which is now being scaled up. They have been designed for use in flexible packaging applications such as highly transparent thermoformable films, and sheets and lamination films for pouches and lid films.

Blown film converters benefit from RB787MF's

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Right: Borealis says the first PP grades using its Borstar Nextension technology offer superior properties for cast and blown film

consistent film clarity at high extrusion throughput, low overall migration, low seal initiation temperature, and high seal strength. RE539MF provides cast film converters with benefits including transparency, high stiffness balance with thermal stability, low overall migration and clean surfaces. Other advantages include high packaging line efficiency, packaging integrity and good organoleptics, says the company.

IMAGE: BOREALIS

Design collaborations

At K2022, **ExxonMobil** demonstrated how its Exceed S performance polyethylene (PE) can be used in film design – through collaborations with several other exhibitors.

Producers have already commercialised bag-in-box liquid packaging, full-PE laminated food packaging and heavy-duty sacks for polymer resins, he said – and 80 projects are undergoing commercial-scale trials. Advantages of the material include its high stiffness and toughness – which help to simplify formulations, improve package durability and reduce film gauge.

The material was showcased on a number of stands at the show. Windmöller & Hölscher ran a five-layer, 40-micron collation shrink film containing 50% PCR. Exceed S 9243 and Enable 4002 were used to ensure that the film delivered acceptable holding force, stiffness, puncture and TD shrink.

In addition, Hosokawa Alpine featured Exceed S PE in high oxygen barrier concepts. These very high PE content (96-97%) MDO PE//PE laminates are alternatives to multi-material structures – which can be difficult to recycle. Exceed and Exact grades were used to deliver high stiffness and packaging integrity.

Below: Innovia's Rayoface CSA46 is aimed at food and beverage, household and personal care applications

IMAGE: INNOVIA

Cutting carbon impact

Innovia Films has developed Rayoface CSA46 – a clear, one-side gloss-coated BOPP film.

The product is aimed at food and beverage, household and personal care applications. The 46-micron film is around 10% thinner than most facestock films. This gives it a higher yield and reduces its carbon impact compared to thicker coated facestock films, says Innovia.

Rayoface CSA film is a high clarity, low haze film giving enhanced product visibility and a 'no-label look' appearance. It has a wide print window and is suitable for printing with flexo, gravure, screen offset and letter press – as well as with UV, low-migration and water-based inks.

"The performance of CSA46 means it has excellent cold foil adhesion and appearance, allowing eye-catching graphics and label designs," said Alasdair McEwen, product manager for labels.

TF-BOPE gets OK

SABIC says that Japan Steel Works (JSW) has validated the use of its LLDPE BX202 material – a linear low-density polyethylene (LLDPE) for processing on tenter frame extrusion equipment for biaxially oriented PE (TF-BOPE) packaging film.

The collaboration endorses the use of the material on JSW film lines, extends the machine supplier's reach into BOPE film for flexible packaging.

JSW has trialled the material on a pilot film manufacturing line in Japan, to prove its performance. The material combines processability with good mechanical and optical properties – including high transparency and superior impact strength, puncture resistance, tensile strength and stiffness compared to conventional blown PE film of equal thickness, says the company. This offers potential for downgauging and reductions in weight, material consumption and carbon emissions.

CLICK ON THE LINKS FOR MORE INFORMATION:

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Ocean Plastic
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Houston, TX, USA

Chemical Recycling
26-28 June 2023
Frankfurt, Germany

Plastics Sustainability Strategies
12-13 September 2023
Dusseldorf, Germany

Plastics Recycling Technology
10-12 October 2023
Vienna, Austria

Plastics Recycling World Expo
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RECYCLING

Phthalate plasticisers improve electrochemical recycling of PVC

Researchers at the University of Michigan in the USA have devised a way to recycle PVC electrochemically – using phthalate plasticisers within the material to drive the reaction.

"PVC is the kind of plastic that no one wants to deal with because it has its own unique set of problems," said Danielle Fagnani, co-author of a paper on the research in *Nature Chemistry*. "PVC usually contains a lot of plasticisers, which contaminate everything in the recycling stream and are usually toxic. It also releases hydrochloric acid really rapidly with some heat."

When PVC is mechanically recycled, the heat used in the process can cause plasticisers to leach out of the material and into the recycling stream, say the researchers. In addition, hydrochloric acid is released – which can corrode equipment and threaten worker safety.

IMAGE: DANIELLE FAGNANI

To find a way to recycle PVC that did not require heat, the researchers looked at electrochemistry – and found that the presence of plasticisers helped to improve the efficiency of the process.

"We found that it still releases hydrochloric acid, but at a much slower, more controlled rate," she said.

Using electrochemistry – rather than heat – introduces an electron into the system, which gives it a negative charge. This breaks the carbon-chloride bond in PVC, producing a negatively charged chloride ion. Controlling the rate at which electrons are introduced into the system helps to control how quickly hydrochloric acid is produced.

The acid produced can be used by industries as a reagent for other chemical reactions. The chloride ions can also be used to chlorinate small molecules called arenes – which can be used in pharmaceutical and agricultural components.

Fagnani says the study shows how scientists might think about chemically recycling other materials.

› **https://umich.edu**

MARINE PLASTICS

Manufacturing plastic from marine waste

LG Chem has entered into an agreement with Netspa to build a system that recycles marine waste into new plastics.

It will allow LG Chem to secure raw materials for its Seokmun National Industrial Park pyrolysis oil plant – which is scheduled to begin operations in 2024. Once Netspa sorts and processes plastics from marine waste, LG Chem will use it to make recycled plastics.

The companies hope the partnership will protect the marine ecosystem and reduce carbon emissions.

Around 50,000 tonnes of marine wastes – such as discarded fish nets – are generated every year in South Korea. However, collecting this is difficult and expensive. Therefore, most was uncollected – or incinerated.

The partners believe that plastics made in this way will have one-third the carbon emissions of a product made the conventional way.

› **www.lgchem.com**

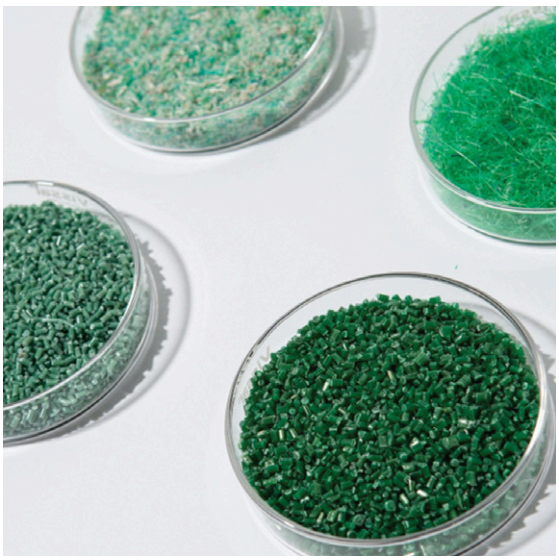

IMAGE: LG CHEM

CONTROL

Control system uses HMI to improve functionality

Davis-Standard has introduced its DS-XEL control system.

The system, which replaces mature discrete controls, implements high-performance HMI features to meet the data and process information needs of modern manufacturing, says the company.

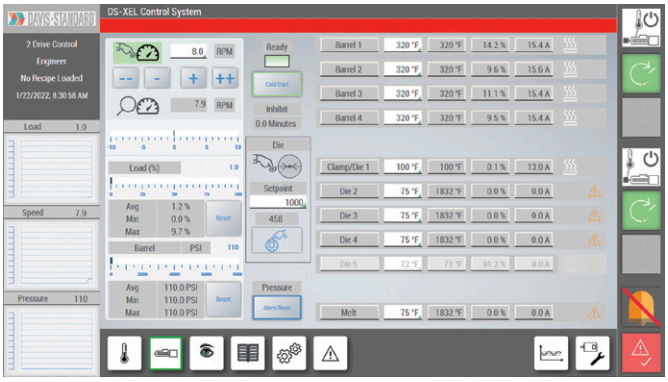

IMAGE: DAVIS-STANDARD

It focuses on active functions for a better operator experience and improved connectivity, according to the company. The DS-XEL will be the new standard control for Davis-Standard's Super Blue and HPE extruder lines and is compatible with the DS Activ-Check cloud-based platform. It is also available as an upgrade to existing extruder controls.

"This controller merges the latest PLC and HMI offerings to enable an operator-friendly package with greater attention to detail," said John Clemens, director of extrusion controls at Davis-Standard. "It also incorporates key features only available with larger system controllers for troubleshooting and process improvement."

The system shows on-screen graphic trending of essential extruder parameters, with visual tracking of temperature, barrel pressure, motor speed and motor load. Speed deviation from setpoint is displayed, along with an extruder maintenance run timer and heater zone alarms – indicating deviation, process temperature, power failure, heater load and sensor break.

Recipe creation and storage allows repeatability of multiple products on the same line. Other benefits include process alarm logging, real-time and historical data trending, auto and self-tuning of heat zones for quick die changes, and an on-screen display of individual zone heaters.

› **www.davis-standard.com**

PUMPS

Maag buys Witte Pumps

Maag has acquired Witte Pumps & Technology, a German developer and manufacturer of gear pumps and aftermarket parts.

Following the purchase, Maag will integrate Witte's gear pump operations with its own to create a combined Gear Pumps business unit. This will be led by Witte Gear Pumps managing director and former owner Sven Wieczorek.

"The acquisition of Witte represents a major step in making Maag the go-to partner for our customers' most critical and demanding gear pump needs," said Ueli Thürig, president of Maag.

He said the move would extend the group's product portfolio and geographical coverage.

› **www.maag.com**

› **www.witte-pumps.com**

ANCILLARIES

Heating up to high temperatures

IMAGE: TECHNOTRANS

Technotrans has launched a new oil temperature control unit.

Its Teco CT 130 Base 60 is compact and has high power density – offering temperatures up to 130°C and a heating capacity of 6 kW. Customised versions go up to 400°C and have a heating capacity of 750 kW

"By adding to our product series, we now offer an extensive portfolio of oil temperature control units with a temperature range of 130-350°C and a heating capacity of 4-54 kW," said Ralf Radke, head of the temperature control sector of Technotrans.

The unit has a recirculation rate of up to 60 litres/minute. Thanks to its integrated 'longlife' stainless steel heating cartridge, heat is transferred in a loss-free manner. In addition, multi-voltage variants from 400 to 460 V – as well as dual-frequency versions for use in 50 Hz and 60 Hz networks – are also available. A large heat exchanger surface provides a cooling capacity of up to 30 kW.

› **www.technotrans.de**

Download these new product brochures

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DIING KUEN: BLOWN FILM

In this brochure, Taiwan-based Diing Kuen provides all the specifications of its blown film technology to produce mono, two three, five and seven layers.. The film lines are divided into four categories: HTRL horizontal top rotating; EBLR vertical top rotating; BFL fixed; and other types.

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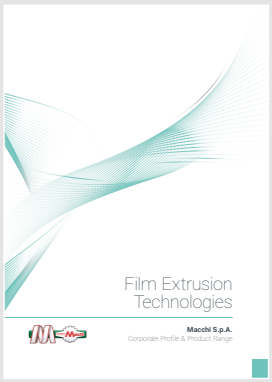
MACCHI: FILM EXTRUSION



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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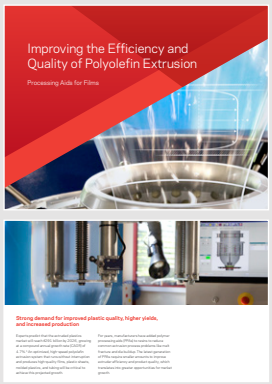
CHEMOURS: PROCESSING AIDS



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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HAN KING

Han King, based in Taiwan, has produced this brochure outlining its machines for blown film extrusion, covering five-layer film, three-layer co-extruded film, agricultural film, geomembranes; plus other products in stretch hood, lamination and bags.

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VAN MEEUWEN: ADDITIVES

Van Meeuwen's functional additive range for plastics film and sheet producers includes anti-blocks, anti-statics, anti-fogs and specialty fluids. Suitable for plastic packaging applications, products comply with EU food contact regulations.

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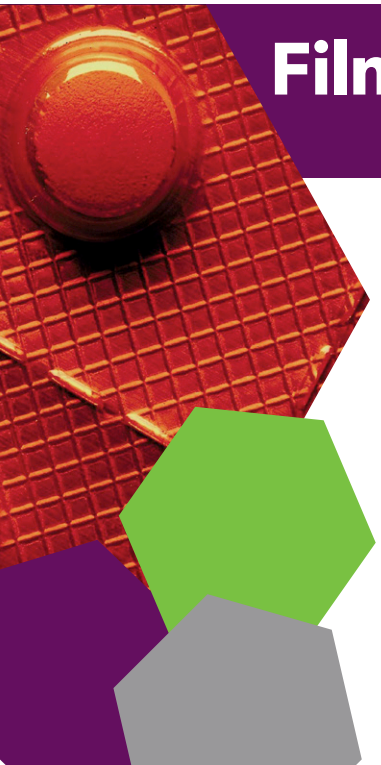
If you would like your brochure to be included on this page, please contact Claire Bishop claire.bishop@amiplastics.com. Tel: +44 (0)1732 682948

SB Packagings

Head office:	New Delhi, India
Managing director:	Amit Banga
Founded:	1989
Ownership:	Private
Profile:	SB Packagings was founded in 1989 by OP Banga. It is a leading manufacturer of both mono- and multi-layer flexible packaging. Its products include rolls, stand-up pouches and bags – and it claims to be India's largest manufacturer of polyethylene (PE) bags. The company supplies two main end markets – food and hygiene – and says it has more than a 50% of the hygiene packaging market in India, supplying companies including Procter & Gamble, Unilever and Tata.
Product lines:	The company supplies packaging in many hygiene applications including baby diapers, tissues and sanitary products. Its success here is partly due to printing ability – whether this is gravure printing on thin PE film, or using its flexographic technology. It also has in-house technology allowing it to make different types of hygiene packaging. In food packaging, it produces lamination pouches for dry goods, stand-up zipper pouches (with a high-barrier option), breathable bags (for fruits and vegetables) and specialist products for frozen foods and petfood.
Factory location:	Its production plant in New Delhi has a total capacity of 11,000 tonnes/year of blown film extruded products. The facility also includes rotogravure and flexographic printing lines, as well as lamination, pouching and bag-making capabilities. The company recently signed a joint venture agreement with Constantia Flexibles, which will see the companies extend further across India and South Asia.

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



Film and Sheet Extrusion FORTHCOMING FEATURES

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

March 2023
Thermoforming
Additives for film
Control & instrumentation
Barrier films

April 2023
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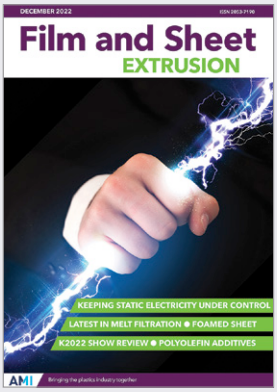

Film and Sheet December 2022
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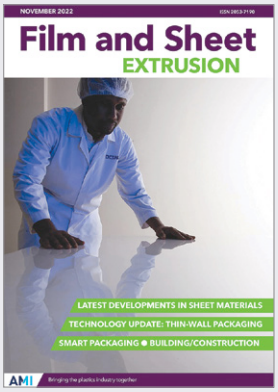

Film and Sheet November 2022
The most recent issue of Film and Sheet Extrusion magazine has a cover story that explores recent developments in the sheet sector. The November edition also has features looking at thin-wall packaging, plastics in construction and smart packaging.

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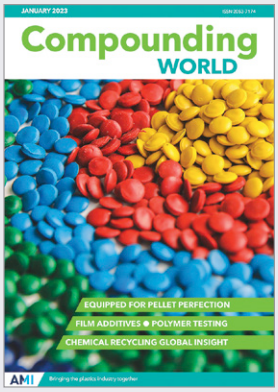

Compounding World January 2023
The January 2023 edition of Compounding World magazine starts the year off with a look at efficiency gains in new pelletisers, pellet inspection, additives for film production, and developments in polymer testing.

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Plastics Recycling World November/December 2022
This edition of Plastics Recycling World takes a look at the latest PET recycling equipment that was on show at K2022 in Germany. It also explores new EU regulations on food contact process authorisation and reviews progress in chemical recycling.

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Pipe and Profile January/February 2023
The January-February edition of Pipe and Profile Extrusion has a cover feature on the diverse applications for pipes made with composite materials. The magazine also has features covering melt filtration, titanium dioxide and the latest in controls and instrumentation.

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Injection World January/February 2023
The first 2023 edition of Injection World magazine looks at the latest developments in thermoplastic composites. It also explores the latest granulator introductions and highlights some of the newest materials for the demanding medical sector.

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2023

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23-26 May	Plastpol, Kielce, Poland	www.targikielce.pl/en
30 May-2 June	Equiplast, Barcelona, Spain	www.equiplast.com
5-8 September	Plast 2023, Milan, Italy	www.plastonline.org/en
26-28 September	Interplas, Birmingham, UK	www.interplasuk.com
17-21 October	Fakuma, Friedrichshafen, German	www.fakuma-messe.de
7-10 November	Plastimagen, Mexico City, Mexico	www.plastimagen.com.mx
8-9 November	Plastics Extrusion World Expo USA, Cleveland, USA	www.extrusion-expo.com/na/
28 Nov-2 Dec	IPF Japan 2023, Chiba, Japan	https://www.ipfjapan.jp/english/

AMI CONFERENCES

22-23 February 2023	Stretch & Shrink Film Asia, Bangkok, Thailand
6-8 March 2023	Agricultural Film Europe, Barcelona, Spain
20-22 March 2023	Plastic Pouches Europe, Barcelona, Spain
18-20 April 2023	Stretch & Shrink Film Europe, Valencia, Spain
20-21 June 2023	Thin Wall Packaging North America, Chicago, USA
15-16 August 2023	Agricultural Film North America, Houston, USA
26-28 September 2023	Biax Film Europe, Brussels, Belgium
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Chemical Recycling

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Chemical Recycling
GLOBAL INSIGHT 2023

Letter from the Editor

Welcome to Chemical Recycling Global Insight 2023, a special publication written and produced by AMI Magazines, with support from AMI Consulting. This takes the story forward from the 2022 publication a year ago, updating news and information on the evolving chemical recycling industry.

The opening article is written by Silke Einschuetz, the chemical recycling specialist in our consulting team, who draws on the knowledge she has gained in preparing an in-depth 2022 report for AMI to present the challenges currently facing the industry.

Included are informative articles on: the various technologies used in chemical recycling, including their differences and relative advantages; a model pyrolysis feedstock specification which aims to improve the quality of input material; and mass balance, as applied in chemical recycling.

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.

David Eldridge – Editor
AMI Magazines

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IMAGE: SHUTTERSTOCK

Chemical recycling issues, such as feedstock availability, echo some of those in mechanical recycling. ***Silke Einschuetz****, author of AMI Consulting's Chemical Recycling Global Status 2022 report, writes about the challenges for the industry*

An assessment of the industry's challenges

Mechanical recycling of plastics has recorded significant growth over the past years, but it comes with technical and legal limitations especially where more highly contaminated material streams are concerned. In particular:

- it has limitations regarding the types of polymers and formats it can process (for example, flexible films, multilayer structures);
- the quality of the polymer deteriorates with each recycling cycle leading to losses in material properties and build-up of additives and other contaminants;
- legal frameworks do at present put strict limitations on the mechanical recycling of materials to be used for food contact applications.

In addition, it is becoming increasingly clear that the volumes of recyclate required because of legislative targets and voluntary brand commitments cannot be delivered by mechanical recycling alone within the given time frame.

Chemical recycling is thus considered as a complementary technology to mechanical recycling to meet legislative targets and voluntary pledges, and to accelerate the transformation to a more circular economic model. It enables the recycling of plastic materials that cannot currently be mechanically recycled, including contaminated, multi-layer and mixed plastics, and some food contact materials.

Based on AMI's research, global installed input capacity for chemical recycling in 2022 was 1.2m tonnes, forecast to increase to 8.7m tonnes by 2030. Pyrolysis is forecast to account for 46% of installed input capacity by 2030.

Four chemical recycling technologies are present in the market landscape today, together with a number of 'other' technologies which to date do not neatly fit into a defined category. (also see Technologies article p9). They differ in the types of polymers they can process, the outputs they produce, and the stage of maturity the facilities present in the market have achieved to date. ›

Chemical and mechanical recycling both have the goal of producing quality products

In its report *Global Plastics Outlook: Policy Scenarios to 2060,* the OECD describes plastic pollution as one of the great environmental challenges of the 21st century. Under current policies the report states that, by 2060, both the use of plastics and the amount of plastic waste could almost triple globally, with half of all plastic waste still being landfilled and less than a fifth recycled.

Feedstock questions

Theoretically, there should thus be plenty of feedstock available for both mechanical and chemical recycling. The challenges lie in the fields of waste collection and sorting – only plastic waste that is collected and, at the same time or in a subsequent step, separated from non-plastic waste and sorted and cleansed is available for recycling processes. Feedstock sourcing can thus be challenging for both mechanical and chemical recycling facilities, with the extent of the challenge growing with a facility's input capacity (also see Feedstock article p16).

Several factors combine to make feedstock sourcing challenging, with the extent of the challenge growing with a facility's input capacity. Closely related to models of feedstock sourcing is the establishment of feedstock aggregation centres and preparation facilities which ensure that feedstock is of the required specification when it enters chemical recycling plants. The development of these facilities has emerged as a clear industry trend during 2022.

Depolymerisation plants and providers of solvent-based purification/dissolution technologies, with some exceptions, tend to design facilities with more moderate annual feedstock volume requirements, as the need to be more selective in the feedstocks they can process presents additional feedstock sourcing challenges. In contrast, some pyrolysis and gasification plants are designed at larger capacities, based on their claim to be able to process a more diverse mix of plastic waste and thus encountering fewer challenges in accessing suitable feedstocks.

When looking at facilities' capacities it also must be considered that feedstock volumes in excess of stated capacities must be sourced to account for feedstock loss during the material preparation process. In any case, chemical recyclers need to make the securing of sufficient feedstock supplies a key focus for their activities, with investors demanding evidence of feedstock security as one of the criteria when making investment decisions. Key questions to be asked include the following:

Volumes – How much feedstock is required for a given time period as well as for the years ahead based on any capacity expansion plans?
Security of supply – How secure are the volumes available from the feedstock sources/suppliers under consideration going forward, which contractual arrangements are necessary to secure supplies?
Composition – How much detail is available on feedstock composition and how homogenous are the volumes delivered over a course of time?
Pre-processing – How much pre-processing is required (sorting, cleaning etc)?
Cost – Is there a cost or a revenue stream associated with feedstock sourcing?
Logistics – Over what distances does the feedstock have to be transported and at what cost?

Despite chemical recyclers' pledges to focus on feedstock not suitable for mechanical recycling, at present, no clearly defined line can be drawn between feedstocks going to mechanical recycling and those targeted by chemical recyclers. As a result, concerns have been raised within the industry about the growing feedstock requirements of the chemical recycling industry creating competition for feedstock with mechanical recyclers.

At AMI Consulting, our detailed assessment of chemical recyclers' feedstock requirements by technology suggests that market forces – developments in the pricing of different types of feedstocks – will have their part to play in deciding which feedstocks will be accessible to the different elements in the recycling industry.

Regarding chemical recycling outputs, the mass balance approach is intended to provide a set of rules for how to allocate recycled content to different end products to be able to claim and market the content as "recycled", especially where pyrolysis technology is used (also see Technologies article). Ultimately, the amount of recycled feedstock that enters a steam cracker needs to equal the amount exiting it, thus providing a means to estimate the average recycled content in a product.

Regional differences

The development of the chemical recycling industry differs between regions across the globe. Europe is at present considered to be at the forefront of technological developments in chemical recycling technology. Combined with a better developed collection, sorting and recycling system and the presence of a variety of research centres and grant funding it has been leading the industry so far. Over coming years, developments in North America are,

however, forecast to accelerate at a faster pace.

South-East Asian markets are attractive for the industry owing to a large and growing population and the associated volumes of post-use plastics. Waste collection and sorting infrastructures do, however, remain largely underdeveloped and, with a few exceptions, there is an initial focus on mechanical recycling.

Approaching the last quarter of 2022, the chemical recycling industry had reached a significant threshold. Following many years of developments and announcements the first commercially active facilities are operating, and a significant number of plants are scheduled to start fully commercial operations imminently and during 2023. Even larger capacities are in the pipeline and scheduled to become operational during the forecast period to 2030.

Across the industry, there appears to be the perception that the time has come to deliver on the multitude of announcements made over recent years. Supply chain partners and investors are keen to see facilities starting fully commercial operations, proving that the relevant technologies can be scaled up to operate in an efficient and financially viable manner in the long term. Evidence that they can do so is, in many cases, still outstanding. The same applies to claims relating to carbon footprints, energy efficiency, risks to human health, and environmental externalities.

Lock-in effect?

Many concerns associated with the growing industry are related to the perception that it, together with other (re)-emerging technologies such as, for example, carbon capture and storage, attempt to offer a technological fix to the world's problems of high carbon emissions and plastic pollution, while otherwise business continues as usual.

A particular concern is that investments into what is a capital-intensive industry will potentially divert attention away from reducing virgin plastic production and plastic waste generation by creating a "lock-in effect" to an industry and supply chain that relies on a growing stream of waste plastic material for its operations.

It is for the chemical recycling industry to show, verified by independent third-party bodies, that it can deliver on its claims and promises without creating the lock-in effects outlined above, and by operating as a complementary technology to mechanical recycling, itself an industry characterised by innovations and advancements for the processing of a growing range of post-use plastics.

What is of concern in the ongoing debate around chemical recycling technology is the strong polarisation of opinions. While some proponents of the associated technologies praise their capabilities and promise the "biggest", "most efficient", "lowest CO2 footprint" plant which will contribute to solving the shortage of recycled material, opponents are quick to condemn "chemical recycling" as if it was one single technology, often with the claim that it involves "burning plastics".

Neither of these two positions is helpful. Overpromising and neglecting the (in some cases) justified concerns regarding facilities' externalities has the potential to damage the chemical recycling industry overall, while point blank criticism disregards the valuable contribution chemical recycling technologies can make in treating previously non-recyclable material streams.

Rather than focusing on the potential competition between two sets of technologies, each of which will need to play its part in improving recycling rates, a whole system approach to waste management and recycling needs to be developed. For this to happen, the focus of attention needs to shift to the ways in which waste material streams are being managed today. This would see the waste management industry evolving from a system that channels significant volumes of unsorted waste into landfill and incineration solutions, towards a system that aims to bring as many materials as possible back into circularity in a clear and decisive recognition of post-use plastics as a valuable resource rather than waste.

In many cases, this will require letting go of long-established vested interests and solidified structures of managing waste, and to move towards a higher level of co-operation and partnerships with the common goal of turning waste into valuable resources.

About the report

AMI Consulting's recently published ***Chemical Recycling Global Status 2022*** consists of two parts: a PDF report and an interactive Excel file. The file lists 181 chemical recyclers and their 456 sites. For each site, AMI analyses feedstock supply and offtake agreements. It provides a view of chemical recyclers' partnerships along the value chain at site level, putting their operations into the context of a network of industry relationships, investors, feedstock suppliers, technology partners, and buyers. The data includes available input capacity by region, technology and polymer to 2030.

To find out more about the report and how to purchase it, contact **astrid.dellaporta@amiplastics.com**.

Contact the author of the report, AMI consultant Silke Einschuetz, at **silke.einschuetz@amiplastics.com**.

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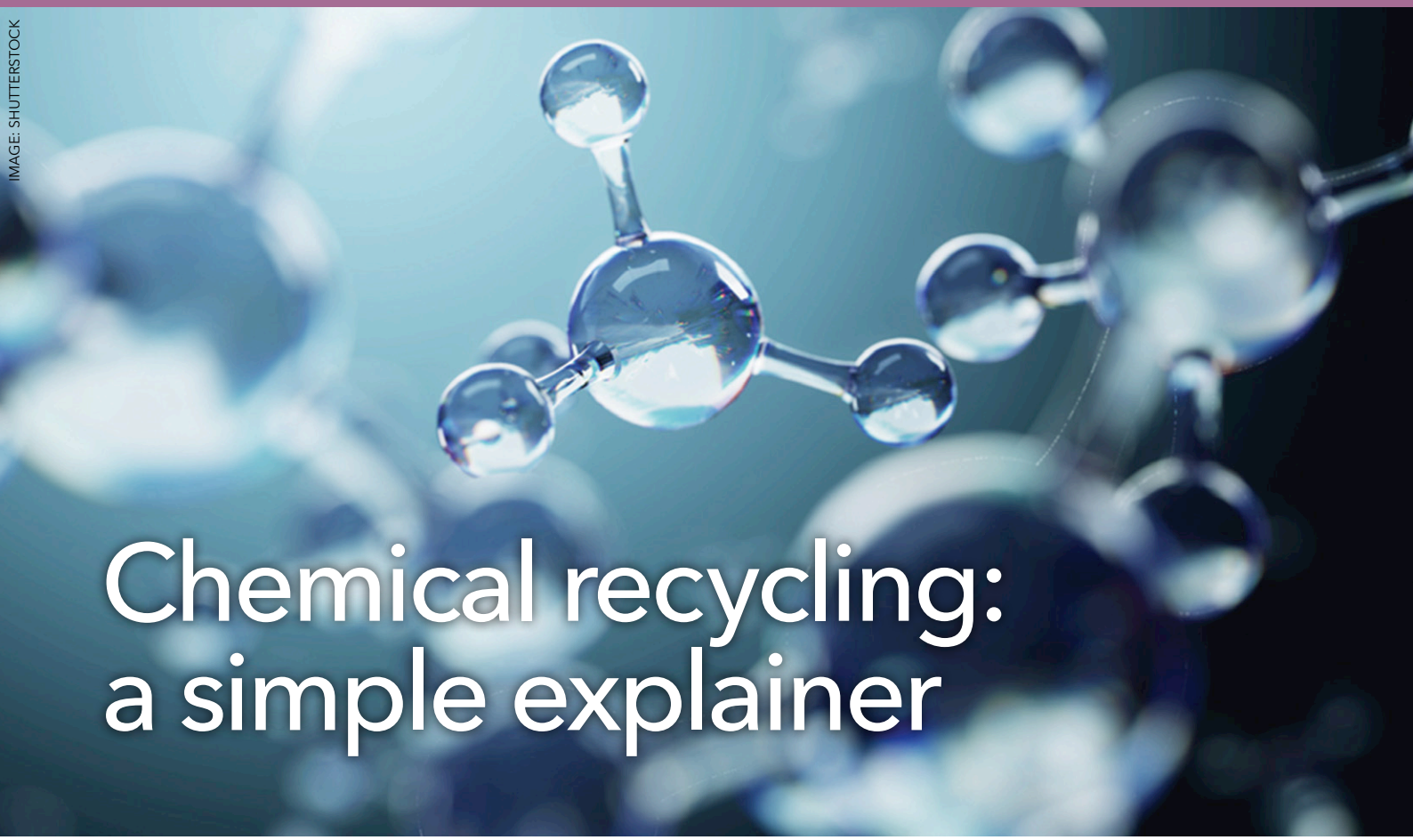

IMAGE: SHUTTERSTOCK

Chemical recycling: a simple explainer

Chemical recycling is a simple term encompassing a wide variety of technologies. ***Chris Smith*** *discusses the key features*

Chemical recycling – referred to as advanced recycling by some – is a simple name that brings together a quite broad portfolio of technologies, not all of which are, strictly speaking, chemical in nature. The first three most certainly are: depolymerisation, pyrolysis and gasification. The fourth – dissolution – does not fall so clearly into the "chemical" classification but is arguably much closer in process terms than it is to established mechanical recycling.

Depolymerisation is clearly a chemical recycling process, typically making use of heat and selected catalysts or enzymes to convert polymer back to building block monomers. It is most suitable for use with step-growth polymers such as PET, which are polymerised by polycondensation. A number of companies are developing processes to depolymerise PET, with pilot projects underway from Carbios in France, CuRe Technology and Ioniqa in the Netherlands, Rittec in Germany, and Eastman in the US.

Depolymerisation of polycondensation polymers generally involves reintroducing the molecular component eliminated during the original polymerisation process. Several solvolytic processes are being investigated to do this, including hydrolysis, glycolysis, methanolysis and transesterification. They involve multiple process steps including 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 depolymerisation technologies that have been shown to be capable of converting PS polymer back to styrene monomer at pilot scale.

Depolymerisation technologies produce new polymer of virgin quality. However, the chemistry used is highly specific so the incoming stream has to be consistent in terms of polymer composition, meaning considerable cost may be incurred in pre-sorting. Process energy requirements can also be quite high.

Pyrolysis is a thermal cracking technology that converts waste plastic – and contaminants that 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). It involves heating the pre-sorted and shredded waste to temperatures of 400-600°C in an oxygen-free system to produce

Main image: Chemical recycling technolgies include numerous processes with very different inputs and outputs

IMAGE: TOTALENERGIES

Above: TotalEnergies is to take feedstock from a 30,000 tonne/yr Honeywell pyrolysis-based recycling plant, under construction in Spain

a range of hydrocarbons. These include gases, waxes, oils and char. As in conventional oil cracking, the yields of each component can be controlled to some extent by adjusting temperature, pressure, and residence time, as well as through the use of particular catalysts and thermal profiles.

Pyrolysis takes place in the absence of oxygen, so 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 mixed polymer waste streams that would be highly challenging for mechanical or depolymerisation chemical recycling methods. However, it is an energy intensive process and the quality and mix of output materials is still dependent to some extent on the input stream. Much of the gas and liquid output from pyrolysis operations is likely to be burnt as fuel, either to provide energy for the process itself or because it is not of sufficient purity to be used as a chemical feedstock. Many of the companies active in this area prioritise conversion to fuel products but, under some regulatory and accreditation regimes, this is not recognised as recycling.

Key players in the development of pyrolysis technologies include Luxembourg-headquartered Clariter, Plastic Energy in the UK, Quantafuel in Norway, Encina, Nexus Fuels and Alterra Energy in the US, and GreenMantra Technologies in Canada.

Gasification is also a thermal cracking process but it differs from pyrolysis in that it is performed in the presence of a limited but controlled amount of oxygen. It can process almost any organic material – including plastic waste and biomass – and unlike pyrolysis can, in theory at least, accept polymers containing oxygen or halogens. The end result is predominantly syngas that, depending on its composition and purity, can provide production feedstocks.

Compared to pyrolysis, gasification requires fewer process steps. Pre-treatment of the waste (including water removal) is followed by the gasification step and then a cleaning stage to remove contaminants such as ammonia, H_2S, alkali metals, NO_x and tars. Like pyrolysis, it is an energy intensive process involving temperatures of 900°C or more and a significant part of the conversion output is used for energy.

Gasification technologies are under development for plastic waste applications by, among others, Enerkem in the Netherlands, Eastman in the US, and Showa Denko and Sekisui/Sumitomo in Japan.

Dissolution differs from depolymerisation, pyrolysis and gasification in that the plastic waste is not chemically converted to a new form but is dissolved in a carefully-selected solvent that allows fillers, pigments and other contaminants – potentially including secondary polymers – to be separated out.

Proponents of dissolution emphasise that the polymer undergoes a physical, rather than chemical, change and use terms such as solvent-based purification. However, it is clearly not a mechanical recycling process and, if for no other reason than its emergence as a recycling contender at the same time as chemical-based technologies, is usually considered as a chemical recycling process.

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 PP with a technology licensed from P&G while Canada's Polystyvert is focusing its efforts on PS. Germany's APK is exploring technology to recover LDPE and PA from multi-layer films. And Fraunhofer's CreaSolv process is being further developed by CreaCycle in Germany and its PS Loop project in the Netherlands.

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

What's new in chemical recycling projects

IMAGE: TOTALENERGIES

The chemical recycling industry continues to be very active in construction, with progress made in pilot and production projects and the launch of major new investments.

Spurred by regulatory pressure and sustainability targets, the sheer number of chemical recycling projects entering the planning and development stages was evident in 2021 and continued through 2022. What follows is a round-up of recent developments around the world.

At the start of 2022, **Plastic Energy** announced its intention to build a second chemical recycling plant in Sevilla, Spain, which will transform end-of-life plastic waste into a feedstock called Tacoil using its patented recycling technology based on pyrolysis. **TotalEnergies** will use this feedstock to produce virgin-quality polymers. The new plant will process up to 33,000 tonnes/yr and is expected to be operational in early 2025.

In what proved to be a busy period for the French oil and energy company, shortly afterwards TotalEnergies entered into a commercial agreement with **New Hope Energy** under which the US company would build a pyrolysis plant in Texas to transform end-of-life plastic waste into feedstock. TotalEnergies has committed to purchase 100,000 tons/year of output. The plant is due to start operations in 2025. New Hope Energy's first plant, which has been operating in Tyler, Texas, since 2018, is currently undergoing an expansion which would make it the largest pyrolysis facility in the world.

In January, plastic feedstock management company **Cyclyx** (a consortium led by Agilyx) signed an agreement with **ExxonMobil** and **LyondellBasell** to develop a new $100m plastic waste sorting and processing facility in the Greater Houston area dubbed the Cyclyx Circularity Centre. The plant will produce feedstock for both mechanical and chemical recycling, and also use new and emerging technologies to analyse plastics based on their composition and sort them according to customer specifications. Engineering work has already begun with commercial start-up expected in 2024.

Pure Cycle Technologies received a financial boost after it made a $250m private placement of common stock and warrants to shareholders in March and welcomed new investor **SK Geo Centric,** which will support construction of its solvent-based PP recycling facility in Augusta, Georgia, US.

Eastman announced in January it was planning to invest up to $1bn in a material-to-material molecular recycling facility in France using its polyester renewal technology. The multi-phase project would include units to prepare mixed plastic waste for processing, a methanolysis unit to depolymerise it, and polymer lines to create a variety of materials for specialty, packaging, and textile applications. The plant, along with a new innovation centre, is expected to be operational by 2025.

In a significant development for chemical recycling in Asia, **Agilyx** and **Toyo Styrene** announced they would be entering into the construction phase of a large-scale project in Japan. Using Agilyx's depolymerisation technology, the plant will convert post-use polystyrene into styrene monomer purified using Toyo's proprietary purification process. The monomer produced can then be converted into high value polystyrene products.

LG Chem made a sizeable equity investment in **Mura**, which in 2021 announced a high-profile

Main image: TotalEnergies has production projects with partners in Europe and USA

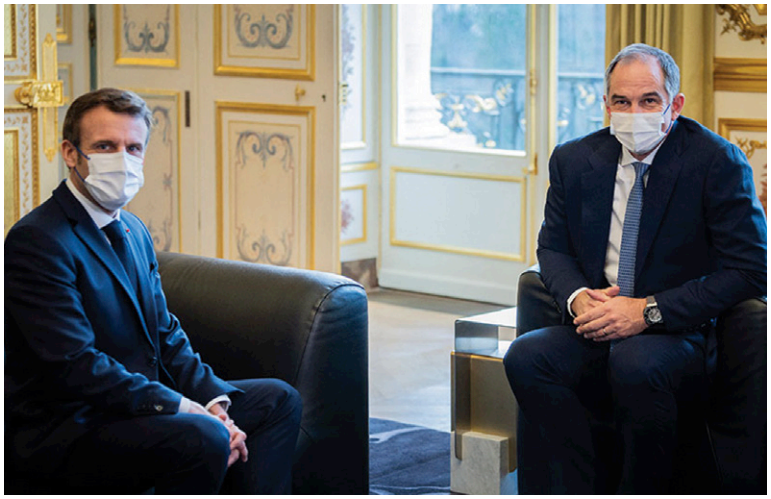

IMAGE: ELIOT BLONDET/ABACAPRESS.COM

Above: French President Emmanuel Macron (left) and Eastman CEO Mark Costa jointly announced Eastman's plan to invest up to $1bn in a recycling facility in France

partnership with **Dow**, and purchased a process licence from Mura's partner KBR to use Hydro-PRT technology in a hydrothermal upgrading facility in South Korea to recycle up to 25,000 tonnes/yr. A new Mura plant situated at Dow's Böhlen site in Germany is set to become the latest in a series of planned projects around the world designed to rapidly scale chemical recycling technology. The facility, expected to be operational by 2025, would deliver approximately 120,000 tonnes/yr at full run-rate. This and the other planned units could collectively add as much as 600,000 tonnes/yr of capacity by 2030.

Honeywell is forming a joint venture with **Avangard Innovative** to co-own and operate a chemical recycling plant within Avangard's NaturaPCR complex in Waller, Texas. This will use Honeywell's UpCycle Process Technology, a pyrolysis-based technology that Honeywell launched in 2021. The planned facility will have the capacity to transform 30,000 tpa and production is expected to begin in 2023.

Honeywell also signed a MoU with Egypt's **Environ Adapt** for **Recycling Industries** to explore the possibility of opening the first UpCycle-equipped facility in the country. The MoU enables Environ to conduct a feasibility study to explore trends, feedstock availability and potential markets, as well as perform technical studies pertaining to the operation of the plant and produce an overall project schedule.

US chemical recycling company **Encina** secured $55m of equity capital with participation from **IMM Investment Global** and **SW Recycle Fund**. It said it would use the funds, in addition to $20m in secured equity financing it had previously acquired, to move forward with the commercialization of its plastic waste-to-aromatics recycling business. Encina's current planned projects include facilities in the US and offshore projects in Asia and South America. Each plant is expected to process approximately 450,000 tonnes/yr of waste.

Early in 2022, **Neste** conducted a feasibility study to examine capacity for pre-treatment of liquefied waste plastic at its refinery in Porvoo, Finland. By mid-July it had secured a positive grant decision for up to €135m from the EU Innovation Fund for what by then was known as the Pre-treatment and Upgrading of Liquefied Waste Plastic to Scale Up Circular Economy (PULSE) project.

Neste also purchased European rights to **Alterra Energy**'s liquefaction technology, having acquired a minority stake in the US company in 2020, and will use it at the plant they are constructing with **Ravago** in Vlissingen, Netherlands, announced in October 2021.

Südpack and **Clean Cycle** signed an agreement for a long-term investment in **Carboliq** technology developed by **Recenso.** The catalytic tribochemical conversion process has been successfully used on mixed waste plastics at a pilot plant in Ennigerloh, Germany.

In Spring, **Toray Films Europe** and **Axens** announced a collaboration to study a potential PET chemical recycling plant in Saint-Maurice-de-Beynost, France. This would use Axens' Rewind PET depolymerisation process with purification steps to remove organic and inorganic compounds in waste PET, including colorants and pigments.

Norwegian chemical recycling company **Quantafuel** and French investment firm **Eurazeo** made an agreement to build a 50/50 sorting facility in Esbjerg, Denmark. The plant, based around a high-tech sorting system capable of separating plastic waste into mono fractions, will have 160,000 tonnes/yr capacity and be operational by the second half of 2023.

Ineos Styrolution signed an offtake agreement with **Indaver** in June to access styrene monomer recovered from waste yoghurt pots using the latter's depolymerisation technology. Indaver is building a plant in the Port of Antwerp, Belgium which is expected to recycle 65,000 tonnes/yr from 2024.

In a development that broadens its circular products offering, **Borealis** introduced its Borvida portfolio of circular base chemicals. The range will initially be based on non-food waste biomass and chemically recycled waste, and in the future will also draw from atmospheric carbon capture. The range will offer base chemicals or cracker products such as ethylene, propylene, butene and phenol with ISCC Plus-certified sustainable content from Borealis sites in Finland, Sweden, and Belgium.

In July, London-based clean tech company **Itero** announced that it had secured €6m (£5m) in funding to design and build its first demonstration

plant at the Brightlands Chemelot Campus in the Netherlands and awarded the construction contract to US engineers Fluor. The plant will employ Itero's patented modular technology based on pyrolysis to convert 27,000 tonnes/yr of plastic waste into oils, waxes and gas.

Valoregen is building what it says will be the largest hybrid recycling site in France combining mechanical and chemical recycling at a location in Damazan. It is hoped bringing these technologies together under one roof will minimise waste and increase energy efficiency. When it opens at the end of Q1 2023, the facility will have the capacity to process up to 70,000 tonnes/yr.

In late August, **Technip Energies** and Agilyx announced the launch of TruStyrenyx, an all-in-one solution for the chemical recycling of polystyrene combining Agilyx's pyrolysis process and Technip's purification technology. This launch followed favourable results from pilot plant testing conducted on various types of waste polystyrene including samples laden with flame retardant.

A collaboration between **Clariter**, **BioBTX**, **Bollegraaf**, and **N+P** unveiled in the autumn will see the construction of what is described as Europe's largest and most advanced chemical recycling sorting plant at Delfzijl in the Netherlands. With a capacity of 350,000 tonnes/yr, the facility will target the lowest-grade plastic waste and is expected to come online by 2025.

KTS, a Koch Engineered Solutions company, and **Ioniqa**, announced a partnership to scale up and commercialize Ioniqa's PET depolymerisation technology. As part of this collaboration, KTS committed to investing up to €30m.

In September, LyondellBasell announced the successful start-up of its MoReTec pyrolysis-based recycling pilot facility at its Ferrara, Italy, site. Then in October, it signed an agreement with **23 Oaks Investments** to create Source One Plastics, a joint venture to build an energy efficient sorting and chemical recycling facility at the Wesseling site in Germany. The final investment decision for the proposed 50,000 tonnes/yr plant is set for the end of 2023.

IMAGE: CARBOLIQ

Above: Carboliq technology

SK Innovation announced it will invest around $1.2bn to build a multi-process chemical recycling plant at its facility in Ulsan, South Korea. The complex could have a capacity of 250,000 tonnes/yr, and will include high-purity polypropylene extraction, PET depolymerisation and pyrolysis. Construction is scheduled to begin in September 2023.

At the K Show in October, **Sabic** presented a video celebrating the one-year construction milestone of the site it is building with Plastic Energy in Brightlands Chemelot, the Netherlands, known as SPEAR-SABIC Plastic Energy Advanced Recycling BV. The plant, which will produce ISCC-accredited circular polymers, is on schedule for an official opening in Q2 2023.

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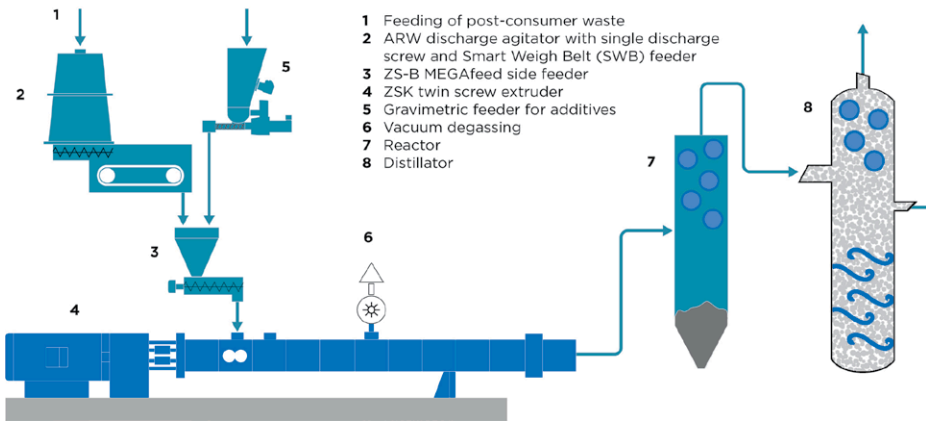

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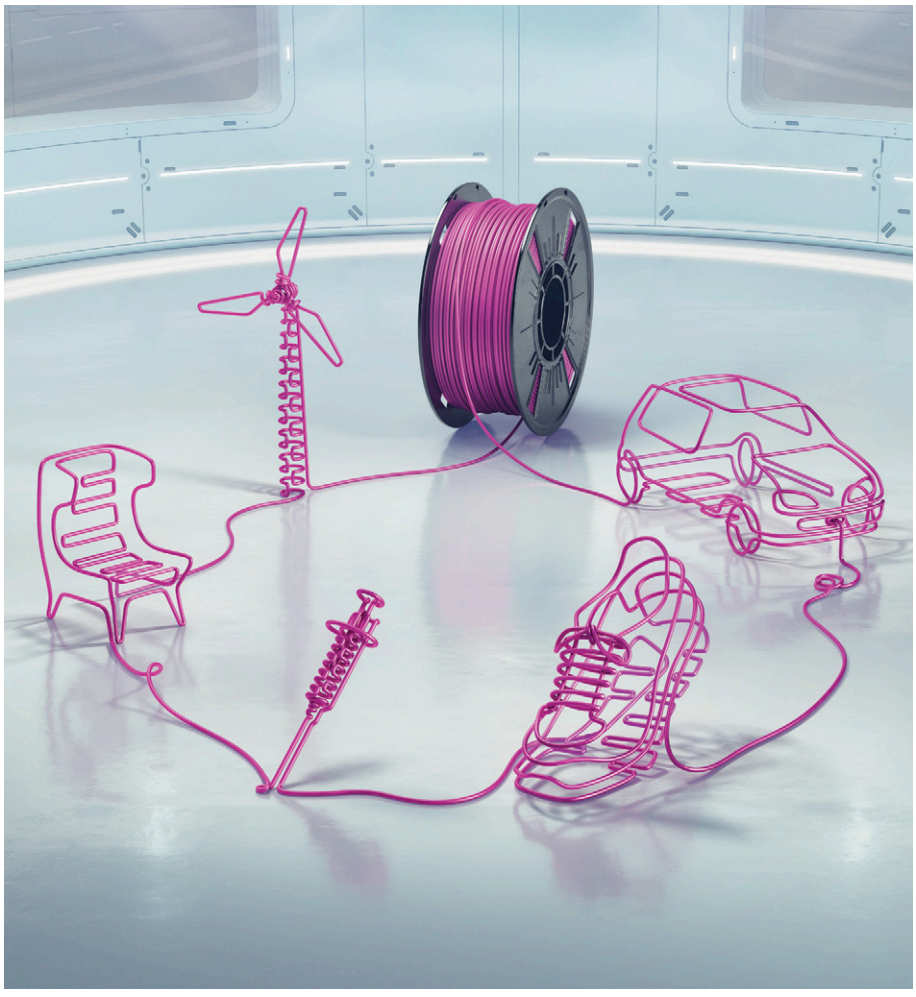

Every Circle needs a Center: Evonik Center for Circular Plastic Solutions.

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IMAGE: SHUTTERSTOCK

Improving pyrolysis feedstock quality

A model specification has been published showing contamination limits for waste input to pyrolysis processes

Pyrolysis recycling of mixed plastics waste requires feedstock with a consistently low level of contaminants, just as mechanical recycling does. Poor quality input results in poor quality pyrolysis oil output. The subject of input quality has been under the radar until recently but is gaining prominence as pyrolysis plant operators discuss their feedstock needs with waste suppliers during pre-commercial development projects.

"Improving our knowledge of feedstock requirements for pyrolysis can help progress the industry's understanding of how chemical recycling and mechanical recycling can work alongside each other," said Martyn Tickner, Chief Advisor of the Technical Solutions Centre at the Alliance to End Plastic Waste. In August, the alliance published a white paper commissioned from Eunomia which provides guidelines for a pyrolysis feedstock model that can be used in supply discussions.

The report *Feedstock Quality Guidelines for Pyrolysis of Plastic Waste* is based on interviews with 32 companies and organisations in Asia, North America and Europe. It finds that pyrolysis operators generally require well-sorted, clean feedstock comprising about 85% PE and PP. Moisture limits of around 7% are recommended and the report includes indicative thresholds for contaminants, such as PVC, PS and multilayer film barrier materials PET, PA and EVOH.

The model feedstock specification in the report allows a maximum of 1% contamination from PVC and PVDC films, as they introduce chlorine atoms

Model pyrolysis feedstock spec

Items made of PE and PP such as containers, trays, cups, films, and bags.

Minimum 85% PE or PP

Maximum moisture content: 7%

Maximum total contamination: 15%

The following individual contaminants must not be present in amounts exceeding their specified thresholds, and the combined presence of all contaminants should not exceed 15%:

PVC/PVDC: 1%

PET/EVOH/Nylon: 5%

PS: 7%

Rigid metal/glass/dirt/fines: 7%

Paper/organics: 10%

Source: Alliance to End Plastics Waste

into the pyrolysis process which can cause corrosion to equipment and persist into the pyrolysis oil as heteroatoms (atoms of any element other than hydrogen or carbon). The potential for chlorine damage led several operators to express a near-zero tolerance for PVC/PVDC, although others indicated a threshold higher than 1%.

The model contamination limit for PS is 7%. The report says: "Polystyrene is generally not viewed as a prohibitive contaminant, and one operator even expressed a preference for using measured amounts of polystyrene as a process aid. Nonetheless, it is common for pyrolysis operators to set limits on the amount of polystyrene in their feedstock."

The materials used in multilayer films are particularly problematic. The model specification places a 5% limit on contamination from PET, PA and EVOH. Oxygen atoms in the feedstock results in oxygenated products, which reduce yield and negatively impact the quality of pyrolysis oil. Also, some more complex hydrogen-carbon structures, such as PA and PET, do not break down as easily as those of PE and PP, and some by-products of their decomposition act as impurities in the finished product.

"Offtakers can accommodate these impurities by diluting the product with larger volumes of virgin hydrocarbons, using the product for lower-grade applications such as fuel, or conducting hydrotreatment, in which hydrogen atoms are reacted with the product to chemically combine with impurities, facilitating their removal. Hydrotreatment can also be done by the pyrolysis operator prior to the offtaker, but this is rare and generally viewed by pyrolysis operators as being cost-prohibitive," the report says.

A 7% contamination limit applies to metal, glass, dirt and fines. The main problem with these contaminants is their abrasive effect on process equipment. As they are relatively heavy, they can also increase costs as input feedstock is typically purchased on a per-unit-weight basis. Pyrolysis operators did not express any specific concern about the aluminium used in laminated packaging.

Responding companies gave a fairly broad range of thresholds for contamination by paper and organics, and the report suggests a 10% limit. Post-pyrolysis refinement can remove impurities, such as by-products of hydrogen, present in the oil. Hydrotreatment, for example, is a process in which hydrogen atoms are reacted with the product to chemically combine with impurities, facilitating their removal. But, as the report points out, hydrotreatment plants are high-cost and are therefore ruled out by pyrolysis operators.

The report concludes that both mechanical and pyrolysis recycling operators require well-sorted, clean and largely homogenous feedstock, but a difference is that pyrolysis operators can take a mix of polyolefins and colours and have a different set of considerations surrounding contaminant threshold limits. One development that would benefit both mechanical and pyrolysis recycling, it says, is changing packaging design to reduce the number of materials. This has started to happen with the launch of mono-material films designed to substitute widely-used multilayer polyolefin films.

The report says the model feedstock specification describes a recycling stream that does not exist at scale today. It says it is important to understand what barriers exist to creating that stream, and to find solutions that take into account existing feedstock streams for mechanical recycling.

It is expected that some operators will have different tolerances to the thresholds in the model feedstock specification. This is similar to feedstock specifications for mechanical recyclers where each recycler has its own process and value considerations. The report also notes that many pyrolysis operators are in early stages of refining and optimising their processes, and their feedstock requirements are likely to evolve over time.

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Understanding mass balance as used in chemical recycling

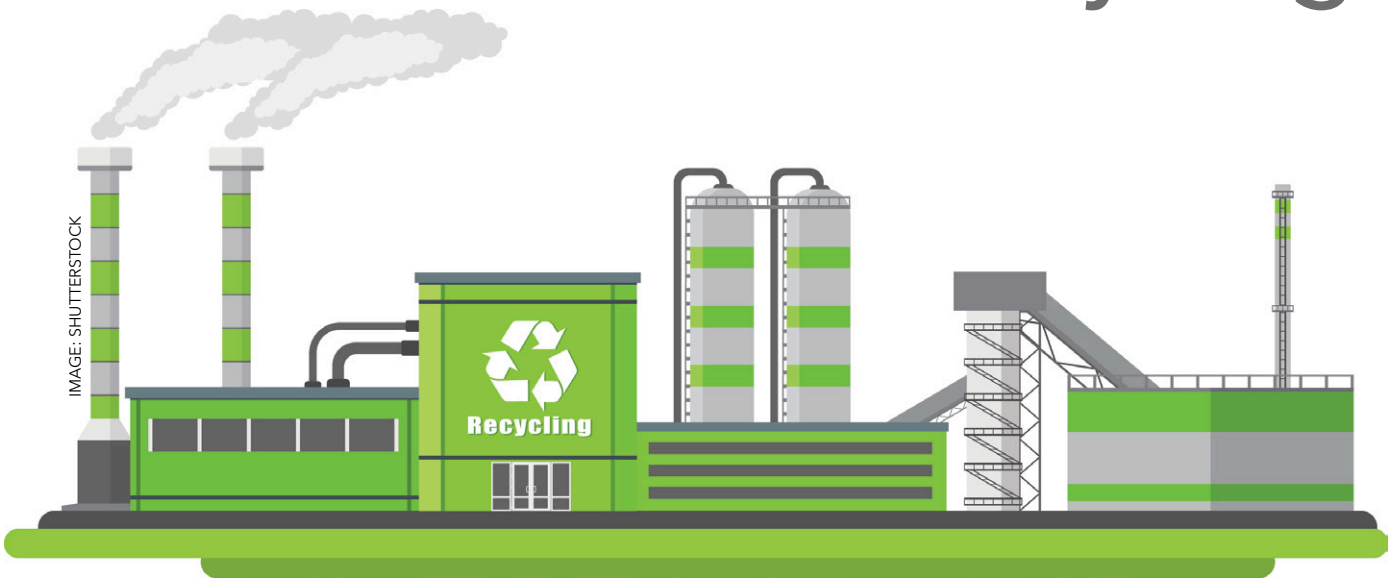

IMAGE: SHUTTERSTOCK

Main image: How are inputs and outputs treated in a chemical recycling process?

Tracking use of mechanically recycled material is straightforward – the recycled resin is simply used as supplied or blended in with virgin. It is not so easy in chemical recycling, where recycled content takes the form of basic hydrocarbons fed into complex cracking and polymerisation processes. Individual molecules cannot be tracked but have to be accounted using the principles of mass balance.

The idea behind mass balance is to measure the input of an individual component in a much larger manufacturing process and allocate its contribution 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 products leaving it. It is not a new concept; the idea is already applied in sectors as varied as electricity marketing and Fair Trade agriculture.

As with many ideas, however, the challenge is in implementation. Different approaches can be taken with regard to what to allocate and where to allocate it. For instance, the entire output of a chemical recycling process – including both fuels and feedstocks – could be allocated as a contributor to any polymer or chemical production process, whether or not there is any direct link. This is called free-attribution. Alternatively, it may be decided to allocate only non-fuel components. Or, at its strictest, only those components used as a non-fuel contributor to production of a polymer.

Trade association Chemical Recycling Europe leans toward the free-attribution approach. In a **white paper** it says: "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, take a different approach. Zero Waste Europe, together with several other environmental NGOs, has published **10 recommendations** it argues will ensure the use of mass balance does not undermine circularity goals. This involves only including 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.

Mass balance will be essential in the development of chemical recycling as an industrial process and to that end it is important it is 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, the International Organisation for Standardisation (ISO) has started work on a global mass balance standard – ISO/AWA 13662 Chain of Custody-Mass Balance-Requirement and Guidelines. This is currently in the preparatory stage.

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