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US compounding start-up to set up in South Carolina

A new US-based compounding start-up, Orion Performance Compounds, is to invest $13m to establish a 4,600m^2 manufacturing plant at Lugoff in South Carolina. Production is expected to start in Q2 of this year.

Orion Performance Compounds COO Tom Drye – a compounding industry veteran and former Techmer executive – said the new plant will be equipped with three compounding lines in its first phase, a combination of twin and single screw equipment. It will also include R&D and QC laboratories.

"Orion Performance Compounds will focus on high-end custom engineered compounds," Drye told *Compounding World*. "The portfolio will be broad based – high mechanical performance, lubricated, conductive (electrical and thermal), FR, custom colour – with a broad look at renewable resins and reinforcements."

He said the company has already "multiple projects" on the table for launch and a number of other potential customers interested in its compounding business offer. "Orion core doctrine is the right product, at the right time," he said. "Delivering initial samples in two weeks or less and production quantities among the best lead time in the industry."

The Lugoff location, in Kershaw County, was selected after an extensive multi-state search, Drye said. "The state of SC and Kershaw County were very welcoming to our planned business and removed any hurdles along the way."

The Coordinating Council for Economic Development approved job development credits related to the project, which is expected to create 54 positions. The council also awarded a $300,000 Set-Aside grant to Kershaw County to assist with the costs of building improvements.

› **tdrye@orioncompounding.com**

Exxon starts Gulf PP plant

ExxonMobil has started production of PP at its new polyolefins plant at Baton Rouge in Louisiana, US, increasing its Gulf Coast PP production capacity by 450,000 tonnes/yr.

The company said the new capacity will help meet demand for high-performance, lightweight, durable plastics for demanding end-use application sectors such as automotive, medical and food packaging.

"With the startup 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**

Herman Miller opts for ocean plastics

Herman Miller's Sayl office chair is the latest in its product portfolio to be offered with some ocean-bound plastic content. The company says each chair will contain up to 1.3kg of "mismanaged plastic waste found near waterways." The precise content will depend on the colour, with black compounds containing most. Already used in the company's iconic Aeron chair, it says the expanded ocean plastic initiative will divert an estimated 95m tonnes of polymer each year.

› **https://millerknoll.ecomedes.com/**

Maag acquires Witte Pumps

IMAGE: MAAG

Maag President Ueli Thürig

Maag said last month that it had acquired Witte Pumps & Technology, a German developer and manufacturer of gear pumps and aftermarket parts.

Following the purchase, Maag will integrate the Witte 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 Dr 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 Maag President Ueli Thürig. He said the move would extend the group's product portfolio and geographical coverage.

› **www.maag.com** › **www.witte-pumps.com**

IN BRIEF...

Following its acquisition by **Grafe Group** last year, Swiss specialty compounder **Color Technik** is now able to offer the full Grafe Polymer Solutions range of masterbatches to its local customers. The company continues to supply its own products, including its specialty products for fluoro and high temperature polymer applications.
www.grafe.com
www.colortechnik.swiss

Aurora Plastics has appointed Tim Huskey to the post of Chief Operations Officer, reporting directly to CEO Darrell Hughes. Huskey is a chemical engineering graduate and joins the compounding company from packaging group Berry Global, where his most recent position was Executive Vice President of Operations.
www.auroraplastics.com

Penn Color grows with Asian technical centre

Colour masterbatch and pigment dispersion specialist Penn Color officially opened its new Technology Centre on the Singapore Science Park earlier this month, underpinning its growing presence in the Asian marketplace.

The $3m centre incorporates laboratory, prototyping and sampling equipment and is intended to speed up the product development timeline for existing and new customers in the Asian region.

"This is an inspiring studio where designers, brand managers, business leaders, process engineers, converters, equipment manufacturers, materials suppliers, and technical experts come together to harness their collective creative power and expertise," said Kevin Putman Jr, President and CEO of Penn Color.

IMAGE: PENN COLOR

Above: Penn Color's new Singapore Technical Centre aims to inspire designers

"Thanks to our world-class capabilities and enabling technologies, new product development teams will condense weeks of development into days, and production-ready products will be available faster than ever before," he said.

The Singapore centre joins two other Penn Technical Centres, one located at the company's global headquarters at Hatfield in Pennsylvania in the US and a second at Venray in the Netherlands.

At present, Penn Color manufactures in the US and Europe but said it is currently planning to add both design and manufacturing capacity to support customers in the Asian region.

› **www.penncolor.com**

Borealis invests to secure recycled inputs

Borealis has taken a majority stake in Renasci, a Belgium-based provider of recycling technology and creator of the Smart Chain Processing (SCP) concept, which combines multiple waste stream treatment platforms in a single facility.

The move increases Borealis' stake in the company to 50.01% (it has held a 10% stake since 2021). According to the resin producer, the move underlines its confidence in the potential of the SCP concept in reaching its own circular ambitions. These include lifting its volume of circular materials to 600,000 tonnes by 2025 and to 1.8m tonnes by 2030.

"With this investment, we mark another milestone on our path to realising our Strategy 2030 goals. Our acquisition of a controlling stake in Renasci has the potential to unlock significant progress on circularity for our entire industry," said Borealis CEO Thomas Gangl.

The Renasci production plant at Ostend in Belgium

IMAGE: BOREALIS

The controlling stake in Renasci will provide Borealis with a secure supply of chemically recycled feedstock for its Borcycle C portfolio from the Renasci plant at Ostend in Belgium.

› **www.borealisgroup.com**

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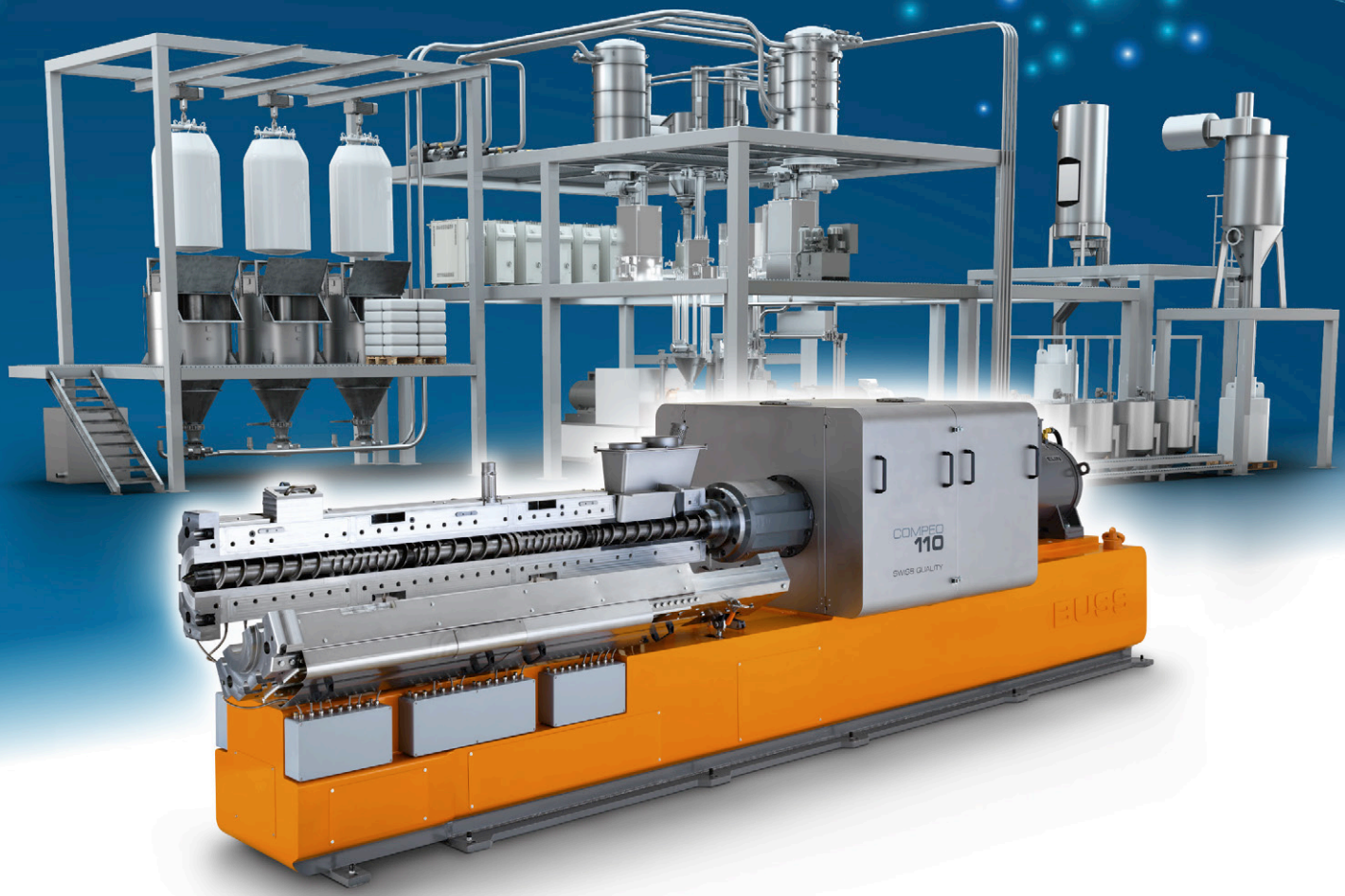

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HeiQ buys antimicrobial IP firm

IMAGE: HEIQ/LIFE MATERIALS

Above: HeiQ has extended its antimicrobial options

UK-listed antimicrobial technologies company HeiQ has acquired Tarn-Pure Holdings, a UK based intellectual property company that holds what it describes as "critical EU and UK regulatory registrations" to sell elemental copper and elemental silver for use in hygiene applications.

"The HeiQ group has an impressive product range of antimicrobials. The acquisition of Tarn-Pure's regulatory asset strengthens HeiQ's ability to offer the market access to Europe and the UK for products containing antimicrobial copper and silver," said HeiQ EVP Tom Ellefsen.

In a statement to the London Stock Exchange, the company said EU regulatory changes last year will see a number of high-volume organic and inorganic biocides phased out. It said the favourable risk assessments of elemental copper and silver position them to replace these products.

"I expect our sales in silver and copper technologies to significantly grow in 2023 thanks to now one of the strongest regulatory portfolios in the market," Ellefsen said.

HeiQ is to pay around £850,000 for the Tarn-Pure business, which generated sales of around $400,000 in 2022, mostly derived from royalties.

› **www.heiq.com**

Coperion's parent exits legacy casket business

US-based Hillenbrand, which owns Coperion and Milacron, has exited the funeral goods sector with the announcement of the $760m sale of its legacy Batesville casket business to LongRange Capital.

The move completes a transformation to a pure-play industrial company, according to Kim Ryan, President and Chief Executive Officer of Hillenbrand. "[It] allows Hillenbrand to concentrate our investments into our APS [Advanced Processing Solutions] and MTS [Mold Technology Solutions] segments, where we see strong growth potential," she said.

Batesville is a leading player in the US funerary goods sector and had been owned by the Hillenbrand family since 1906. Last year it accounted for around 22% of Hillenbrand's annual $2.9bn revenues.

Hillenbrand has been following a strategy of acquiring key players in the process engineering sector in recent years. It bought the plastics compounding and materials handling specialist Coperion in 2012, followed by Milacron in 2019. Last year saw it add plastics recycling systems maker Herbold Meckesheim, and food processing and plant automation specialists Peerless Food Equipment and Linxis Group.

› **www.hillenbrand.com**

EU project sees TPEs in waste

Spanish technical institute Aimplas is part of a multi-partner EU research project to develop additive-free TPEs from recycled waste.

The RePurpose project aims to develop building blocks derived from biomass or enzymatically degraded polyolefins, PET or paper waste for production of circular specialty TPE grades.

› **www.aimplas.net**

Avient's distribution division goes to HIG

Investment firm HIG has completed its $950m acquisition of Avient Corporation's distribution business, agreed back in August last year, which will now operate as a standalone entity under the new Formerra name.

"HIG's partnership begins an exciting new chapter for the company as it is poised to accelerate growth as an independent business," said Formerra CEO Cathy Dodd. "We look forward to continuing to invest in value-added solutions, technical support capabilities, commercial sales, and the digital platform to drive further value for Formerra's existing and future stakeholders."

Formerra distributes polymers and compounds to customers in North and Central America, including Mexico, and in South East Asia and China. It generated sales of around £1.6bn in 2021.

› **www.formerra.com**

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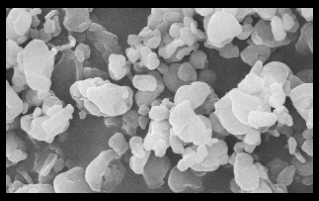

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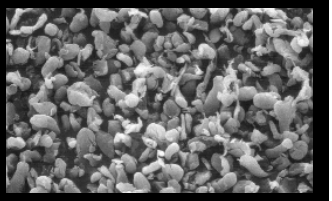

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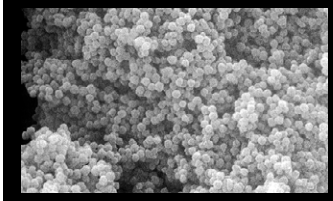

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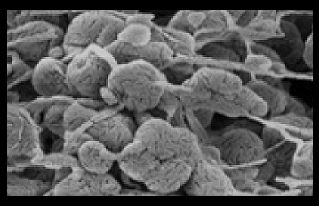

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PureCycle moves into Europe

Recycling technology company PureCycle has announced plans to build its first solvent-based PP recycling plant in Europe. Work is expected to begin on the facility at the Port of Antwerp in Belgium in 2024.

PureCycle said the Antwerp plant will have an initial annual capacity of 59,000 tonnes/yr, but the 14ha site has space for expansion to 240,000 tonnes in the future. It said it is currently engaged in feedstock sourcing and financial planning with the intent to secure a final project timeline by mid-2023.

IMAGE: PURECYCLE

Left: A Krauss Maffei extruder being delivered to PureCycle's Ironton site

The announcement comes as its major US investment at Ironton in Ohio nears completion. The company took delivery of the final extruder for the operation from Krauss Maffei in December, which it puts it on track to begin pellet production in Q1 of this year. When fully operational, it will have an annual capacity of around 48,000 tonnes.

PureCycle also recently announced a JV agreement with global energy company SK geo centric to open its first PP recycling plant in Asia in 2025.

› **www.purecycle.com**
› **www.kraussmaffei.com**

Ineos signs JV with Sinopec

Ineos and Sinopec have announced a new JV that sees Ineos take a 50% share in Sinopec's existing Tianjin Nangang Ethylene Project in China.

The project at Tianjin includes a 1.2m tonne/yr ethane cracker, which is expected to come on-stream at the end of this year, and a number of derivative units including a 300,000 tonne/yr ABS production plant and a previously announced 500,000 tonne HDPE plant.

The ABS plant will use Ineos Terluran technology and is the second of three ABS units that Ineos has agreed to build and operate with Sinopec in China, the first a 600,000 tonne plant under construction at Ningbo.

The Tianjin HDPE plant is the first of three the two companies are planning together and will produce Ineos pipe grade resins.

› **www.ineos.com**
› **www.sinopec.com**

Techmer PM targets Latin America

IMAGE: TECHMER PM

Techmer PM has appointed Ricardo Vásquez General Manager Latin America

US compounder Techmer PM has appointed Ricardo Vásquez as General Manager for the Latin America region, where he will develop the company's growing position in the agricultural, automotive, healthcare, and packaging markets.

Educated in Guatemala, Vásquez holds an MBA from Universidad Mesoamericana and a masters degree in Chemical Industrial Engineering from Universidad Rafael Landívar. He previously spent around 20 years with BASF Mexicana, most recently as Business Director.

Techmer PM CEO Michael McHenry said Vásquez brings significant commercial and operations experience to the company. "Ricardo's team leadership will be instrumental in the execution of Techmer PM's customer-centric growth strategy in the region", he said.

› **www.techmerpm.com**

IN BRIEF...

Asahi Kasei, together with Japan's National Institute of Technology, Kitakyushu College and Tokyo University of Science, has developed a new process to recycle continuous carbon fibre from thermo-set or thermoplastic composite parts.
www.asahi-kasei.com

BASF has appointed Dr Achim Sties to lead its Singapore-headquartered global plastic additives business unit effective from 1 January 2023.
www.basf.com

Finnish energy company **Fortum** has announced that its Circo polymer compound, which is produced from post-consumer plastic waste, is now certified compliant with the EU Toy Safety Standard EN 71-3.
www.fortum.com

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UK extends its REACH deadlines

UK government department Defra has pushed back submission deadlines for the country's post-Brexit UK REACH chemicals regulation – which is intended to replace and will for many companies duplicate EU REACH – by three years.

The **move** follows industry consultation over the time and cost required to gather the necessary data, estimated by Defra at around £2bn.

The new plans push deadlines for each tonnage category back to October 2026, 2028 and 2030. Aside from easing the challenge for businesses, Defra said the delay also gives the UK government more time to develop its so-far-undefined Alternative Transitional Registration model.

EPA denies call to list PVC waste as hazard

The US Environmental Protection Agency (EPA) has published a "**tentative denial**" of a petition that waste PVC materials should be listed as hazardous waste under the country's Resource Conservation and Recover Act (RCRA).

The decision follows an agreement the EPA entered into with the petitioner – The Center for Biological Diversity – back in May last year to consider the petition by the end of this month. 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.

IMAGE: SHUTTERSTOCK

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

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 on its decision.

› **www.epa.gov**

Polykemi starts up second Chinese plant

Sweden's Polykemi has commenced production at its second compounding unit in China. The 9,300m² factory at Chongqing is now producing virgin and recycled compounds on two manufacturing lines.

Current production is focused on compounds based on PP, PA6, PA66, PC and PC/ABS. According to Magnus Lindahl, CEO of Polykemi Compounds Kunshan and Chongqing, total annual capacity will be up to 5,000 tonnes, depending on the product mix.

Polykemi has had a presence at Kunshan, near to Shanghai, since 2005. The Chongqing plant is located in central China close to many companies active in the automotive industry. "It is one of the most growing regions in the country, with major universities and centres for both manufacturing and research," said Lindahl.

IMAGE: POLYKEMI

The new production facility is another step in Polykemi's strategy to manufacture close to its customers. It is currently building a plant in North Carolina, US, which will have two compounding lines and is expected to start production early this year.

› **www.polykemi.com**

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SECURE YOUR PLACE TODAY

IMAGE: SHUTTERSTOCK

*Circular demands for increased recycled content in films is driving demand for development of new sustainability-focused additives. **Mark Holmes** reports*

Sustainability the key driver in film additive innovation

Sustainability is one of the most dominant topics in any plastic film discussions today. Producers are responding to demands from consumers and brand owners for greater use of recycled material in packaging and that, in turn, is driving new developments in additive technology. The latest introductions aim to support larger quantities of recyclate in films while maintaining the mechanical properties and aesthetics, as well as enabling the development of film structures with fewer and thinner layers of dissimilar materials to facilitate easier recycling.

In today's marketplace, suppliers of flexible packaging have to become more creative in their development, according to **Milliken**. "They need robust solutions in order to achieve all the desired mechanical properties, shelf-life needs and recyclability goals of flexible packaging," says Katie Kellogg, Global Product Manager in Milliken's Chemical Division.

"The desire for more mono-material polyethylene film structures requires manufacturers to evolve the typical multi-layer structure that has been used to achieve the package goals, which Milliken's UltraGuard Solutions can help enable. Also, with the world's ever-evolving supply chains, improved barrier properties in flexible packaging have the potential to allow for improved shelf-life, which may enable less food waste over time," she says.

According to Milliken, both consumers and brands want to see improved circularity and recyclability and that is shifting industry demand to mono-material solutions. With this shift comes the need for technologies to provide standard physical properties and shelf-life, for example, which have typically been achieved with alternative formulations such as EVOH, PA and metallized film layers (all of which can create problems for recyclers downstream). The company says the incorporation of its UltraGuard Solutions tailored

Main image: Film producers are looking for additive solutions that provide performance with sustainability

Right: Milliken partnered with Huhtamaki to develop a mono-material laminate for use in tubes for personal-care applications

masterbatches can help reduce the thickness of the EVOH layer, which can improve recyclability.

The company says it is working to improve the barrier properties of HDPE film and flexible packaging to reduce the amount of film and the variety of barrier layers used. "We are improving the package's overall barrier performance so that less materials need to be used in the package design and inter-material replacement of less circular package formulations can be achieved," says Kellogg.

Multi-material constructions are highly effective but can present a recyclability challenge. As a result, groups such as the Association of Plastic Recyclers (APR) in the US and RecyClass in Europe advocate the use of mono-material structures whenever possible. "Milliken UltraGuard Solutions improve barrier performance of HDPE up to 50% and enable mono-material flexible packaging made with less material," Kellogg says.

HDPE is often favoured over LDPE or LLDPE in PE-based structures when higher levels of moisture barrier are required. The addition of UltraGuard can allow HDPE to achieve a WVTR (water vapour transmission rate) below 2g/m^2/day per mil (25 micron) of film thickness.

Some structures require blending different types of PE in a single layer – LDPE may be added to HDPE to get a more stable bubble or to reduce wrinkling, for example. But adding LDPE can significantly reduce the barrier properties of the film. This can be compensated for by using UltraGuard, says Milliken. Where barrier is achieved with a core HDPE layer, the additive can be used to minimise its thickness. This helps to maintain other physical properties such as toughness and stiffness, which can often suffer when using HDPE.

UltraGuard is said to work by controlling the orientation of the polymer crystals to create a more tortuous path for permeation of molecules. Due to the nature of the passive barrier, it is effective in reducing the permeation of any substance in HDPE, including water, oxygen, grease, carbon dioxide, alcohols, gasoline and fragrances, for example.

Plant-based Einar 611 provides anti-fog performance in PE film packaging

IMAGE: PALSGAARD

Mono-material option

Milliken says it has partnered with Finnish flexible packaging company **Huhtamaki Group** to develop a more sustainable, mono-material laminate for use in tubes targeting cosmetics, toothpaste and other personal-care applications. The HDPE tube resulting from this joint development work was produced using Huhtamaki laminates optimised with the UltraGuard Solutions additive.

"The tube resulting from this joint development work is opaque with a silver shine, making it ideal for beauty product applications," says Dr Detlev Schulz, Senior Manager - Sustainability and Business Development for Huhtamaki's Global Tube Laminates business. "White would work as well, offering outstanding moisture barrier and improved oxygen transmission for all who do not need a shiny silver option." The most likely end uses will be in 40-200 ml tubes.

The HDPE tube project fits with Huhtamaki's blueloop initiative for sustainable, flexible packaging, which includes a range of recyclable solutions based on mono-material structures using PP, PE and paper.

Milliken says it has committed to and has validated targets with the Science Based Targets initiative (SBTi) towards reaching net-zero greenhouse gas emissions across the value chain by 2050. "For Milliken, this means focusing both on the footprint of the products we manufacture and on providing circular solutions to our customers," says Kellogg. "Our efforts to promote circularity involve both enabling customers to design their parts to be more recyclable through mono-material construction and through technologies that

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www.cargill.com/bioindustrial

facilitate the incorporation of more recycled content in plastic packaging and durable goods."

Danish bio-derived additive producer **Palsgaard** says that its recently developed Einar 611 bio-based anti-fog surfactant has been successfully specified by a major Korean supplier of food-grade PE film solutions. It says the customer had been looking for a cold anti-fog additive that would effectively protect the packaged food from spoilage by preventing formation of condensation droplets on the inside of the film. At the same time, the surfactant had to eliminate regulatory concerns with regard to its chemistry and provide superior functional performance at a cost-effective low concentration.

"The importance of food packaging and its role is ever-changing, from the mere protection of food items from the outside in nice packaging to concerns about food safety and product shelf life," says Ulrik Aunskjaer, Global Business Director for Bio-Specialty Polymer Additives at Palsgaard. "Our plant-based Einar 611 anti-fog has proven itself a perfect choice in this PE film application to minimise the risk of moisture accumulating in small reservoirs on the inner surface of the packaging film, where bacteria could grow and then drop down and spoil the food."

In an iterative sampling process focused on the customer's specifications and needs, comprehensive experimental and trial data was shared to optimise and validate the film solution. During this process, Palsgaard's Polymer Application Centre in Denmark provided support in assessing the right concentration level of Einar 611 required for the application, helping to accelerate time-to-market of the new PE food packaging film.

Einar 611 is a renewable polyglycerol ester made from vegetable oils that are said not to compete with either food or animal feed sources. It has been developed as a highly effective replacement for conventional anti-fog chemistries, such as glycerol monooleate or sorbitan esters, in demanding PE film formulations for sensitive food packaging.

With anti-fog performance matching or exceeding that of non-vegetable fossil-based alternatives, it is said to deliver good results in LDPE and LLDPE as well as coextruded and laminated PE film at low loading levels (typically 0.2-0.4%) for both cold-fog and hot-fog applications. Available in a paste form, the company says the additive has proven to be a good option for PE masterbatches. It is said to result in no adverse effects on the mechanical, optical or barrier properties of the film while also offering high heat resistance and low volatility.

The company says the long-lasting anti-fog performance of Einar 611 contributes to reducing food waste by preserving freshness. It supports a clear view of the packaged product, which promotes its consumer appeal over a longer shelf-life, and meets all global food-contact standards, including kosher and halal. In addition, it exhibits a good sustainability profile across the entire value chain from production to processing.

Palsgaard also recently introduced Einar 981, an anti-fouling additive designed to eliminate the build-up of static during the PP and PE polymerisation process. In so doing, it prevents

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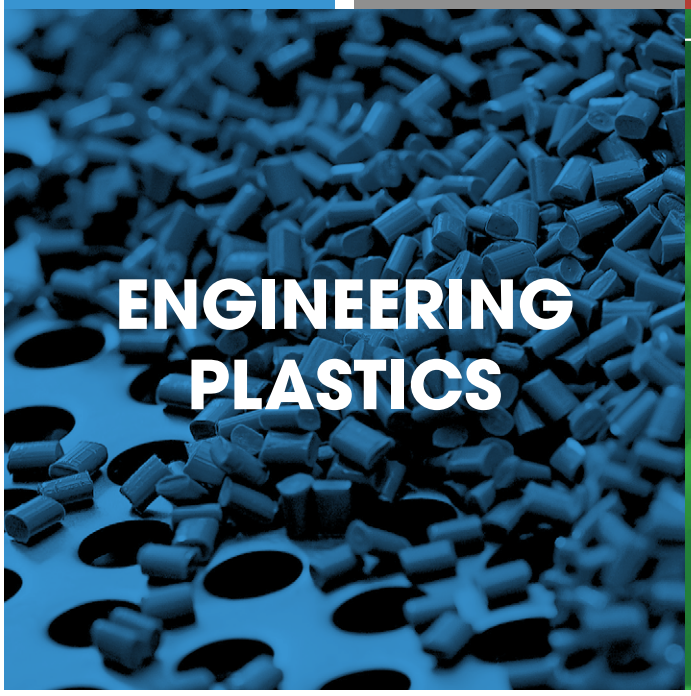

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IMAGE: PALSGAARD

Right: Palsgaard's polymer application centre develops and tests additive solutions that simulate the polymer or masterbatch production environment

particles from fouling the wall of the reactor, which reduces cooling efficiency and slows production.

Made from a polyglycerol ester blend of fatty acids derived from RSPO-certified sustainable palm oil, the additive is a direct replacement for ethoxylated amines (which it says are being withdrawn from the market). It can also be used as an efficient alternative to sorbitan monooleates.

Expected to be in commercial use early this year, Einar 981 is intended to be used at concentrations as low as 100-300 ppm and is said to have no negative effects on the catalyst, productivity or final polymer performance. The additive is also non-toxic and has food contact approval.

"It is an ideal choice for use in PP and PE polymerisation where the materials may be used in the production of sensitive end products such as medical applications or baby food containers," says Aunskjaer. "This is our answer to the challenge of providing a highly sustainable, renewable and food-grade aid to anti-fouling."

Palsgaard adds that both of these new additives are produced in a way that will help PE film manufacturers, masterbatch makers and processors to minimise Scope 3 emissions and to reduce the use of non-renewables. "Our production sites have been carbon dioxide neutral since 2018," says Aunskjaer. "We are planning to install a solar power plant able to cover all future electricity needs in 2024 and are currently introducing our own biogas plant. We are continually looking for ways in which we can support our customers in moving towards their own ESG initiatives; helping them to become greener and more sustainable."

Recyclable demands

Demand for more durable and reusable products, and for products that are more readily recycled or can be degraded, is also identified as a trend at **Cargill Bioindustrial**, which last year acquired the industrial and performance chemicals business of Croda International. "The knock-on effect for the additives market is that there is a higher demand for solutions to help plastics become more durable or recyclable. These additives often need to be bio-based, sustainable and have a low carbon footprint," says Michelle Downham, Marketing Manager – Polymer Additives.

"These trends are also being driven by new legislation demanding an increased recycled content. Many OEMs and brand owners have a desire to be more sustainable and are creating challenging sustainability goals to reduce their carbon footprint, waste and energy usage, for example. This filters down the supply chain, meaning that raw materials, including additives, must also be sustainable or deliver sustainability benefits in the final polymer."

Many of Cargill's polymer additives for films are produced with 100% bio-based carbon. "This includes the Crodamide, Incroslip and IncroMax slip, torque release and anti-scratch additives," says Downham. "We have measured the carbon footprint of our slip additives and found that they are 'carbon negative'. This means that they absorb more carbon dioxide during the growing of the crops than they emit during the manufacture of the product. These figures have been externally verified and can be used in customers' Scope 3 carbon emissions calculations.

"We also recently tested our Incroslip C product to understand its effect on the mechanical recycling of HDPE. We found that it demonstrated several positive effects on the recyclate including enhanced flow, no impact on mechanical properties and whiter recyclate. After three cycles of mechanical recycling, with the addition of Incroslip C the HDPE had a melt flow rate twice as high as HDPE without the additive. There was no negative impact on mechanical properties of the polymer. The

IMAGE: CARGILL BIOINDUSTRIAL

Above: HDPE pellet samples show the whiter colour that can be achieved when using Incroslip C

IMAGE: SHUTTERSTOCK

Above: New stabilisation solutions can extend the lifetime of PE-based greenhouse films exposed to pesticides

recyclate was also a whiter colour."

Citing projected growth in the plastics additives market of 5.6% CAGR from 2021 to 2026, **SI Group** predicts demand for film additives and masterbatches expanding proportionally. "The polyolefin industry's projected growth in the coming years will be partly driven by increased demand in packaging end-use applications, which in turn drives demand for film additives and masterbatches" says Francis Olajide, Market Development Director for Polymer Solutions.

"There is a major innovation push in the development of additive solutions and masterbatches that enables reuse of plastic scrap – post-consumer and post-industrial recyclates – in film packaging. SI Group recently launched the Evercycle technology platform to address this major need in the market. One challenge is how to enable more recycled resin to be incorporated into a larger variety of flexible film end-use applications without sacrificing the application performance, convenience and product sustainability."

SI Group says a key technical area of development in plastics recycling, particularly in films, is to bolster secondary antioxidants in post-consumer recyclates. Another area of technical development is compatibilisation or homogenisation of dissimilar materials typically found in post-consumer recyclates.

Plastic flexibles entering the recycling stream also require stabilisation and protection against thermal degradation within the recycling process and further re-converting steps. Good quality recycled resins can now be used with higher levels of recycled content for specific flexible film end-use applications. In addition, multi-material film structures often get recycled into a single recycled resin, impacting the final structure properties and creating compatibility issues with virgin resins.

SI Group launched its Evercycle additives platform at K2022 with a product portfolio that enables customers to increase the circularity of their products. The new platform is designed to address some of the technical challenges in the recycling industry with the first products focused on mechanical recycling of polyolefins and PET, providing tailored additive solutions to improve the quality of the recycled resins. The Evercycle range addresses issues such as discolouration of PET in recycling and the loss of mechanical performance in polyolefin recyclates.

One of the Evercycle products is a customised additive solution for films that enables more than 30% of recycled polyethylene to be incorporated in high performance stretch film applications. Evercycle LD-104P is available as a masterbatch and is said to provide reduced gel levels and improved mechanical performance over standard additive solutions.

SI Group says it is working closely with customers in developing tailor-made film additives and/or masterbatch solutions. "We are looking to further develop robust and easy-to-apply solutions that tackle the material challenges created by circular material flows," says Olajide. "We are focused on demonstrating the value and fit-for-purpose nature of our solutions across the polymer value chain and not just one step of the lifecycle."

Removing the gloss

Matip 347 is a new additive solution from **Ampacet** designed to provide a luxurious matte finish for premium packaging in areas such as personal care and cosmetics. Developed specifically for blown and cast film and BOPP, the company says Matip 347 target applications include food wrap, food packaging, pet food, pouches, labels, and laminates. Used in the outer layer of a film structure, it reduces gloss and increases haze. The company says in low-thickness blown film, cast film and BOPP applications of between 6-8 microns, gloss is less than 10 and haze greater than 75% at 133°F (56°C).

Ampacet has also introduced AgriStab, a new high-performance UV stabiliser range offering good UV resistance for greenhouse films used under intensive pesticide conditions. The company says the sulphur and chlorine found in many commonly used insecticides can interact and deactivate light stabilisers used in plasticulture and lead to early degradation of the film, shortening the life span of greenhouses. It says its AgriStab solutions provide good UV protection against up to 5,000ppm of sulphur and 250ppm of chlorine. The masterbatches help achieve service lifetimes for multi-season

Right: Sukano and Emery Oleochemicals have developed a PET anti-fogging compound for direct food contact PET packaging applications

greenhouse films of more than three years.

Agricultural film is also a target market for **Clariant**, which recently introduced a light stabiliser for use in mulch films, which optimise growing conditions by protecting both crops and soil from contamination and loss of moisture and nutrients. AddWorks AGC 970 enables converters to extend the service life of their products, in particular by increasing UV resistance and resistance to high levels of agrochemicals. The granular additive can be dosed directly during conversion.

Swiss additive and colour masterbatch producer **Sukano** has partnered with **Emery Oleochemicals**, a producer of natural oil and fat-based chemicals, to develop a PET antifog for direct food contact PET packaging. The companies say that two years of intensive testing and simulation of end-use applications have gone into the product, which is formulated to be used at 100% in cold applications.

The additive compound is designed for both rigid and oriented coextruded films, using the co-polyester compound in one cap-layer of an A/B film structure and PET as the core-layer. According to the companies, the resulting product performance is so robust that, even after orientation in several different ratios, the anti-fog function remains active and integral, and the film remains transparent.

Fogging – the unwanted formation of small water droplets on the surface of films – is a common problem when packing moisture-containing products such as fruit, vegetables or meat in a tight container. The droplets form due to the lower surface tension of the plastic and not only hinder a clear view into the packaging but in

IMAGE: SUKANO

sensitive applications can damage or reduce the shelf life of the packaged products.

Anti-fog for PET

Anti-fog coatings, which encourage the formation of a homogenous transparent water layer rather than droplets, are well known and in use in the PET sector but have the downside of adding another operational step. While internal anti-fog additives are used in polyolefins, current anti-fog additives do not work in PET, according to Sukano and Emery, which has a number of antifog additives in its Green Polymer Additives line.

"Additives that work well in flexible vinyl meat wrap films or polyolefin films do not necessarily work well in PET. Polarity, crystallinity and other physical or chemical characteristics of the base polymers are too different, and the additive molecule design needs to take that into

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Safe solutions for electronic goods

Designed for producers of packaging films for the protection and shipping of semiconductors and electronic devices, AS-307 is a new permanent antistatic additive from Adeka.

"ESD can potentially damage finished products by rendering the circuits useless," says Marie-Raphaël Morvillier, Technical Director at the company. "That is why ESD packaging, and films in particular, have become so valuable in today's world, being designed to help prevent build-up of electrostatic charge both on the inside as well as on the outside. Different types of ESD films and trays can now be found on the market based on their working principle - antistatic, conductive and/or dissipative."

IMAGE: AMI/CHRIS SMITH

Left: Antistatic additives prevent risk of electronic damage

Adeka's AS-307, which was launched at K 2022, provides immediate and long-term antistatic performance for polyolefin films while maintaining good transparency. With a surface resistivity of 10^6 Ohms/sq, it can provide levels of antistatic performance from anti-dust to ESD. Available in pellet-form, it can be dosed into thermoplastics during melt-compounding and is suitable for use with the pink and blue pigments typically used to identify electrostatic packaging films.

› **www.adeka.eu**

consideration," says Dr Annika Heinrich, Technical Development Manager at the Emery production site at Loxstedt, Germany.

The Sukano additive compound has been tested in PET lidding film applications, PET clam shells and thermoformed lids and trays where final parts were shredded, ground, washed and submitted to additional heating conditions to simulate recycling of a dedicated PET tray recycling stream according to the PETCORE TCEP protocol.

Everglide is a PFAS-free processing aid from **Mitsui Plastics** in the US that is said to perform well when compared with traditional fluoro-materials. The company says that it allows film producers to achieve good melt processability, print adhesion, and a stable coefficient of friction over a broad temperature range, allowing faster speeds on lines.

Suitable for use with a variety of different polymers, the Everglide material offers both internal and external process aid benefits. Mitsui says it is a good alternative to fluoropolymer-based process aids with key benefits including reduced die pressure, extruder energy draw and apparent viscosity, which means process temperatures can be lowered. It has global compliance for food contact applications.

As part of its move to meet the sustainability demands of its plastics additive customers, **BASF** now offers product carbon footprints (PCFs) for a number of its antioxidant and light stabiliser products as a premium service within its Valeras portfolio. The company says that by improving CO_2 transparency in the value chain, it can support customers in reaching their greenhouse gas emission reduction targets.

Using its proprietary digital solution and validated calculations, BASF says it can now provide cradle-to-gate PCFs. These include the total greenhouse gas emissions that occur from extraction of resources through the manufacturing of precursors to the making of the final chemical product itself.

The first wave of available calculations includes products from the Irganox, Tinuvin and Chimassorb portfolios. BASF says more products will follow.

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IMAGE: SHUTTERSTOCK

The latest pelletiser introductions are engineered for better and more efficient performance with simplified maintenance. Jennifer Markarian reports

Pelletiser innovations target quality gains

Pellet quality is not simply a cosmetic issue; irregular pellets can lead to melt quality issues and feeding problems. So taking steps to ensure pelletisers run at their best and produce pellets of optimal quality makes sound sense. The first step towards optimising pellet quality is to understand the material being processed.

According to Martin Baumann, Vice-President and General Manager of **Maag Americas**, both the type of resin being processed and the additives it contains play a part in selection of the best pelletising equipment. Speaking at the Compounding World Expo in Cleveland, Ohio, US last year, he said strand pelletising can be better for abrasive materials while underwater pelletising has a reduced sticking tendency. "In our lab, we can test customer compounds to help choose the optimal system for their product," he said.

A common problem in underwater pelletising is that some polymers tend to build up tails during the cutting process, and these tails can easily break off to generate fines. Meanwhile, in strand pelletisers fines are created not by cutting but rather through the die drool phenomenon on the die plate, Baumann explains.

A recent Maag development for strand pelletising equipment is its Hot-Air Knife, which eliminates die drool using compressed and heated air. "It is a small change with a big impact," says Baumann. The Hot-Air Knife can be equipped as an add-on to all MAAG strand die heads or as a stand-alone machine. Maag's EBG dry-cut belt conveyor pelletising system also uses the Hot-Air-Knife technology. This system can be used for water-sensitive or soluble polymers as well as for highly filled compounds. EBG systems can also re-feed broken strands to efficiently reduce downtime and production interruptions.

Choosing a melt filtration system that is able to keep contaminants out of the pelletiser is also

Main image: Improved pellet quality is one of the key aims in pelletiser development

Maag's EBG200 dry-cut conveyor pelletiser uses the company's Hot-Air Knife technology

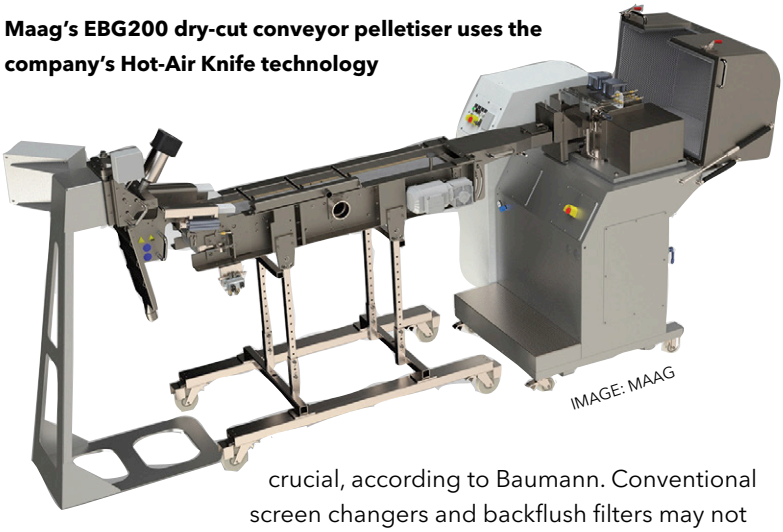


IMAGE: MAAG

crucial, according to Baumann. Conventional screen changers and backflush filters may not be sufficiently effective when compounding recipes with recycled content, which typically contain increased contamination levels.

Maag's Ettlinger continuous filtration system can handle up to 16% contamination. Material flows over a rotating drum to remove contamination in the equipment, which is self-cleaning. The filters are equipped with a pressure sensor to automatically adjust and maintain a steady pressure, allowing them to run for weeks or months at a time without intervention. Baumann says the minimal pressure change characteristic of this system is beneficial for any type of compounding, whether or not it contains recyclate.

Below: Maag's new Pearlo XXL high output underwater pelletiser uses AMN's liquid-heated die plate

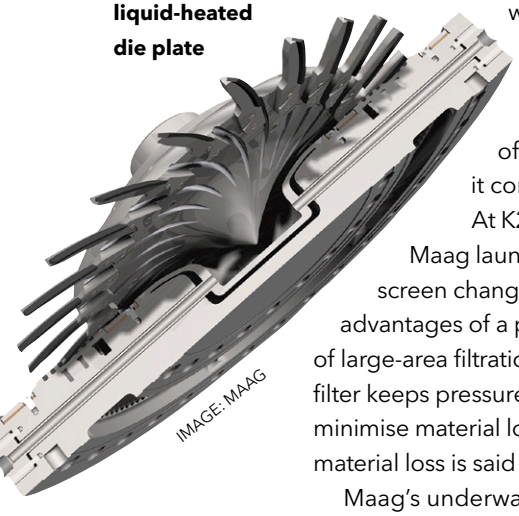


IMAGE: MAAG

At K2022 in November last year, Maag launched the ContiNeo backflush screen changer, which it says combines the advantages of a piston screen changer with those of large-area filtration. The automated, self-cleaning filter keeps pressure constant and is designed to minimise material loss. On average, backflush material loss is said to be 0.5-1%.

Maag's underwater pelletisers use turbine-style blades that are designed to produce less turbulence for more consistent water cooling while tangential input into the cooling chamber optimises pellet residence time in the cooling chamber. Careful attention to cooling is especially important for handling of crystalline polymers, such as PET, says Baumann, who explains that consistent cooling produces more consistent crystallinity.

The company also introduced some new pelletising hardware at K2022. The Primo SI strand pelletiser is an updated version of the Primo S, providing an open frame design that is flexible in terms of configuration and is accessible from all sides. A centralised drive system allows the operator to configure parameters via a Bluetooth interface and read process data in real time, while all controls are located next to the cutting head to make them easy to access and read. The sound insulation system has been optimised to reduce operational noise levels. Maag says spare parts can be exchanged between the original Primo S and new SI models.

Advanced die plates

Also new is the Pearlo XXL high-capacity underwater pelletiser, which is designed for production throughputs of more than 40 tonnes/h. It features updated tools and chamber that improve thermodynamic performance. The large-diameter, liquid-heated die plates include more than 2,000 die holes using technology from AMN, a French specialist that Maag Group acquired in 2022.

AMN dies include a cutting face with tungsten carbide nibs, intelligent one-way heating circuits, and a vacuum insulation system. The latter places insulation under the cutting face and is said to help create a tight pellet size distribution. The AMN Central Injection System is said to improve pellet cooling and injection and can provide benefits in high-volume pelletising of high melt index materials.

Maag's new introductions are completed with the eXso pellet dryer, which is an updated, smaller-footprint version of the company's legacy dryers. It offers multiple pellet inlet and water outlet connections that make it suitable for a wide range of underwater and wet cut strand pelletising applications with throughputs up to 8,200 kg/hr. The new design also has fewer wear items and improved access for cleaning.

The SP line of strand pelletisers from **Coperion** has been updated with new features that are designed to simplify handling, reduce downtime for product changes, and improve pellet quality. The SP140, SP240 and SP340 pelletisers cover throughputs from 100 to 3,000 kg/h and use an improved strand intake design in which strands are continuously and directly guided into the cutting

Right: Coperion's SP strand pelletisers are said to offer easier operation and improved pellet quality

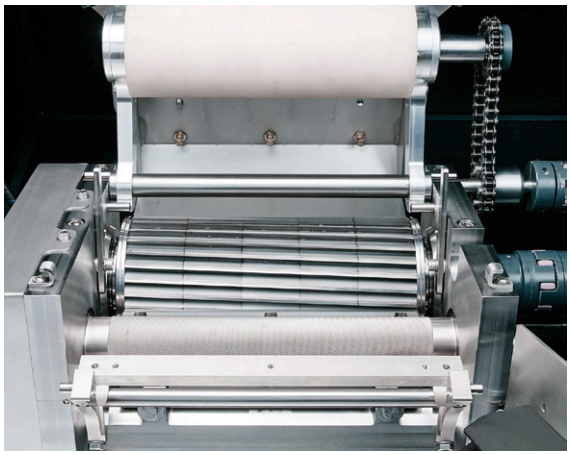
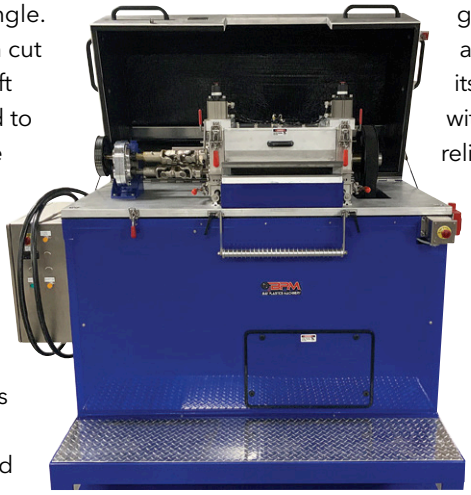


IMAGE: COPERION

IMAGE: BAY PLASTICS MACHINERY



Left: BPM's AXP (HD) is a heavy duty version of its current X-Class pelletiser

section at the optimal cutting angle. This is said to ensure that a high cut quality is achieved even with soft polymers. Flanges are designed to enable optimal use of the entire width of the cutting rotor while the compact cutting chamber design leaves very little dead space, which reduces cleaning time.

The updated pelletiser design also significantly reduces setup times. Coperion says the cutting gap can now be adjusted quickly with no tools. The company adds that the complete cutting area is now accessible without tools and the cutting unit can be exchanged quickly and easily in one piece, which further minimises machine downtime.

Other standard SP features that ease operation include a pellet outlet chute with soundproof cladding, frequency-controlled rotor drive and upper feed roll, and pneumatic control of feed roll pressure that can be directed from the control panel using an air pressure display.

Expanded strand options

Two new strand pelletisers were introduced by **Bay Plastics Machinery** (BPM) at the end of last year. The AXP (HD) system is a heavy duty version of the company's A-Series X-Class pelletiser. Available in 12" and 16" cutting widths, the new version incorporates larger motors to handle compounds such as heavily glass-filled materials. Larger diameter rolls and bearings reduce deflection across the cutting width, and a push-pull bed knife holder enables users to easily adjust the bed knife gap so that the cutter is consistent from end to end.

AXP (HD) series pelletisers can be equipped with an optional gearbox that allows users to engage both upper and lower feed rolls. Positive drive of the upper feedroll assists in pulling heavy filled materials, which may be difficult to feed, especially on start-up, says James Forgash, Vice-President of Sales at BPM. He says having both feed rolls engaged reduces the chance of strands slipping or possibly dropping and makes start-up much easier.

Feed roll air cylinders are larger on the HD machines than on the standard design, so users can apply more clamping force as needed. An optional rotor coupling drive allows the rotor to remain free of belt load with higher horsepower options.

US-based BPM has been stepping up its focus on global markets, including Asia, according to Forgash. As a result, its equipment is being designed with AC motors that are more reliable and more accepted globally compared to DC motors, he says.

An updated version of its BT25X benchtop pelletiser, which previously used a 110V DC motor, now uses an AC motor that drives in a range of voltages. The new design offers a wider speed range than the previous model, and also provides the option to run in batch or continuous mode. Drives are housed in the control cabinet, which gives the new system a higher environmental rating. A new safety feature on the BT25X is a streamlined version of the Safe Torque Off (STO) function found in the company's full production models. A lockable rotary disconnect has also been added as a safeguard for maintenance procedures.

Safer operation

New feature additions to **Nordson**'s BKG pelletising systems focus on safety and ease of use, both of which are especially important in compounding applications that frequent product changes, according to the company. One example is a new locking system that improves coupling of the pelletiser to the water box.

In the past, the pelletiser was coupled to the water box with a special clamping flange and security was ensured with a key system. In the new system, the safety lock is activated upon closing and this action releases the signal for the start. After start-up, the safety lock remains active until the pelletiser motor is stopped completely. "This is more comfortable for the operator. Start-up and shut down are also done much quicker," says Reinhild Bolwerk, Global Product Category Manager at Nordson.

Below: The BT25X laboratory pelletiser from BPM offers AC drive and improved safety features

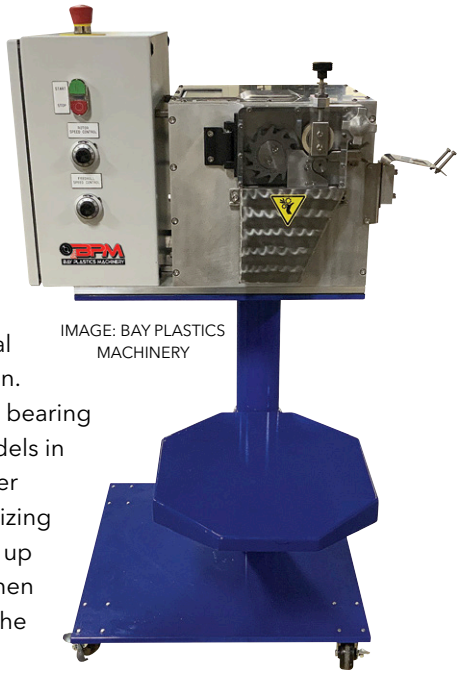


IMAGE: BAY PLASTICS MACHINERY

Another new feature is an updated bearing design used in some of the dryer models in the Nordson BKG pelletiser. "The lower bearing of a dryer is susceptible to seizing since polymer material tends to build up in that area. As a result, particularly when processing wear-intensive materials, the mechanical seals are highly stressed

Erema doubles up for better PCR pellets

Melt filtration is critical when working with recyclates. Erema's Intarema TVEplus DuaFil Compact double-filtration machine for processing of post-consumer materials to pellets combines the company's TVEplus extruder with its new DuaFil Compact filtration technology.

"Because there is no discharge metering zone and the melt pump is custom designed to the application, the pressure build-up required for the second filtration unit is especially efficient and only needs a much lower temperature", says Sebastian Sochor, R&D Engineer at Erema. As a result, the extruder can be 10 L/D shorter than the previous system design.

Sochor also says that the lower melt temperature – 18.5°C lower than its predecessor – improves melt quality and reduces energy consumption. It also prevents the risk of combustion of impurities such as paper labels and wood particles, which reduces odour formation and discoloration.

Right: Erema's Intarema TVEplus DuaFil PCR to pellet recycling system uses low pressure build-up double filtration

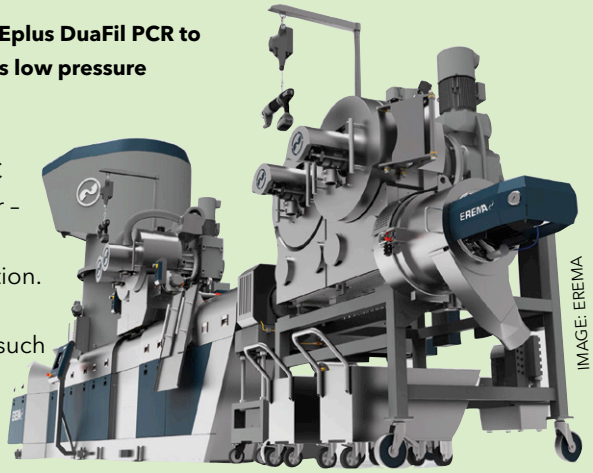


IMAGE: EREMA

"Ultimately, the high quality of the recycled pellets that we achieve with this system creates the opportunity to increasingly replace virgin material with recycled material in end products, meeting the current market trend and sustainability requirements," says Michael Heitzinger, Erema Managing Director.

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and must be replaced more frequently. And this is quite a bit of work. It isn't easy to pull the bearing from the shaft, especially when it is seized. But it is also no option to remove the shaft itself," says Udo Hoesker, Application Engineer at Nordson.

In the redesigned lower bearing area, the shaft is divided into two parts. Each is fixed with an easy-to-release coupling and can be taken out separately. It is then easy to take out the smaller part with the bearing and work on it, Hoesker says.

The improvements are valuable for compounding applications and also beneficial when processing recycled material. "We expect more inquiries from the recycling sector in the coming years, and we are prepared for it," says Bolwerk. "In recycling, time is money, and easy and quick equipment handling is key to an efficient process."

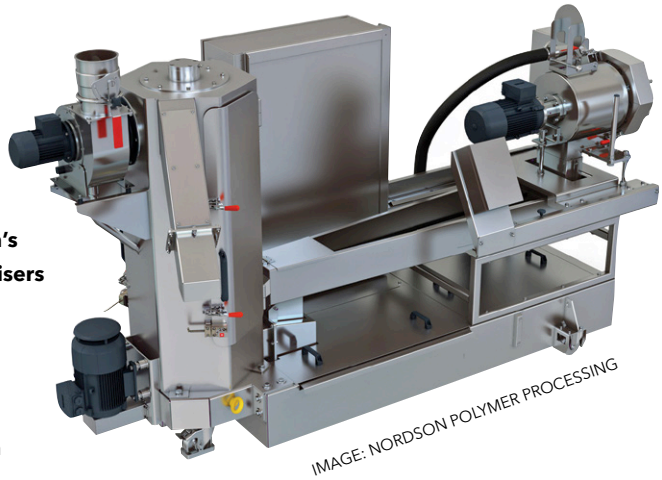

IMAGE: NORDSON POLYMER PROCESSING

Right: Updates to Nordson's BKG pelletisers include an improved water box safety connection

Robust recycling

Demand for recycled material is increasing and recycling companies are looking for robust and flexible pelletising systems that can handle a large variety of materials, according to Simon Weis, Product Manager for Underwater Pelletising Systems at Germany-based **Intelligent Pelletizing Solutions** (IPS).

The company recently commissioned an ips-UWG 120 S underwater pelletising system for use with highly viscous polyolefins at RSH Polymere, a compounder of recycled plastics located at Hamburg in Germany. A challenge in this application was to design the die plate to generate as low a pressure drop as possible for the required throughput of 3,000 kg/h, says Weis. The installed system uses a perforated die plate design and a new size of the company's ips-GT 3000/3 pellet dryer to achieve the high throughput required.

In 2022, IPS added a co-rotating twin-screw extruder for compounding, recycling, and LFT production to its portfolio. Weis says the company can now quote complete production lines and be a single-source equipment supplier for its customers.

CLICK ON THE LINKS FOR MORE INFORMATION:

› **www.maag.com**
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IMAGE: SHUTTERSTOCK

Ensuring perfect pellets

The latest in-line optical inspection systems can help ensure that pellets are free of a wide range of contaminants, including black specks and degraded material

Whether it be for high performance packaging films or high voltage cable compounds, there is a growing number of plastics application sectors where contaminants cannot be tolerated. Optical inspection systems can provide polymer producers and compounders with a means to guarantee every pellet that leaves the plant meets the most demanding standards.

"Every polymer has some level of optical defects that can be seen by either the naked eye or by camera-based vision systems, and they have a myriad of root causes," says **Southern Analytical** President Ted Schrein. "These defects can cause either aesthetic or performance problems, or both. They can be found in resins produced by virgin resin producers that are shipped out in pellet or powder form to downstream customers, or in subsequent production of films, sheets, mouldings, and coatings. In short, they can be found in any step throughout the entire supply chain. As the end use quality of polymer products becomes ever more stringent, optical inspection becomes ever more necessary."

With the advent of high-speed CMOS cameras, Schrein says high level optical inspection is now a practical, affordable and accessible option that can be carried out on either representative statistical samples or on the entire production.

"For resin producers, optical defects include gels in film grade resins, black specks or other contaminations in pellets or powder, misshapen or mis-sized pellets that can cause extrusion feeding problems or subsequent film quality problems," Schrein says. "Resin producers check each production lot before shipping, often by testing grab samples from the production line or loading points. However, continuous online sampling of a production process is becoming more and more popular because problems can be found earlier and corrected."

Southern Analytical distributes the **OCS** range of laboratory and in-line optical inspection systems in the US. This product line includes the PS-25C

Main image: In-line inspection can help ensure the high pellet quality required for the most demanding polymer applications

camera-based pellet analyser for black speck and colour contaminant detection at up to 25Kg/hour; the PSSD analyser for classification of pellet defects such as tails, smears and dust; the PA-66 pellet analyser, which combines the PS-25C and PSSD into one integrated system; and the large PS-400C pellet analyser for black speck and colour contaminant detection and sorting at up to 400 kg/hour. According to the company, the PS-400C is particularly effective with clear pellets.

Italy's Industrie Polieco-MPB group is using Purity Scanner Advanced optical technology from Germany-based **Sikora** to inspect and sort maleic-anhydride grafted functional polymers for use as adhesives layers in packaging films and multi-layer pipes.

According to Sikora, in this application the Purity Scanner Advanced system reliably detects pellets with colour deviations, as well as those with small black spots on the pellet surface, which occur due to side-reactions during the production of grafted polymers. The system automatically detects and sorts out all pellets with contamination from a size of 50 microns. It also provides detailed statistical data to allow Industrie Polieco to optimise its production process.

"During the development and continuous improvement of our production processes, we have been able to minimise the formation of black spots and of pellets with colour deviations. However, the presence of such defects cannot be completely avoided: sorting systems like Sikora's Purity Scanner Advanced have the essential task to get rid of such residual defects so that we can provide our clients a superior quality material,"

Sikora's Purity Scanner Advanced in-line pellet inspection system is in use at Industrie Polieco

IMAGE: SIKORA

explains Marina Ausonio, Research & Development Executive at Industrie Polieco-MPB.

According to Sikora, most pellet inspection system use a maximum of two cameras. However, at last year's K show it demonstrated a system with three 25 micron high-resolution black-and-white cameras, which it says further lifts detection rates. "By using a third black-and-white camera in the Purity Scanner Advanced, a significantly higher detection rate is achieved, so that more contaminants are detected – this is unique with our system," says Ralf Kulenkampff, Head of Sales – Plastics.

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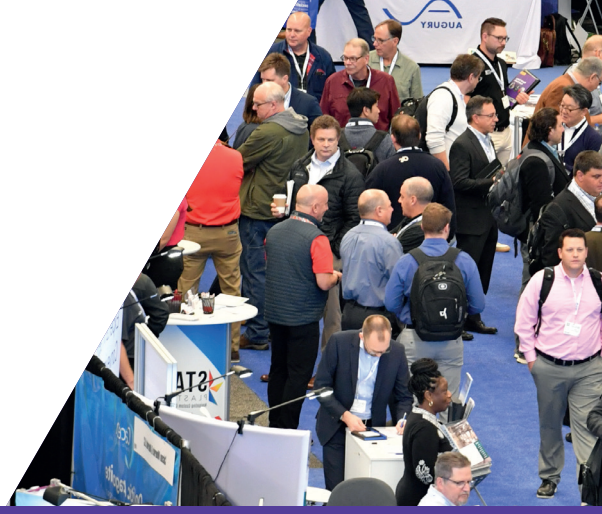

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Testing times for plastics

For reasons ranging from the growing use of recyclate to tougher regulation, testing and indentification of plastics is becoming increasingly important. Chris Saunders learns more

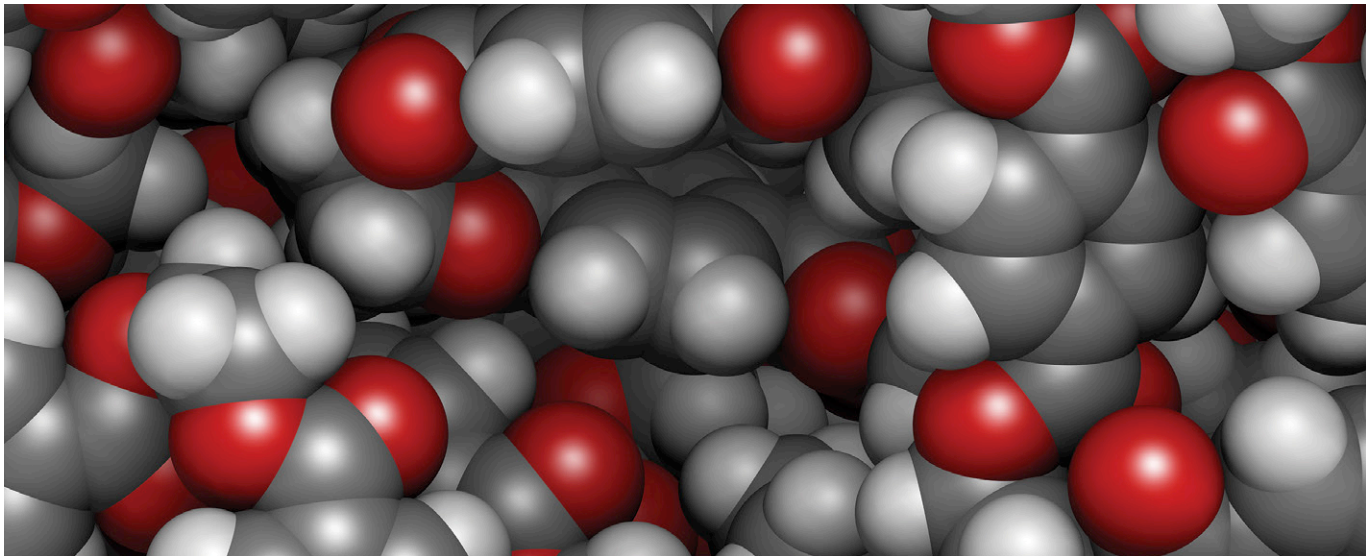

IMAGE: SHUTTERSTOCK

Main image: Fast and effective polymer identification and analysis is seen by many as a key enabler for a circular economy

In today's rapidly changing world, the plastic industry faces numerous and often unforeseen challenges. The ongoing recycling boom and constantly evolving regulatory requirements, for example, together with changing consumer and customer expectations mean that accurate polymer analysis and testing capabilities have never been more crucial. Or complex. This article takes a look at some of the latest testing developments and emerging trends.

Polymeric material manufacturers have long been seeking ways to save energy, reduce cost and improve efficiency while maintaining the same product quality, if not improving it. In response, analytical instrument manufacturers have had to quickly adjust to help the industry meet new requirements.

Like many testing equipment manufacturers **Netzsch**, which over the past 60 years has become a leading name in thermal analysis, rheology and fire testing, finds itself increasingly focused on recycling. "Polymer characterisation is important for the circular economy of plastics. To increase recycling rates, firstly it is essential to sort the different pre- and post-consumer streams into the individual materials," says Dr Shona Marsh, Application and Product Marketing Manager Rheology at the company.

"Secondly, it is necessary to analyse the resulting composition both qualitatively and quantitatively. Different tools for analysis are available, but quantification is still limited. One technology that is suitable for both is Differential Scanning Calorimetry (DSC). The characteristic melting peaks and enthalpies can be used to identify and quantify using additional software tools such as Peak Separation and Identify, unique to the Netzsch ecosystem of analysis instruments," she says.

"The melting peaks of a polymer mixture can be seen in the image [Figure 1]. Two peaks are observable, which can be separated into individual peaks using the Peak Separation tool. Once separated, the peaks are identified as LDPE and PP using the Identify software. When the reference material is known the mass associated with the peaks can be calculated using the Concentration feature [and]

IMAGE: NETZSCH

Left: The DSC 300 Caliris is the latest addition to the Netzsch DSC range, designed to maximise testing flexibility and ease of operation

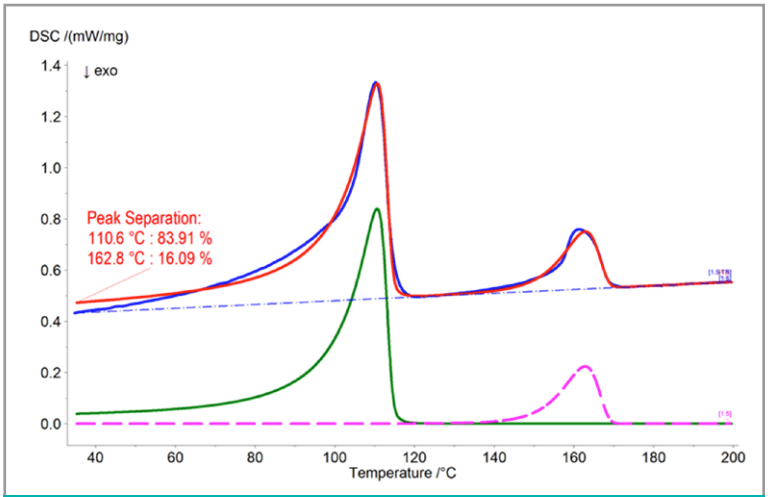

Figure 1: Melting curves from a Differential Scanning Calorimetry (DSC) analysis can be used to identify and quantify amounts of different polymers, in this case LDPE and PP, using software tools to separate the peaks
Source: Netzsch

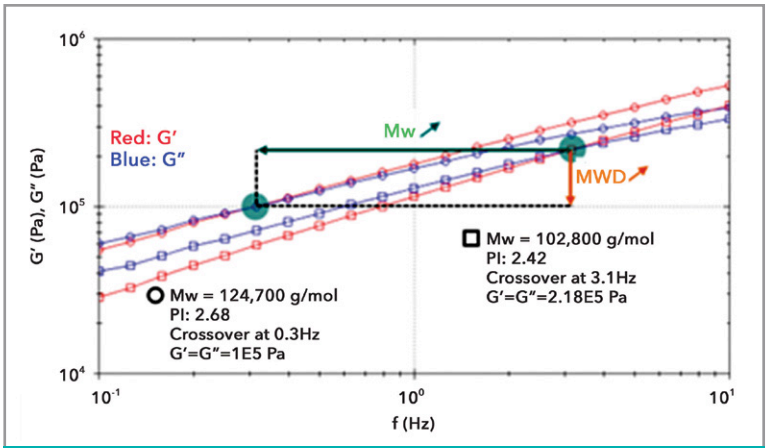

Figure 2: Rheological data showing storage and loss shear modulus of two PA12 polymers. The square data points represent virgin material and the round data points a recyclate. The shift in the cross-over point on the X-axis shows that molecular weight increased during processing
Source: Netzsch

the results summarised on the graph.

"In addition, quantification of inorganic materials such as metal fragments in a polymer delivery can be measured with a Thermal Gravimetric Analysis (TGA), where mass loss during decomposition can be precisely determined," Marsh says.

Dr Natalie Rudolph, Business Field Manager Polymers - Global Business Development at Netzsch, says the company's testing expertise also extends to processing insights. "Rheological characterisation can assist in optimising processing parameters. Rheological measurements range from establishing shear and extensional viscosity in order to assess processability, through to the determination of viscoelastic properties, namely storage and loss shear modulus, to gain insight in molecular weight and molecular weight distribution."

Data in Figure 2 shows the storage and loss modulus of two PA12 materials. It can be seen from the shift in the cross-over point of both moduli on the X-axis that the molecular weight has increased during processing. It can also be seen that the molecular weight distribution was only slightly affected, indicated by the small shift in the cross-over point on the Y-axis.

Software innovations

Thermal analysis techniques have been an essential part of raw materials and finished goods analysis for many years and analytical instrument manufacturers have responded by using the latest software to push the limits of the techniques and increase detection limits. **Hitachi High-Tech Analytical Science**, part of Hitachi High-Tech Group, is investing considerable development effort in software tools.

"Driven by Industry 4.0, many polymetric material manufacturers are looking for ways to improve traceability, prevent human error and increase effectiveness," says Olivier Savard, Product Manager Thermal Analysis at the company. "Software options like the recently launched Hitachi High-Tech Analytical Science's input/output software update improve workflow efficiency through automatic analysis to allow end users to simply scan a bar code to have the sample information, method settings, analysis method and where/how the results need to be saved included automatically within its thermal analysis software. When used with an autosampler, users get a complete automation from sample information input to results export which helps to reduce costs."

According to Savard, material analyser connectivity is also an increasingly prominent emerging trend. "The idea of a fully integrated, connected, and flexible analysis equipment that feeds smart factories with a constant stream of data is coming and is much closer than many think," he says. "This data provides valuable information to the workforce, enabling them to make the right decisions at the right time to reduce wastage and costs to improve production yield, throughput and crucially, bottom line."

Another trend highlighted by Savard is the combination of different technologies. "Extra information like the effect of temperature on the sample colour can now be investigated with camera systems fitted on thermal analysis instruments, like Hitachi High-Tech Analytical Science's RealView," he says.

"Over the last few years, it has become easier to gather more information from thermal analysis by

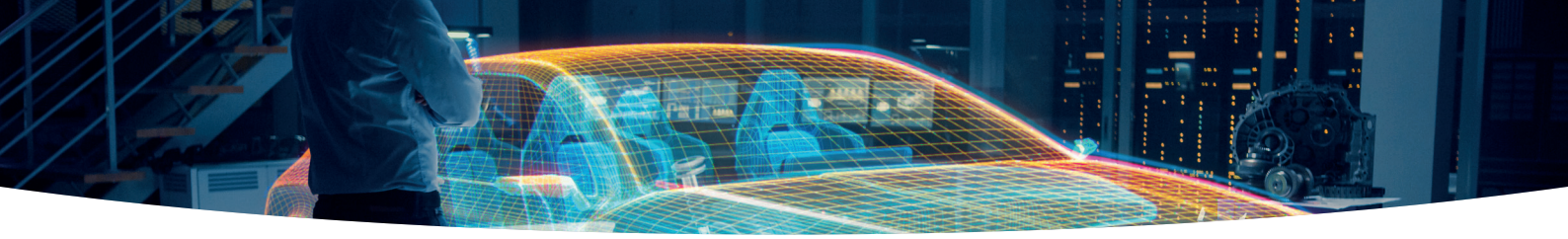

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IMAGE: HITACHI HIGH-TECH ANALYTICAL

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

connecting other techniques such as FTIR, MS, and GCMS to provide R&D teams essential information about material composition and stability. For example, Hitachi High-Tech Analytical Science'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."

German AI software specialist **LabTwin** has developed a voice-powered digital lab assistant that enables hands-free data capture through voice notes or connected lab instruments while working at the bench. Its system is intended to provide on-the-go access to safety or operational information and can talk scientists through protocols and record any deviations or out of specification results. Captured data is then automatically structured using LabTwin's deep learning capabilities and enriched with metadata, the company says. Late last year, DSM said it had signed a multi-year license and collaboration agreement with LabTwin and will apply the technology in several of its Science & Innovation laboratories globally (it did not disclose if this included polymer sites).

Regulatory compliance

The growing use of recycled polymers in production, together with new regulatory compliance requirements, brings added challenges for plastics processors and users. More testing is needed to ensure raw materials and finished goods meet specifications, with many manufacturers having to rethink their production processes as a consequence.

Working within the UK-based Sustainable Certification Group (SCG), **Impact Solutions** has lead a team of scientists and academics to develop a methodology for determining the recycled content of PET structures (now published by BSI as FLEX 6228). The work was initiated following the announcement of the UK tax on packaging products containing less than 30% recycled content.

The concept behind the FLEX 6228 standard is that a bottle can be taken from the shelf in a supermarket and a reasonably accurate estimate made of its recycled content. The standard is not intended to be used as an alternative to a mass balance/supply chain audit approach, but in parallel with it.

"The standard works by recording results from a number of simple analytical tests: Transmission and Absorbance at 350nm and 678nm; Colorimetric measurements including Lab and Yi (Yellowness index); and Crystallisation temperature. These values are then compared against a 'training set' of data which was used to build a mathematical model, based on 'R' which can predict whether the tested material has a recycled content of greater than 30%, with a 95% confidence level," explains Steven Burns, Commercial Director at Impact Solutions.

The standard deliberately biases the classification to make false assessment of tax liability less likely by setting the probability threshold for the recycled content of the sample being >30% at a 0.3 probability (rather than 0.5 which is equivalent to 50:50), Burns says.

"The testing parameters chosen were selected based on screening 86 different industrially produced packaging products, with a range of recycled contents from fully virgin to fully recycled from across the globe. They were tested in several techniques with parameters recorded and a Lasso model used to select those which best correlated with recycled content," he says.

"The principal selection criterion was to minimise overall error of the predictions, the Lasso model enabling parameter selection by identifying those variables highly correlated with the target variable and selecting the best parameter from groups of variables that are highly correlated with one another and eliminating the remainder. While the testing parameters ultimately employed are perhaps not those one might have expected at the outset, they produce the best model from the available data," according to Burns.

The standard allows blind testing to ascertain whether a material might contain recycled content and provides accurate determination of recycled content where both the source of virgin material and recycled resin are available. The data used to create the model could also be redeployed to allow the calculation of probability of recycled content being above a higher threshold.

Traditionally, polymer testing takes place in a laboratory, minutes or more often hours after

production. However, **SKZ** (the German Plastics Centre) aims to challenge the status quo by focusing its research and development on non-destructive testing methods for inline use.

For example, using UV/VIS/NIR-spectroscopy, the centre says it should be possible to detect the amount of a specific additive in a highly filled polymer melt in real time using chemometric models. The accuracy of such models depends on the training data as well as the accuracy of the reference data. According to SKZ, in a model for a melt filled with 50 wt% $CaCO_3$ the achieved error of additive concentration was as low as 0.025 wt%.

The implementation of chemometrics combined with machine learning could offer a solution to many current issues in polymer testing and could be implemented inline in polymer recycling, SKZ says. Using feedback loops, automatic adjustment of feeders could lead to a reduction of excess ingredients such as additives or colour masterbatch while guaranteeing or even improving the quality of the regranulate. This should greatly improve the quality of the recycled material and allow a broader use, even in highly sophisticated applications.

Current research at SKZ also indicates that non-destructive testing methods such as THz-spectroscopy and ultrasonic-testing can be used to reliably detect gel particles and foreign material such as metal, paper or wood, in a polymer melt. These measurement techniques can make an important contribution to comprehensive and reliable quality assurance, particularly where a high proportion of recycled material is used.

Inline measurement technology can also contribute to continuous quality assurance in polymer foam extrusion. In recent years, SKZ says it has been able to successfully use microwave radar technology as well as THz-spectroscopy for non-contact determination of foam parameters such as density and cell size distribution.

SKZ maintains that the use of quality-assuring measurement technology will be indispensable to both the transition to a circular plastics economy and the continued high quality of products. It expects non-destructive testing to be a viable option in the shift from time and cost intensive random testing to 100% inline testing.

Molecular analysis

A broad range of analytical and quality control solutions for characterisation of polymers, biomacromolecules and polymer-containing composites are available from **Oxford Instruments**. Its portfolio extends to techniques for monitoring properties at atomic, molecular, and macroscopic levels, and includes AFM, SEM, EDS, Raman spectroscopy and imaging, and cryogen-free benchtop NMR instruments.

Asylum Research Atomic Force Microscopes (AFMs) provide detailed imaging of polymer blends and composites using a probe to 'feel' the sample. This physical interaction means AFM can map both sample topography and nanoscale modulus and visualise not just the size and distribution of additives

Mobile spectrometer to ease plastic waste

With support from the Alliance to End Plastic Waste, BASF-subsidiary **Trinamix** has developed a portable handheld solution for identification of different plastic types on the spot.

The solution, which is intended for use in locations where waste management infrastructure is limited or industrial sorting solutions not viable, combines Trinamix's Mobile NIR Spectroscopy unit with a smartphone, data analysis in the Trinamix spectroscopy cloud, real-time access to results via a mobile app, and documentation of results in a customer portal.

The partners are making 50 kits available, with usage free for the first year. The aim is to work with partners globally in projects to explore where plastic waste occurs, how it is handled and where it ends up.

Left: The Alliance to End Plastic Waste worked with Trinamix to develop a mobile spectroscopy system to help develop plastics waste management systems

Speaking at the launch of the initiative at the K fair in Germany last November, Trinamix Business Development Manager Adrian Vogel said: "Our solution allows users to identify plastic waste within seconds using a mobile device. The technology can help the sorters identify unknown samples and thus reduce wrong sorting due to uncertainty."

› **www.trinamixsensing.com**

like silica and carbon black in rubber blends, but also localise small quantities of oils and coupling agents. New generation AFMs are said to have greatly simplified this nanoscale characterisation and require minimal sample preparation compared to other microscopy techniques.

Raman spectral analysis is another method of characterising polymers and sample contaminations and defects. Confocal Raman microscopes from WITec enable fast and high-resolution Raman imaging, visualizing the spatial distribution of components and material properties such as crystallinity, orientation and stress states. The chemical information is colour-coded in the Raman images.

Last year, Oxford Instruments launched the X-Pulse benchtop broadband NMR spectrometer with X-Auto automatic sample changer. New functions increase ease of use, throughput and remote working capability, while further reducing ongoing costs by removing the need for deuterated solvents. Continuous flow monitoring and advanced sample temperature control are coupled with broadband nuclei selection to address a diverse range of analytical chemistry needs.

The combination with the new X-Auto sample changer, which allows up to 25 samples to be preloaded, and the new functionality of the SpinFlow 3.1 software lifts overall efficiency. By reordering experimental queues, short duration experiments can be prioritised to quickly determine the value of continuing with longer experiments. Pre-loaded samples can also be changed and new experiments added or modified through a remote connection.

"The new X-Pulse and X-Auto sample changer allows our customers to make a step change in throughput and efficiency of their research and process control, enhancing new remote and hybrid working patterns," claims Dr Ian Wilcock, Managing Director Oxford Instruments Materials Analysis.

IMAGE: BRABENDER

Below: Brabender's TSSR-Meter can be used to analyse stress relaxation behaviour within thermoplastics and elastomers under iso- and anisothermal conditions

Exploring stress

Polymer testing is extending to every facet of production. **Brabender** says it has become particularly adept at testing quality of films where it says its TSSR-Meter (Temperature Scanning Stress Relaxation), which characterises the stress relaxation behaviour within thermoplastics and elastomers under iso- and anisothermal conditions (AISR-method – Anisothermal Stress Relaxation), has become a crucial tool.

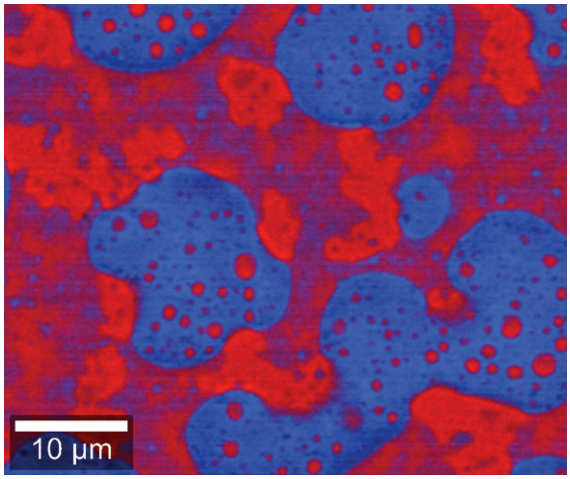

IMAGE: OXFORD INSTRUMENTS

Above: Raman spectral analysis provides a tool to characterise polymers and sample defects using special imaging techniques to visualise spatial distribution of components or material properties such as crystallinity, orientation and stress

"Developed initially for the characterisation of elastomeric materials, the TSSR-Meter can also be applied for the analysis of thermoplastic materials in form of thin rod-shaped specimens and films," says Michael Stanko, Business Development Manager Plastics and Rubber at Brabender.

"The performance of TSSR tests for films are similar to the tests on elastomeric materials [whereby] specimens according to DIN EN ISO 527-3 are inserted into appropriate clamps and subsequently tested," he says. "In the AISR mode, the sample can be heated in a temperature chamber during the relaxation process at a user-defined constant strain by means of a temperature ramp to a maximum of 300°C. This provides information on the time and temperature dependent progression of the force respectively stress drop."

The TSSR represents a useful tool for rapid quality control and evaluation of expected long-term properties, particularly in the context of monitoring manufacturing processes, which are strongly influenced by batch fluctuations. As the use of recyclates and bioplastics with material-specific property variations increases, this aspect is becoming increasingly important, Brabender claims.

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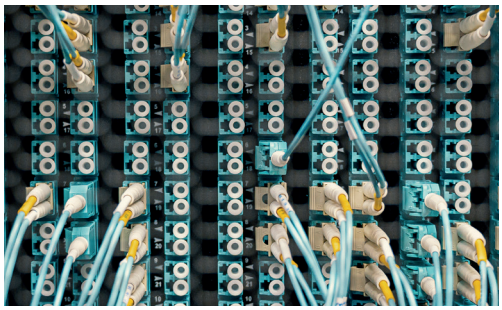

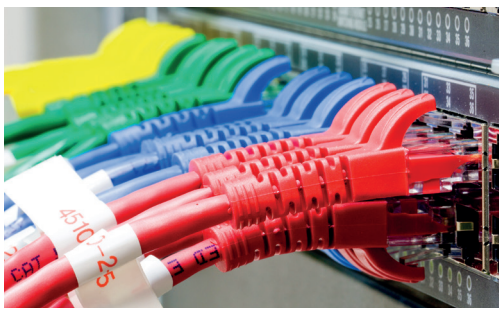

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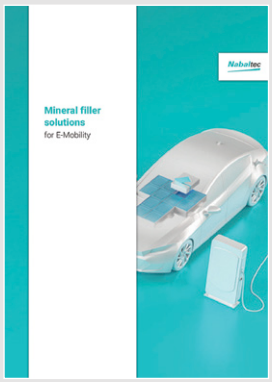

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The Compounding World December issue has a cover feature on flame retardants, the latest products and new market developments. Plus anti-counterfeiting additives, laboratory compounders and materials testing and a review of K2022.

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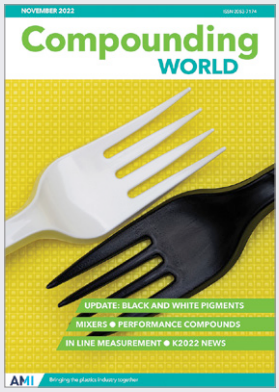

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The Compounding World November issue has a cover feature that looks at black and white pigments and how they must meet demanding regulatory, environmental and performance needs. Plus features on high-performance compounds, inline measurement and mixers.

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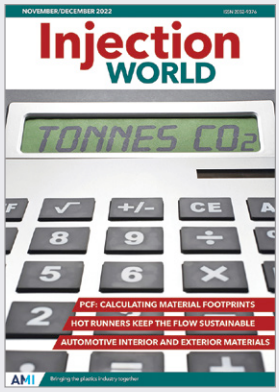

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The November/December edition of Injection World magazine looks at the fast emerging area of Product Carbon Footprints. It also explores developments in hot runners and automotive plastics, plus a review of key news from October's K exhibition.

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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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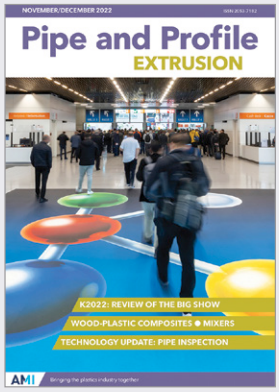

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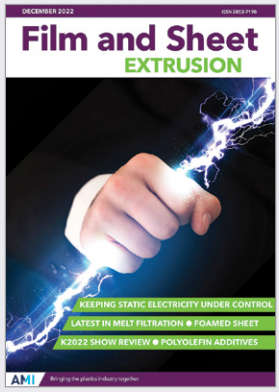

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The final 2022 edition of Film and Sheet Extrusion looked at some innovations in the field of static control. It also explored the latest developments in melt filtration, foamed sheet, and new additives for clarifiying and nucleating polymers.

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	30 May – 2 June	Equiplast, Barcelona, Spain	www.equiplast.com
	14-15 June	Compounding World Expo Europe, Essen, Germany	www.compoundingworldexpo.com/eu/
	5-8 September	Plast 2023, Milan, Italy	www.plastonline.org/en
	20-21 September	Injection Molding & Design Expo, Novi, MI, USA	www.injectionmoldingexpo.com
	26-28 September	Interplas, Birmingham, UK	www.interplasuk.com
	17-21 October	Fakuma, Friedrichshafen, Germany	www.fakuma-messe.de
	8-9 November	Compounding World Expo USA, Cleveland, USA	www.compoundingworldexpo.com/na/
	28 Nov-2 Dec	IPF Japan 2023, Chiba, Japan	https://www.ipfjapan.jp/english/
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6-8 March 2023	Cables Europe, Cologne, Germany
18-20 April 2023	Masterbatch Europe, Cologne, Germany
26-27 April 2023	Fire Retardants in Plastics, Philadelphia, PA, USA
16-17 May 2023	Functional Fillers, Philadelphia, PA, USA
6-7 June 2023	Plastics in Electric Vehicles, Munich, Germany

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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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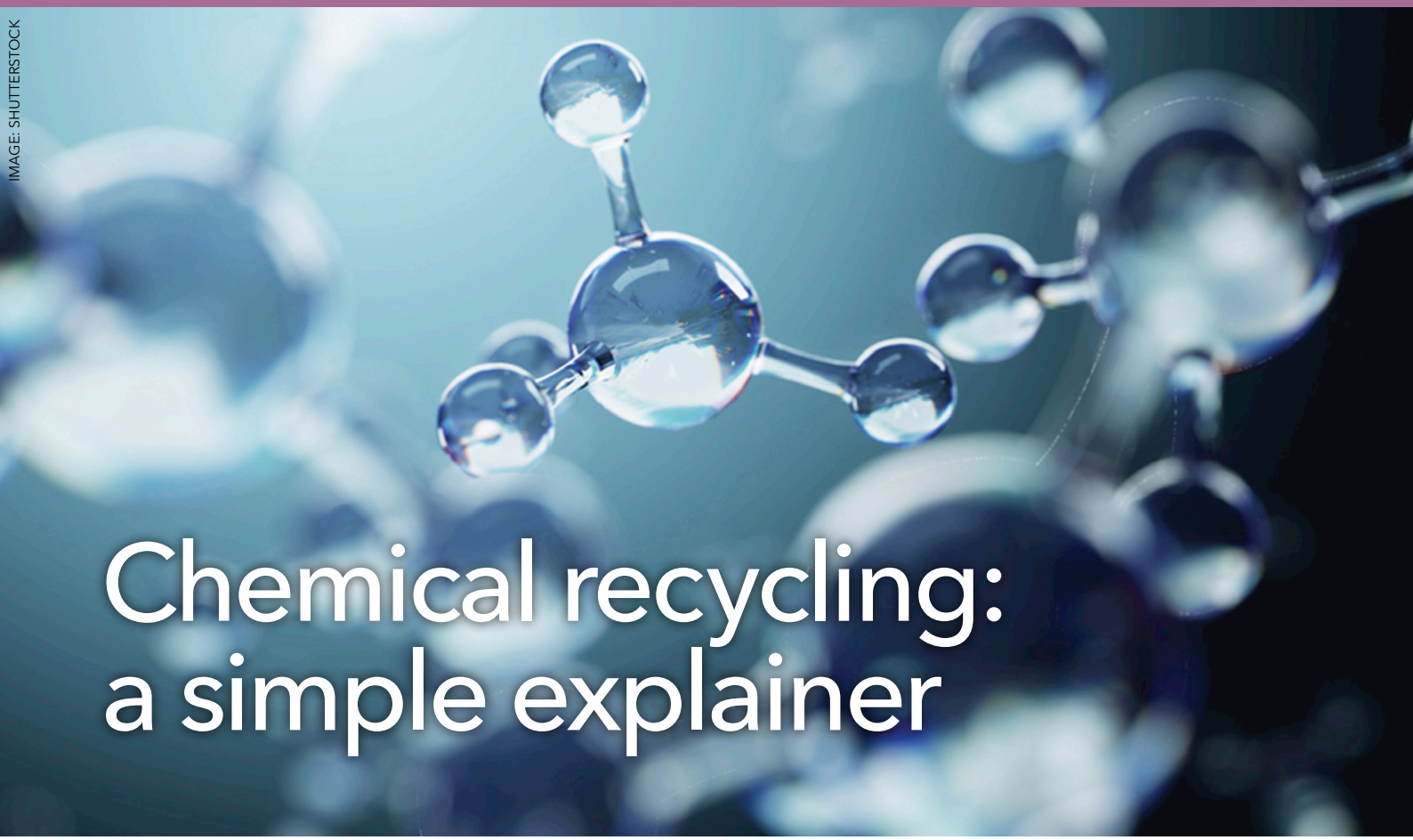

IMAGE: SHUTTERSTOCK

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

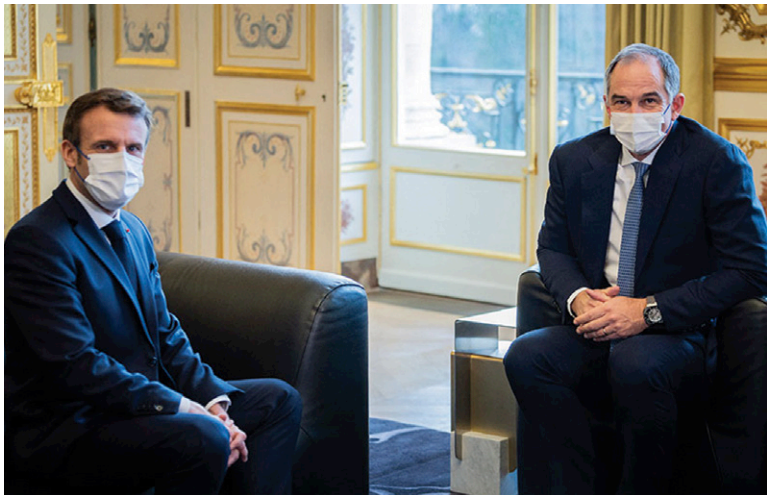

IMAGE: ELIOT BLONDET/ABACAPRESS.COM

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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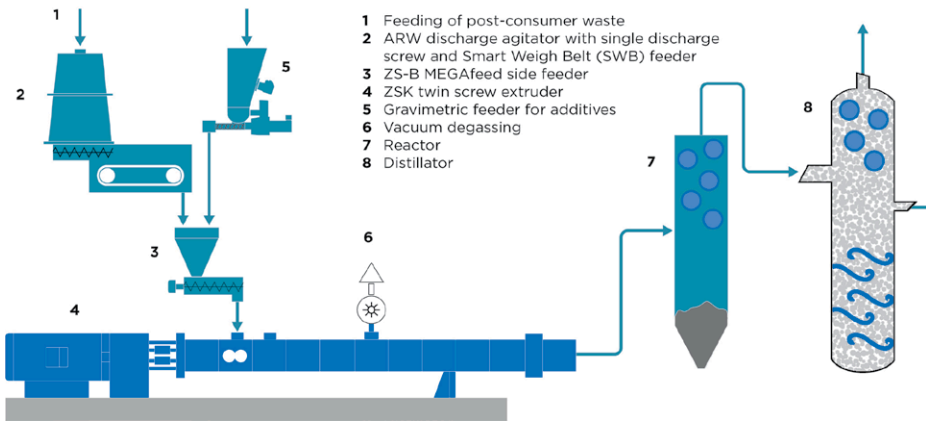

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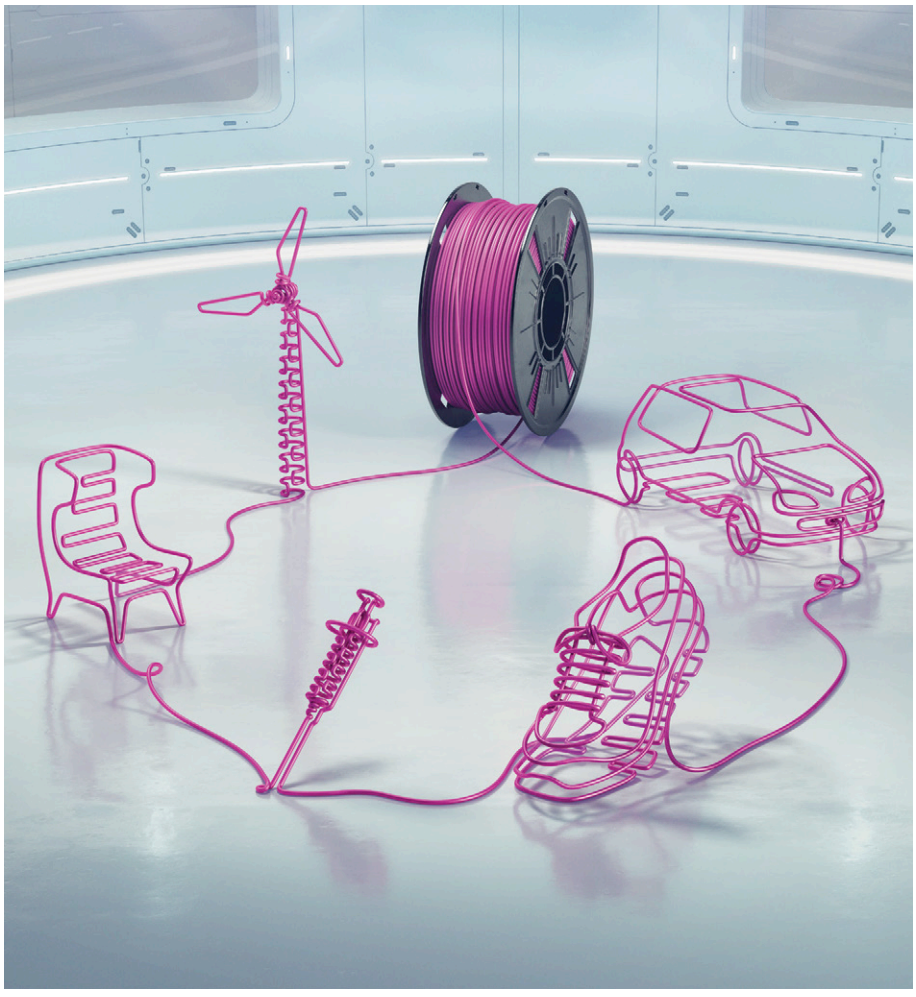

Every Circle needs a Center: Evonik Center for Circular Plastic Solutions.

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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

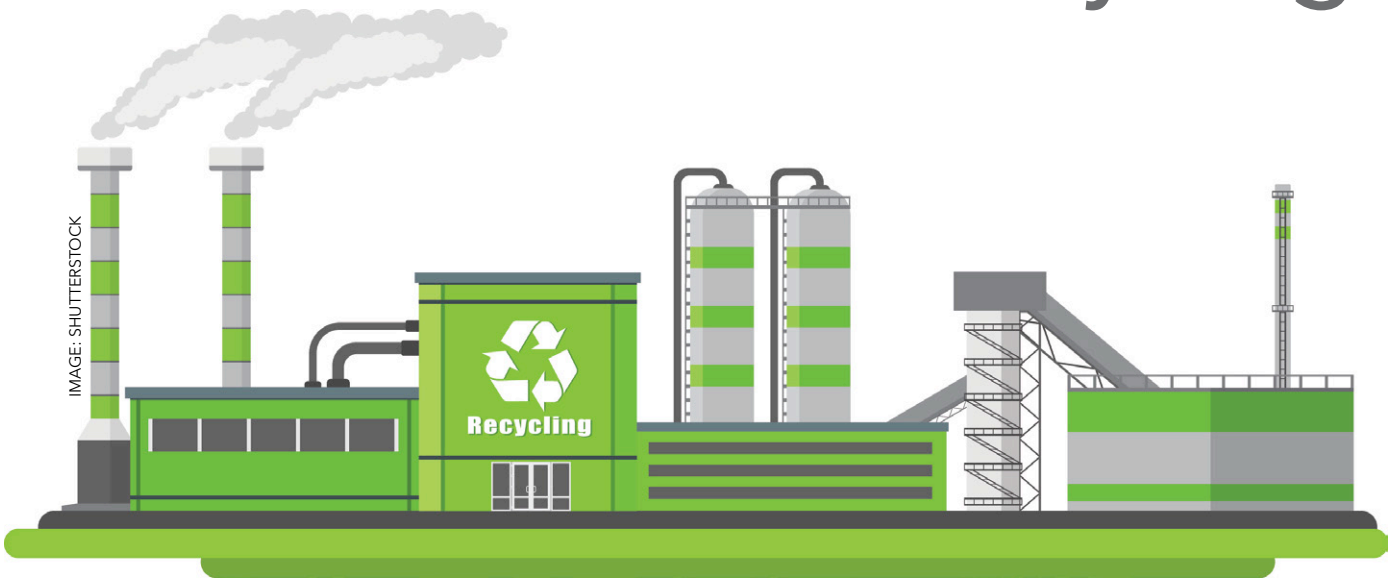

IMAGE: SHUTTERSTOCK

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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