

# Compounding WORLD

A thermal image of a circuit board, showing various components and traces in shades of blue, green, yellow, and red, indicating different temperatures. The image is used as a background for the magazine cover.

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**BIO-BASED PATH TO PVC PLASTICISERS**

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# Compounding WORLD

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COVER PHOTO: SHUTTERSTOCK

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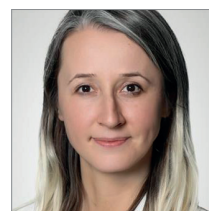
## Speakers include



**Pierre Furtwengler**  
Technical Polymers Specialist,  
Renault Group



**Marta Pérez Argilés**  
Researcher of Construction and Renewable Energies Group, Aimplas



**Buket Turan**  
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# Aurora expands in Ohio

US-based Aurora Plastics has broken ground on a new compounding plant at its Streetsboro location in Ohio.

The company said the expansion of what is already its largest facility will add to its thermoplastic compounding capabilities in rigid PVC, rigid PVC alloys and CPVC and will provide more than 100m pounds (45,000 tonnes) of new capacity.

"We see continued strength in our end markets for Aurora's products and services over the next several years," said Darrell Hughes, Aurora Plastics CEO. "The expansion facilitates our main goal, which is to be our custom-



**Above: Aurora Plastics is building a new rigid PVC compounding plant at Streetsboro in the US**

ers' first choice in polymer solutions by combining the highest quality products with rapid delivery."

The new facility is expected to commence production in Q4 of next year and will see the company take on an additional 30 staff.

Aurora Plastics is owned

by investment group Nautic Partners. The company has five manufacturing sites in North America - Streetsboro in Ohio, Welcome in North Carolina; Lunenburg in Massachusetts; Pasadena in Texas; and Marieville in Québec, Canada.

> [www.auroraplastics.com](http://www.auroraplastics.com)

# Alphagary offers bio-based TPEs

Alphagary has introduced the Evoprene Eco 1000 series of TPE compounds, which are formulated using bio-based raw materials.

The introduction is described as part of the company's wider strategy to

expand its portfolio of sustainable materials.

The company says that tests on grades with 25% bio-based content show they match traditional petrochemical-based compounds in terms of

mechanical properties (such as specific gravity, durometer, and tensile strength). They also provide good heat resistance, and consistent flow and surface finish.

> [www.alphagary.com](http://www.alphagary.com)

## Teknor Apex aims for PA66

Teknor Apex's team at Rothenburg-ob-de-Tauber in Germany has developed a family of glass-filled engineering PP compounds that offer E-modulus of up to 11,000 MPa and a heat deflection temperature of 160°C, allowing them to replace PA66 in certain applications.

The new grades are said to offer a similar shrinkage to PA, allowing them to be processed in existing moulds. Dimensional, thermal and UV stability is all said to be good, while the ability to process without pre-drying at lower temperatures offers energy savings over PA alternatives.

According to the company, a 45% glass reinforced version of the new PP compound is being used in place of a 30% glass reinforced PA66 to injection mould an AdBlue diesel exhaust fluid tank cover for Mercedes.

> [www.teknorapex.com](http://www.teknorapex.com)

# Trinseo halts PS sale as markets tighten

Trinseo said last month it was to pause efforts to sell its styrenics business, which were initiated earlier this year and intended to include its feedstocks and PS reporting segments and 50% stake in Americas Styrenics.

The company said the process had generated "broad and significant interest," but that deterioration of financial markets and economic uncertainty created by the war in Ukraine mean it will not be possible to realise the full value.

"While the separation of the styrenics business is part of our transformation strategy, the current economic and financing environments make it challenging to get a value for the assets that is reflective of their significant cash generation," said Frank Bozich, President and Chief Executive Officer of Trinseo.

He said the decision does not change the company's transformation strategy and it will re-evaluate a potential sale when macroeconomic

conditions improve.

■ Earlier in July, Trinseo announced an expansion of its Altuglas acrylic resins plant at Rho, Italy. It said a new compounding line will be installed in Q3.

"This added capacity supports Trinseo's mould-in colour paint replacement solution," said Olivier Bourgeois, Resins Business Director, Engineered Materials EMEA. "There's a growing interest in this solution - particularly with automotive customers."

> [www.trinseo.com](http://www.trinseo.com)

## Campine adds PP recycling

Belgian metals recycler and chemicals company Campine has acquired plastics recycling company C2P, which is based at Villefranche-sur-Saône near Lyon in France, and two lead battery recycling plants that belonged to now insolvent Recylex.

The company paid €750,000 for the businesses, which had sales of around €88m in 2021 and have a current recycling capacity of some 11,000 tonnes/yr of PP and 90,000 tonnes/year of used batteries.

CEO Willem de Vos said the company sees interesting opportunities in plastics. "There are considerable synergies with our Specialty Chemicals business in terms of technology and customer base and the plastics recycling business offers plenty of chances for growth."

➤ [www.campine.com](http://www.campine.com)

## Delta Tecnic sales up 12%

Spanish masterbatch maker Delta Tecnic, which specialises in colour masterbatches for cable and PVC applications, reported a 12% increase in sales for 2021 to €51m.

According to the company, it has benefited during the turbulent post-pandemic period of supply chain tightness and war in Ukraine from its focus on the energy, construction and telecoms sectors, which it says are characterised by technological transformation and essential need.

This market diversification, according to CEO Eric Xirinachs, has allowed it "to navigate through an environment of volatility unprecedented in the company's history while maintaining our



IMAGE: DELTA TECNIC

**Above: Delta Tecnic has gained from its focus on energy and telecom markets**

growth and profitability."

Establishing a manufacturing site in Mexico in 2020 – its first outside of Spain – has also helped, providing a strategic base from which to supply the key markets of the US, Canada and south America. The company has had a distribution presence in the region for more than

20 years but in its first year of local production saw a 28% increase in sales to €5.6m.

Despite the current market conditions, 2022 has started strongly for the company. It says overall sales were up by more than 21% year-on-year for the first four months.

➤ <https://deltatecnic.com>

## SAX ups capacity in Vienna

Hromatka Group company SAX Polymers has added two new twin screw compounding lines at its site at Vienna in Austria.

The technical compound-

er says the new lines almost double production capacity at the Vienna location. The investment is supported with the addition of two additional storage silos.

SAX said it is planning to invest more than €7m across its two production sites in Austria and at Oberriet in Switzerland by 2025.

➤ [www.saxpolymers.com](http://www.saxpolymers.com)

## SABIC launches talc PP for foam moulding

SABIC has launched a range of mineral-reinforced PP compounds for production of foamed injection mould parts requiring high surface aesthetic, such as automotive door panels and trim, seat and trunk cladding, A/B/C/D pillar covers and centre consoles.

The range includes three grades – PPc F9005, PPc F9007 and PPc F9015. The PPc F9007 grade is formulated for short-shot and low impact applications; the other two are

medium impact grades intended for core-back moulding (this requires part redesign and new tooling but can push part weight reductions to up to 30%).

SABIC says that unlike traditional

FIM materials, which typically exhibit surface defects such as silver streaking, swirl lines and dimples, the new grades provide a surface quality similar to solid injection moulded parts. This is achieved through the nucleating effect of the talc filler, which results in the generation of finer bubbles.

All three grades are currently available in selected automotive interior colours, with custom colouring also available.

➤ [www.sabic.com](http://www.sabic.com)

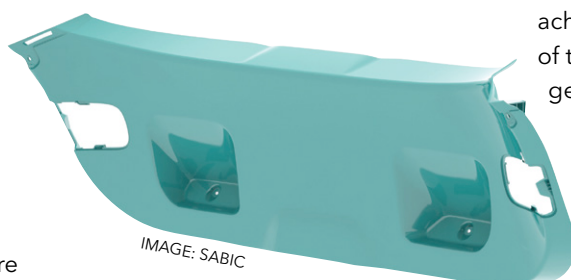


IMAGE: SABIC



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# Techmer gains ISO 13485

US compounder and materials development firm Techmer PM has secured ISO 13485:2016 certification for its site at Batavia in Illinois, where it plans to produce its recently launched HC medical grades.

Techmer CEO Michael McHenry said that the move “reinforces our corporate goals of continuous improvements and creating safe formulations for the medical device industry”.

The company says ISO 13485 certification means that its healthcare customers should be able to accept Techmer’s outgoing quality certifications as their incoming quality certifications.

➤ [www.techmerpm.com](http://www.techmerpm.com)

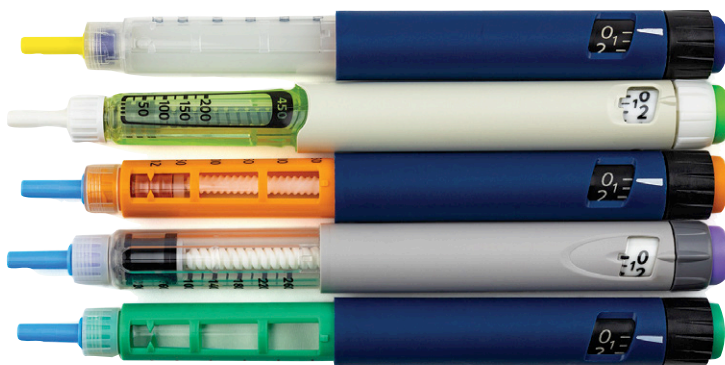


IMAGE: TECHMER PM

Above: Parts produced using Techmer PM’s HC medical compounds

## Recycling blockchain ideas

SABIC has launched a pilot project in partnership with technology company Finboot, chemical recycling firm Plastic Energy and packaging specialist Intraplás to investigate the use of blockchain technology in supporting end-to-end digital traceability of circular feedstock.

Finboot’s Marco software will be used to track Tacoil pyrolysis oil produced by Plastic Energy’s chemical recycling process, its delivery to SABIC for conversion into Trucircle, and ongoing delivery of polymer to Intraplás.

The aim is to ensure that all of the data gathered remains unchangeable while being shared, so providing “transparency, auditability and accountability in a complex industrial ecosystem”, according to SABIC.

➤ [www.sabic.com](http://www.sabic.com)

## BASF steps up China plans

BASF has given final approval for construction of its long-planned verbund site at Zhanjiang in Guangdong province, China. The focus will now be on building the core, including a steam cracker and several downstream petrochemical and intermediate plants.

The company commenced work at the site in 2010. The first engineering plastics

unit is currently starting up and another for TPUs will come onstream in 2023.

BASF expects to invest up to €10bn at Zhanjiang by 2030, when it is expected to be fully operational. It will be its third largest verbund site after those at Ludwigshafen in Germany and Antwerp in Belgium.

➤ [www.basf.com](http://www.basf.com)

## Sumitomo to launch LCP LFTs

Sumitomo Chemical Advanced Technologies plans to commercialise a new family of long fibre reinforced (LFT) compounds based on its high performance liquid crystal polymers (LCPs).

Currently available for customer evaluation, the company says the two new development grades – SumikaSuper SCG-379 with 30-50% glass fibre and SumikaSuper SCG-420 with 30-40% carbon fibre – will significantly lift the thermal and mechanical performance available from LFT technology.

“It has long been established that mechanical properties of plastics

increase with longer fibre lengths,” said Takayuki Sugiyama, Sumitomo Product Manager. “However, it also is well known that rarely do fibres longer than 2mm survive the screw, runners, and gates to make it into the mould and the moulded part.”

The company believes the high flow rates of LCP resins means the new LFTs, which the company says have been under development for four years, will suffer much less fibre breakage during moulding.

According to Sumitomo, one area of interest for the new LFT compounds is production of automotive energy-management

structures such as bumper boxes and pillar reinforcements as the LCP-based parts can be mounted to the body-in-white (BIW) during initial vehicle build.

“These materials are being positioned against lightweight metallic alloys and even steel where they offer comparable or higher mechanical performance at much lower weight, better energy management, elimination of corrosion, reduced manufacturing and finishing steps, and very-fast processing times, which will help offset initial higher material costs,” said Tomohiro Sato, Sumitomo Senior Manager.

➤ <https://sumichem-at.com/>



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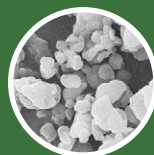
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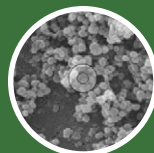
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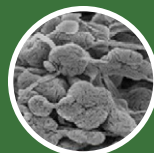
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# Coperion-owner Hillenbrand acquires Linxis and Herbold

US-based Hillenbrand, which owns Coperion and Milacron, has been on the acquisition trail, securing deals to buy France-headquartered process engineering group Linxis and German recycling machinery maker Herbold Meckesheim.

The company said last month it will buy Linxis Group from Iberis International, an affiliate of IK Partners, for an enterprise value of around €572m. It

hopes to close the deal by the end of the year.

Linxis manufactures dosing, kneading, mixing, granulating, drying and coating systems for multiple end markets, which Hillenbrand said are complementary to Coperion's. The business is expected to generate sales of around €300m this year and includes the Bakon, Diosna, Shaffer, Shick Esteve, Unifiller and VMI brands.

"By leveraging the

combined capabilities of our Coperion brand and the Linxis Group brands, we will be able to offer more comprehensive processing solutions," said Kim Ryan, President and CEO of Hillenbrand.

Three weeks prior to the Linxis move, Hillenbrand announced the acquisition of Herbold Meckesheim. It is to pay €79m for the company, which makes washing, separating, drying, shredding and pulverising plant

for recycling applications. Sales amount to around €50m annually.

Separately, Hillenbrand is exploring strategic options, including a potential sale, for its Batesville business, which is a major supplier of funerary and cremation products in the US. Last year, it accounted for around of the company's \$2.9bn sales.

➤ [www.hillenbrand.com](http://www.hillenbrand.com)

➤ [www.linxisgroup.com](http://www.linxisgroup.com)

➤ [www.herbold.com](http://www.herbold.com)

## Solvay stabilisers for UV-C

Solvay has developed a portfolio of UV-C stabilisers for use in polyolefin components used in healthcare applications, that are disinfected using UV-C light irradiation.

"Healthcare and other markets, such as aerospace and shared mobility, are increasingly using UV-C light to disinfect high-contact surfaces in an effort to combat pathogens, including coronaviruses," said Sophie Poelmans, Global Marketing Manager for Polymer Additives at Solvay Materials.

The UV-C spectrum extends from 200-280 nm. Current stabilisers may not handle the higher energy, Solvay claims.

➤ [www.solvay.com](http://www.solvay.com)

## Pineapples gain from Irgacycle booster for recycled resins

BASF's Irgacycle UV033 DD recycled resin booster is being used by Malaysian recycler 3T industries to produce protectors for pineapple cultivation made from 100% recycled HDPE sheet.

The protectors are designed to shield the fruit from potentially harmful effects – including bleaching of the skin and damage to the fruit tissue – caused by solar radiation and temperatures of more than 32°C, while still allowing photosynthesis to occur. They are designed to last for three growing seasons.

Part of BASF's Valeras portfolio, Irgacycle additives are formulated to address some of the quality issues associated with recycled resins, including poor



IMAGE: BASF

**Above: Irgacycle additives are helping to protect pineapples in Malaysia**

processability, long-term thermal stability and weathering.

The additives are supplied as a one-pack solution that eliminates the

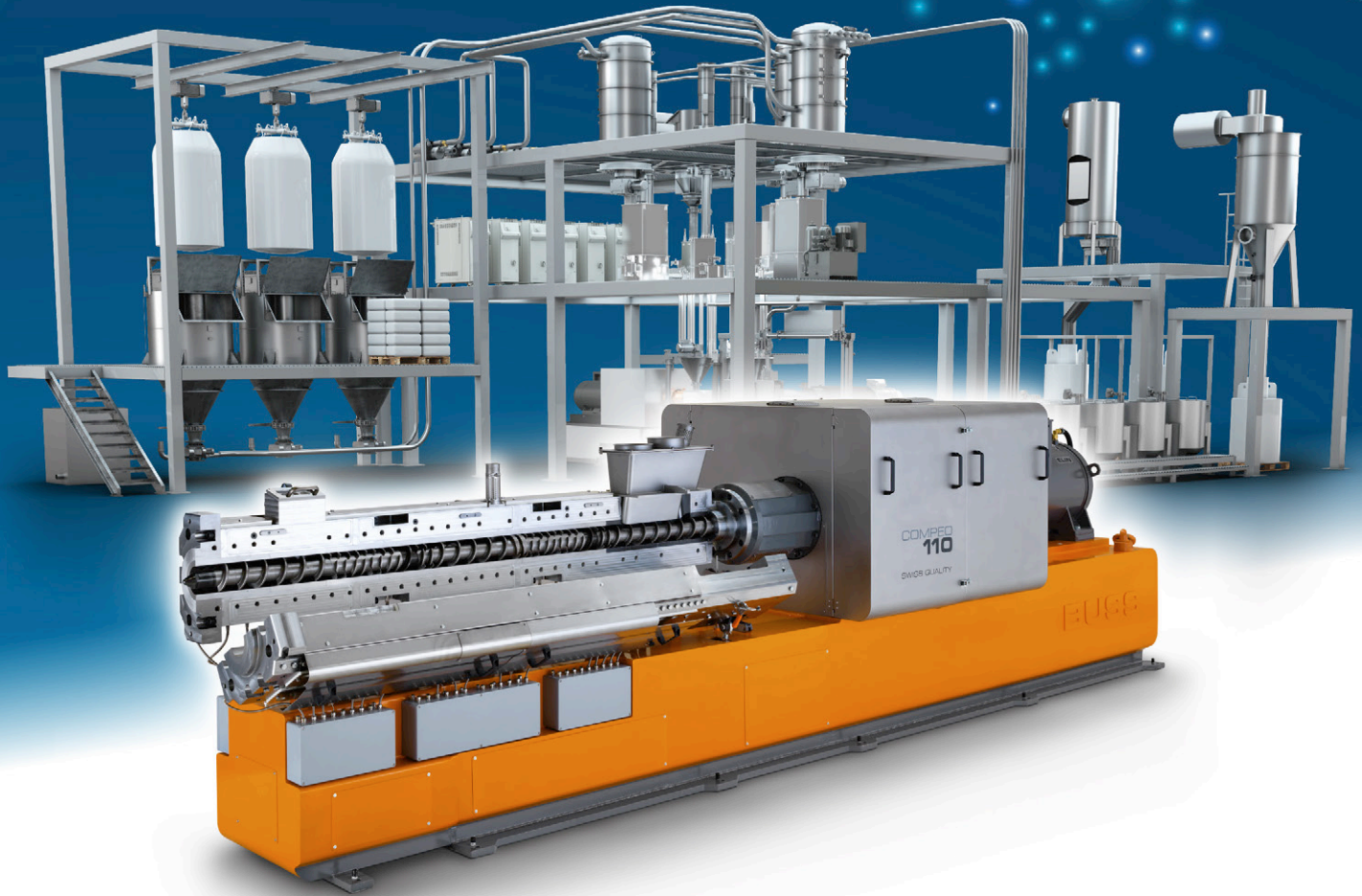
need for further premixing. Previously, 3T had used a combination of antioxidants and light stabilisers in this application.

➤ [www.plasticadditives.basf.com](http://www.plasticadditives.basf.com)



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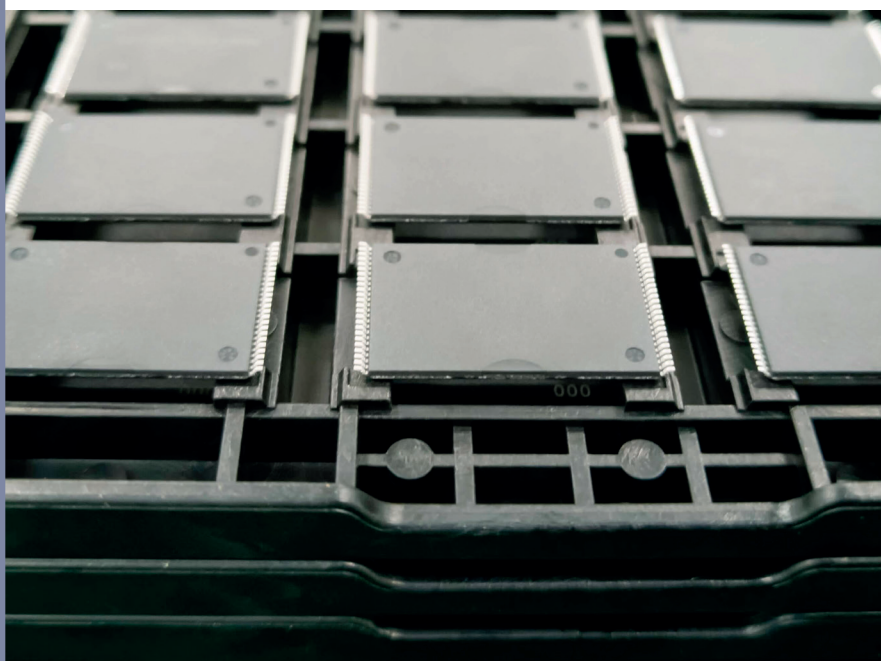


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# Dates and venue set for US moulding expo

The second Injection Molding and Design Expo is to take place in Novi, Michigan, on September 20-21, 2023. The event is organised by AMI (publisher of *Compounding World*) and Crain Communications and combines a free-to-attend exhibition and conference streams.

The first event, which took place in Detroit in May 2022, attracted 135 exhibitors and more than 2,000 visitors. More than 50% of those visitors came from injection moulders, OEMs and mouldmakers.

"The reaction to our first expo was

very positive, with exhibitors and visitors appreciating its clear focus on injection moulding, plus its Michigan location," said Andy Beevers, Events Director at AMI. "We're looking forward to building on this successful debut with an even larger event in 2023."

The 2023 expo will take place at the Suburban Collection Showplace in Novi, Metro Detroit, which is the largest privately-owned expo centre in Michigan. To find out more about the show visit [www.injection-moldingexpo.com](http://www.injection-moldingexpo.com)

## Heartland PP plant begins

Heartland Polymers has successfully commissioned its PP plant and started initial production at the Heartland Petrochemical Complex in Alberta, Canada.

"The PP plant has been producing pellets since late June," said Jim Madro, Senior VP of Petrochemicals. "The entire Heartland Complex remains on schedule for an integrated

start-up in Q3 this year, at which point Heartland will begin commercial production."

Once commercial production is under way, the plant is expected to produce 525,000 tonnes/year of PP. Heartland initially plans to produce homopolymers but aims to add random copolymers in 2023.

> [www.heartlandpolymers.com](http://www.heartlandpolymers.com)

## IN BRIEF...

**Cargill** has completed its acquisition of the majority of Croda's Performance Technologies and Industrial Chemicals business, which was announced in December last year. The acquired activities are now integrated into the Cargill Bioindustrial business. [www.cargill.com](http://www.cargill.com)

Perc Pineda has rejoined The US **Plastics Industry Association** (Plastics) to resume his former role as Chief Economist. Pineda left the organisation in February this year, before the surprise March departure of former CEO Tony Radoszewski.

New CEO Matt Seaholm said his return brings "significant expertise that is unparalleled in our industry." [www.plasticsindustry.org](http://www.plasticsindustry.org)

Swiss machinery maker **Buss** has supplied a Compeo co-kneader extruder to Swiss start-up **Tyre Recycling Solutions**. Its Intelligent Compounding concept aims to convert powder tyre waste into high value secondary materials by compounding with various TPE/TPU based resins.

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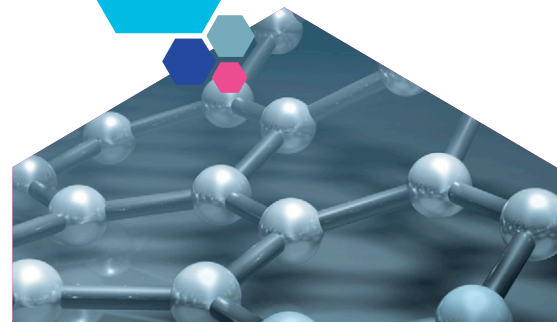
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# PVC Formulation

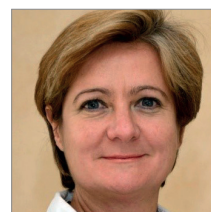
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# Plasticiser producers take a bio approach

*Many of the latest developments in PVC plasticisers are focused on bio-based solutions that meet or exceed current performance and migration expectations, writes Peter Mapleston*

One of the key areas of development in plasticisers for PVC is sustainability, with many of the latest introductions produced either in full or in part from renewable feedstocks. Given how much of a flexible PVC compound is accounted for by the plasticiser, renewable and bio-based options can provide a highly effective means of enhancing sustainability of items manufactured using this important and versatile polymer.

Two new 100% bio-based polymeric (polyester) plasticisers –Edenol 2178 and 2192 – have been introduced recently by **Emery Oleochemicals**. The difference between the two is mainly in their molecular weight, which manifests itself as viscosity. Each can be used on its own, or in combination with the other, or with another different plasticiser. Both are made from building blocks that comply with indirect food contact regulations for plastics and food-contact approvals for the plasticisers themselves are pending.

Emery says the polymeric nature of the new grades means they exhibit reduced migration when compared to lower molecular weight types. Test carried out by the company comparing Shore

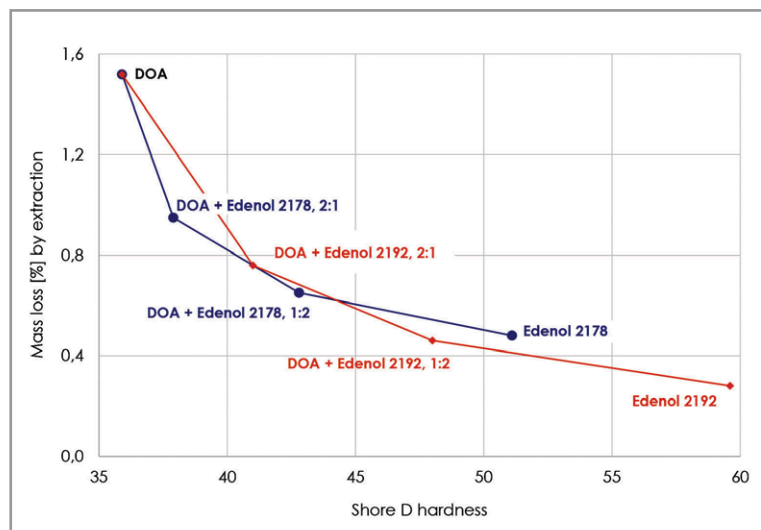
D hardness and extraction resistance in isooctane (Figure 1) for the new Endemol grades and a di(2-ethyl hexyl) adipate – DEHA/DOA – showed a notable reduction in plasticiser migration.

“The crucial finding of this analysis is that by replacing the DEHA monomeric plasticiser with one of the polymeric plasticisers, the extraction resistance can be clearly improved while rarely compromising Shore hardness,” says Christian Müller, Global Head of Business Development and Marketing at the company. “Replacing DOA by a 2:1 blend of DOA with Edenol 2178 or Edenol 2192 does not alter the tensile strength and modulus too much. However, it results in an approximately 35% reduction in mass loss.”

In addition to PVC formulations, Edenol 2178 and 2192 can also be used to increase flexibility in bioplastics, most notably PLA.

Elatur DINCD is one of the newest plasticisers from **Evonik Performance Intermediates**. An isononanol-based cyclohexanoate, it is said to provide very good low-temperature flexibility, high UV resistance, and low volatility. The company says that Elatur DINCD is also easy to

**Main image:**  
Rape seed is one of a number of bio-based sources being explored for production of more sustainable PVC plasticisers



**Figure 1: Mass loss and hardness performance comparing Emery's new Edemol 2178 and 2192 plasticisers with DEHA/DOA at 40phr in PVC with a K-Value of 71 mixed using a two-roll mill. The plasticisers were used in neat form and as blends. Milled 0.5 mm sheets were compacted together to create 3mm specimens to compare Shore D hardness and extraction resistance in isooctane (4 h/60 °C).**

Image: Emery Oleochemicals

process due to its low viscosity and good gelation performance. Volatility is on a similar level to Evonik's well-established Vestinol 9 diisononyl phthalate (DINP) – Figure 2.

The new plasticiser is said to be particularly suitable for demanding outdoor and indoor applications such as textile fabrics, roofing membranes, floor coverings, adhesives and sealants as well as paints and varnishes – Figure 3.

Elatur DINCD fits with Evonik's long-term strategy to expand its portfolio of plasticisers to meet specific customer needs, according to Director of Marketing for Plasticisers Janina Fischer, who says it "complements our existing and proven product family."

The plasticiser will be produced at Evonik's site at Marl in Germany. An initial production campaign has already been successfully carried out. Production will be expanded step-by-step, in response to market demand, the company says, adding that it is taking additional steps in its C4 Verbund (integrated supply chain) to further strengthen supply security and the availability of all plasticisers.

Elatur DINCD is offered alongside Evonik's Elatur CH and Elatur DPT fast fuser plasticis-

ers. The company says all of its plasticisers are available as bio-attributed versions using the ISSC PLUS mass-balance allocation system.

### Extended portfolio

Bio-based Drapex Alpha primary plasticisers have been available from **Galata Chemicals** for several years and the company continues to extend the portfolio. It has established grades for calendered compounds and plastisols – Drapex Alpha 200 and Drapex Alpha 215 respectively. The latest addition to the range is Drapex Alpha 250, a non-GMO bio-based plasticiser grade manufactured from renewable feedstocks non-related to the food supply chain.

According to Peter Frenkel, Vice President Technology at the company, the Drapex Alpha plasticisers "consistently demonstrate their excellent extraction resistance, low volatility and low smoke generation as well as resistance to microbial growth while imparting low-temperature flexibility, enhanced processability and heat stability." He says a completed cradle-to-gate Life Cycle Assessment (LCA) shows incorporation of the plasticisers results in substantial reduction in Global Warming Potential (GWP) of PVC compounds.

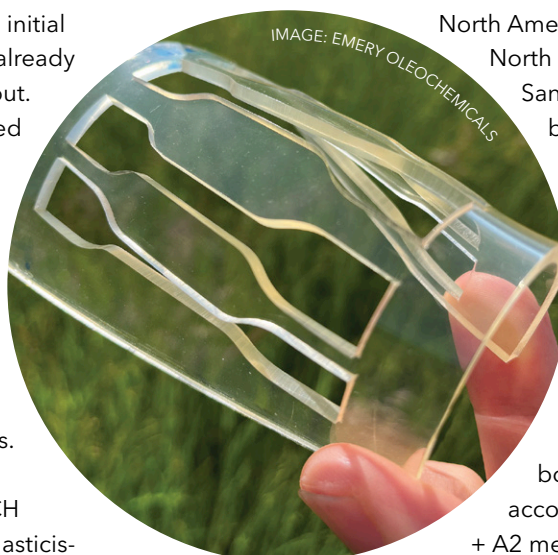
Galata has also developed a range of high efficiency heat stabilisers, such as Mark 3600, which are designed specifically for use in compounds plasticised with the Drapex Alpha plasticisers. "This type of bio-based plasticiser/stabiliser combinations [provide] substantially extended long-term heat stability at stabiliser loadings reduced by up to 50-80% compared to compounds stabilised with the conventional Ca/Zn stabilisers and plasticised with the conventional plasticisers," says Frenkel.

Two bio-based plasticisers were recently added to the **Valtris** product line-up. Santicizer Platinum G-2000 is based on soybean oil sourced in North America and is marketed in North and South America.

Santicizer Platinum G-2030 is based on EU-sourced rapeseed oil and will be offered in Europe and Asia Pacific. Both plasticisers are claimed to provide an 85% renewable carbon content.

The company has completed LCAs to ISO 14040 and ISO 14044 on both products, conducted according to the LCIA EN 15804 + A2 methodology. Key results of

**Right: Emery's new 100% bio-based polymeric plasticisers are claimed to offer good migration performance**







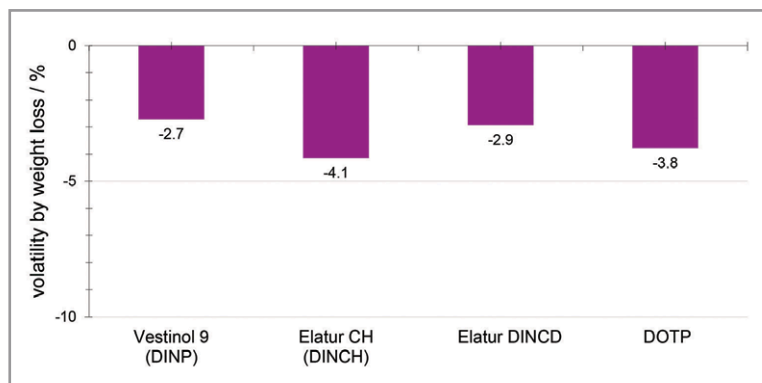
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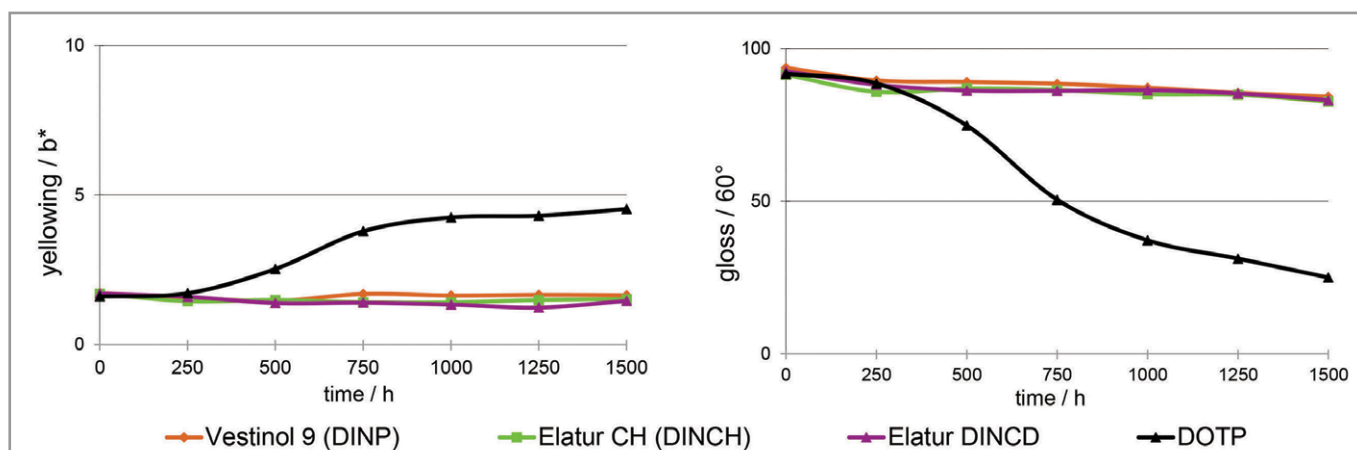
**Figure 2: Comparison of volatility of Evonik's latest Elatur DINCD plasticiser against its Elatur CH (DINCH) and Vestinol 9 (DINP) products, and DOTP. Volatility determined as weight decrease (DIN EN ISO 176 Method B, 3 days 120°C) for a formulation comprising 100 phr PVC K70, 50 phr plasticiser, 3 phr ESBO and 2 phr stabiliser.**

Source: Evonik

the cradle-to-gate analysis include a GWP (kg CO<sub>2</sub> equivalent) of -0.39 for Santicizer Platinum G-2000 and -0.55 for Santicizer Platinum G-2030.

According to Amanda Freshwater, Technical Service Manager Polymer Modifiers at Valtris, the new products can be used as a replacement for general-purpose plasticisers. Both grades are epoxy soyate esters with performance said to be comparable to other non-phthalate general purpose plasticisers.

"They offer good processing performance, excellent low temperature properties, and outstanding heat stability, she says. Formulators can also combine Santicizer Platinum G-2000 or G-2030 with one of Valtris's Santicizer non-phthalate plasticisers, to create optimised solutions for their specific processing needs."



**Figure 3: Comparison of weathering properties (yellowing and gloss) of PVC compounds containing Evonik's Elatur DINCD plasticiser against its Elatur CH (DINCH) and Vestinol 9 (DINP) products, and DOTP. Test carried out in a xenon device to ISO 4892-2 at 500 W/M2 global, 60 W/M2 UV, 38°C, 1500 h, dry/wet: 102/18 min. Compound formulation 100 phr PVC K71, 40 phr plasticiser, 5 phr TiO<sub>2</sub>, 3 phr stabiliser.**

Source: Evonik



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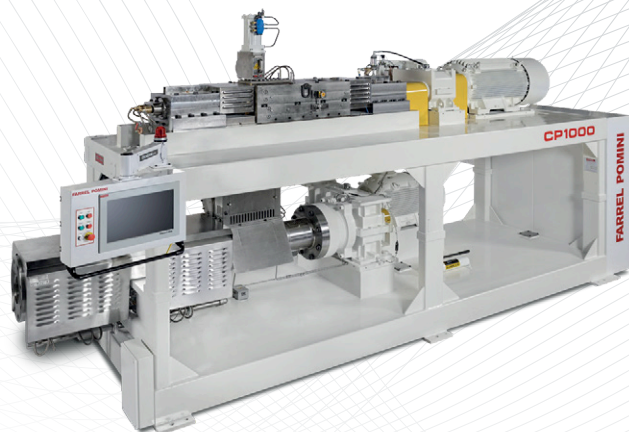
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# Plasticisers – sticking to the facts

European Plasticisers, the trade association representing around 85% of European plasticiser production capacity, has provided this update on regulations within the European Union and on new scientific moves its hopes will back up safety claims for PVC plasticisers.

It says that although an opinion from the European Food Safety Authority (EFSA) on the use of phthalates in food contact materials (FCM), published in December 2019, concluded that “current exposure to these five phthalates [DBP, BBP, DEHP, DINP and DIDP] from food is not a concern for public health”, a new mandate has been given to EFSA to assess phthalates, structurally similar substances and replacement substances.

European Plasticisers has already contributed to calls for data published in the context of this new mandate. It will provide input to the currently open consultations on the “Call for collection of data on phthalates, structurally similar substances and replacement substances migrating from or occurring in food contact



IMAGE: SHUTTERSTOCK

materials (Plasticisers\_FCM\_2022)” and the “Call for continuous collection of chemical contaminants occurrence data in food and feed,” the latter being part of a separate mandate (EFSA M-2010-0374).

European Plasticisers also contributed to a call for evidence in December 2021 for ten “Annex XIV” phthalates, aiming at assessing if they are adequately controlled after their sunset date. For seven phthalates (entries 33 to 39), the sunset date has passed. For three more phthalates (44 to 46), no applications for authorisations were submitted before their latest application date of 27 August 2021.

ECHA has said there is no need to submit restriction dossiers at this stage, although further examination of

the risks may take place as part of the Restriction Roadmap exercise on ortho-phthalates. European Plasticisers will contribute to consultations on this regard with data and information as appropriate.

Turning to plasticiser safety, a project aimed at developing a physiologically-based pharmacokinetic (PBPK) model for plasticisers was initiated in

2017 by European Plasticisers and co-funded by VinylPlus, the sustainability initiative of the wider PVC value chain. Its aim was to assess the safe use of plasticised PVC and support scientifically solid risk assessments, rather than those using simple in-vitro studies that may not be representative of the complex metabolism in whole organisms.

A first PBPK model for DINCH was published in a peer reviewed journal in 2019, the model for DINP was published in August 2020, and one on DPHP in September 2021. PBPK models for DEHTP, DEHA, DINA and DBA are also being developed and the respective studies will be submitted for publication in scientific journals.

➤ <https://www.europeanplasticisers.eu/>

Also new from Valtris is Santicizer Platinum P-1700. Based on benzyl cyclohexanoate technology, it is claimed to combine high solvating ability with ultra-low volatility and excellent migration resistance. It has a high molecular weight and branched structure. Valtris says Santicizer Platinum P-1700 can be used in a variety of applications and contributes to the permanence and processing of acrylic/PVC screen inks, automotive sealants and high performance polysulphide sealants.

“We have seen a lot of customer success using Santicizer Platinum P-1700 in plastisol screen inks for its excellent permanence, low bleed through, and favourable water wash characteristics,” says Megan Kravec, New Business Development Polymer Modifiers at Valtris. “When using Santicizer Platinum P-1700 in combination with general purpose plasticisers, manufacturers will see

improved efficiency and processing speed without sacrificing emissions or migration.”

## DEHP alternative

Citroflex B-6, from **Vertellus**, is partially derived from bio-based raw materials and is said to demonstrate biodegradability. It is marketed as a phthalate-free plasticiser solution for flexible PVC blood storage and transfusion systems that can provide an alternative to di-2-ethylhexyl phthalate (DEHP). The company says DEHP has long been the predominant plasticiser used in PVC medical devices. While questions about its safety in blood bag systems have been raised since the 1970s, it says it has only recently been labelled as a reproductive toxin.

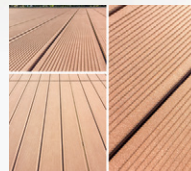
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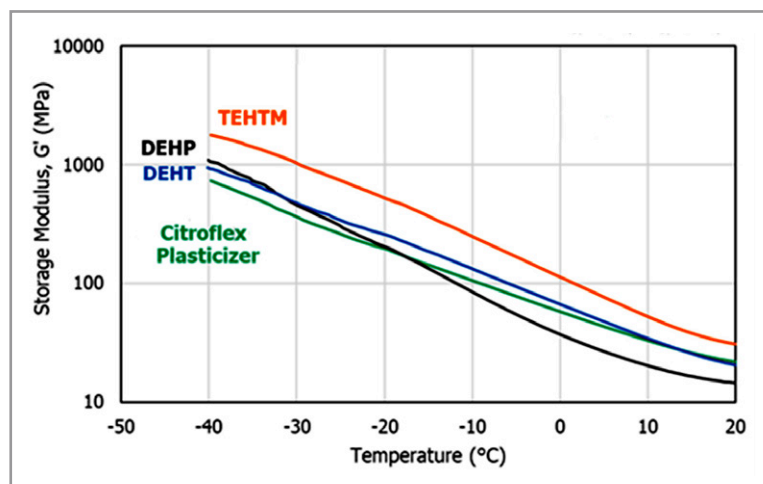
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**Table 1: Representative data for medical grade PVC films comparing Citroflex B-6 plasticiser from Vertellus with DEHP. Formulation comprises 50 phr plasticiser, 2.5 phr stabiliser, 0.25 phr lubricant.**

	DEHP	Citroflex B-6
Hardness, Shore A	79	81
Tensile Strength, MPa	18.95	20.16
Ultimate Elongation, %	395	427
100% Modulus, MPa	9.43	9.39
Brittle Point, °C	-24.5	-33.5
Volatile loss (air), %	4.8	1.7
Volatile loss (A/C), %	3.4	1.4
Soapy water extraction, %	2.7	2.2

Source: Vertellus



**Figure 4: Dynamic rheology temperature ramp data for PVC films containing Citroflex B-6 from Vertellus against other commonly used plasticisers. Formulation comprises 70 phr plasticiser, 2.5 phr stabiliser, 0.25 phr lubricant.**

Source: Vertellus

2017/745), as well as Amendment Annex XIV per ECHA REACH mandates, use of DEHP will require authorisation based on Benefit Risk Assessment, thereby complicating supply and prolonging the path to product commercialisation,” the company claims. “Medical PVC compounders and blood transfusion product brand owners are now preparing for next-generation products, fast-tracking the development of alternative, phthalate-free technologies.”

Citroflex B-6 is a butyryl trihexyl citrate (BTHC), which is listed in the European Pharmacopoeia as an approved alternative to DEHP for medical products. Vertellus says it enables brand owners to comply with various regulatory mandates – not only the MDR and REACH Regulations but also RoHS EU Directive 2015/863 (RoHS 3).

PVC films plasticised with Citroflex B-6 are said to display similar physical properties to those containing DEHP – Figure 4.

### Combined efforts

With considerable experience in the bio-based plasticisers market in the US and South America, **Innoleics USA** and **Varteco** have recently agreed to combine their efforts to introduce Innoleic bio-based primary plasticisers into the European, North African, and Middle Eastern markets.

Innoleics has plasticiser production agreements with third parties in South America and offices in the US and Europe. Its Innoleic plasticisers are acetylated and epoxidized soybean oil fatty acids esters with a high bio-based carbon content (as determined by 14C analysis and certified under the USDA BioPreferred programme). ➤



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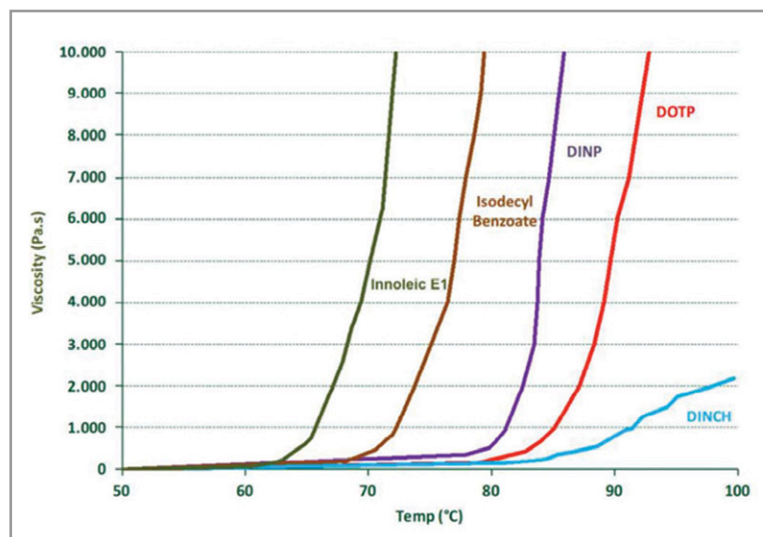
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**Figure 5: Chart showing the relationship between temperature and viscosity in PVC formulations plasticised with a variety of plasticisers tested in a plate-plate viscosimeter. Formulation comprises Solvin 382NG 100 phr, plasticiser 50 phr, Ca/Zn stabiliser 2.5 phr.**

Source: Varteco/Solvay

Varteco has two production sites in Argentina, as well as offices in Spain. It has recently certified its San Luis production site with the Round Table for Sustainable Soy Chain of Custody Standard, which ensures zero deforestation from soybeans used in its production process.

The Innoleic plasticiser portfolio includes: Innoleic E1, a fast-fusing plasticiser developed as an alternative to low molecular weight phthalates and benzoates (Figure 5); Innoleic B5.2 and Innoleic MB25, designed for extrusion processing technologies in flooring, cable, shoes, hoses; and Innoleic B5 and Innoleic MB50, which are intended for plastisol technology.

Diego García Touza, Area Business Manager for Varteco Quimica Iberica in Barcelona in Spain, says one of the most recent and innovative developments using an Innoleic plasticiser was carried out by Safari Klip in Turkey. It developed a bio-leggings apparel collection using a synthetic leather produced with bio-attributed PVC (Inovyn's Biovyn) and Innoleic B5, which is certified as 100% bio-based under the BioPreferred label.

### Specialty focus

The Oxoplast business unit within **Grupa Azoty** is expanding its plasticiser range into specialty products. As of last year, in addition to its Oxoviflex DOTP general-purpose plasticiser, its product portfolio now features the Oxofine line of specialty plasticisers. These include Oxofine DBT, Oxofine TOTM, Oxofine DOA and the first polymeric plasticiser in the portfolio, Oxofine Poly2K.

Grupa Azoty says that it is continuing its R&D

work to synthesise new products, including renewable-based types. "We see extending the value chain toward specialty products as essential. To this end, we are soon launching a second Research and Development Center (CBR II) to provide solid support for developing new technologies," according to a spokesperson for the company.

The company is also working to reduce CO<sub>2</sub> emissions related to its products. "We are implementing changes within our production facilities to ensure that Segment Oxoplast will benefit from energy utilities produced with a vastly reduced and, periodically, even zero carbon footprint," says Oxoplast BU director Maciej Budner.

Last year, **Lanxess** completed the acquisition of Emerald Kalama Chemical, the US-based specialty chemicals company. As a result, the plasticiser portfolio of the Polymer Additives division of Lanxess now includes specialty plasticisers based on benzoate chemistry. These are being produced at two production sites in the US and in Europe.

The K-Flex dibenzoate plasticiser product line contains a variety of high solvating dibenzoate plasticisers for PVC applications. "K-Flex 850P and K-Flex 975P have found broad utility as fast fusers in numerous applications and have served as tools for formulators to increase fusion speed, compatibility, and performance when switching from traditional phthalates to the less compatible phthalate alternatives, such as DOTP," according to Lanxess.

"In addition, the K-Flex plasticisers impart exceptional stain and extraction resistance, especially versus oily solvents. As little as 15% DOTP can be offset using K-Flex 850P or K-Flex



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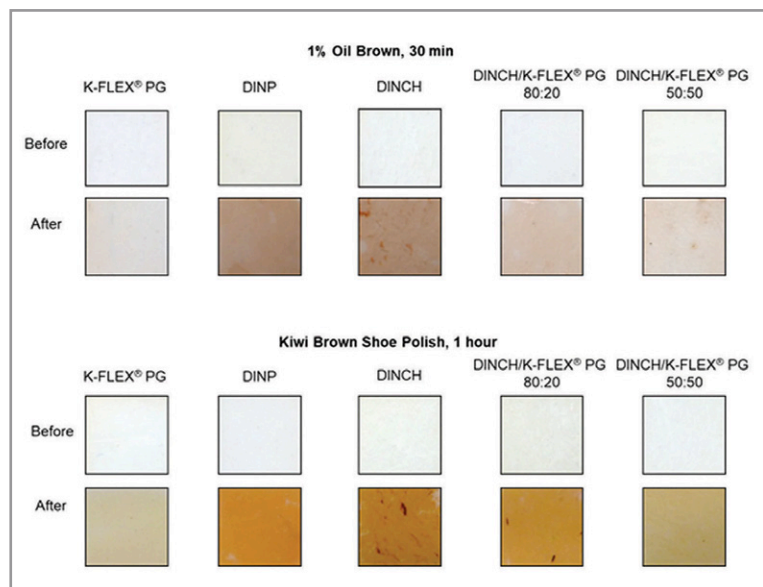
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**Figure 6: Stain tests on highly filled luxury vinyl tile formulations containing different plasticisers. Stain resistance is improved when offsetting as little as 20% DINCH with K-Flex.**

Source: Lanxess

975P to achieve fusion and compatibility performance very similar to that traditionally found with DINP, while simultaneously improving stain resistance, extraction resistance, and strength. In addition, K-Flex PG can be utilised when toughness, stain resistance, and extraction resistance are required to be unparalleled" (Figure 5).

Another speciality chemicals company, **Polynt**, has been developing and marketing a wide range of trimellitate speciality plasticisers for different technical needs for some years. At the beginning of July, the company, which is headquartered at Bergamo in Italy, said that to support its future growth it will install a new esterification plant to produce speciality plasticisers, mainly trimellitates, at its site in Atlacomulco in Mexico.

"Special high-performance plasticisers, with their superior technical performances in electrical and high temperature applications, are a main

component for the electrification of cars and transportation," says Polynt President and CEO Rosario Valido. "Trimellitates represent the most effective family of products that can satisfy those outstanding performance characteristics."

Swedish speciality chemical group **Perstorp**, acquired earlier this by Malaysia's Petronas, has long been a player in bio-derived plasticisers, launching its first part bio-based Pevalen Pro polyolester plasticiser in 2019. It was introduced as an alternative to established plasticisers such as DINP, DOTP and DINCH. The first products were offered with a 40% bio-content.

Last year Perstorp supplemented the Pevalen Pro plasticiser family with the introduction of Emoltene 100 Pro. This is a dipropylheptyl phthalate (DPHP) plasticiser produced using biogas rather than fossil-derived natural gas. Using ISCC Plus mass balance principles, the company claims a 40% bio-based content.

Earlier this year, the company announced the launch of a bio-based 2-ethylhexanol (2-EH), again based on a mass balance approach. 20-EH is used in the production of a number of specialty products, including plasticisers. The company said having a bio-based version of the feedstock available would allow it to further extend its Pro sustainable product lines.

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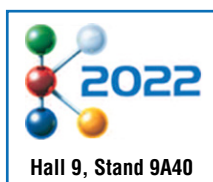
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*Compounding extruders are now equipped with a wide range of monitoring and communication tools to deliver data to improve productivity and quality. Mark Holmes reports*

Collection of data during the compounding process is vitally important for monitoring the performance of the production line and to provide quality control information. Meanwhile, as the compounding process becomes increasingly automated, predictive maintenance can be used to keep downtime of extrusion lines to the absolute minimum. Manufacturers of compounding extruders and associated equipment are incorporating ever more sophisticated levels of process control and "Industry 4.0" features to make these goals reality.

A general demand for process data integration and automation, driven both by requirements for compliance with wider industry standards as well as the growing scarcity of skilled workers, can be seen as a trend right across the compounding sector, according to **Maag**. "We expect the degree of automation to increase further, along the learning curves for condition monitoring and its interpretation by machine learning models," says Michael Stadler, Director BU Digitalization.

"Compounding faces similar issues to any other plastics industry these days, with additional challenges regarding high variation within a product and material mix, requiring specific know-how regarding processes and operational control. Our automation and data integration solutions are tailored to support the compounding industry address these topics. Further trends include total resource consumption, process automation and adherence to requirements from a variety of regulative backgrounds," Stadler says.

The company's latest development for enhanced process control includes the Maag Integration Platform, which is intended to keep track of all data relevant for process analysis and predictive maintenance purposes. It is said to allow integration of procedural data within an existing IoT landscape via the use of industry-standard interfaces. Taken together with the Maag Remote mobile app, the system provides mobile access and full data visualisation.

**Main image:**  
Improved line control together with system to predict maintenance are helping compounders lift quality and uptime

IMAGE: MAAG



**Above:**  
Increased demand for process data and automation is driven by compliance demands and scarcity of skilled staff, according to Maag

Maag Integration Platform options include a variety of sensor-based solutions that support the machine communicating its status and shed light on the inner workings of the 'black box' compounding process. This allows data-based decisions to be taken in real time to help reduce energy and resource consumption, increase product quality, enable predictive maintenance, and facilitate better production planning.

Stadler says that Maag's future developments will include a variety of machine learning applications, built with the aim to support customers with automatic process setting improvement.

### Predicting failures

Japanese extruder maker **JSW** has developed a predictive alert system application for the extruder gearbox. "All equipment downtime due to machine failure becomes a critical factor for decreasing productivity on twin-screw extruders," says Tasuku Okimoto, Chief Engineer of IoT development.

"There is no doubt that the most crucial mechanical component in the twin-screw extruder is the gearbox. Unexpected and usually catastrophic failure of this component can take weeks, sometimes months, to repair."

For this reason, Okimoto says many extruder users take additional precautions for maintaining gearbox reliability, including periodic oil changes, daily vibration measurement and scheduled overhauls. "However, for various reasons gearboxes still fail occasionally," he says. "To minimise the risk of unexpected failure of the extruder gearbox, we have been developing a technology to detect actual micro-deterioration within the gears and bearings, and alert this before it fails completely."

The JSW Gearbox Alert System is a predictive alert system for the gearbox of its TEX twin-screw extruder. The system monitors the signals from multiple vibration sensors mounted on various locations around the gearbox. Evaluation of abnormalities of the internal components are undertaken by frequency domain and time domain statistical analysis.

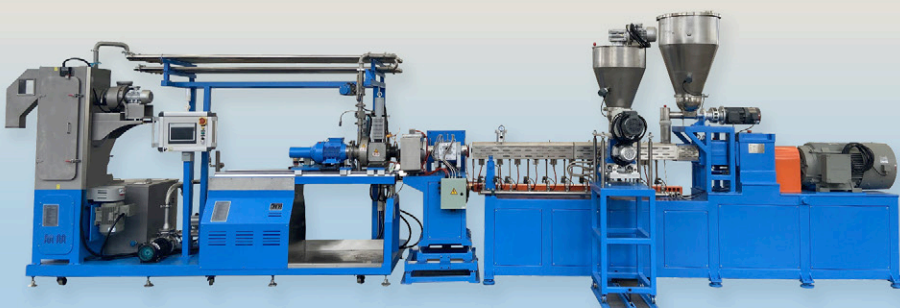
The prototype of this predictive alert system was installed for a number of selected extruder users some years ago, and the company has now been acquiring data over an extended period of time under actual continuous operational conditions. Figure 1 shows vibration levels over time obtained by the prototype detection system. The transition of RMS (root mean square) of vibration shows an increasing tendency for vibration after point A.

As well as vibration RMS, the system uses multiple analytical methods, including AI-based decision logic, to determine accurately when to provide an

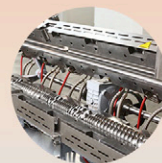
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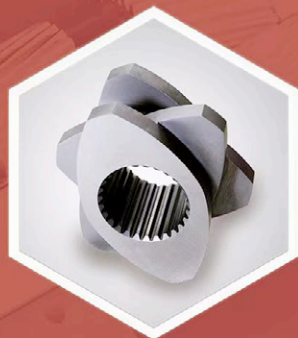
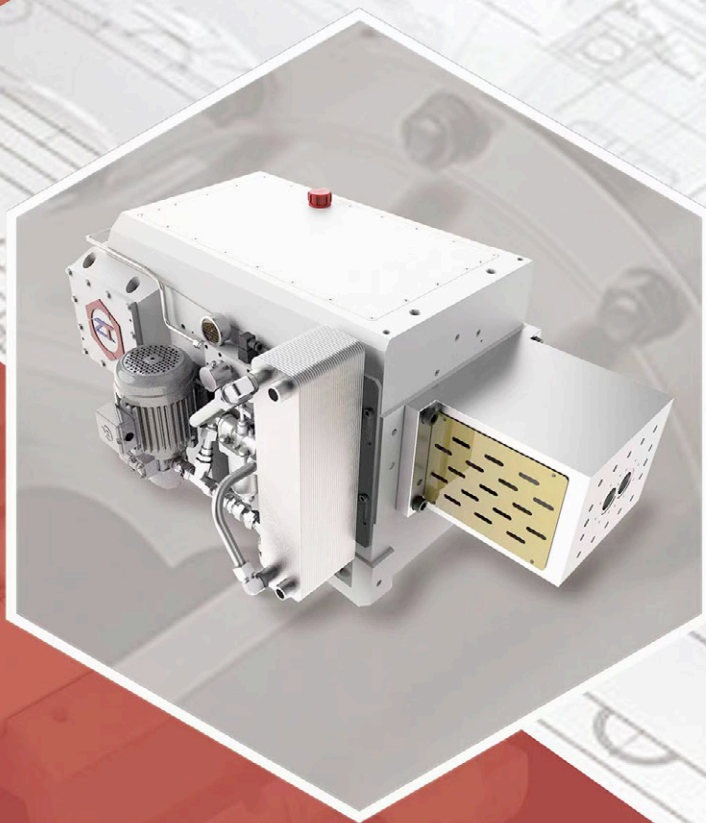
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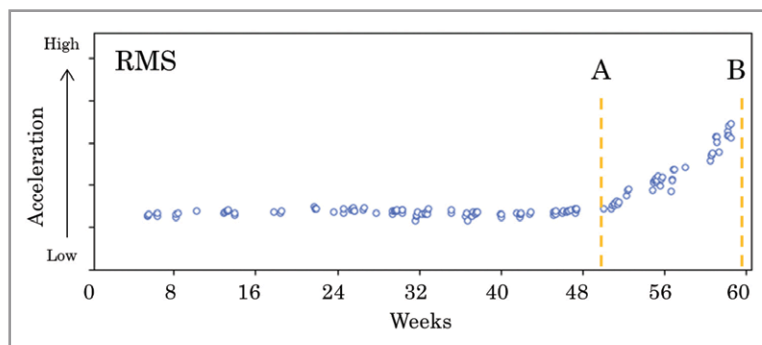
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**Figure 1: Vibration monitoring data captured by JSW's Gearbox Alert System, which uses statistical analysis techniques to predict bearing wear issues**  
Source: JSW

alert. Inspection inside the gearbox at point B, for example, indicated there was damage to one of the bearings and that it was no longer usable. The system has been shown to be able to detect micro-failure as far as three months in advance of a component no longer being usable. In this case, the deteriorated gearbox was repaired with minimal part replacement and reduced downtime.

German compounding machinery maker **Coperion** now offers the option to equip gearboxes on its small to mid-sized ZSK twin screw extruders (43mm to 133mm) with a condition monitoring system capable of data analysis. Such a condition monitoring system has been in use on large ZSK extruders for many years and has proven itself able to significantly improve maintenance task plannability.

The company says the reliable and affordable system identifies irregularities in extruder gearbox operation early enough to avoid potential damage. As a consequence, required

service calls can be scheduled in advance allowing downtime interruptions to be kept to a minimum. Using the remote service option for ZSK extruders, Coperion can provide support to customers at short notice including direction to personnel on site.

The condition monitoring system focuses on two important ZSK extruder gearbox parameters - vibration and oil condition. To monitor vibrations, accelerometers are mounted on the extruder gearbox at several points, each measuring individually arising vibrations for each gearbox bearing. When the vibrations approach a critical threshold, a warning signal is sounded.

Using the EpcNT extruder control tool, an engineer or machine operator can visualise the operating condition of every gearbox bearing and gauge the overall gearbox condition at a glance. Moreover, important condition parameters, such as the vibration amplitude in the corresponding frequency band, can be added to the display separately for each bearing. Over the long term, damage to the ZSK extruder gearbox and corresponding downtimes can be avoided, the company claims.

The gearbox's oil condition is determined using flow sensors that constantly measure the oil quality in the lubrication system. Extended oil use can cause the quality of the oil to fluctuate and, as the gearbox oil approaches a critical threshold, the condition monitoring system will alarm for this as well. Required oil changes or maintenance tasks are identified early and can be carried out as part of long-term planning.

In addition to making machine insight available to



IMAGE: COPERION

**Right: Coperion offers condition monitoring as an option on ZSK extruders from 43mm upwards**

## Euromap updates OPC data specification

Euromap - the umbrella organisation representing the European plastics and rubber machinery industry - has released version 2.0 of Euromap 84, which includes OPC UA information models for extrusion equipment.

According to Dr Harald Weber, Director Technical Commission Euromap within the German machinery association VDMA, the association had published specifications for

extrusion applications in June 2020, designated as the OPC 40084 series. He says the background to the new release is that VDMA is covering more machine types and therefore needs to harmonise information models.

Euromap 84 version 2.0 includes definitions for complete extrusion lines as well as component-focused sections covering individual system components such as extruders, melt

pumps, filters, dies, and pelletisers. It covers three broad models of information flow: where each component has its own OPC server and is connected directly to an MES, where a line control collects data from the components and forwards to the MES using OPC or other protocols; and where the line control is included in an extruder.

> [www.euromap.org](http://www.euromap.org)

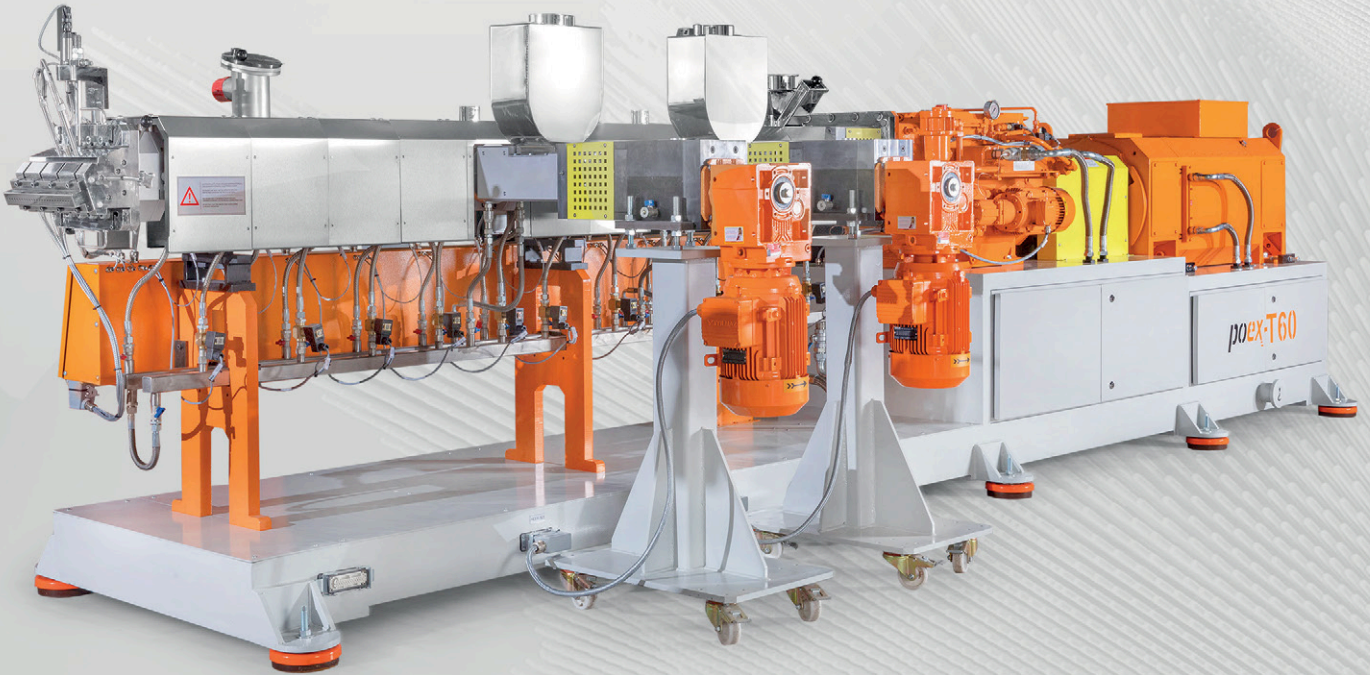


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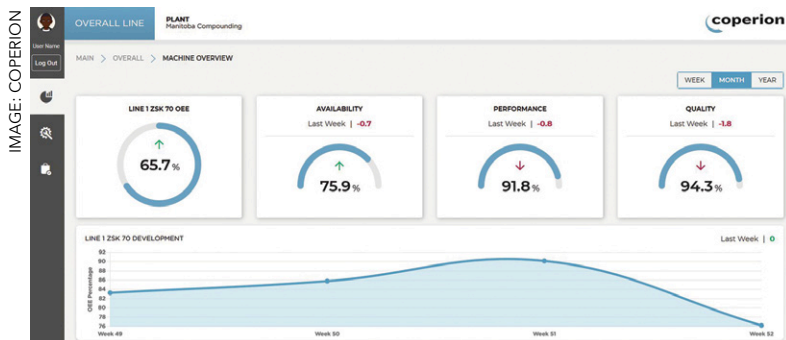
**\*\* 1300  
kg/h**

**16 Nm/cm<sup>3</sup> (at 900 rpm)**



\* According to the laboratory test results based on  
TS EN ISO 3451-1:2019 and TS EN ISO 1183-1:2019 standards.

\*\* The maximum capacity should be taken into account  
as non-binding suggestion for poex T60 co-rotating twin screw extruder line.



**Above: The OEE cockpit from Coperion provides clear insight in to equipment effectiveness to aid process optimisation**

a customer's local engineering team, Coperion can provide support as required using its remote service tools. At K2022, the company will exhibit a new version of its ServiceBox. It says that ServiceBox CSB 4.0 expands remote service support options for Coperion compounding systems to include both extruder operation as well as material conveying and associated components. It also provides access to Coperion's C-Beyond 4.0 platform.

The company says ServiceBox CSB 4.0 can actively support the system start-up process on request, generating rapid online remote diagnostics and helping to optimise system efficiency with expert know-how. Error messages can automatically be forwarded to Coperion to ensure fast remote diagnostics while software updates are said to be easy to run. A new addition to the system is to provide the operator with the ability to activate each Coperion system independently for remote service.

Coperion says the new CSB 4.0 allows the operator to not only capture and export relevant production data but also to evaluate it in real time. This is achieved through the smart OEE (Overall Equipment Effectiveness) cockpit, which is available

on request and identifies and displays machine availability, capacity, and achieved product quality.

Production disruptions due to recipe changes or maintenance tasks, for example, are logged and can be evaluated in the OEE cockpit's Availability area. Using this data as a basis, the potential for system availability increases can be determined and realised, the company says. Machine performance is handled similarly. Using the OEE cockpit's Performance feature, the operator can see when a machine has fully exhausted its capacity and at what point more potential is available. The Quality feature allows collected data on targeted product quality to be documented and evaluated.

For production managers, the OEE cockpit is said to serve to monitor compounding systems and delivers a good overview of their overall efficiency.

### Performance data

Compounders are looking for data on their process to monitor the overall performance of their production lines and Industry 4.0 features can provide this, according to US-based machinery maker **Entek**.

"Companies want the ability to generate metrics to show they are meeting their performance goals," says Tammy Straw, Marketing and Business Development Manager at the machinery builder.

"Compounders also want the ability to run continuous production of high outputs with minimal downtime," she says. "In addition, for compounders running small- to mid-sized lots of materials because of frequent colour changes, for example, there is a need to clean out the extruder and change screw sets quickly. Improved process control can assist with this."

The HT72 twin-screw extruder was introduced

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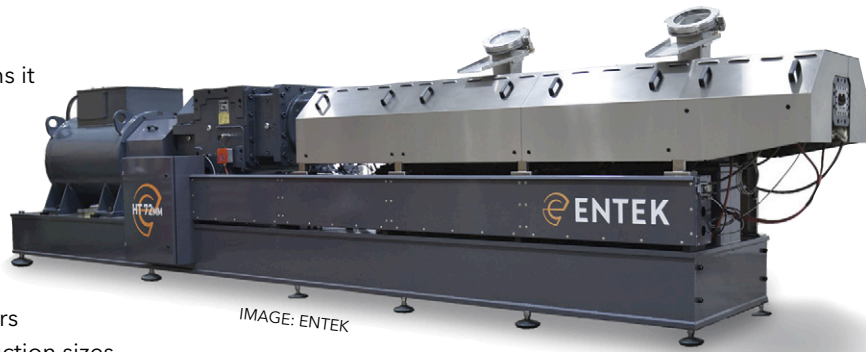
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**Right: Real time local and remote data availability is a feature of Entek compounders, including its new high output HT72 model**

by Entek last year. The company claims it provides a higher output rate in lbs/hour and offers the highest free volume at 18 torque density of any twin-screw extruder currently on the market. The HT72 is designed for the commodity compounding and masterbatch industry, where customers require medium-to-large batch production sizes and high production rates are especially important. When coupled with the company's new Vacuum Feed Technology (VFT), it is said to be able to drive throughputs even higher for processes which involve feeding low density fillers.

The HT72 provides real-time monitoring on the Entek Dashboard with Overall Equipment Effectiveness (OEE) data provided at the machine or via remote monitoring and access from mobile devices. This is said to allow for quick reference to numerous statistics including oil life, quality, and vibration information – providing more data on how the extruder is running on a minute-by-minute basis. This data helps compounders keep track of monitoring the overall health of the machine, Entek says, as well as monitoring performance to see if it



is meeting defined parameters for output and efficiency, for example.

### Dynamic processing

According to Italian compounding extruder manufacturer **Maris**, Industry 4.0 represents a concept that is able to turn production into a leaner, more dynamic and more flexible process that provides improved efficiency and sustainability. It believes it will set users on the path to fully automated and interconnected industrial production.

The criteria for the application of Industry 4 principles vary, the company says, but the general guidelines applied to extrusion lines include: control by means of PLC (Programmable Logic Controllers); interconnectivity with factory informa-



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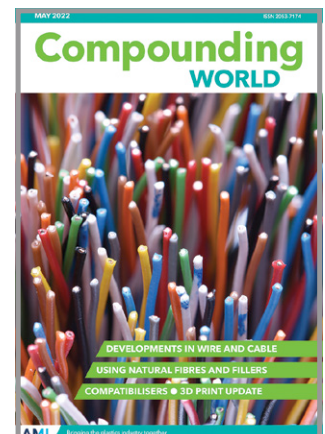
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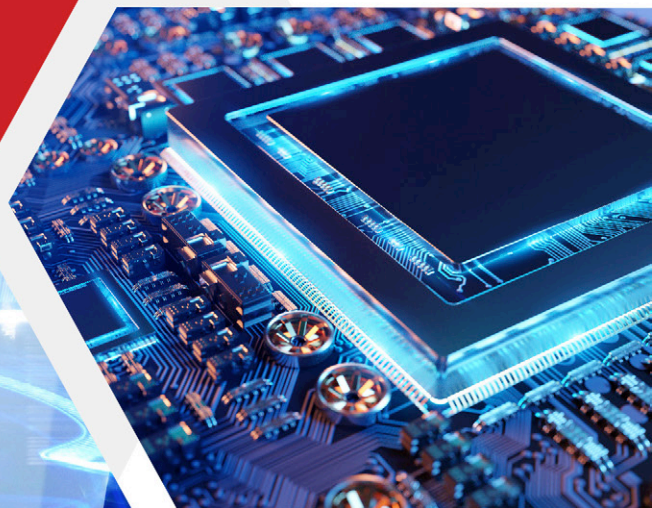
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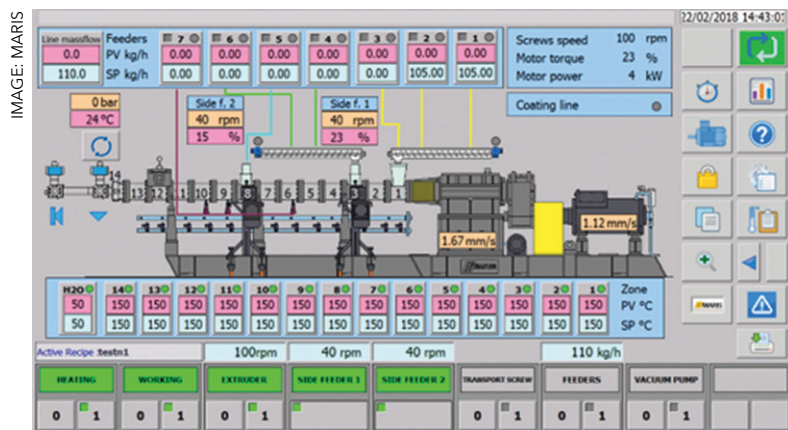
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**Above: This Maris control panel shows the broad range of data that is collected from its compounding extruders**

tion systems and remote loading of instructions (recipes); automated integration with factory logistics systems, supply networks or other production machinery; simple and intuitive human-machine interface; remote maintenance, diagnostics or control; and continuous monitoring of working conditions and process parameters through appropriate sets of sensors and the adaptability to process deviations.

Systems developed by Maris to provide Industry 4.0 features include CNC (Computer Numerical

Control) or PLC hardware and software that allows communication within different fieldbuses to meet interconnectivity requirements. Automated integration with factory logistics systems, supply networks and other machinery in the production cycle is also provided.

Industry 4.0 allows the intensive use, assessment and analysis of production data within an IT system at a corporate level. PLC programs can collect large amounts of data on production and process levels, including pressure values, temperatures and totalisers. Exchange of data between production and corporate levels of a company, or with other systems in the line, is ensured to improve product quality, for example. Maris uses globally recognised protocols such as Profinet or the open OPC Unified Architecture (UA).

According to Dr Krischan Jeltsch, Head of Innovation & Digitalisation at Swiss co-kneader extruder maker **Buss**, the company is seeing increasing activity in Industry 4.0 projects at research centres, as well as requests from customers and value chain partners, with a focus on IoT (Internet of Things) via sensors for condition monitoring. Additional topics include services such as AR

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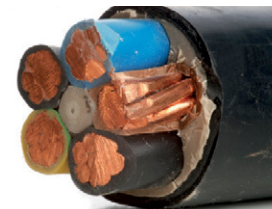
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**Right: The Mini-Compounder B-TSE-A 12/36 from Brabender is designed for recipe and process development**

(augmented reality) usage and other remote tools.

Jeltsch adds that machine health, process optimisation, energy efficiency control and product quality management are all areas benefiting from new process control solutions. He says this will help reduce machine downtime and process stability, as well as facilitate labour automation and remote control. As a company, he says Buss is continuously working on advancing machine status monitoring capabilities via remote services and looking to add additional sensor capabilities to improve operational machine reliability.

### Future automation

In the future, compounding processes will require higher degrees of automation in both production and maintenance, according to Switzerland-based **X-Compound**, also a manufacturer of co-kneaders. "Current challenging conditions, such as raw material availability and pricing, also need to be addressed with easy-to-maintain and stable production processes to meet increasing demands on the compounds to be produced," says Karsten Kretschmer, Sales Manager at the company.

"Industry 4.0 and new process control solutions can also provide support in maintenance processes. This includes easy identification of mechanical and electrical problems, as well as access to documentation, and identification and ordering of spare parts," he says. "Predictive maintenance processes can also be implemented to minimise unplanned downtime and increase overall equipment availability. In addition, production can be supported through process control and analysis to guarantee product quality and ensuring the availability of production data from anywhere in the world."

X-Compound has developed an augmented reality (AR) tool for its continuous kneader com-

**Below: Process data displayed in X-Compound's AR (Augmented Reality) tool**



IMAGE: X-COMPOUND



IMAGE: BRABENDER

pounding lines. It says that using the tool allows the requirements for both better understanding and usability of lines to be fulfilled, as well as providing improved maintenance features. The AR tool allows the display of relevant data from a current line in real-time and allows the process to be monitored from any point. This can include the temperature of the product, motor data or data of additional sensors (real or virtual), such as vibration sensors on the motor or gearbox.

German process engineering specialist **Brabender** has included a touchscreen through which the integrated browser-based Brabender MetaBridge software is operated to ensure user-friendly operation for its new Mini-Compounder B-TSE-A 12/36. This can be used to call up ongoing measurements via various end devices such as smartphones or tablets, regardless of their location.

The Mini-Compounder B-TSE-A 12/36 is designed for recipe and process development or for production of small quantities of material. The mini compounder can process standard pellets up to 3 mm in diameter. It features an openable barrel which simplifies cleaning and allows processes to be observed more easily. Temperatures of up to 400°C are possible in the four separately controlled temperature zones of the unit, with cooling is provided by air or liquid.

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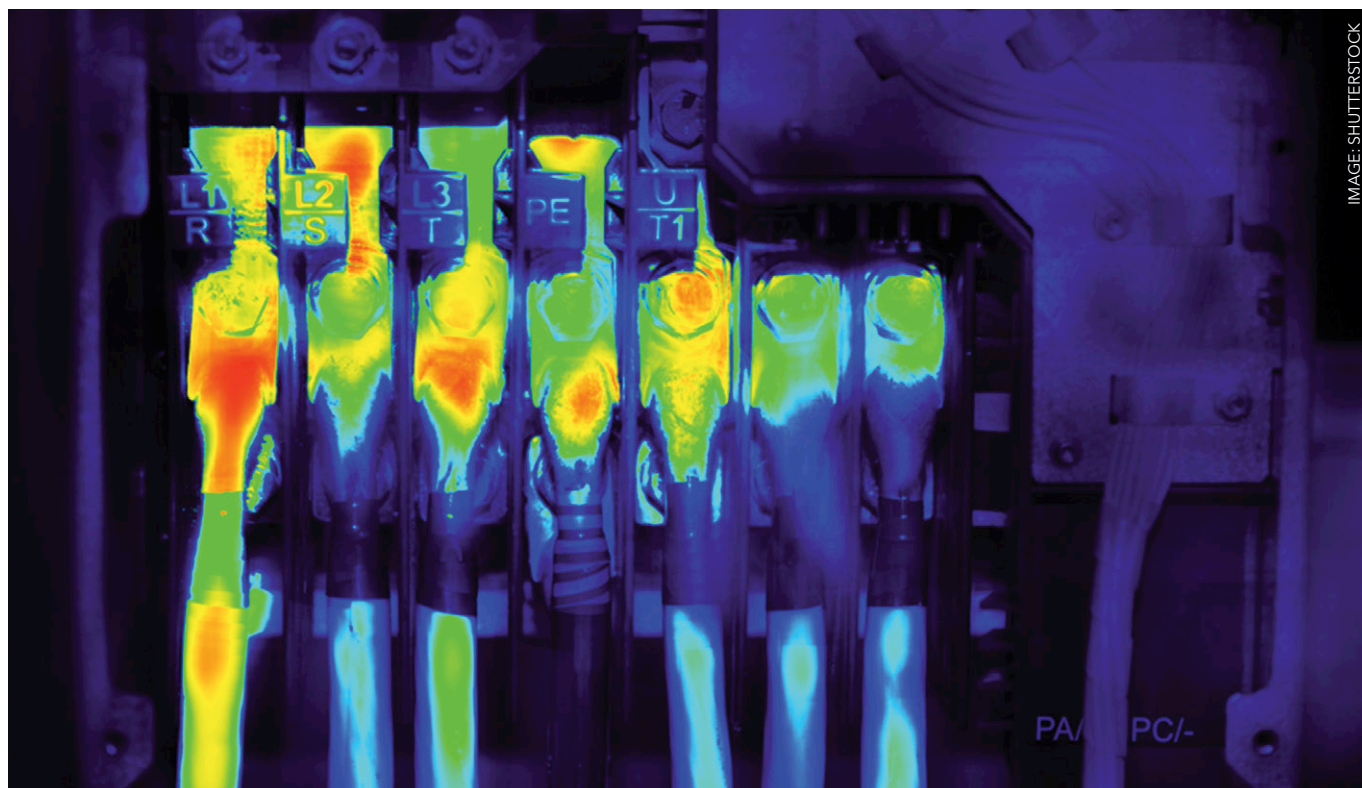
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# Working to manage heat



*The increasing penetration of electronic devices, together with growth in electric vehicle production, presents opportunities for thermally conductive polymers. Peter Mapleston reports*

The need for thermally conductive plastics compounds continues to grow, thanks largely to the rise of new technologies in areas such as lighting (LEDs) and electric vehicles (EVs). As electronic devices get smaller, the need to keep the sensitive electronic components within them cool increases. Thermal management is also expected to play a key role in improving the efficiency and safety of large battery packs used in EVs.

There are a broad range of additives available to enhance the thermal conductivity of plastics, both thermoplastics and thermosets. However, suppliers and specialist compounders uniformly emphasise the importance of collaboration along the supply chain to make the most of them in what is often considered a disruptive technology area where expert knowledge is often at a premium.

The use of lightweight, polymer-based thermal management systems has attracted much interest, even while most polymers possess low thermal conductivity, simply because of the other inherent

advantages of plastics (mechanical performance, design flexibility and so on). Traditionally, thermal conductivity is increased by incorporation of high levels of thermally conductive fillers, but there is an obvious trade-off – the fillers increase the density of compounds and they make them more difficult to process. They may also reduce recyclability.

Masterbatch maker **Colloids** believes it has an answer to this challenge in its Graphanced product range, a family of masterbatch products that contain graphene (carbon in two-dimensional form just one atom thick). Graphene is 200 times stronger than steel (130GPa) and is both stiff and elastic. Most importantly for thermally conductive applications, it is also extremely conductive. Graphene conducts heat better than metals such as copper and silver.

Colloids has been working with the University of Manchester in the UK, where graphene was pioneered, for more than seven years on graphene research and on development of graphene-con-

**Main image:**  
The proliferation of 'smart' devices presents opportunities for plastics that can integrate thermal management capabilities

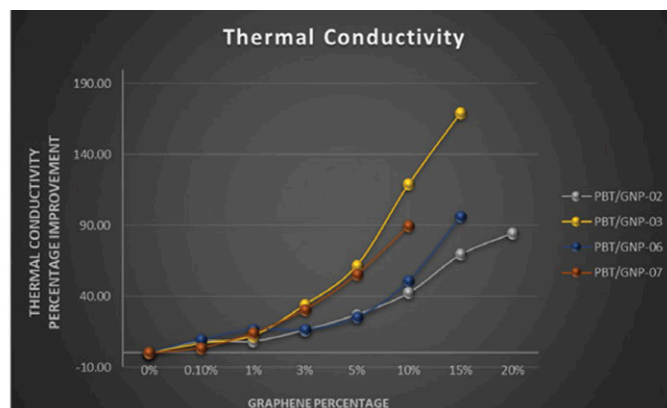
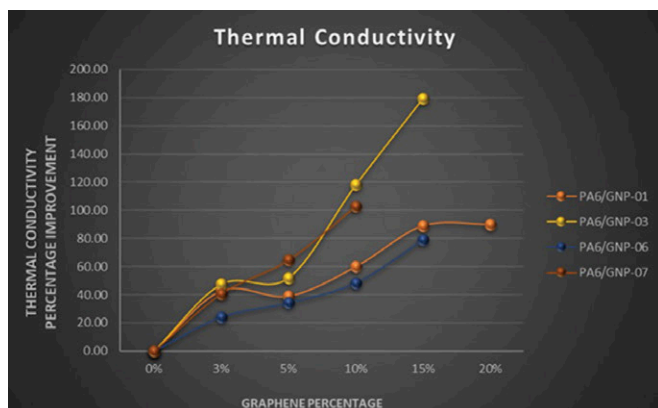


IMAGE: COLLOIDS

**Above: Colloids has achieved good thermal conductivity results in polyamides (left) and polyester polymers (right) using its Graphanced masterbatch at low addition levels. The company says as little as 3 wt% of graphene can achieve an increase in thermal conductivity of around 50%**

taining polymer composites. The company says it has also collaborated with leading graphene producers in the development of its Graphanced products.

It is generally understood that the thermal conductivity of graphene is accomplished by phonons. A phonon is defined as a definite discrete unit or quantum of vibrational mechanical energy (as a photon is a quantum of electromagnetic or light energy). However, when combined in a compound or composite matrix, the morphology of the graphene and the many interfaces with the polymer can lead to phonon scattering, negatively affecting the potential thermal conductivity. The appropriate choice of graphene and graphene morphology is critical to unlocking the potential benefits of graphene polymer composites, says Colloids.

The base resins of the Graphanced product range include PA6, PA66, PBT, PET, PC, polyolefins, PS, SAN, and various TPEs. Work is underway for development of masterbatches compatible with higher-end polymers such as PEEK and PPS.

### Focus on dispersion

"Our focus is on dispersion, especially with nanoparticles. As you go down in size to nanometre scale, the tendency is for particles to agglomerate, to minimise surface energy. We've developed our technology to reduce those agglomerates," says Derek Hepburn, Colloids' Technical Director. "It's a question of how much energy you put into the compound when you're processing it. If you put in too much energy you can start to degrade the polymer or you can start to damage the graphene flakes. It's a very narrow operating window."

Marios Michailidis, who has a PhD in nanomaterials and is Colloids' R&D Technologist leading the new product developments, says that collaboration with the National Graphene Institute (NGI) at the

University of Manchester led to the idea of using hybrid systems, combining graphene with other nanomaterials such as carbon nanotubes to develop multifunctional applications that take advantage of the properties of the different materials.

Mark Bissett, a Senior Lecturer in Nanomaterials at the university involved in the collaboration, explains some of the challenges. "There's quite a lot of parameter space here, and a lot of variables to play around with. Different ratios, different chemical functionalisations of those materials and different processing conditions. And then scaling all that up to the masterbatch volumes that Colloids use," he says.

One problem is that different loadings in the polymer lend themselves to different functionalities. For mechanical strength, a low loading of graphene works best while for conductivity (electrical as well as thermal) higher loadings are needed. So some compromise may be involved, depending on the target application.

Graphanced was launched at the Compounding World Expo in Essen in September 2021 and Colloids says it has attracted much interest from customers. Depending upon the final application, the company can develop a solution based on graphene and, if necessary, other 2D materials to meet performance targets.

Graphite-based products with a wide range of morphology and particle size distributions are available from **Imerys Graphite & Carbon**. According to Anna Ellett, a Field Application Engineer, Polymers, says these enable fine-tuning of polymer compound properties such as thermal and electrical conductivity as well as mechanical properties.

The company's Timrex natural and synthetic graphites and specialty high-aspect-ratio Timrex C-Therm products can confer high levels of thermal



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conductivity to polymers. "With these high performance thermally conductive additives, targets above 20 W/m.K in-plane and 4 W/m.K through-plane can be achieved while maintaining good processability of the final compound," Ellett says. "In most resin systems, 20% C-Therm loading is sufficient to reach 1W/m.K through-plane thermal conductivity."

C-Therm can also be added to boost the thermal conductivity of standard graphites. "A synergistic effect on thermal conductivity has been observed by blending C-Therm and graphite with a significant increase in in-plane as well as through-plane thermal conductivity," Ellett says. "For example, substituting as low as 5% graphite with 5% C-Therm enables an increase in thermal conductivity of around 25% in the through plane direction and of around 20% in the in-plane direction [Figures 1 and 2]."

According to Imerys, C-Therm can be used to boost thermal conductivity of compounds in combination with other conductive additives, such as conductive minerals, at low loading level to maintain electrical insulation and at higher loading when high thermal conductivity targets need to be achieved.

### High expectation

"Market expectations are high but still the requests for thermally conductive plastics compounds remain rather low," says Christine Van Bellinghen, Business Development Manager, Conductive Compounds, at compounding company **Witcom Engineering Plastics** in The Netherlands. "Struggling for raw materials supply was probably the major concern in the market, delaying the start of innovative projects requiring thermal conductivity. Sustainability concerns should, however, bring back the interest, knowing that replacing metal for light-weighting will contribute to lower energy consumption and all in all, lower carbon footprint."

EVs are expected to place renewed focus on weight reduction. "The minor space available and high weight of EVs will push for new plastics developments involving thermally conductive or EMI shielded thermoplastic compounds, for ECU housings, battery cooling or LED lighting for instance. Getting a better heat dissipation can also help selecting other plastics with lower carbon footprint."

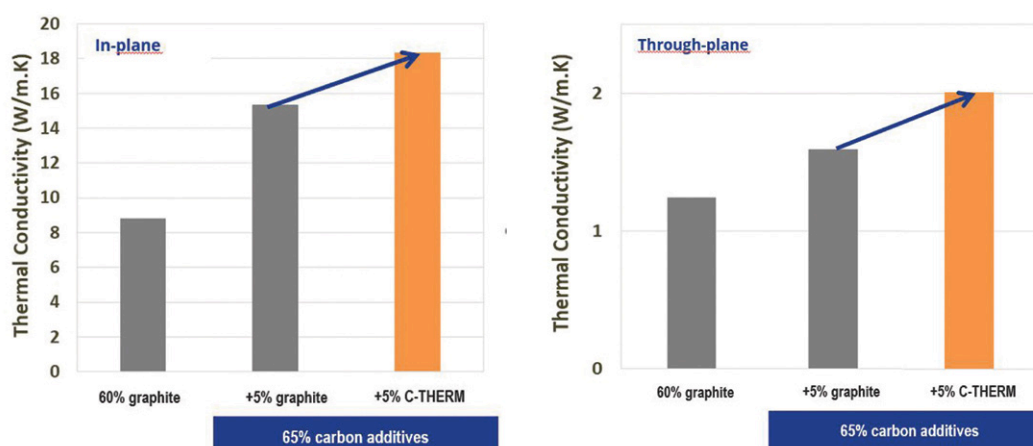
Another compounder, **Tisan Engineering Plastics** in Turkey, says the thermally conductive compounds it has developed are proving themselves in applications where metals and ceramics are disadvantaged. "Compounds have improved thermal conductivity 50-100 times that of conventional plastics," says Binnaz Coşkun, R&D Executive at the firm. It has developed compounds based on polyamides and thermoplastic polyesters.

Meanwhile, **Radical Materials** in the UK produces thermally and electrically conductive compounds branded **Konduct**. Technical Director Chris Vince says there are many factors that need to be considered when selecting an additive/polymer system to meet the required performance portfolio. "These include particle geometry/aspect ratio and size, electrical properties and addition rate. Very specific blends of additives can often be tailored to optimise thermal conductivity and cost of the final compound and further modifications can also be made to minimise the effect of the often high additive content on mechanical and processing performance."

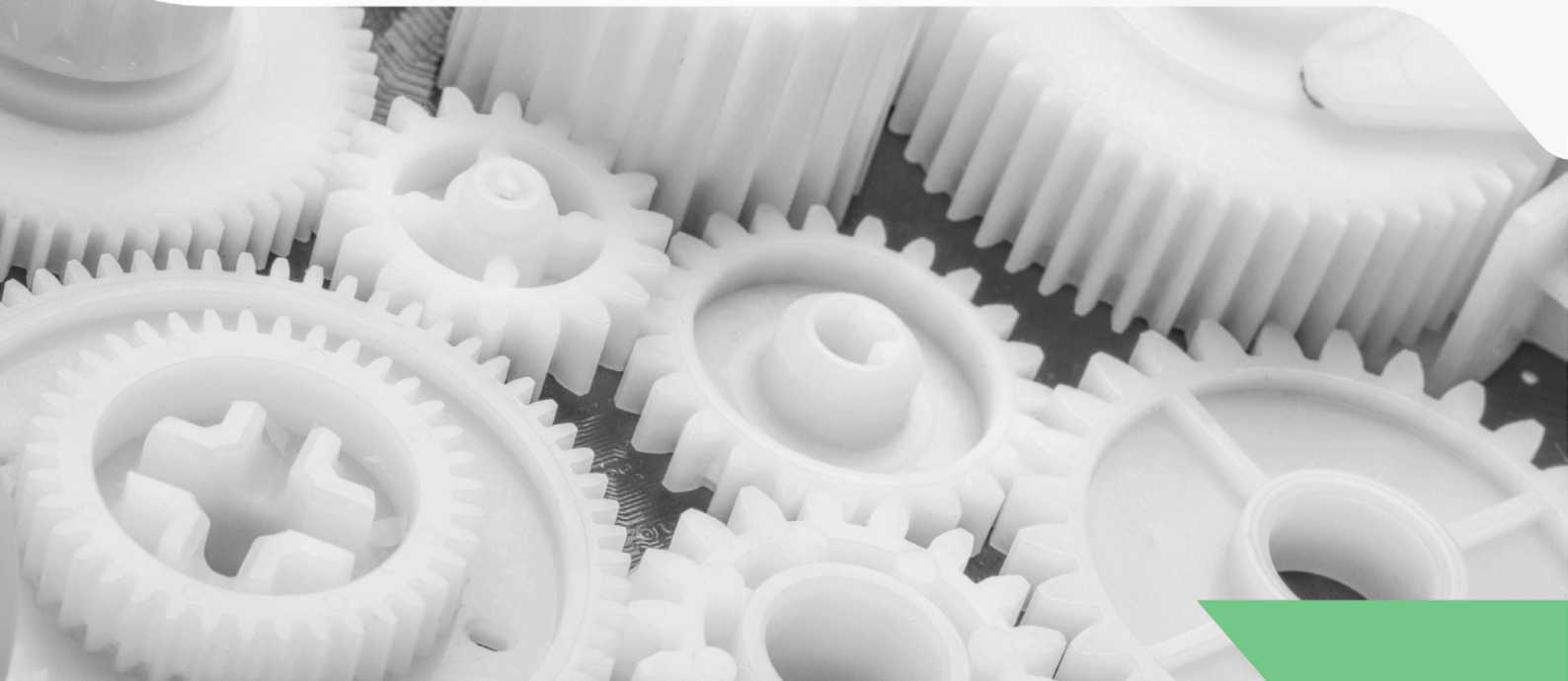
Vince says a wide range of polymers can be offered with enhanced thermal conductivity, with typical values of 1-2W/m.K through-plane and 5-20W/m.K in-plane being achievable. Like Van Bellinghen at Witcom, he says the use of such materials in thermal management situation is still not mainstream though and, echoing comments from both her and Tisan's Coşkun, says strong

**Figures 1 and 2: In-plane (left chart) and through-plane (right chart) thermal conductivity (measured by laser flash instrument) of a graphite-PP compound showing effect of addition of 5% C-Therm high aspect carbon from Imerys. All compounds produced in an internal mixer and compression moulded.**

Source: Imerys Graphite & Carbon







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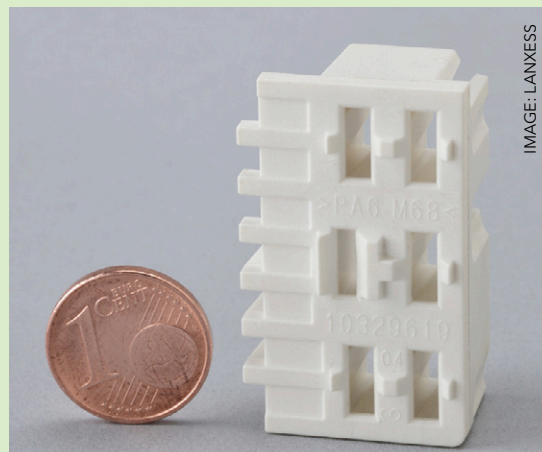
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## Controlling the charge

This cooling element is part of the charge controller used in a Germany-manufactured electric sports car and is produced in Durethan BTC965FM30 from Lanxess. This thermally conductive but electrically insulating PA6 prevents overheating during the charging process and meets the strict requirements for flame-retardant properties, tracking resistance and design.

According to Bernhard Helbich, Technical Key Account Manager at Lanxess, the special mineral heat-conducting particles, which the company declines to identify, give the compound an in-plane thermal conductivity of 2.5 W/m.K and 1.3 W/m.K through plane.

➤ [www.lanxess.com](http://www.lanxess.com)



partnerships are required to allow successful implementation and grow confidence.

"Radical Materials is able to offer standard as well as custom designed compounds and can support with material selection, measurement of thermal and mechanical performance and small-scale development trials to full production," he says.

For non-electrically insulating applications, compounds are typically carbon-based and commonly a form or blend of graphite. "If electrical insulation is an issue in the final compound then specific grades of boron nitride are common but, from a commercial standpoint, these would typically be blended with selected minerals of lower cost," says Vince.

One project the company is currently working on is for an injection moulded electronics housing where the additive is graphite-based and the component performs with an achieved through-

plane thermal conductivity of around 1.5W/m.K and in-plane around 8-9W/m.K.

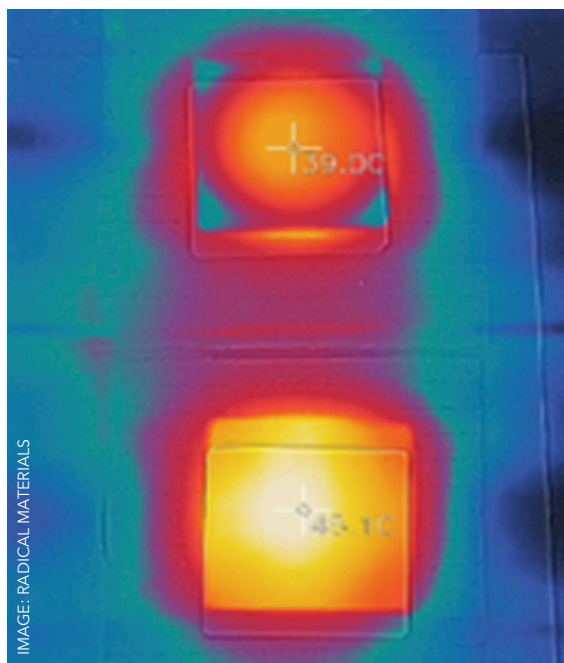
### Interface options

Thermal interface materials (TIMs) – also known as gap fillers – are used to improve battery cooling in EVs. These crosslinking or non-crosslinking materials can have a thermal conductivity of up to 3 W/m.K or even higher. Depending on the base polymer, filling levels of 90 wt% or more are required to achieve such levels of thermal conductivity. With standard filler particles, such levels cannot be achieved at all or only with significant losses in processing and flow properties, says **HPF The Mineral Engineers** (a division of Quarzwerke), which supplies various high-performance fillers.

In a recently published technical information paper, the company says that by using fillers from its Silatherm Plus and Extra range of modified aluminosilicates, these filling levels can be achieved in combination with good flow properties. "If the filler is provided with an individually matched coating, the already achieved filler levels of 90 wt% can be raised even up to 93 wt%," the study says. "By filling the voids between individual battery cells in a battery pack with soft-curing or paste-like TIM, the battery can be cooled efficiently even under heavy electrical loads and connected to the active cooling system."

HPF has developed various fillers that allow high filling levels at low viscosities. "This is possible by utilizing packing density optimised products and the selection of a suitable surface coating," the company says. Products in the Silatherm Plus 1432 and 1443 series are based on specially shaped mineral particles that differ slightly in packing structure and achievable thermal conductivities. Products from the Silatherm Extra series, which HPF says are cost-optimised, have different flow

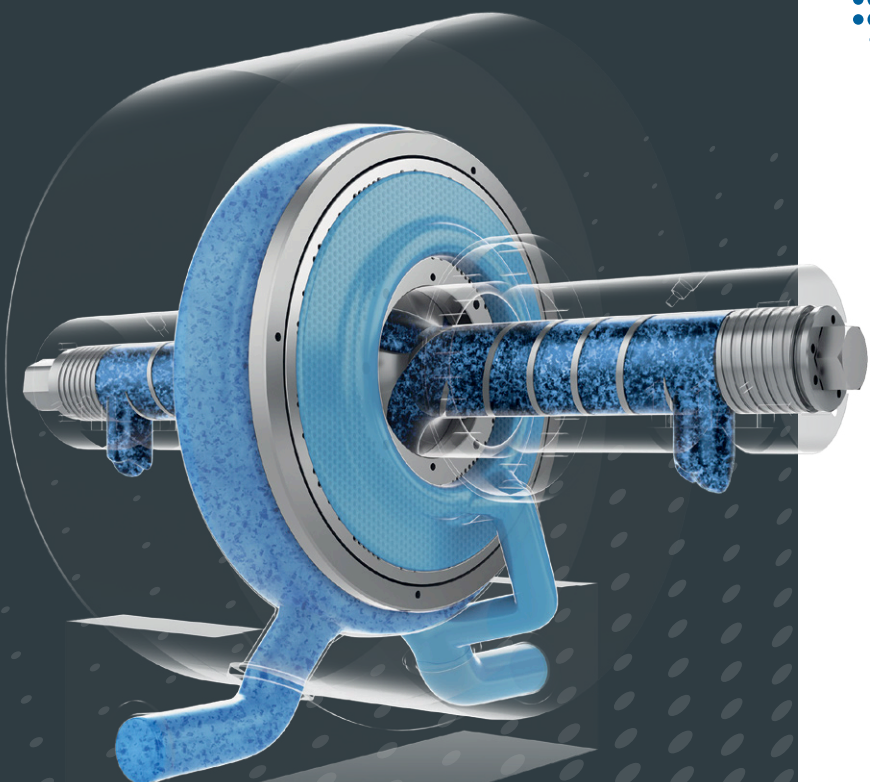
**Right: Thermal image showing surface temperature and heat spread across a standard polymer (top sample) and thermally conductive polymer (lower sample) after one minute contact with a heat source**





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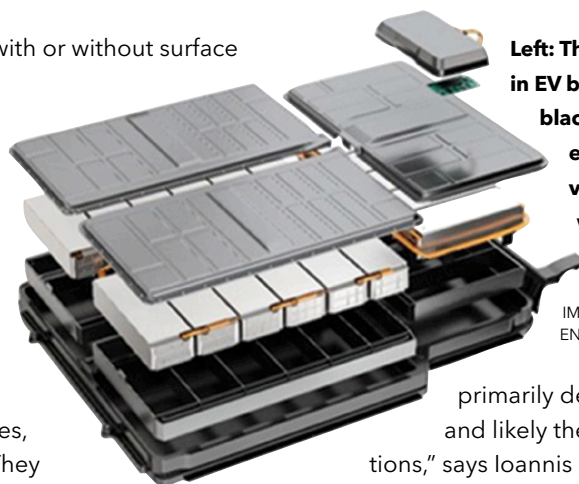
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properties. All are available with or without surface coating.

For the same applications, **Huber Engineered Materials** highlights its Martinal TM (Thermal Management) grades, which are aluminium hydroxide (ATH)-based thermally conductive inorganic materials intended for resin systems such as polyurethanes, epoxy, silicone, and acrylic. They are developed to complement the company's existing Martoxid TM products, which are alumina-based and offer higher processing temperatures.

The company says the battery pack on an electric vehicle may need up to 5 litres of TIMs. "The choice of the conductive additives is what



**Left: Thermal interface materials in EV battery packs (shown in black under the white battery elements in this exploded view) require compounds with high levels of conductive fillers**

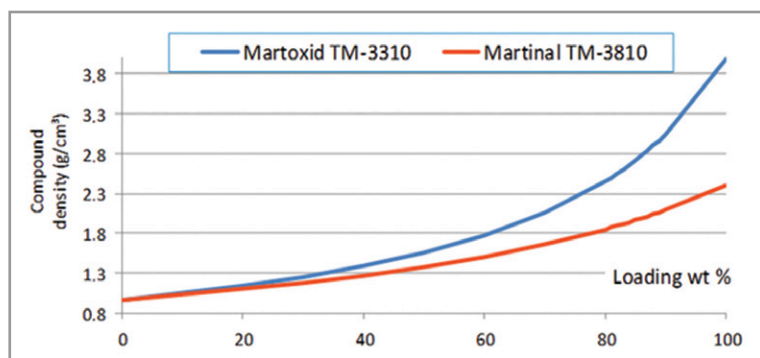
IMAGE: HUBER ENGINEERED MATERIALS

primarily determines the weight and likely the cost of the formulations," says Ioannis Papazoglou, Research and Development Scientist.

Martinal TM products can replace denser additives, so increasing an EV's mileage and reducing overall manufacturing costs, while at the same time providing sufficient thermal conductivities, he says. "However, the additional feature of fire retardance, arising from the inherent chemical properties of ATH, is what makes Martinal TM products suitable for such demanding applications. Heat dissipation accompanied by flame retarding properties are the two features necessary to prevent and suppress a thermal event and its consequences."

**CLICK ON THE LINKS FOR MORE INFORMATION:**

- > <https://colloids.com/>
- > <https://www.imerys.com/>
- > <https://wittenburggroup.com/witcom/>
- > <https://www.tisan.com.tr/>
- > <https://www.radicalmaterials.com/>
- > <https://www.quarzwerte.com/en/> (HPF Mineral Engineers)
- > <https://www.huber.com>



**Figure 3: Graph shows the effect of loading level of different Huber fillers (Martinal TM based on ATH and Martoxid TM based on alumina) on density of a silicone resin composite TIM material**

Source: Huber Engineered Materials

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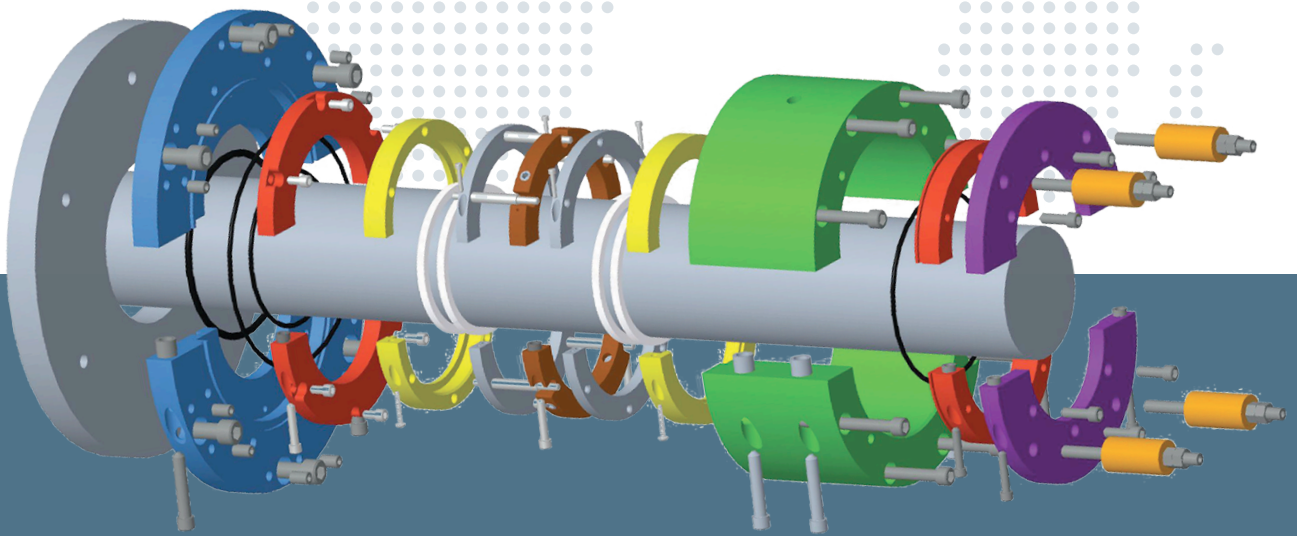
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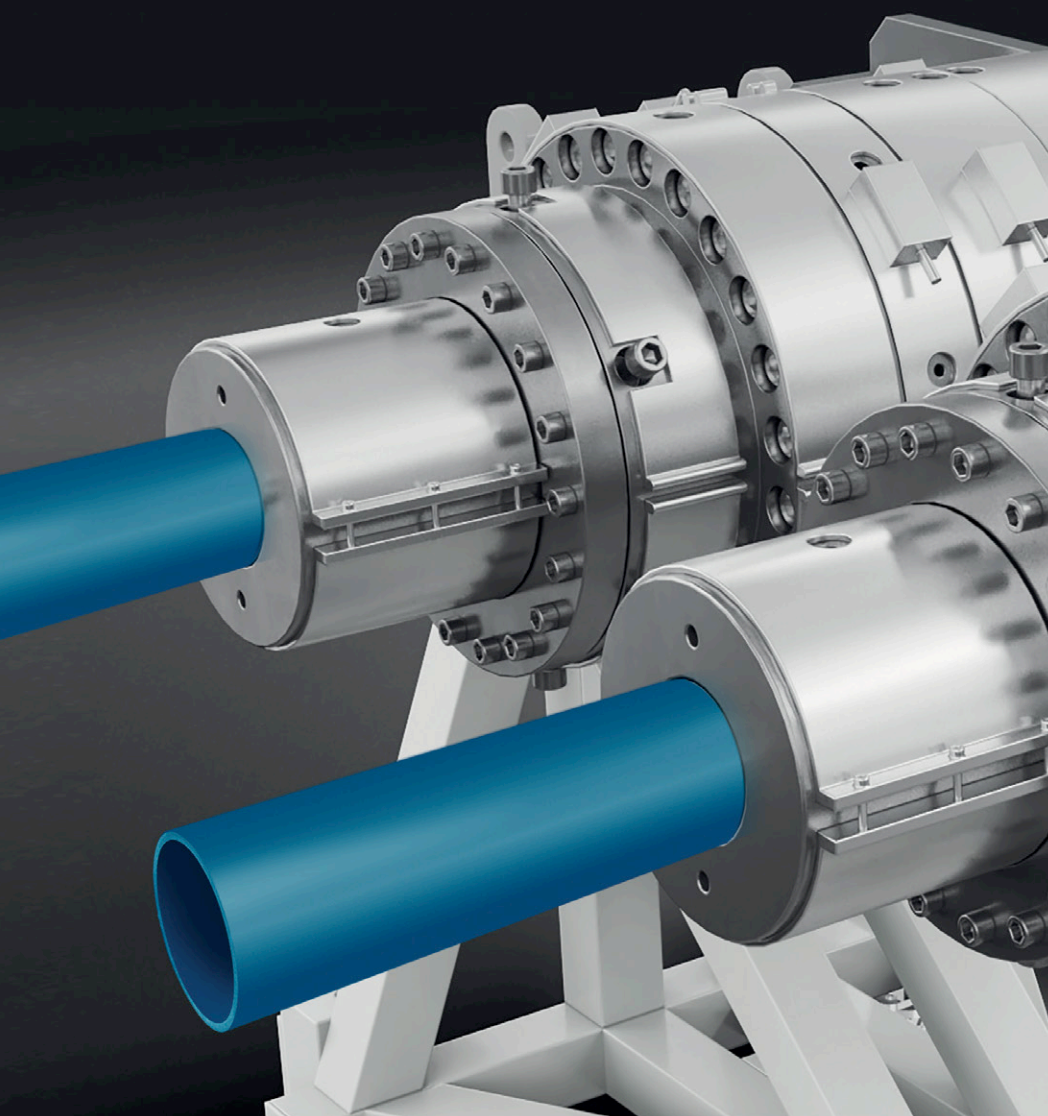
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# Gearing up for K2022

*It's that time again: K2022 kicks off in a few short months. In this special section, we look ahead to the global plastics industry's key event - and provide essential links to help you get the most from your visit*

In just three months, the world's largest plastics show will open its doors. K2022 runs from 19-26 October 2022 in Dusseldorf, Germany.

The show will fill all 18 halls of the venue - with more than 3,000 exhibitors from over 60 countries expected to promote their raw materials, additives, semi-finished products, machinery, ancillary equipment and services to the plastics industry.

The previous K show in 2019 recorded 3,330 exhibitors from 63 countries on 177,000m<sup>2</sup> of net exhibition space. It also welcomed 224,116 trade visitors - of whom 73% came from outside Germany.

Sustainability is a growing concern within the plastics sector, so the circular economy will feature heavily at the show. As well as machinery - such as

equipment for processing, recycling and waste management - there will also be multiple examples of new materials - including bioplastics and formulations that contain higher levels of recyclate.

There is also a return for the Science Campus - which allows business to exchange ideas and information with academia - as well as two special events: 'Plastics shape the future', and the VDMA's Circular Economy Forum.

A further new element of the show is the Start-up Zone, which will showcase new and small companies in the plastics sector. This area, in Hall 8b, will feature companies that are less than 10 years old, have fewer than 100 employees and generate a turnover below €10m (US\$9.5m).

## Compounding World magazine at the show

*Compounding World* will be exhibiting at K2022 on stand C11 in Hall 7. By paying a visit, you can find out more about all of our digital plastics magazines and apps.

The stand is run by our parent company AMI, which will be showcasing its latest industry directories and

market reports, and information on our many conferences including the Compounding World Expo 2022.

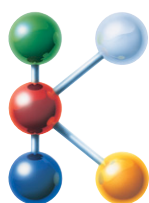
In the run up to the K2022 event, *Compounding World* will be publishing detailed previews of the innovations that will be on show.

Look out for our K Preview issues in

September and October. Follow the news on our @plasticsworld Twitter feed. We will review K2022 in detail in our November and December editions.

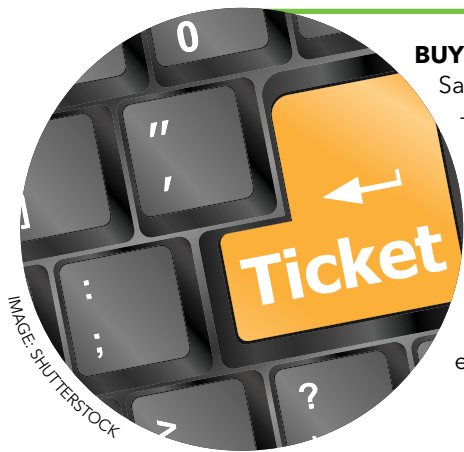
Exhibitors can send press releases to [chris.smith@amiplastics.com](mailto:chris.smith@amiplastics.com). Full details of our special coverage of K2022 are in our [media pack](#).

**Dates:** 19-26 October 2022 **Venue:** Dusseldorf Fairground, Dusseldorf, Germany  
**Hours:** 10:00 to 18:30 daily **Organiser:** Messe Dusseldorf **Website:** [www.k-online.de](http://www.k-online.de)



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*Use our selection of web links to make your visit to Dusseldorf - and K2022 - as productive and enjoyable as possible*



## BUY YOUR TICKETS

Save queueing - and money - by buying entry tickets in advance. A three-day ticket costs €120, while one-day tickets cost €55 when bought in advance. Order tickets by clicking [here](#). A catalogue is €25: buy a voucher online and exchange it at the show.



## GET K ON THE PHONE

Lots of useful K2022 data is now available on your smartphone or tablet - including exhibitor and product databases, exhibition plans, travel information, hotel listings, city guides and restaurant reviews - via the 'The K App'. To download the free app, visit the page [here](#), which has links to both the AppStore (for iPads and iPhones) and Google Play (for Android devices).

## BOOK YOUR ACCOMMODATION

Dusseldorf accommodation fills up fast during K and the best options go early. Find out what's still available and make your reservation as soon as possible at the official [website](#).



**CHECK OUT THE REST OF DUSSELDORF**

After a hard day at K2022 you will have earned some relaxation time. Make the most of your evenings in the city by checking out the restaurants, pubs, bars, culture and entertainment on offer. This official guide has useful listings, as well as guides to the sights and neighbourhoods:

**<http://bit.ly/DusseldorfGuide>**

Also worth a look is the Wikitravel page on the city:  
**<http://bit.ly/wikiguide>**

And if the Altstadt and its 260 pubs get too crowded, try heading to the **Media Harbour**, for its modern architecture and venues, which include restaurants, bars and clubs.





IMAGE: SHUTTERSTOCK

### ORGANISE YOUR TRAVEL

Dusseldorf is well connected and getting around the city is easy thanks to its excellent public transport network. There is one important change to note this year: your admission ticket to the show does not include free use of local transport, as it did in the past. Instead, visitors can travel using the **eezy app**, which is like an 'e-ticket'. Details on transport can be found [here](#).

### GET ROUND THE EXHIBITORS

With more than 3,000 exhibitors to choose from and a total exhibition area of more than 170,000m<sup>2</sup>, it makes sense to plan your time at the show before you head off. The good news is that you can search for participating companies by name and by product using the online K2022 database.

To search by company, click [here](#)

To search by products, click [here](#)

You can also locate companies using the interactive floorplan which can be found [here](#)



IMAGE: MESSE DUSSELDORF, CONSTANZE TILLMANN



IMAGE: DUSSELDORF TOURISMUS

### SOAK UP SOME CULTURE

Dusseldorf is more than just K2022. As the capital of North Rhine-Westphalia, it is home to more than 100 galleries and museums. One celebration is for the artist Joseph Beuys, who spent much of his life in the city. While his centenary fell in 2021, there are still several ongoing events. These include: an augmented reality (AR) experience (at three separate locations); and, if you're feeling fit, a Beuys-themed cycle tour.

[Find out more here](#)

### TRY SOME RETAIL THERAPY

If retail is your thing – and especially designer goods – then Dusseldorf will not disappoint. Königsallee – known as 'Kö' to locals – includes many of Europe's leading fashion names and is likened with London's Knightsbridge or New York's Fifth Avenue. However, neither of those locations can boast a setting to match the tree-lined, man-made 'river' that runs through this premium shopping district. Catch the flavour [here](#).



IMAGE: DUSSELDORF TOURISMUS, MARKUS LUGS



IMAGE: DUSSELDORF TOURISMUS, U. OTTE

### DON'T FORGET THE ALTBIER!

Regular visitors will already know that Dusseldorf's local brew is the Altbier, a malty copper-coloured ale of around 4.5% strength produced using a special top-fermented lagering method. The name translates as 'old beer' but is actually derived from the Latin word 'altus', which means 'high' and refers to way the yeast rises during brewing. Try it out in one of the city's numerous brew-pubs. Details of these and a short history of Altbier can be found [here](#).



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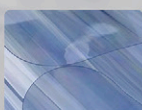
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*Performance-enhancing formulation improvements combined with high recycled contents are helping establish WPCs as sustainable construction options, writes Jennifer Markarian*



IMAGE: TREX

# Durability and sustainability drive the appeal of WPCs

Wood-plastic composites (WPCs) – often made with recycled plastics mixed with wood fibre or flour – continue to enjoy growing demand, particularly in building and construction products such as decking and railing. Formulations and processing have been refined over the years, so much so that many of today's WPC products are able to combine the attraction of using recycled material along with good long-term performance and appearance.

In the US, many manufacturers of WPC decking and other building and construction products are expanding to meet the increasing demand for 'outdoor living' products. **Fiberon**, for example, broke ground on a new manufacturing facility at Columbia in Tennessee in May 2022 and expects to begin production of WPC products at the new site using recycled PE by the end of 2024.

The Fiberon project includes an on-site recycling

facility, which will convert baled plastic waste into pellets and will use automated material shredding and sorting systems. Fiberon also added automation to its recycling processes at its production operations in North Carolina and Idaho sites earlier in 2022.

Early this year, **Oldcastle APG** – a CRH Company – announced that it would double its manufacturing capacity for its MoistureShield Elevate capped WPC products through the expansion an existing plant at Springdale in Arkansas. The company also said it was planning to expand its manufacturing lines for production of its capped MoistureShield Vision with DiamondDefense WPC products.

Meanwhile, **Trex** recently expanded capacity at its sites in Virginia and Nevada and, in late 2021, detailed plans to build a new production site at Little Rock in Arkansas. This site will be the company's third WPC facility and is expected to start operating in 2024. The company said the additional

**Main image:**  
**Decking producers such as US-based Trex see no let-up in demand for WPC decking from the outdoor living sector**



**Right: Oldcastle is investing in more capacity for its MoistureShield Elevate capped WPC products at Springdale in Arkansas, US**

capacity would help meet growing anticipated demand for its WPC decking and railing.

"With the outdoor living category continuing to show strong momentum and our success to-date in converting share from the wood decking market, the time is right to further expand our capacity so that we can meet future customer demand efficiently and effectively," said Trex Company President and CEO Bryan Fairbanks when announcing the move.

Emphasising the contribution that recycled polymer plays in its WPC activities, Trex says the company diverts nearly 400 million pounds (around 180,000 tonnes) of plastic film from landfills annually through its use of PE waste. The PE films come from both household waste (grocery bags and bubble wrap, for example) and retail waste (primarily pallet wrap and industrial packaging). The company also uses reclaimed wood, meaning its product portfolio uses 95% recycled and reclaimed material.

The latest expansion of the Trex product portfolio is the Transcend Lineage decking line, which is described as having graining that provides a more natural appearance and is available in two new colours: Raineir (described as an airy mountain grey) and Biscayne (a light coastal brown). The Lineage line uses heat-mitigating technology in the shell that reflects incident sunlight to help keep boards cooler.

### WPC additives

WPC products intended for outdoor application generally use a thin capstock layer of polymer that is stabilised with additives to improve properties such as weatherability and scratch and impact resistance. The capstock can also be pigmented and textured to give the required realistic wood-grain appearance.

**Teknor Apex** recently introduced its Weather-guard line of capstock compounds and concentrates for vinyl WPC applications. Each is generally

**Below: Teknor Apex modifies its Weather-guard line of capstock compounds for vinyl WPCs to suit specific customer requirements**



IMAGE: OLDCASTLE APG

customised for specific customer requirements, according to John Macaluso, Building & Construction Industry Manager, Vinyl Division at Teknor Apex.

"Aesthetics tend to be the number one property followed closely by weatherability, physical properties, stain resistance and flame retardance," says Maaluso. "Teknor Apex has several products well suited for WPC substrates as well as capstocks utilised on PVC-based substrates – including Vinyl Alloys, ASA, and acrylic options – the latter of which has been further expanded through our recent acquisition of Lanier Color Company."

Greg Walby, Vice President of Sales at **Lanier Color Company** (now a Teknor Apex Company), says that while consumer colour trends change frequently, they've traditionally been limited to a palette of colors that weather well in WPC applications. "With the introduction of highly weatherable capstocks, we've seen consumer preference shift to a wider palette that includes darker colors and even more toward dark variegated (wood-like) aesthetics," he says.

"In the last few years, we've seen a major shift in focus to outdoor living spaces creating more need for materials with greater weatherability (colour-fastness, resistance to environmental/stress whitening), low heat buildup, and flame retardancy for decking, railing, fenestration and many other outdoor durable applications," adds John Hickman, Building & Construction Business Development Manager, Vinyl Division at Teknor Apex. "Finally, the added expense over traditional wood products has resulted in consumer expectations for longer warranties and low/no maintenance."

While the capstock is critical for weatherability, the composite core may also use additives, including lubricants and coupling agents, which improve



IMAGE: TEKNOR APEX



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**Right: Mixaco's HM/KM Wood mixing system is designed for the specific challenges of WPCs**

bonding between the wood fibres and polymer matrix. Matthias Stuecke, Deputy General Manager at **Mitsui** in Germany, says that maleic anhydride (MAH)-grafted coupling agents are the "gold standard" in polyolefin-based WPC compounds. "We have received quite positive feedback from the market [on Mitsui's coupling agents]. Nevertheless, we hope to present some more new developments at this year's K2022," he says.

The WPC product portfolio from **Dow** extends to capstock formulations, lubricants, compatibilisers, and what is described as a "next-generation" product that provides both lubrication and compatibilisation. "Historically, process and performance aids have been independent products that sometimes interacted with each other in negative ways," says Jim Keenihans, Senior Technical Service & Development Scientist, Dow Consumer Solutions.

"The most common chemistries of lubricants can actually inhibit wood-polymer compatibilisers such that the full properties cannot be reached. Because of this, formulators have been forced to make compromises on lubrication—which is critical to quality, stability, and rate—and compatibilisation, which is critical for mechanical strength, moisture stability, and melt strength," Keenihans says.

Dow says that its Amplify Si PE 1000 product was developed with the intention that both lubrication and performance work at their peak performance. Keenihans claims that the product can "achieve a whole new echelon in WPC additives."

Dow's research has shown that the Si PE 1000 additive is more thermally stable than metallic stearates and will not degrade as quickly as

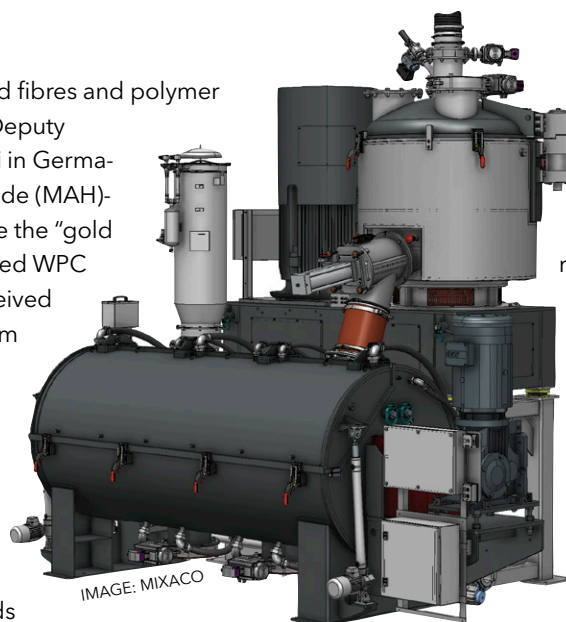


IMAGE: MIXACO

process temperatures and rates are increased. "One of our most interesting findings is that mechanical performance is improved so significantly that strength can be achieved with lower cost materials, for example utilising linear low density polyethylene instead of, or blended with, high density polyethylene," he says.

### Mixing ideas

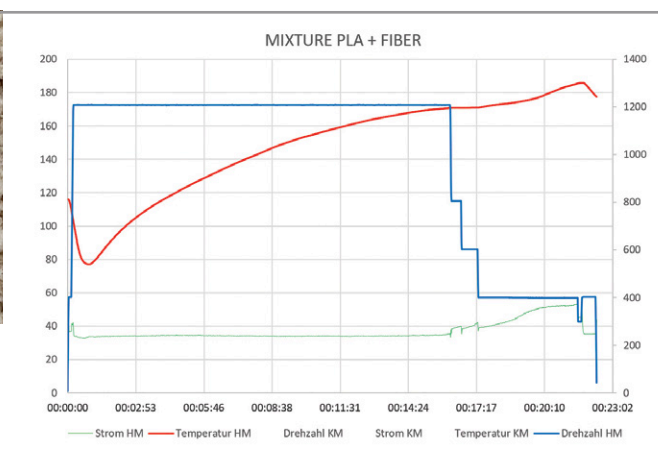
Mixing the high volume of natural fillers required in WPC compounds is a challenge, according to Nicolas Gehring, Global Sales Manager at equipment manufacturer **Mixaco**. He explains that in the mixing process in general, it is easier to homogenise materials and to prevent post-mixing separation if the particle sizes and shapes of the components are similar.

In WPC compounds, however, the fine low bulk-density wood flour or fibres are very different from the polymer powders or granules. "Mixing is a matter of moving particles consistently in order to create a uniform blend. However, particles with different bulk densities behave very differently. Lighter products need less power to get moved, while heavier products need more energy," Gehring says. Dispersing the additives into the blend is also challenging because of the high loading of natural fillers.

Achieving a uniform blend is key for the production of the WPC end-product. "Uniformity can affect the intake behavior of an extruder, or the material transport handling," says Gehring. "The smallest change in the [mixing] process can affect the further processing of the product." He adds



**Figure 1: To create a blend of 60% PLA with 40% cellulose fibre, such as that shown above, Mixaco's HM/KM Wood system regulates parameters including hot mixer rpm (blue), hot mixer temperature (red), and hot mixer torque (green)**



SOURCE: MIXACO



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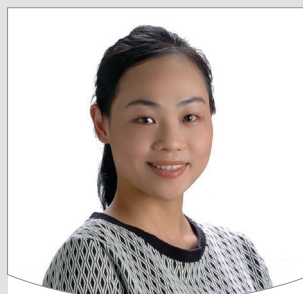
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IMAGE: FRAUNHOFER WKI/MANUELA LINGNAU



**Above: Wood fibre filled PLA pellets and 3Dprint filaments produced in a Fraunhofer WKI development project**

that wear and tear of the mixing system can affect consistency of the blend over time, so compounders should be aware of when maintenance is needed.

Moisture of the natural fillers is also a consideration, as these fillers are generally hydrophilic and easily absorb water if stored in a bag without a plastic liner. Before drying, they can contain more than 10% moisture in some cases, says Gehring. Mixaco's HM/KM Wood mixing system is specifically designed for WPC and provides a dehumidifying effect that reduces moisture.

The system is comprised of an HM Heating Mixer and KM High Efficiency Horizontal Cooler, adapted with other features for mixing of wood or natural fibres with PVC/PP/PLA or other polymers. "Even with a moisture above 10% [in incoming material] we can achieve a residual moisture of less than 1% in the final blend," says Gehring.

If moisture is not effectively removed, the material will stick to surfaces and flowability of the blend is affected. "Moisture inside a WPC blend affects the process stability in further processing (for example, injection moulding, extrusion, or rotomoulding)," he says. Gehring adds that Mixaco has experimented with WPC mixing and has

defined a standard mixing process for most WPC applications using its system. He says that the machine automatically adjusts speed to control torque and temperature.

### Testing for building

Testing requirements for WPC in the US are governed by ASTM D7032, which was adopted into the US model building codes beginning in 2009, with only editorial updates since the original 2004 version, according to Craig Wagner, Chief Engineer for **Intertek Building & Construction** product certification and chair of the ASTM subcommittee on WPC decking.

Wagner explains that ASTM D 7032 outlines testing requirements for composite decking materials that include end-use factors (for example, flexural performance, load, creep recovery), biodeterioration, and surface burning characteristics. "IBC [International Building Code] Chapter 26 and IRC [International Residential Code] R507 both apply to deck boards, stair treads, handrails, and guards, and evaluate structural performance (span/load rating), end-use factors (temperature and moisture effects), durability (weathering), and termite and decay resistance," he explains.

Wagner says that one area of regulation and testing that has expanded over recent years is the adoption of special fire resistance testing for application in areas prone to wildfires, commonly known as Wildland Urban Interface (WUI) requirements.

Another aspect of testing that WPC processors should be aware of is the need to investigate the range of colours that might be used in a product. "This is not so much a concern for the colours (pigments) making a significant difference in the various test results, as it is more for making sure that you're addressing differences in the base material compound. Sometimes one or more capstock colors are a different material from the others [for example, acrylic or PVC]. Another

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**Right: A 3Dprinted sample produced at Fraunhofer WKI for evaluation in construction and building applications**

variable in [coloured] compounds could be different additives [such as] the amount of additive for UV stabilisation. UV resistance is one of the primary requirements of the product standard and the complete range of different compounds used must be considered in the evaluation," he says.

Recycled plastics can potentially have more variability than virgin plastics, which is another consideration in testing. "A trend that we're seeing in the use of recycled plastics is manufacturers getting into the plastics recycling business to gain greater control over the materials they use in their products," says Wagner.

One of the most challenging requirements for WPC decking is the structural performance needed for use as stair treads, says Wagner. "This is primarily due to a deflection limit under a 300lb concentrated load required in ASTM D7032. Manufacturers often need to limit stair tread spans to something less than what you'd find in typical deck construction or develop installation details that provide some additional support for the stair tread," he says.

### 3Dprint ideas

While most WPC products are produced using extrusion, Germany's **Fraunhofer WKI** (Institute for Wood Research) has initiated a new project that aims to demonstrate what is possible in novel light-weight 3D-printed designs for building and construction applications that incorporate wood-based filaments and as much bio-based content as possible. Project lead Dr Arne Schirp says the researchers are exploring wood particles, pure cellulose and lignin, and mixtures of these in PLA (polylactic acid, a biobased thermoplastic polyester) compounds with 20 and 40% fibres by weight.

The compounds will be made into filaments and 3D-printed. "One of the main challenges is to find the right balance between printing speed and quality when it comes to large parts. This summer, the first prototypes will be designed and printed by our project partners," says Schirp.

Additive manufacturing has the potential to save material and cost in the production of complex, customised components, according to the Fraunhofer team. The project will look at simplifying production of existing architectural components, such as facade elements and partition walls, as well as development of new and innovative designs.

PLA reinforced with wood or cellulose fibres has already been used in 3D-printed parts but (so far) rarely in building applications, says Schirp. PLA is, however, desirable as a material based on renewable resources.



Researchers are working to improve fire-retardancy and heat resistance of the materials, which is particularly challenging in the PLA matrix. "We are currently investigating the benefits of electron beam irradiation, which can be used to crosslink thermoplastics (in our case, PLA and bio-based polyamides). The crosslinking takes place in the amorphous regions of the polymer," he says.

"The crosslinked systems also include [phosphate] FR additives. The idea is to find out if a combination of the crosslinking agent and FR can achieve the same performance as with the use of FR only. At present, we try to understand the interaction between FR additive and cross-linking agent better. We [can] confirm that increased heat resistance can be obtained using irradiation, while the effects on fire-retardancy are still under investigation. Tests such as the UL-94, glow wire test and comparative tracking index are in progress," says Schirp.

The researchers are also working on continuous fibre filaments based on hemp, flax and used in conjunction with bio-based thermoplastics. "We are currently working on achieving a homogeneous coating of the fibres with PLA prior to 3D-printing. Our project partners have been working on modifying a printer specifically for this long-fibre material, and they are also designing and implementing a cutting mechanism," Schirp says.

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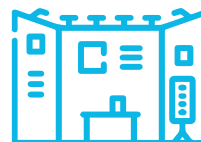
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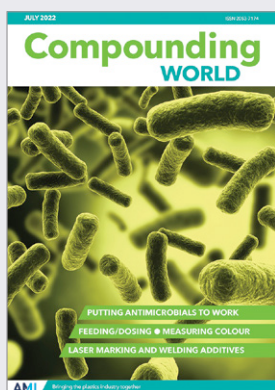
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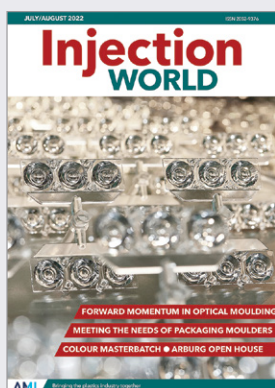
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<b>29 Nov-1 Dec 2022</b>	Polymers in Footwear Virtual Summit, Online event
<b>7-8 Dec 2022</b>	Oil & Gas Non-Metallics Europe, London, UK
<b>8-9 Dec 2022</b>	PVC Formulation Asia, Bangkok, Thailand

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