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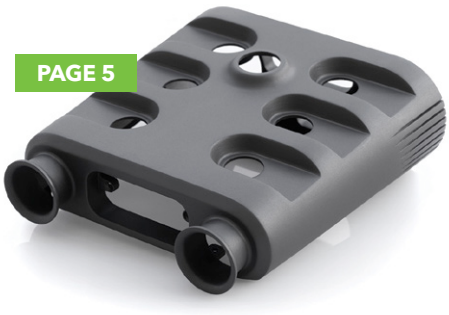

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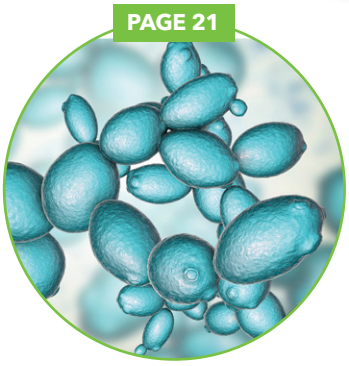

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CONTACT US

AMI
Third Floor, One Brunswick Square,
Bristol, BS2 8PE, United Kingdom
Tel:+44 (0)117 924 9442
Fax:+44 (0)117 311 1534
www.amiplastics.com
www.twitter.com/plasticsworld
Registered in England No: 2140318

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EDITORIAL

Editor-in-Chief: Chris Smith
cs@amiplastics.com

Technology Editor: Peter Mapleston
editorial@compoundingworld.com

Contributing Editor (USA): Jennifer Markarian
editorial@compoundingworld.com

Contributing Editor (UK): Mark Holmes
editorial@compoundingworld.com

Events and Magazines Director: Andy Beevers
abe@amiplastics.com

ADVERTISING

Advertisement Manager: Claire Bishop
cb@amiplastics.com T/ +44 (0)7905 848744

Head of Business Development: Paul Beckley
pb@amiplastics.com T/ +44 (0) 117 311 1529

Advertising Sales (China/Hong Kong): Maggie Liu
maggieliu@ringiertrade.com T/ +86 13602785446

Advertising Sales (Taiwan): Ms Sydney Lai
sydneylai@ringier.com.hk T/ +886-913625628

Advertising and Expo Sales (India): Yogesh Vyas
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AMI | Events

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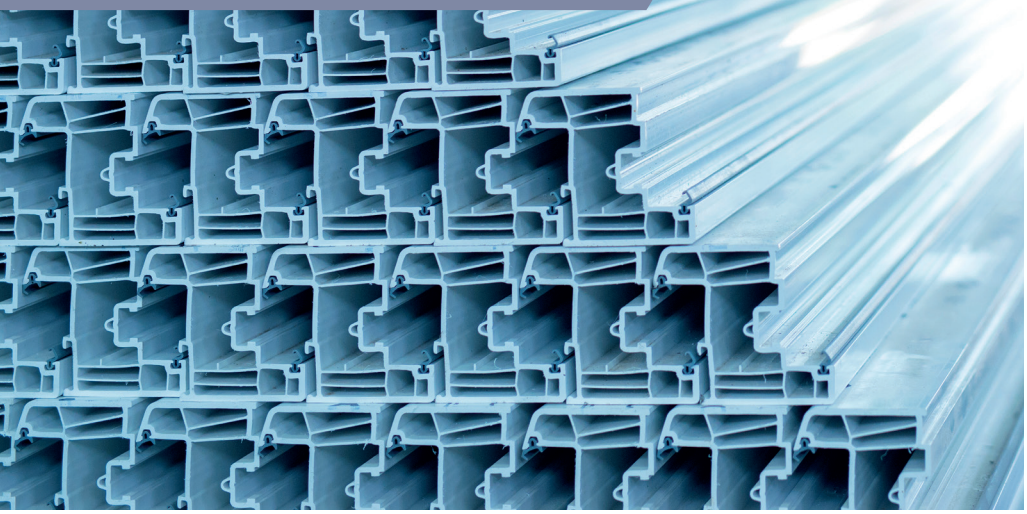

Hear from industry experts:

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Cefic - European Plasticisers

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Coperion invests in recycling

Coperion has commenced construction of a 'recycling innovation centre' next to its existing test centre for bulk solids handling at its production facility in Niederbiegen/Weingarten, Germany.

The company said the 5,000m² centre will support customers in developing new products and recycling processes. "All essential recycling process stages will be covered within the facility, including materials conveying, feeding, extrusion, pelletising and materials post-processing. In addition, Coperion will conduct its own research activities on plastics recycling," the company said.

Separately, but also with recycling in sight, Coperion has launched the ZS-B Megafeed side feeder, which is claimed to significantly increase fibre and flake feed rate into ZSK twin-screw extruders.

IMAGE: COOPERION

Above: Architect's rendering of Coperion's planned 5,000m² innovation centre

The feeder's design enables high rates of fibre and flakes – such as PA, PE, PET and PP – to be fed. In tests with PA fibres with a bulk density of 40-50 kg/m³, throughputs increased fourteen-fold from 70 to 1,000 kg/hour, the company said. Throughput rates increased from 50 to 2,500 kg/hour when feeding recycling carbon fibre, from 50 to 700 with PCR flake, and from 80 to 1,300 with multi-layer film flakes.

Last month Coperion's parent company, US-based Hillenbrand, announced the acquisition of German recycling system maker Herbold Meckesheim for €79m. It said the company's activities are highly complementary to the Coperion brand and will accelerate growth opportunities in the recycling market.

› **www.coperion.com**
› **www.hillenbrand.com**

Kubota acquires Brabender

Japan's Kubota Corporation is to buy Germany-based Brabender Technologie, which following completion of the deal will become a wholly-owned subsidiary of Kubota Holdings Europe.

Kubota said the acquisition will provide synergies through the integration of Kubota's strong position in gravimetric feeders in Asia with Brabender's technology and sales networks in Europe and North America. It sees considerable growth opportunities from the shift to increased automation of manufacturing and through wider trends towards carbon neutrality.

"The production of many of the materials used for the secondary batteries that contribute to carbon neutrality, as well as the plastics and other recycled materials in a circular economy, require a blend of bulk materials," Kubota said. "The use of high-performance gravimetric feeders is expected to provide a reliable and highly precise supply of bulk materials with a variety of unique characteristics."

› **www.kubota.com**
› **www.brabender-technologie.com**

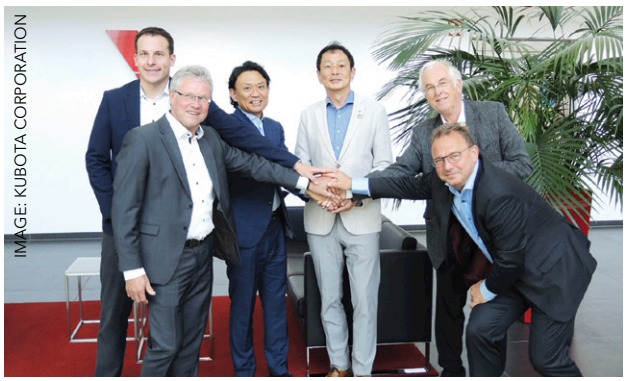
IMAGE: KUBOTA CORPORATION

The Kubota and Brabender teams mark the deal. From left, Brabender Services Director Jan Pardon, Brabender Technologie Director Dr Günter Kuhlmann, Kubota Manager Precision Equipment Hideki Saiki and Managing Director Tomohiro Fukihara, Holzhauer Director Peter Eßer and Brabender Technologie Director Bruno Dautzenberg

LG Chem targets EV power

LG Chem said it has invested in production plant to produce a new flame retardant polymer suitable for prevention of thermal runaway in EV battery packs (a major contributor to fire).

Based on PPO, PA and PBT, the new material is claimed to be able to delay thermal runaway by more than 400s at 1,000°C. It is also said to have "superb dimensional stability".

The company said it is currently filing global patents and plans to start industrial-scale production in 2023.

› **www.lgchem.com**

Graphene master-batches

Brazilian graphene nanomaterials specialist Gerdau Graphene has developed graphene-enhanced polymeric resin masterbatches formulas for PE and PP in partnership with Embrapii Senai/SP.

These new masterbatches are being piloted in a series of industrial applications within Gerdau's facilities, according to the company.

"The new thermoplastic products created using these formulas will be stronger and offer greater overall performance while costing less to manufacture and producing significantly less waste across the value chain," Gerdau said.

The company said the first commercial deliveries were made in June.

Gerdau Graphene was established in 2021 by US steel producer Gerdau.

› **www.gerdaugraphene.com**

Avient/Solvay extend LFTs

Avient and Solvay have both announced extensions to their long fibre reinforced plastics product lines and capabilities.

Aiming at sustainable applications, Avient has extended its Complet REC range of LFTs. The PA6-based products, which use resin recovered from end-of-life fishing nets, are now joined by two more product lines containing 25-100% post industrial recycled PA66 and 25-75% recycled TPU.

The new grades are formulated to provide stiffness, strength, and toughness comparable to standard PA66 and TPU LFTs using virgin resin, according to the company. Like their virgin alternatives, they can help achieve significant weight and cost-savings in metal replacement applications.

Formulations are available globally in black and natural colour and with long glass fibre, long carbon fibre, and hybrid reinforcement combinations. Potential applications include adventure gear and office furniture.

Meanwhile, Solvay said it has recently invested in enhancing its Xencor LFT production capabilities. This includes new manufacturing assets and additional capabilities at Solvay's Oudenaarde facility in Belgium, as well as an expansion of R&D resources at one of Solvay's technical centres at Alpharetta, Georgia, US.

Solvay said Xencor LFT is one of the key pillars in its light-weighting portfolio. The company said the materials open up opportunities to replace die-cast aluminium in electric vehicle applications such as braking and steering parts, electric-drive units, inverters, and battery modules.

› **www.avient.com**
› **www.solvay.com**

Geon buys Cary Compounds

Geon Performance Solutions has acquired US-based Cary Compounds.

Founded in 1999, Cary is a specialist in development and production of compounds for the North American cable industry in particular. Its product slate includes flexible and rigid PVC, CPE, alloys and custom compounds.

The company said the Cary assets at Manalapan, New Jersey, will be consolidated into Geon's manufacturing campuses.

Geon, which is owned by SK Capital, manufactures PE, PP and PVC compounds for markets including appliances, building and construction, electronics, healthcare, transportation, and wire and cable. It has around 1,000 employees and 11 manufacturing plants.

› **www.geon.com**
› **www.carycompounds.com**

ITT invests in CRP Technology

US-headquartered ITT has taken stakes of 46% and 33% respectively in CRP Technology and its CRP USA subsidiary. The companies are known for the Windform brand of reinforced polymer composite materials for 3D printing applications.

"With almost three decades of leadership and innovation in additive manufacturing, CRP enables ITT to expand its position in material science and gain hands-on experience with additive manufacturing as the industries we serve continue to transform," said Luca Savi, CEO and President of ITT.

CRP Technology is based in Modena in Italy and has manufacturing plants and offices worldwide. CRP USA, which is based in North Carolina, markets its technology in North America.

CRP was originally focused on production of high-performing parts and applications for motor racing, but has since grown into aerospace, defence and premium automotive industries.

› **www.itt.com** › **www.crptechnology.com**

Above: Housing for military binoculars made in CRP's Windform 3D print compound

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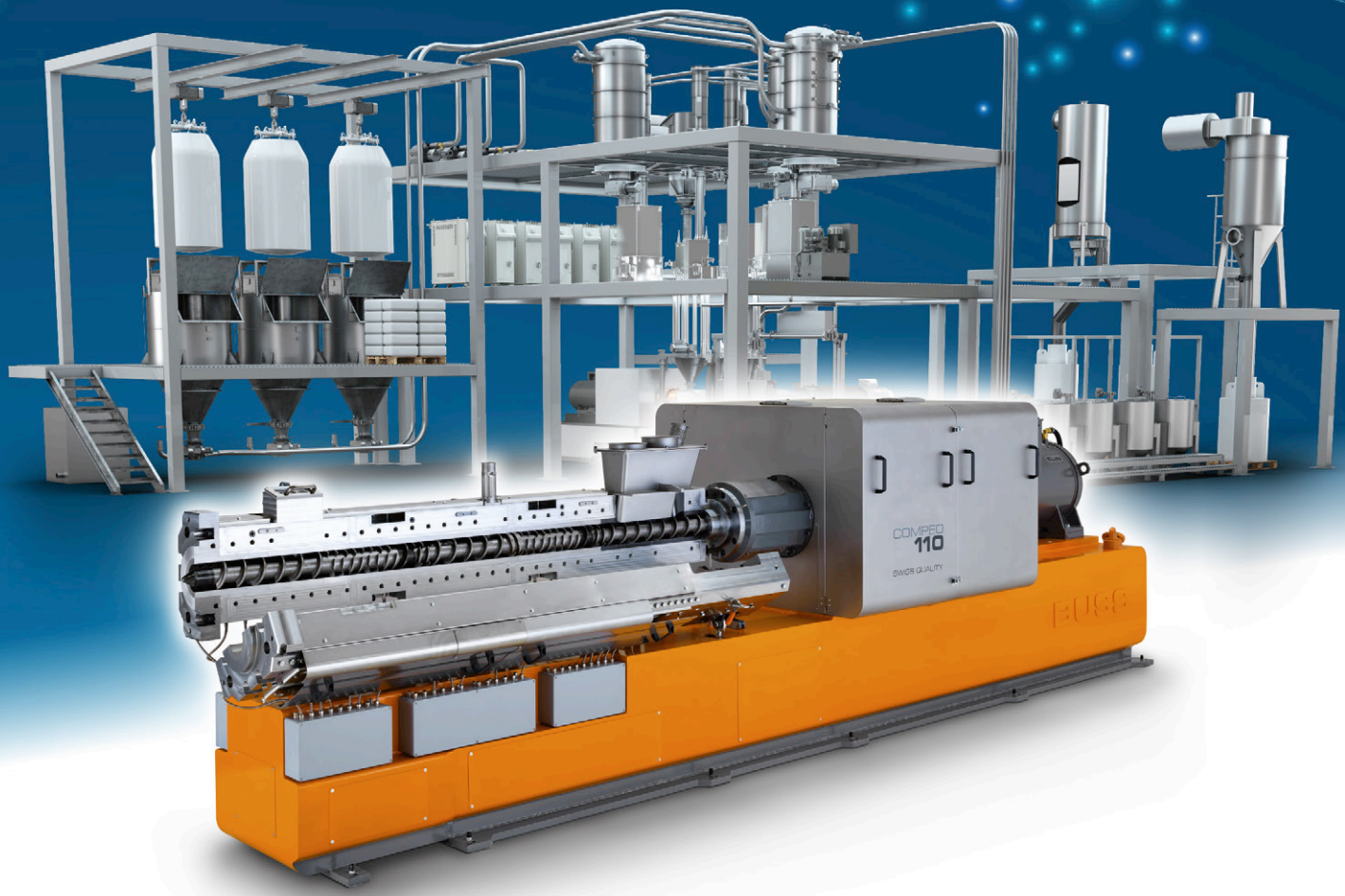

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Growing in carbon black

Birla Carbon and Orion Engineered Carbons have separately announced major expansions in carbon black production capacity.

Birla Carbon will add a further 200,000 tonnes/yr of capacity for applications in plastics, rubber and other speciality markets, including 80,000 tonnes/yr at plants in China and India and a further 40,000 tonnes in Hungary. All are expected to be complete in 2024.

The company said it will continue to evaluate additional expansions in various geographies.

Meanwhile, Orion Engineered Carbons said it will complete its gas black expansion at its plants in Dortmund and Cologne in Germany by early 2023. Gas blacks are known for their dispersion and colour characteristics and Orion claims to be the only carbon black producer active in them.

› **www.birlacarbon.com**
› **www.orioncarbons.com**

China tops global machine exports

Global production of plastics and rubber machinery 2016-2021 by value and country share

	World Production*	Shares of particular countries (%)					
Year	(m €)	EU27+UK	China	Germany	Italy	USA	Japan
2016	34,948	40.8	32.3	21.3	7.7	7.0	4.7
2017	36,312	42.0	30.6	21.3	8.1	7.1	4.7
2018	36,795	42.3	31.1	21.5	7.8	7.1	3.9
2019	35,971	43.9	31.1	21.7	7.8	6.6	4.6
2020	34,193	40.9	34.4	20.4	7.0	7.0	4.1
2021	38,597	40.0	35.0	19.6	7.1	6.7	4.1

Source: VDMA / Federal Statistical Office

**Estimate*

China exported more plastics and rubber machinery than any other country in the world for the first time last year, according to preliminary figures released by Euromap, the umbrella organisation of major European plastics machinery manufacturers.

During 2021, global production of plastics and rubber machinery is estimated to have grown by 13% to a record €38.6bn. Exports totalled €23.7bn, near matching the industry's previous record result of 2017. China's share of plastics machinery exports increased its by 28.2% to €5.7bn, leaving long-time export leader Germany in second place with €5.2bn (up by 9.4%).

"In the medium term, companies in Europe will have to prepare themselves for a significantly higher price level, as raw materials and energy in particular, have become much more expensive," said Euromap President Luciano Anceschi.

Germany's VDMA plastics and machinery association said member order books remain reasonably well filled but, due to supply chain issues resulting from Covid lockdowns, and now the war in Ukraine, it is becoming increasingly difficult to convert orders into turnover.

"In the first four months of the current year, new orders fell 17% short of those of the same period last year," said Thorsten Kühmann, Managing Director of the association. "Availability of supplier parts is the predominant issue."

› **www.euromap.org**
› **www.vdma.org**

Uponor debuts 'renewable' PEX pipe

Below: Uponor's PEX Pipe Blue uses Borenewables PE from Borealis

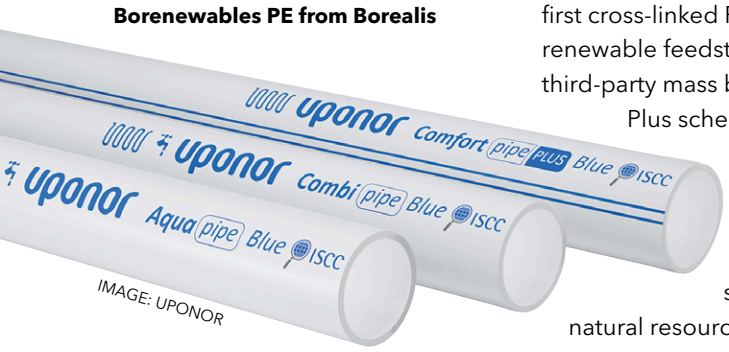

IMAGE: UPONOR

Uponor claims its PEX Pipe Blue is the first cross-linked PE pipe to be based on renewable feedstock accredited by third-party mass balance under the ISCC Plus scheme.

The pipe is made from Borealis Borenewables PE from feedstocks including second-generation natural resources such as waste from pulp production or residues from food processing (mass balance).

Borealis claims its Borenewables can deliver a 90% reduction in carbon footprint reduction when compared to conventional fossil-based PE-X pipes (based on Environmental Product Declaration (EPD) calculations according to EN15804+A1 and CML/ISO21930).

› **www.uponor.com**
› **www.borealisgroup.com**

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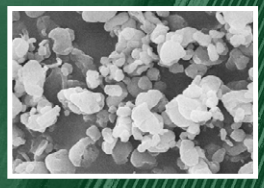
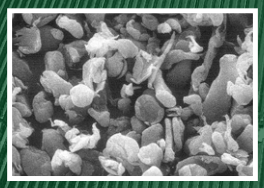


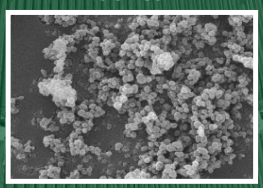
Recycled Sintered PTFE

MicroFLON® S-203-RC, S-205-RC



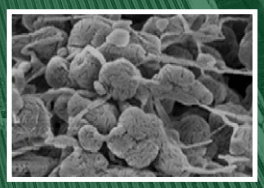
Suspension Grade Natural Prime PTFE

NanoFLON® Series



Emulsion Grade Natural Prime PTFE

MicroFLON® NanoFLON® for food contact



Natural Prime PTFE for Food Contact 21 CFR 177.1550

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Repsol/Borealis invest in cable compounds

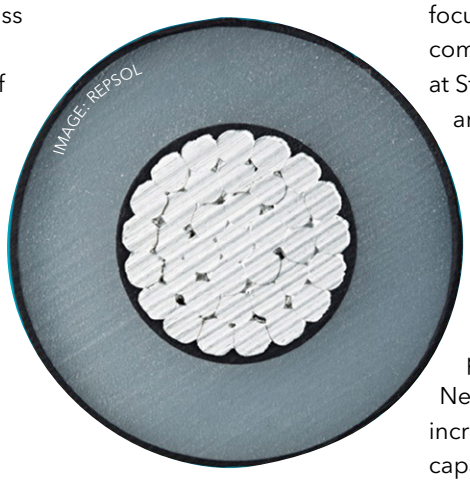
Spanish petrochemicals group Repsol and Austria's Borealis have separately announced major investments in the European cable compound marketplace.

Repsol is to invest more than €35m to build an off-line plant to make cross linkable PE (XLPE) compounds for production of high and extra high voltage DC cables at its plant at Tarragona in Spain. It will have a capacity of 27,000 tonnes/yr and will begin production in 2024.

The new plant will use Linear Short Hyperclean (LSHC) technology from Swiss machinery maker Buss and will be the first commercial installation for the technology, which was developed in cooperation with P&M Cable Consulting (also based in Switzerland).

LSHC technology combines direct peroxide injection and compounding of a newly-developed additive package using a Compeo co-kneader extruder. It is claimed to offer the same quality and process efficiency as conventional soaking technologies but eliminates the need for a soaking tower, which reduces space requirements and capital cost.

The LSHC production



Above: Repsol will use the new LSHC XLPE technology from Buss

technology is said to meet the levels of cleanliness and electrical performance required for AC and DC high voltage (HV) and extra high voltage (EHV cables).

Buss will have a pilot plant for production of HV and EHV materials using the LSHC available for trials around the end of this year at its site at Pratteln in Switzerland.

Meanwhile, Borealis is investing around €200m to upgrade and expand its XLPE and semicon assets in Europe. The Investments are focused on its XLPE compounds production unit at Stenungsund in Sweden and its semicon compounds facility at Antwerp in Belgium.

The company is also evaluating a capacity expansion at the Borealis Compounds. production facility in New Jersey. It plans to increase XLPE production capacity at the site by 10,000 tonnes/yr to 42, 000 tonnes/yr by 2024 to meet "steadily growing demand" for medium voltage power cables in the Americas.

The investments come two years after Borealis acquired South Korea-based DYM Solutions, expanding its Asian cable footprint.

› **www.repsol.com**
› **www.busscorp.com**
› **www.borealisgroup.com**

IN BRIEF...

Benvic announced two new additions to its recently launched Linkflex line of LSZH cables at the Wire exhibition in Germany last month. Linkflex HFS606 and HFS607 are intended for CPR-compliant sheathing of optical fibre and data comm cables.
www.benvic.com

Perstorp has introduced 2-EH Pro 25, which it claims is the first renewable (mass balance) 2-ethylhexanol (2-EH). 2-EH is widely used in the production of plasticisers for flexible PVC and other applications and will form part of the Swedish company's ISCC Plus-certified portfolio of Pro-Environment Oxo products.
www.perstorp.com

VampTech is to distribute **Trinseo**'s TPEs in Italy, Spain, Portugal and North Africa. The deal covers Raplan TPS-SBS and Mego TPS-SEBS styrenic block copolymers, Apigo TPO and OBC olefinic TPEs, Apilon 52 TPUs and API L copolyester TPEs.
www.vamptech.com
www.trinseo.com

KraussMaffei realigns machinery division

Plastics machinery maker KraussMaffei has announced a realignment of its New Machines (NM) Division, which includes its injection moulding, extrusion and compounding, and polyurethane units.

Xiaojun Cui, CEO of KraussMaffei China, takes over global management of the NM Division Business (including sales, R&D, project management), also retaining his current responsibility for KraussMaffei China.

Lars Hoppe will be responsible for Operations (manufacturing, quality and procurement) on a global scale. Both report to CEO Dr Michael Ruf.

"The changes…are aimed at making the entire KraussMaffei organisation faster and more efficient worldwide, for example with regard to delivery times and cost structure," said Ruf.

"We want to use and utilise all of our locations in the best possible way for our business in order to be able to optimally serve our customers all over the globe," he said.

› **www.kraussmaffei.com**

IMAGE: AMI

Above: The Compounding World Expo returns to Cleveland for its third North American edition in November

Free registration opens for US plastics expos

Free online registration is now open for the North American AMI Plastics World Expos, which are being held at the Huntington Convention Center in Cleveland, Ohio, US, on 9-10 November 2022.

Taking place for the third time, the Plastics World Expos (which are organized by *Compounding World* publisher AMI) will be 2022's biggest plastics industry event in North America, bringing together the Compounding World Expo, Plastics Extrusion World Expo, Plastics Recycling World Expo, and Polymer Testing World Expo.

By registering in advance, visitors will receive free admission to all four exhibitions, featuring more than 250 suppliers, plus free entry to the five conference theatres hosting technical presentations, educational seminars and business debates.

"The event will provide visitors with a great opportunity to meet and compare suppliers from around the world, as well as giving them the chance to learn from business leaders and technical experts in the conference theatres," said Andy Beevers, Events Director at AMI.

The four expos will occupy the largest halls at the state-of-the-art Huntington Convention Center in downtown Cleveland. The exhibitor line-up includes companies such as Amfine, BASF, Brabender, Buss, BYK, Chroma Color, Clariant, Coperion, CPM Extrusion, Dover Chemical, Entek, Geon, KraussMaffei, Leistritz, Maag, Milliken, Mixaco, Omya, Orion, Orlen Unipetrol, SI Group, Steer, Struktol, TPEI, Troy, Wacker and more.

To book your free ticket for the expos and conferences, valid for both days of the event, visit:
www.ami.ltd/Plastics-World-Expos-NA-Register

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Flexible options for feeding

*The latest feeding and dosing equipment designs aim to optimise feeding of a range of materials. **Jennifer Markarian** reports*

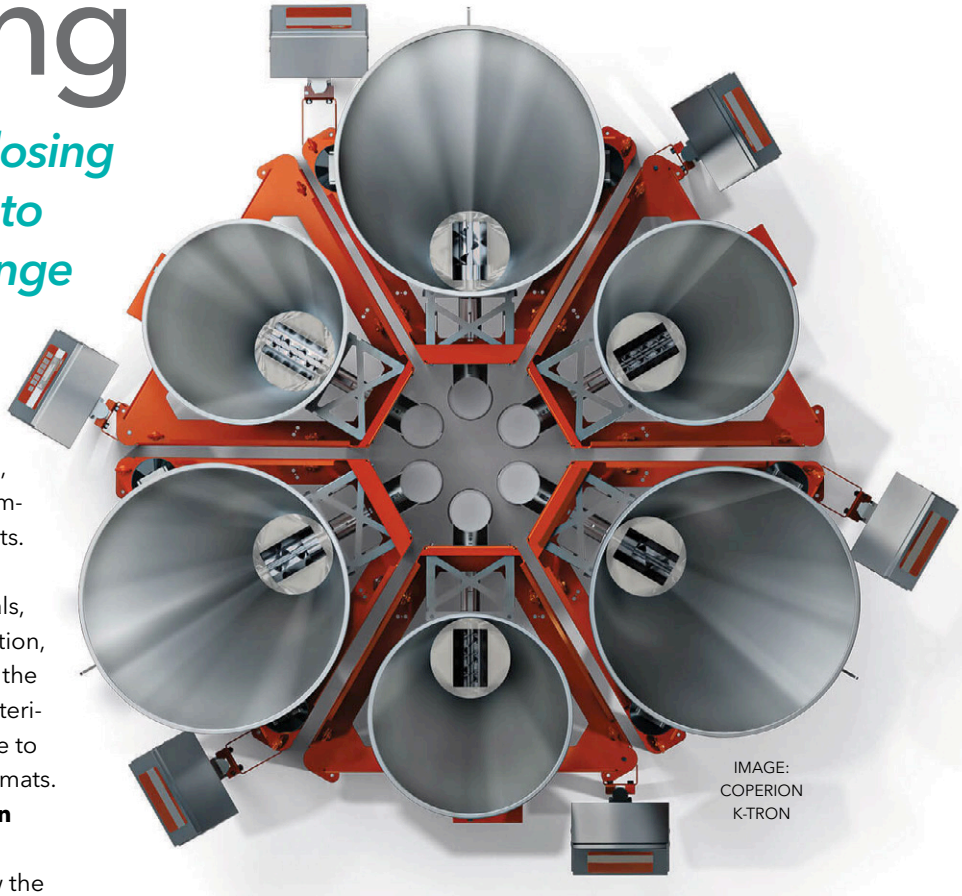

IMAGE: COPERION K-TRON

Main image: Feeder systems such as Coperion K-Tron's ProRate Plus allow processors to more accurately control recipes

Accurate dosing of ingredients—liquids, pellets, fibres, powders, and other solid forms—into compounding equipment is crucial for quality results. Poorly flowing ingredients, such as cohesive powders or fluffy (low bulk density) dry materials, can be particularly challenging to feed. In addition, current supply-chain challenges, together with the drive to use more sustainable and recycled materials, mean compounders are needing to be able to successfully feed a wider variety of material formats.

At the **Kansas State Bulk Solids Innovation Center** in the US, researchers emphasise that reliable delivery of ingredients starts from how the material is received, stored, conveyed, and dosed to the process. "We have been doing work to optimise each of those aspects, because they have to work together, in concert, to ensure reliability of the feeding and dosing equipment," says Todd W Smith, Manager of the centre.

"We have been evaluating how material properties affect selection of best equipment and methods. Since each ingredient has different properties, and the layout and use rates are different as well, no one method works for all ingredients. Delivery, storage, conveying, and feeding have to be fine-tuned for each ingredient. And in many cases, the equipment and methods used for one ingredient is quite different than those used for another ingredient," he explains.

Having a feeder that can handle poorly flowing materials is critical in many situations, as is versatility. Due to the ongoing supply chain challenges of recent times, compound producers are at times having to use materials or grades that are different from their usual choices and so may need to quickly change their feeder setup for that purpose, says Fabian Siffert, Global Market Insight and Sales Process Manager at **Coperion K-Tron** in Switzerland. "A compounding line may be set up for a micro-granule titanium dioxide, but if this is no longer available they may have to switch to a titanium dioxide with poorer flowability," he cites as an example.

Natural fibres are particularly challenging to feed. "Natural compounds are sensitive to fluctuations within the ingredient mix and the breakage of the bulk materials. The feeding equipment must ensure a high accuracy and reduce the breakage of fibres to a minimum. Highly accurate vibratory feeders have been shown to be very successful in such applications," says Siffert.

The use of natural powders, such as starches or plant proteins used in bioplastics, is also challenging. "These materials are often dry and dusty but still somehow moderate flowing. But when they are under mechanical pressure, they become very sticky and poorly flowing. To address this problem, it is very important to set-up the whole process correctly, from storage until the bulk material gets fed into the extruder," Siffert advises.

An energy-saving feature, which some are beginning to use for bulk materials coming directly

IMAGE: MAGUIRE

Right: Maguire blenders are available in eight sizes and can be configured to handle up to 12 materials

from a dryer or other processing step, is to maintain the temperature of the material rather than allowing it to cool down before feeding. "This requires the ability to feed warm to hot ingredients," Siffert says. "The feeder design must include heat-resistant materials while ensuring critical parts are insulated and appropriate seals are used."

Recycled materials, such as shredded films, present feeding difficulties due to their low bulk density. Siffert says feeders for these materials must be able to handle high volumes with accuracy. "It has been shown that bottom-agitated silos with screw feeders underneath, in combination with a gravimetric weigh belt feeder, are the best solution to bring the shredded film sheets into the extrusion process," he says.

Recycling solutions

Compounders and processors are increasingly installing additional feeders for recycled material used for recipes that combine recycled and virgin resin. "Testing is critical prior to purchasing new equipment, since the recycled material isn't always as consistent as virgin material. The feeder selected needs to be able to handle the variability," says Rene Medina, Executive Vice-President for **Gericke** in the US. Medina says Gericke's GAC 232 family of feeders is especially useful for handling difficult-to-feed materials as it uses a proprietary gearbox design that supports two different speeds from one electric motor.

"Plastics processors are looking for economical solutions to incorporate additional materials, more diverse materials, and changing material content in their final product," according to Frank Kavanagh, Vice President of Sales and Marketing at **Maguire**. He says the company's Maguire Weigh Scale Blender provides that capability, offering the ability to handle up to 12 different components. The units are offered in eight sizes.

"Each blender is configured with the appropriate size hopper and dispense device for the given material (pellet, granular, flake, powder or liquid). Without the proper dispense device, a blender cannot achieve a repeatable, accurate dispense," says Kavanagh. He says the control – in Maguire's case a touch-screen unit capable of controlling third-party loading systems – is also a key piece of the system. "The software allows [dispensing] of minute quantities of additives, while maintaining an accuracy of 0.1% of set point," he claims.

Below: Entek's Vacuum Feed Technology works with fluffy fillers to achieve higher output compared to conventional atmospheric venting

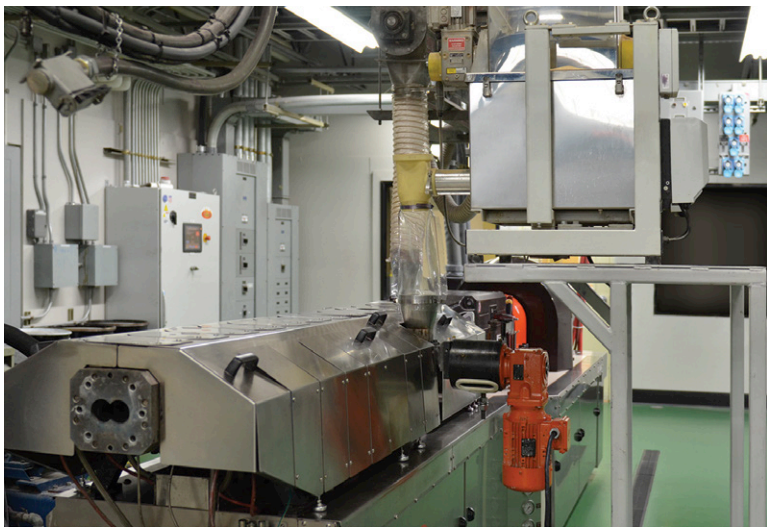

IMAGE: ENTEK

Venting limitations

Feeding "fluffy" (low bulk density) fillers is a common challenge for compounders. "These fillers tend to draw large amounts of air into the extruder, causing a volumetric limitation which restricts output rates," says Dean Elliott, **Entek**'s Technical Processing Manager. Another problem is that the fluffy powders can potentially be discharged through the atmospheric vents traditionally used to vent out the air. Entek's VFT (Vacuum Feed Technology) offers a solution to both.

"VFT ultimately densifies the material prior to entering into the extruder, making the material easier to feed," Elliott says. The company claims that processors experiencing volumetric limitations due to fluffy fillers can achieve much higher throughput, as much as doubling output rate, by using VFT. Entek's VFT technology is available on all of the US-based company's twin-screw extruders. Trials can be conducted to configure the extruder for the customers' materials and to demonstrate the throughput rate improvements that can be obtained compared to traditional extruder atmospheric venting.

Although some formulations need special designs to optimise feeding, other formulations can benefit from streamlined, simple equipment. **Coperion K-Tron**'s new ProRate Plus Feeder Line is an economical solution for simple applications in

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IMAGE: COPERION K-TRON

Coperion K-Tron's ProRate PLUS single-screw feeders are designed to handle free-flowing ingredients

the plastics industry, says says Fabian Siffert, Global Market Insight and Sales Process Manager. "We programmed our controller to be able to control up to eight feeders with one central processing unit, and we adjusted the mechanical design to reduce the number of loadcells," he says.

The ProRate Plus feeders use P-SFT [Smart Force Transducer] load cells that provide a direct digital weighing signal and have high tolerance to vibration and electrical noise. Meanwhile, the design has a high level of standardisation – many parts for all three feeder sizes are the same so fewer spare parts need to be kept on hand.

Siffert says that the new design also resulted in a smaller footprint, with stands that allow clusters of up to six feeders around one extruder inlet. The new ProClean Rail design ensures accessibility to the screw and the base unit so the feeder can be maintained and cleaned without moving it out of the cluster position.

ProRate Plus single-screw feeders are designed for free-flowing ingredients and can handle a small number of moderate flowing ingredients. For moderate to poorly flowing bulk materials, the standard Coperion K-Tron feeder is an optimal choice, says Siffert.

Data collection

Siffert says there is an increasing need for collecting real-time data from feeders in companies that are tracking and analysing all their production data. For this reason, Coperion K-Tron's configurable data interface allows feeder parameters to be shared over all common industrial protocols.

New user interfaces take advantage of automation and artificial intelligence, he says. "When an error occurs, the interface guides the operator

through the failure-searching process and provides direction to solve the problem," Siffert explains. Common problems in daily operation can be more quickly solved by the operator, while maintenance engineers can focus on more complex problems.

User-friendly interfaces with intuitive operation make training faster, adds Rene Medina, Executive Vice-President for **Gericke**. Another benefit is supporting remote operation so that equipment can be controlled from one location, even outside the facility. Gericke's new Universal Controller for feeding (GUC-F), for example, allows automated control over four different feeders at the same time from a single screen. "New controllers with more processing power and expanded monitoring capabilities provide even more actionable data," Medina says.

Material control

In some applications, such as compounds for medical devices or high-voltage cables, the purity of the incoming or produced materials is especially important, according to Oliver Kraushaar, Sales and Project Manager at **OCS Optical Control Systems** in Germany. "More online devices are being used for quality control," he says. ›

MAC Automation puts a cap on pellet losses

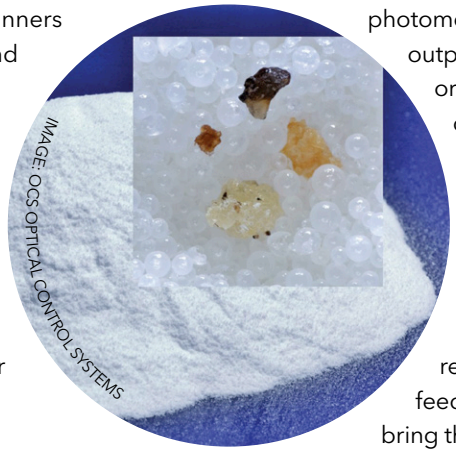
MAC Automation Concepts has introduced a new line of gaylord covers, which are designed to fit standard US sizes and provide access ports for vacuum wands and a vinyl window for visual level checks. The covers can be easily installed by one person and help to keep contaminants out and to avoid pellet loss. Two telescoping rods mounted across the width of the cover help prevent sagging.
› **www.macautomation.com**

Right: MAC Automation Concepts' Gaylord cover helps prevent contamination and pellet loss

IMAGE: MAC AUTOMATION

Right: Examples of some of the defects that can be avoided using OCS powder inspection equipment

The company offers pellet scanners for throughputs up to 25 kg/h and 1,000 kg/h, as well as powder scanners. An in-line bypass sample is transported to the OCS measuring device, which analyses the sample using a colour matrix camera. Data from the analysis can be connected to data processing systems or stored as needed. For both pellets and powders, the testers can be set up to sort out material that is out of specification.



US-headquartered Ampacet created its **CISystems** business unit to apply Industry 4.0 technology from LIAD Weighing and Control Systems, an Israeli company that it acquired back in 2020. CISystems recently introduced the SpectroMetric in-line colour measurement and correction technology, which is intended to analyse real-time colour data and automatically adjust the extrusion process to maintain colour specification.

The system uses a spectrophotometer to continuously measure the output (either pellets or an extruded or moulded plastic part) and compares the L.a.b value to the set colour specification, explains Doug Brownfield, Commercial Director at CISystems. "If the colour deviates at a desired delta E range, then it communicates in real-time to the SpectroMetric feeder to adjust the feed rate to bring the colour back into specification. This is Industry 4.0 technology for in-line colour measurement and correction. It reduces scrap and improves overall quality," he says.

Brownfield explains that corrections are made gradually, so as to not overcompensate, and adjustments are continually made to keep the colour in specification. An example of where the system could be applied is in compounding of recycled PET. "R-PET processors who have challenges in controlling the yellow undertone of their recycled resins can now monitor their production quality in real-time by continuously measuring their 'b' value within their L.a.b colour specification," he says.

Below: Gericke's Universal Controller allows automated control over four different feeders at the same time

IMAGE: GERICKE

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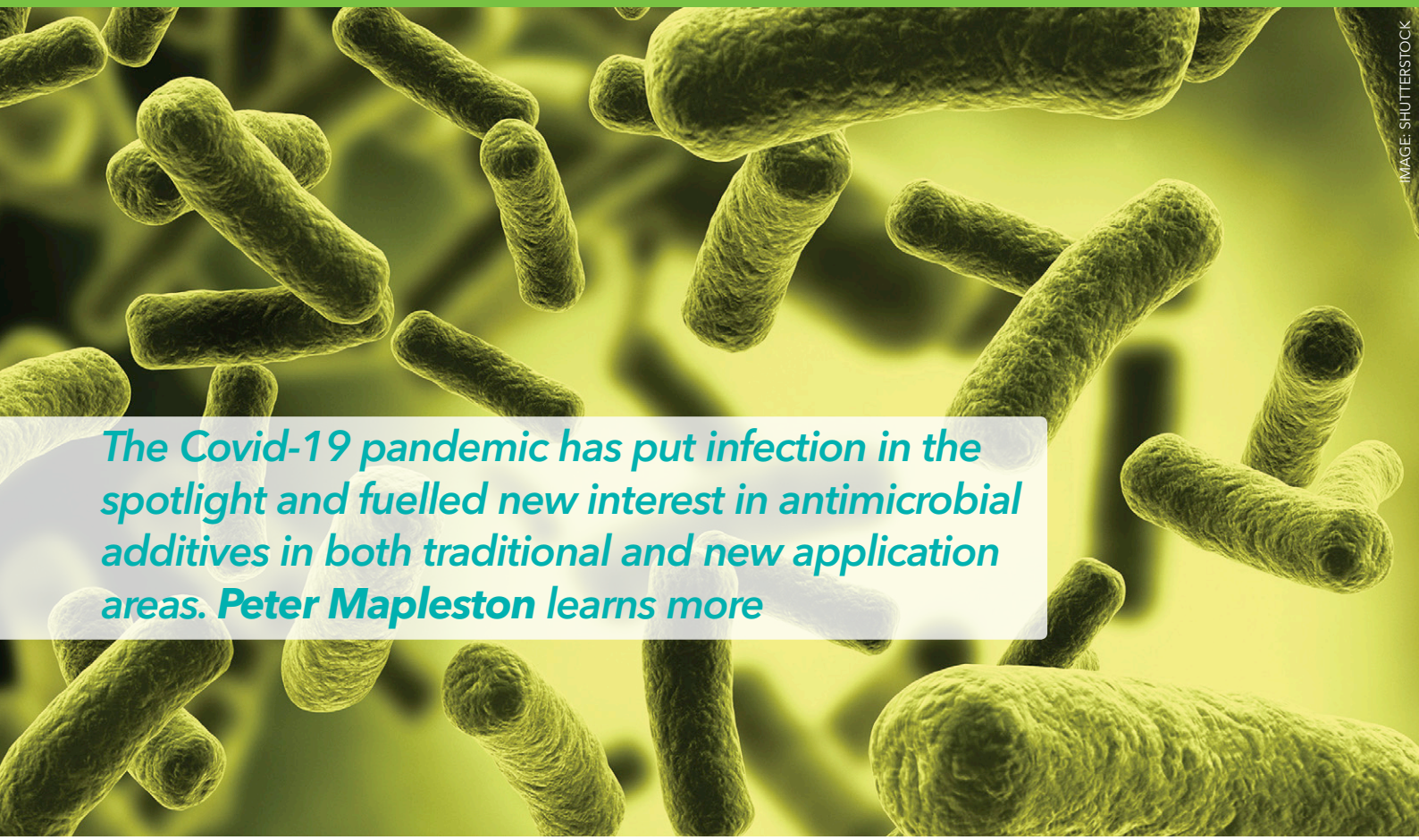


IMAGE: SHUTTERSTOCK

The Covid-19 pandemic has put infection in the spotlight and fuelled new interest in antimicrobial additives in both traditional and new application areas. ***Peter Mapleston*** *learns more*

Antimicrobial interest spikes post Covid

Since the onset of the Covid-19 pandemic in early 2020, interest in antimicrobial solutions for incorporation into plastics used in multiple applications has increased hugely. Numerous suppliers report strong demand across multiple markets, with the greatest interest coming from the healthcare, packaging, clothing and transportation sectors. Particularly high levels of interest include protective films and frequently touched surfaces.

Biocides incorporated into plastics provide protection against microbial attack of the final article, extending its lifetime. Where optimum conditions for growth exist, then fungi, algae and bacteria may colonise and degrade the plastic within the bulk, or on the surface, of the plastic article. Microbial growth can result in surface staining, pitting, reduction of structural strength, embrittlement, change in conductivity or flexibility, bad odour, and other physical or mechanical property changes.

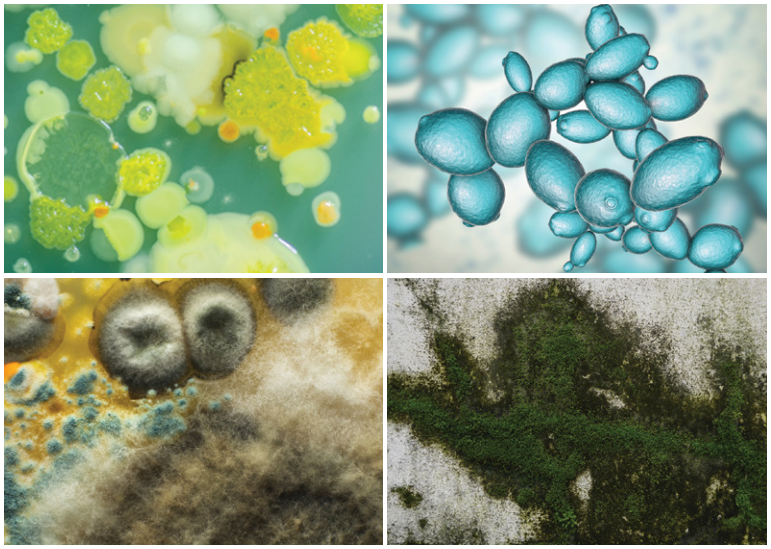
Developers and producers of antimicrobial solutions have upped their efforts to develop new offerings, many of them based on natural products. Swiss company **Sanitized** claims to be a leader in natural odour-management, antimicrobial hygiene function and material protection for plastics and textiles. "During the pandemic we have seen a growing demand for clean surfaces and hygiene in public as well as in private spaces," says Polymer Additives Product Manager Christine Niklas. "The first lockdown increased the demand for applications in the private sphere. For example, cleanliness in the kitchen became more important, and it remains so. However, public areas have not moved out of focus either. We observed this trend worldwide, and it is certain to continue even after the pandemic."

Niklas says demand for products with broad protection is increasing. "We have recently completed the Sanitized Broadtec product family and can offer now all delivery forms for all application processes and all needs. The products are suitable for various manufacturing processes like calendering, extrusion, injection moulding, and coating."

US-headquartered **Microban International** says it will launch several novel antimicrobial products

Main image: Integration of antimicrobial – and antiviral – properties into plastics has intensifed over the past two years of the pandemic

IMAGE: SANITIZED



Above: Sanitized's Broadtec antimicrobial product family is claimed to be effective against top left: bacteria; top right: yeasts, bottom left: mould; and bottom right: algae

later this year. The introductions include a new antibacterial chemistry that the company says can be seamlessly integrated into low temperature polymers during production for long-lasting efficacy, without affecting the texture, optical clarity, colour or durability of the final parts.

"The active ingredient in this next generation technology is naturally occurring, sustainable, non-toxic, and free from heavy metals," says Microban. "The additive also has high chemical, thermal and UV stability, and is already approved for food contact applications in the EU. This will be complemented by another new technology that has already been proven to be an effective antibacterial and antifungal, and can be easily incorporated into PVC, PP, TPU and EVA products at the point of manufacture. Suitable for both indoor and outdoor use, it has potential applications in areas such as the automotive and roofing markets."

Silver alternatives

UK-based **Wells Plastics** has been producing antimicrobial solutions under the Bactiglas brand for more than 20 years. Mike Wright, Business Development Manager for the brand, says the company recently began to explore new and innovative antimicrobial additives that could step away from the traditional silver-based additives, yet remain within regulatory (the EU Biocidal Products Regulation – BPR) compliance. These can be both organic and inorganic additives to suit a given application.

"These are not just additives that can be compounded into masterbatch, but may be applied post manufacturing in applications such as fabrics, textiles, powder and wet paints as well as new coatings for sustainable cardboard-based packaging systems," he says.

New applications are beginning to emerge across markets such as the construction sector. Wells says that incorporation of a Bactiglas additive into building materials such as cladding, pipes and flooring systems can reduce costs involved in maintenance. "Using antimicrobial materials in construction can result in more sustainable projects with a significant reduction on the environmental impact of construction," the company says.

Antimicrobial technology from French company **Pylote** has been marketed since June 2020 in Coversafe antimicrobial adhesive films produced by Pylote's partner Gergonne Industrie for application to tables and counters, windows, door handles, switches, handrails, payment terminals and the like. Since September 2020 it has also been marketed in a range of special adhesive films produced by another partner, Adhetec, for protection of airline seat shelves and screens. It has also been used since February 2021 in high protection UNS1 fabric masks by Biotex Technologie.

In March this year, Pylote and packaging major Berry Global announced a strategic commercial partnership covering antimicrobial packaging solutions. The first joint offering is Activated Rispharm, a multidose ophthalmic dropper combining high barrier with antimicrobial protection said to be effective against Adenovirus type 3 Virus (conjunctivitis), Escherichia Coli and Staphylococcus aureus bacteria.

Pylote's communications specialist Jean-Christophe Huertas says the company's technology involves the integration of mineral ceramic microspheres into materials such as plastics, paints or varnishes. "After application, the coated surfaces are activated to destroy micro-organisms. The microspheres act as a catalyst causing microbial decontamination of the surfaces and an immediate, continuous and stable protection against microbial contamination with a very high level of safety, efficiency and hygiene." ›

IMAGE: PYLOTE/BERRY GLOBAL

Right: Berry Global has partnered with Pylote to develop antimicrobial packaging such as this opthalmic dropper

IMAGE: HEIQ

Left: HeiQ's new HyProTEcht silver-based antimicrobial masterbatch is already commercialised in sanitary applications

Extending options

Switzerland's **HeiQ**, an established player in odour control and other functional technologies for textiles, has been investing significantly in novel built-in antimicrobial technologies for plastics and coatings. Last year it acquired Hong Kong-based **Life Material Technologies** and Germany's **RAS**. The former markets a botanical-based active technology called Life Natural and a broad portfolio of metallic and synthetic organic actives widely used by leading consumer and industrial plastics as well as coatings, paper, fibre extrusion and building materials. RAS offers BPR-listed metallic silver technology used in antimicrobial, conductive and antiviral coating compounds.

Lisa Owen, Sales Director at HeiQ Life in Charlotte, NC, US, says the company has been developing and launching a number of new technologies with commercial partners around the world. HeiQ HyProTecht, for example, is a new line of EPA and BPR-compliant silver-based antimicrobial masterbatches said to offer "near-perfect" transparency in polymers such as PC, PET, GPPS and PP.

In addition – responding to strong demand for botanical and bio-based solutions for consumer applications – it is launching a broad range of EPA and BPR-compliant masterbatches using natural plant extracts as active substances. The HeiQ Life Natural masterbatches are suitable for use in lower processing temperature polymers such as TPEs, TPU, EVA, PVC, PE and PP and can be used in both pigmented and transparent compounds. HeiQ Life Natural masterbatches comply with food contact regulations in China, the US, and the EU.

Andrea Morandini and Lodovico Agostinis, chemical technology researchers at Spanish research centre **Aimplas**, see carbon-based

nanomaterials playing a part in the development of "circular" bio-based antimicrobial products. "Considerable interest has…been shown in different application sectors in the shift away from common additives such as metal ions and oxides of silver, copper and titanium, which are under scrutiny due to their possible toxicity and disposal issues," they say.

Antibacterial CNTs

The Aimplas researchers say carbon-based nanomaterials have recently been found to display strong bactericidal properties. "Their antibacterial mechanism is complex and depends on factors such as composition and surface concentration, but they appear to be able to act on cell membranes and destroy them and/or cause oxidative stress, as in the case of silver-based nanomaterials. Because these materials can act on contact without releasing substances, they are suitable for medical applications such as prostheses and implants in constant contact with the body," they say.

Natural antibacterial agents derived from extracts from animals, plants and microorganisms are generally considered safe and environmentally friendly. However, natural antimicrobial peptides such as nisin, natamycin, leucocin, enterocin and pediocin – which are already used to prevent food spoilage – are sensitive to high temperatures, making them difficult to use in thermoplastic compounds. "However, they can be encapsulated in porous inorganic or heterostructure (inorganic/

Biocides and the EU Green Deal

The European Union's Green Deal initiative aims to see the development of manufactured products that are more durable, have longer lifetimes, and avoid waste. The Microbial Control Executive Council (MCEC), an initiative of leading companies developing and supplying microbial control technology and solutions, believes its members' products support these policy objectives.

In a recent presentation, the MCEC said the overarching aim of EU chemicals legislation is to better protect people and planet and boost innovation towards the production and use of safe and sustainable chemicals. It said that the focus of innovation in microbial control technologies is on solutions where only the unwanted microorganisms are targeted, and humans and environment remain unharmed. However, whereas regulation aims to boost innovation in general, the MCEC said for biocides lengthy and repetitive approval and reapproval procedures can form a hurdle for for R&D investment

MCEC said its members are calling for a supportive EU policy framework that promotes coherence across the different instruments of chemicals management. Clarity on which legislation prevails over another for the active and non-active substances

IMAGE: SHUTTERSTOCK

Above: European antimicrobial producers see regulatory inconsistencies in the EU's Green Deal strategy

that a biocidal product is composed of, is essential, according to MCEC Chairman José Mosquera.

In the EU, biocides and biocidal applications are mainly regulated by the Biocidal Products Regulation (BPR). Under the Chemicals Strategy for Sustainability (CSS), published in October 2020, new legislation and criteria are on the horizon. The MCEC says the BPR is not mentioned, but this may not mean the CSS will not have an impact on biocides. Major changes will be introduced in the overarching chemical regulations that apply to all chemicals, including to components of biocidal products, through REACH and the Classification, Labelling and Packaging regulation, CLP.

The proposed changes raise questions, according to Mosquera. These include the introduction of new hazard categories for Endocrine Disruptors (EDs), Persistent Bioaccumulative and Toxic (PBT) chemicals, and Persistent Mobile and Toxic (PMT) chemicals under CLP. Active and non-active substances alike fall under the CLP and more hazard classes will apply to them. it is unclear whether the categorisation, proposed by EU policymakers, to manage EDs will differ from that of the BPR.

The MCEC also highlighted additional data requirements under REACH to better identify the possible properties of substances. Increased data requirements could impact the availability of co-formulants, it said.

In its definition of Safe and Sustainable-by-Design (SSbD) and essential use, the EC has a vision that chemicals "are produced/used in a way that maximises their benefits to society while avoiding harm to planet and people". This approach is intended to foster the development of chemicals that are safe and deliver environmental, societal, and/or economical value through their applications but Mosquera asks what will be considered "safe". He says this is a key question for biocides, which have a certain degree of controlled toxicity as an intrinsic property. Similarly, Mosquera asks how "essential use" will be defined.

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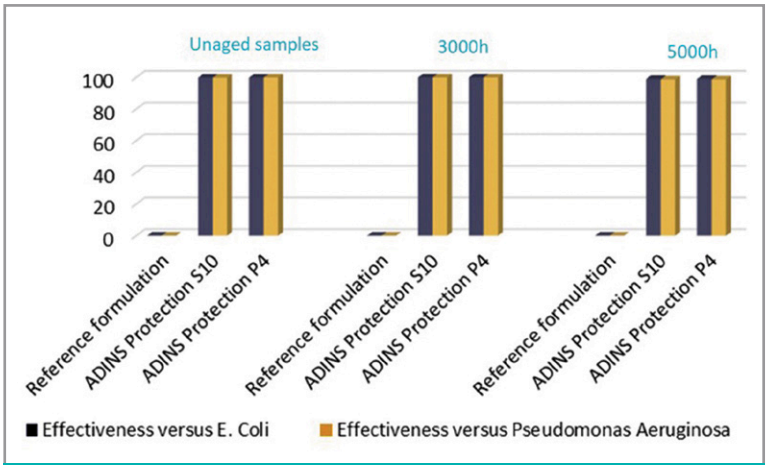

Figure 1: Comparison of microbial effectiveness of Tolsa's Adins Protection S10 antimicrobial in PVC after accelerated weathering (measured by % eliminated)
Source: Tolsa

organic hybrid) matrices to make them more resistant to high-temperature processes," say Morandini and Agostinis.

"Chitosan is one of the most intensively researched and used biopolymers for food coating and packaging and has excellent antimicrobial properties. It is the most abundant polysaccharide in the world and is also biodegradable and biocompatible. Chitosan is becoming increasingly important as an antimicrobial additive in plastic applications and its derivatives are widely used as natural alternatives to antibacterial and antioxidant agents, especially in food contact applications," they say.

"[Antimicrobial resistance] is and will be a very important issue for hospitals and the healthcare sector. Developing new antimicrobial materials that do not allow bacteria and other microbes to generate resistance is a key area for future development in the medical sector," the researchers predict.

Mineral biocides

Spanish mineral additives company **Tolsa** offers three different biocide products for thermoplastic applications under the Adins Protection name, two based on silver and one based on zinc. The company's Adins technology enables the incorporation of different active substances on natural magnesium silicate. This allows optimal distribution of the active substance in the matrix in which it is incorporated, which Tolsa claims results in high antimicrobial activity. It also improves the thermal and chemical stability of the active substance, helping to minimise the amount necessary for any given level of protection. Target applications include automation, plastics toys, swimming pools, external furniture, and architectural and hospital products.

Tolsa recently carried out a study (in collaboration with Spanish masterbatch specialist Delta Tecnic) of antimicrobial activity in PVC formulations for swimming pools incorporating Adins Protection products. "Once it was verified that the resulting PVC was biocidal against two of the most common bacteria in swimming pools (E.Coli and P.Aureuginosa), it was decided to carry out an aging treatment in a Suntest XXL+, which simulates half (3,000h) and all (5,000h) of the material lifetime," says Dr Marta Sacristán, Project Leader Biocides. "After this aging treatment, the antimicrobial activity versus the same bacteria remained practically unchanged." See Figure 1.

Adins Protection is also said to be active against all enveloped viruses, including Coronavirus types,

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Antimicrobials – an M&A hotspot

The antimicrobials market has seen considerable merger and acquisition (M&A) activity in recent months. In January, for example, Sweden's Polygiene bought business related to the SteriTouch material portfolio from UK company Radical Materials. The acquisition was made through its subsidiary Addmaster, a UK-based business it acquired a year earlier.

"There are great synergy opportunities for Polygiene to increase its market share in antimicrobial products for plastics, coatings and paints," says company CEO Ulrika Björk. "Polygiene will buy the customers and incorporate them into Addmaster's production set-up."

Late last year, Arxada (formerly Lonza Specialty Ingredients) completed its acquisition and merger with Troy Corporation. Both were leading players in antimicrobial technology and Helena Kim, Global Business Unit Manager – Plastics with Troy, says have now combined into a single powerful force in performance additives.

"This combination represents a number of advantages for customers, as we leverage the platforms, resources, technical expertise, services, and portfolios of the two companies," she says. "We are offering customers our combined product portfolios, including the established Micropel, Plastiguard, and Vanquish lines of antimicrobials, and Acrawax and Glycolube lines of plastic additives, comprising one of the broadest ranges of active chemistries and formulated products in the plastics and textiles markets. Customers will benefit from a wide selection of advanced chemistries for optimum performance, formulating flexibility, and regulatory compliance, as well as the company's enhanced R&D capabilities."

Switzerland's HeiQ invested significantly during 2021 in novel built-in antimicrobial technologies for plastics and coatings through the acquisition of Hong Kong-based Life Material Technologies and Germany's RAS. Life markets the Life Natural botanical-based active technology together with a broad portfolio of metallic and synthetic organic antimicrobials ; RAS offers a BPR-listed metallic silver technology.

Last year, also saw Microban International bring together its Microban and Ultra-Fresh brands and technologies. The move follows the 2016 acquisition of Thomson Research Associates and completes the integration of the two organisations.

Below: BioCote has permanently ended supply of zinc pyrithione antimicrobial masterbatches globally following its Reprotoxic Category 1b classification in the EU

Norovirus, Rotavirus and Adenovirus, according to European Standard 14476:2013+A2:2019. The products also comply with the European Directive on toy safety (2009/48/EC). "We have some customers who are in the final process of homologating the final formulation with ADINS Protection for toys," says Sacristán.

Market regulation

Antimicrobial additives are tightly regulated and use is controlled in key global markets, explains UK-based **BioCote**. In Europe, the placing on the market and use of biocidal products is regulated by BPR 528/2012 (the Biocidal Products Regulation); in the US, antimicrobial additives are regulated by the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) under the governance of the Environmental Protection Agency (EPA).

IMAGE: BIOCOTE

BioCote notes that under FIFRA, there are two categories for antimicrobial products – pesticides and treated articles. Companies manufacturing products that incorporate antimicrobial technology can either register their product as a pesticide or market their product as a treated article. Pesticides need to be registered in a specific category that indicates how they are meant to be used. A treated article is a product that contains a pesticide for the purpose of protecting the product itself and is exempt from the requirement to register as long as certain requirements detailed under FIFRA are met. The company says that registering a product containing antimicrobial additives as a pesticidal product can be a costly and lengthy process.

BioCote says it puts regulatory compliance top of its agenda, citing a recent decision to cease supply of zinc pyrithione. It says, when the European Commission implemented the Commission Delegated Regulation 2020/1182 in March this year, an "unexpected addition" to the list of prohibited substances was zinc pyrithione (ZnPT), which has been commonly used as an active anti-fungal ingredient for decades. "Formally, ZnPT now has the reclassification of a Reprotoxic

Category 1b," the company says.

The Commission's ruling applies only to the EU market. BioCote says ZnPT is still used throughout the rest of the world and says in the US several companies include ZnPT as the main active ingredient in a wide range of products, including shampoo and wood preservatives. Nevertheless, the company says it has decided to permanently cease supply of ZnPT based additives for use in treated articles across its entire global customer base.

Arxada, previously Lonza Specialty Ingredients, is a significant supplier of zinc pyrithione and remains committed to the product. "ZnPT is one of the most effective and versatile antimicrobial additives used by polyolefins processors. Arxada continues to support ZnPT for use in polymer and textile applications and continues to significantly invest in the chemistry," the company says.

"With the updated classification in Europe, a major project has been initiated by Arxada's regulatory affairs team to secure continued compliance with the Biocidal Products Regulation (BPR, Product Type 9). The objective is to show that conditions for Art. 5.2 approval (under derogation) are met. This approval will ensure that our valued customers can continue to use ZnPT in preservation applications today and in the future," it adds.

PVC protection

Biocides are particularly important in flexible PVC, since the plasticiser component can be especially susceptible to microbial attack. **Valtris Specialty Chemicals** offers a full line of biocidal products for PVC applications under the Intercide and Micro-Chek tradenames. Phil Clegg, Biocides Business Manager Europe & Asia Pacific, says one key trend the company has seen over the past few years in the plastics market in several geographic regions is the move away from arsenic-based biocides, such as oxybisphenoxarsine (OBPA). Neither OBPA, nor PVC articles containing OBPA, are available in the EU since the biocide has not been registered. As a result, isothiazolinone alternatives are dominant, says Clegg (Valtris is a major player in dichlorooctylisothiazolinone, DCOIT, and octylisothiazolinone, OIT).

Approval of Active Substances and Biocidal Products via the European Chemicals Agency (ECHA) is a lengthy process and, in recent years, there have been some delays in registrations, according to Clegg. "For the products Valtris sells into plastics applications, we expected to see active substance registrations completed by now, and to be in the process of applying for Biocidal Product registrations. As it is, there have been general delays at ECHA level due to volume of work, plus the known delays due to the pandemic."

IMAGE: BUSINESS WIRE

Above: Cupron, which has partnered with US compounder Techmer PM, supplies a powder-form oxidised copper that is claimed to impart durable antimicrobial and anti-odour properties

IMAGE: AVIENT/GETTY IMAGES

Above: Avient's antimicrobial GLS TPEs inhibit bacterial growth by 99.9% or more and resist fungal growth

The UK's departure from the EU has also had an impact. "In addition, there have been delays to active substance approvals where the UK was acting as the evaluating member state. These applications have been reassigned to other member states, but work has been slowed by this transition," he says.

Clegg, who is based in the UK, says Brexit also means some uncertainty around UK regulation. "Due to Brexit, we now have duplicate regulations in the UK," he says. "Recent UK activity has focused on reapprovals of already approved actives; no timeline has yet been published for the remaining applications including PT9 (plastics)."

OBPA is used and approved in the US. In June 2021, the EPA published an Interim Decision following completion of the public portion of a registration review. According to Adrian Krygsman, Director Product Registration at Troy Corporation (part of Arxada and a manufacturer of OBPA), the EPA's draft risk assessment and Interim Decision are closed with no red flags on OBPA's toxicology or concerns for its use as an industrial preservative for plastics.

Compound developments

Last year, **Techmer PM**, a leading materials design company, struck a deal to strengthen and expand a long-standing partnership related to **Cupron**'s patented, copper-based antimicrobial technology. Techmer now acts as Cupron's primary technology partner, manufacturer, and sales and marketing representative for a wide range of market applications.

Cupron, a copper-based antimicrobial technology company based in Richmond, VA, US, formulates an active, oxidised copper ingredient in powder form, which Techmer encapsulates during its polymer compounding process. The additive is said to help eliminate bacteria and imparts durable antimicrobial, anti-odour, and skin-enhancing properties to various finished products. It is said to be suitable for use in sectors such as transportation, healthcare, recreational and consumer products, and retail and workplace environments.

"Techmer designs and formulates materials with Cupron's additive to achieve optimum dispersion, colour control and processing stability for the desired end-use for mouldings, fibres or films in a wide range of different polymers," says Techmer PM Product Development Manager Kaan Serpersu.

"Although the natural colour of our copper material is rust red, our colour experts can tailor a custom formula to a customer's specific colour needs," says Steve Loney, Director of Market Development at Techmer PM. "Examples of copper-infused custom colours can be seen in performance apparel, and other fabrics spun on Techmer's in-house fibre lines."

Cupron has been used in extrusion coating over non-woven fabric to create hospital and surgical gowns. However, Loney reports increased interest in anti-microbials in plastic films. "The incorporation of anti-microbials in plastic film applications has expanded beyond the healthcare area with use in building materials to help combat mould and other fungi. Specific applications include vapour barriers in walls and film to protect the crawl space of a house," he says.

"Cupron has proven to be an excellent functional choice for these applications. The copper colour helps construction workers apply the film correctly where the copper side is placed towards the most prone to contamination," Loney adds.

In May 2021, **Avient** introduced three GLS thermoplastic elastomer (TPE) formulations that contain antimicrobial additives. Tested in accordance with JIS Z2801 and ASTM G21-15 standards, these additives protect moulded plastic parts by inhibiting bacterial growth (99.9 percent or more) and resisting fungal and mould growth. The grades are available under the Versaflex and OnFlex banners. Potential applications include consumer electronics, personal care item grips, and automotive applications such as cup holder mats and HVAC seals.

The new TPE compounds protect finished parts from microbial growth on both textured and smooth surfaces. They are formulated with what Avient says is an EPA-registered antimicrobial from Arxada, understood to be zinc pyrythione. They are commercially available in the US and Asia. Additional antimicrobial-containing formulations are in development.

Viruses and bacteria can survive on plastic surfaces for several days, meaning that surfaces can be a continuing risk for cross-infection. UK-based **Symphony** says its d2p suite of antimicrobial

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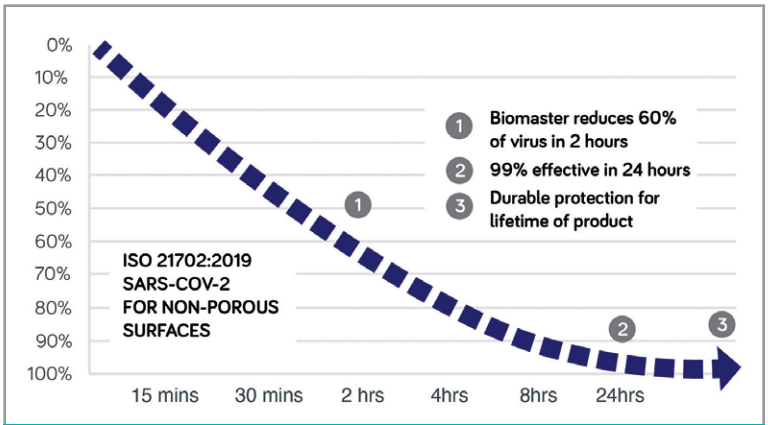

Figure 2: Indicative effect of Addmaster's BioMaster additive against the SARS-CoV-2 virus (actual rate depends on the matrix material and Biomaster addition level)
Source: Addmaster

masterbatches are intended to deal with this problem. It does not identify the active ingredient but says d2p is effective against gram positive and negative bacteria, mould, mildew, algae, fungi and viruses. It has obtained FDA approval for d_2p antibacterial food-packaging, which applies to all types of polyolefins, and polyester film for wrapping bread. Health Canada has also approved d_2p for bread packaging. Commercial use has commenced, the company says, and successful customer-led trials have recently been completed on plastic water pipes and tanks.

Swiss company **Sukano** says it has developed a range of antiviral masterbatches to prevent plastic parts from becoming a possible transmitter for viruses. Initially developed for personal protective equipment (PPE) used to protect against SARS CoV-2, they are now formulated and suitable for extended applications and polymers.

The company says there is an increasing customer demand to provide virus transmission protection in areas beyond PPE, such as industrial applications or durable goods that are frequently touched but not necessarily as frequently cleaned. It cites panels and buttons in lifts, which are touched by different people many times during a day.

Sukano has run tests in a certified external laboratory specialised in microbiological testing. Results confirmed the effectiveness of the masterbatches on various viruses with a reduction of up to 99.9% on an item's surface within the first 30 minutes. "We developed the masterbatch further into other carrier systems such as ABS, PC, PA, PET and PLA", says Onno Treur, Business Development Manager at the company. "This enables a broader field of applications for anti-viral surface protection such as in the E&E market."

Polygiene company **Addmaster**, an additives and masterbatch company well-known for its antimicrobial products, says extensive testing has shown that its Biomaster antimicrobial is active against SARS-CoV-2. Tests carried out according to ISO 21702 for non-porous surfaces (including plastics) showed a 68% reduction of SARS-CoV-2 in 15 minutes and over 99% in four hours (Figure 2).

Many (but not all) Biomaster products are based on silver ion technology. Addmaster sells them in the form of powders, liquids and masterbatches. One compounder using Biomaster is Germany-headquartered **Mocom**, which is using it in its Alcom HM compounds. Available in a range of base resins, these are aimed at inhibiting microbial growth in technical hygienic applications. The compounder says the HM products "combine a durable antimicrobial product protection of the plastic material with individual customer requests regarding specific colours and material properties such as stabilisation, impact strength or reinforcement."

Mocom says the Biomaster technology it uses is based on silver ion technology and is compliant with the EU Biocide Regulation EU 528/2012 and Article 95 therein. "The Alcom HM compounds are classified as treated articles and are in line with the requirements of Article 58," the company says.

According to Mocom, the silver ions on the plastics surface have been tested against more than 50 different types of bacteria, such as E.coli, Campylobacter, Legionella, MRSA and Salmonella. It says the antimicrobial effect of silver ions is apparent after 15 minutes, with a typical reduction of up to 99.9% after 24 hours.

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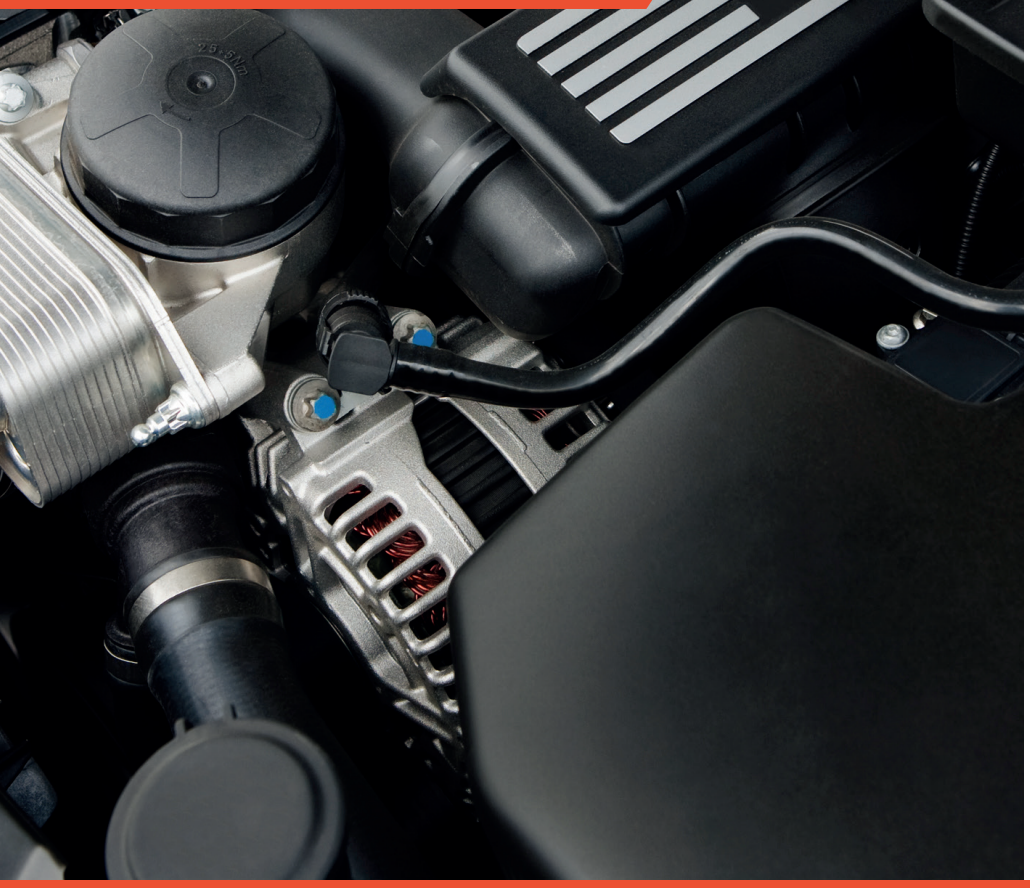

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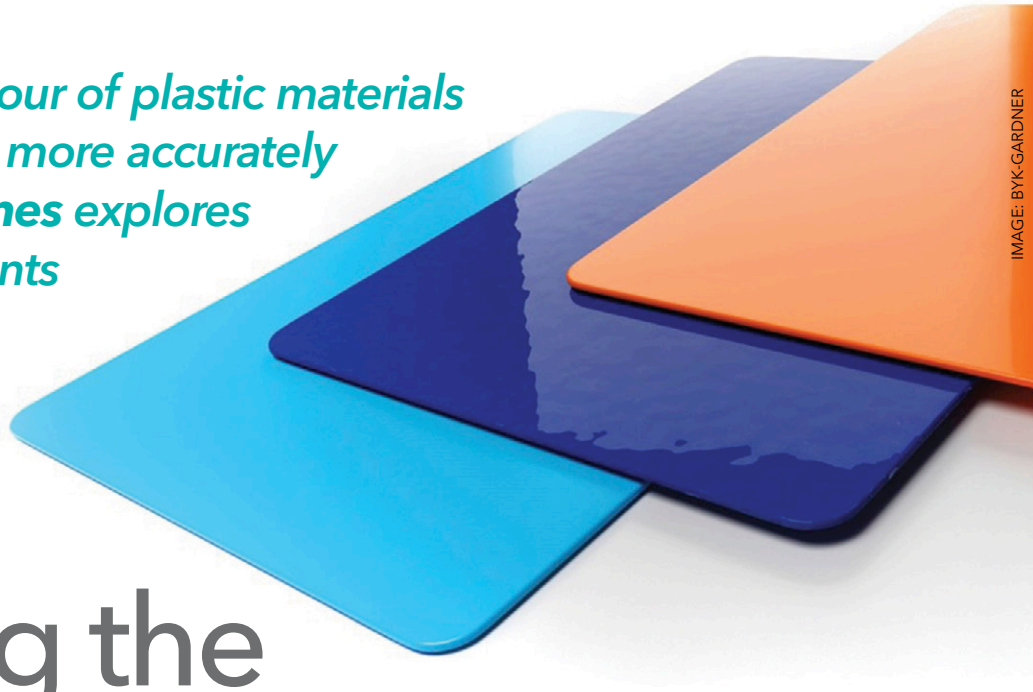

IMAGE: BYK-GARDNER

Digitising the colour workflow

The need for effective communication of digital colour data around multiple global locations – and throughout the entire plastics supply chain – is a key driver for innovation in the development of colour measurement. The global pandemic and current material supply problems have accentuated the issue, which manufacturers of equipment for colour measurement aim to resolve.

The plastics compounding industry continues to move rapidly towards digital colour workflows regarding colour management, according to **X-Rite**, which says Covid-19 has created significant new challenges for brands needing to communicate colour targets and control colour consistency. "It is critical for compounders and masterbatchers to investigate their full portfolio of colour needs, from integration of design needs, through recipe creation to control of production," says Matthew Adby, Product Management Director.

He says the company is seeing increasing demand to connect the stages of digital colour workflows to speed up the process and improve quality. "Key to a digital colour workflow is leveraging industry leading formats, such as X-Rite's CxF (Color Exchange File) and AxF (Appearance Exchange File), to support colour and appearance communication. With a connected ecosystem of integrated colour measurement instrumentation and software, compounders and masterbatchers can access colour standards immediately and get to the right colour quickly while minimising colour errors and rework," he says.

Adby highlights the increased use of recycled materials as a further trend driving colour management advancement. In addition, he says there is a requirement for selection and identification of materials that are compatible with automotive sensor systems. Material storage challenges and rising costs have also forced many compounders to find new suppliers and ingredients, which calls for colour matching to optimise the balance of ingredients.

Together these trends are driving a need for solutions that offer features such as automated measurement and selection, wider measurement capability, higher accuracy, and improved formulation and correction software (which, the company says, can help optimise usage of waste and recycled materials).

X-Rite says that its Color iMatch software version 10.6 has introduced new functionality to assist users to find trials and perform matches to meet customer requirements better. This has included the addition of search and match with opacity functions and colour tolerancing, as well as filtering properties using material attribute tagging, for example temperature fastness, light fastness and thickness. It says use of colorant tagging and rules can help in handling recycled materials and improve management of components with regard to current supply chain issues.

For inline colour control of plastic pellets, X-Rite's ERX130 system can operate in a closed loop system to provide on-the-fly colour correction based on the quality variance of recycled and raw materials. ›

Main image: Technology developers such as BYK-Gardner are developing high performance spectrophotometers to measure colour "as it is seen"

IMAGE: X-RITE

Above: X-Rite's latest Color iMatch software includes improved search and match features along with opacity and colour tolerancing

Maintaining performance

In addition to its new software and hardware developments, X-Rite says it is also making it easier for customers to ensure that their colour measurement devices are operating at peak performance. "Maintaining and servicing instrumentation is an essential part of achieving consistent and accurate colour in production. The new X-Rite Link cloud-based platform provides customers with real-time insights into colour measurement device health, such as device calibration, location, certification and maintenance, for example, in one central dashboard," says Adby.

"With data-driven insights into fleet performance, even across multiple locations, managers can have confidence in every measurement," he says. "Our development team is working to develop a next-generation ecosystem of cloud-based software and measurement devices that creates a seamless digital colour workflow from design through production. The team is also actively working on solutions to better handle emerging needs around recycled materials and automation."

For masterbatch producers, X-Rite says its systems can accelerate formulation and cut waste. With time-to-market expectations increasing and requests for complex colour palettes and additive concentrates such as flame-retardancy and UV absorbers on the rise, it says masterbatchers must remain nimble and precise during formulation to stay ahead of the competition. Each incorrect formulation leads to wasted materials and time, it says.

Vague specifications and ambiguous colour descriptions can lead to multiple rounds of re-work to achieve a customer's target colour, according to X-Rite. Back and forth review to gain approval on an acceptable colour standard also adds time to the process, opening the door for a competitor to win the bid, while multiple formulation attempts leads to costly colorant and resin waste.

X-Rite's offering for masterbatch producers includes a high-performing and repeatable bench-top spectrophotometer that can measure colour objectively and set an accurate master standard, combined with formulation software that can deliver fast and accurate matches. Quality is assured using software to monitor, verify, and optimise the performance of all devices in the workflow.

The system works as follows. The customer provides a sample or requests a bid for a colour match. The masterbatcher measures the target colour and sends the exact colour data to the Color iMatch software, which identifies the best candidate formulas using the pigments and resins on hand (and gives the option to include leftover materials to work off waste). The masterbatch maker then creates a sample plaque and measures it to ensure it is within colour tolerance before sending to the customer for approval. Once approved the formulation is ready to send to the extruder.

The company estimates that a typical laboratory formulates five colours per day, mixing an initial formula and at least two corrections to obtain the right colour. Assuming each correction takes about two hours and material waste costs around $100 per batch, it says the X-Rite solution can save about 2,200 hours and $110,000 worth of material annually (depending on the specific process and materials).

Beyond the eye

According to **Datacolor**, recent developments in colour management tools and technology complement a fully digital workflow, using full-spectrum instruments that generate colour data beyond observation by the human eye. "The ability to calculate and quantify colour matching recipes is particularly important in the plastics industry," says Earl Balthazar, Senior Applications Engineer.

"Using advanced colour management solutions and formulation software, industry professionals can measure, analyse and manage colour digitally

IMAGE: DATACOLOR

Right: The Spectra 1000 is one of the latest spectro-photometers from Datacolor

RAL researches colour design

RAL, the provider of colour samples, is collaborating with the Institute International Trendscouting (IIT) at the University of Applied Sciences and Arts (HAWK) in Hildesheim, Germany on digital communication of professional colour design.

RAL says the cooperation will include research projects on the subjects of design, colour and surfaces, as well as an expansion of the range of products and services. The company says that it is no longer sufficient to talk about colour as a separate component of design, because stakeholders expect integrated information and inspiration on surfaces, materials and colour-related topics via various channels and media.

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from anywhere in the world and quickly share those analyses across the supply chain. For example, higher-end hyper-spectral spectrophotometers can be used to skip the time-consuming process of creating plaques - a process that can take up to 25 minutes just to make a single pass/fail decision. With modern technology, this decision can be made in five minutes," he says.

"In addition to improving precision and efficiency, modern spectrophotometers can capture sample temperature measurement. This is important because plastics samples right off the line are much hotter than ambient temperature – something that can significantly impact colour appearance. This feature increases operational confidence and enhances reliability," he explains.

Balthazar says colour measurement is changing in plastics compounding. He says that historically there has been limited adoption of digital colour management on the end-processor side of the plastics industry. However, ongoing global economic challenges, including recent factory closures and lockdowns in Asia, are forcing many companies to shift production locations to different countries or regions. As a result, they are now relying on digital colour management to transfer colour standards globally. Together with raw material shortages and increased calls for sustainability, this is leading industry professionals to seek out technologies that increase efficiency, improve agility and minimise the risk of colour error - reducing waste.

As market shifts continue, he says the industry will further increase its embrace of digitalisation to streamline communications and production across the supply chain. Combining specialised software with hand-held, ultra-portable spectrophotometers allows the measurement, analysis and communication of colour digitally from any part of the world. When using portable devices, it is also now possible to have good inter-instrument agreement (IIA) – two or more spectrophotometers reading the same colour. While a single spectrophotometer in one location may not rely as heavily on IIA, it is essential if communication of colour is required across different offices or a supply chain. The closer the IIA, the more consistent colours will be across products, materials and locations.

Datacolor believes high raw material prices, pressure from consumers and government policy to implement sustainability measures, and supply chain challenges will continue to raise concerns among plastics manufacturers. "This combination of factors is spurring the industry to adopt modern technology that lowers costs, enables virtual communication, and helps facilitate the use of recycled material," says Balthazar.

"Digitalisation, automation, and cloud-based software will soon become the go-to solutions for cost and communication concerns, further advancing production processes," he says. "The industry will eventually come to expect seamless interactions across the supply chain – from suppliers and manufacturers to retail locations and consumers – while immediately identifying manufacturing errors or off-shade colours to save time that would be otherwise wasted on multiple rounds of corrections."

IMAGE: SHUTTERSTOCK

Above: Recycled materials present additional challenges in terms of colour management and control, says Datacolor

Recycling challenges

Sustainability and the use of recycled materials also provide challenges in colour management and quality control because the physical characteristics of plastics vary widely and can be difficult to replicate without compromising their stability. Balthazar says that the plastics industry recognises that production errors resulting from off-colour products have both economic and environmental repercussions and are showing increased interest in digital colour management solutions that can reduce waste and assist in reuse of off-colour product.

Spectrophotometers and software, such as Datacolor's Match Pigment with its 'recycle feature',

IMAGE: KONICA MINOLTA

Right: Konica Minolta's CM-36dG spectrophotometer is a benchtop device with a built-in ISO compliant gloss sensor that can measure both colour and gloss

can meet this growing demand by creating reproducibility across the supply chain and ensuring that there is minimal waste. Its tools make it possible to identify manufacturing errors or off-shade colours, saving time otherwise wasted on multiple rounds of corrections and so decreasing the unnecessary waste of raw materials. If corrections are necessary, Match Pigment can help companies reformulate off-colour products instead of disposing of them, says Balthazar.

Datacolor's most recent product releases include high-end spectrophotometers and version 4.0 of Match Pigment. High-end spectrophotometers include the Spectro 1000 and 700 benchtops. Match Pigment 4.0 allows the operator to control colour formulation through features such as Gamut Mapping, Smart Correction, Smart Match and Recycle.

Gamut Mapping, for example, informs masterbatch makers in advance if a formula is achievable before the colourants are mixed. Smart Correction can reduce the amount of raw materials used by up to 64% by providing the most efficient colourant combinations, while SmartMatchis claimed to improve first-shot match rates by up to 80%. The Recycle feature allows masterbatchers to reuse off-colour material by reformulating instead of disposal.

Future thinking

Future developments will need to help customers comply with government-led initiatives to encourage the use of recycled materials in plastic production. "For example, in April 2022 the United Kingdom enacted a policy stating that some domestic, as well as foreign plastic manufacturers importing to the UK, must be using at least 30% recycled plastic in the production of new materials or face a tax," says Balthazar. "This is problematic because most base polymers in their raw state are inherently unstable or unsuitable for how end users employ them. To combat that, some fairly robust additive packages are usually required, including stabilisers, UV protectants, lubricants and fillers, to give the plastic its necessary properties."

Adding recycled material to virgin material reduces its processing stability and performance of the final product will likely suffer. "One way to alleviate this is to increase the amount of stabilising agents being used, but that in turn will make the process more expensive at a time when raw materials are already facing shortages and disruptions," Balthazar says. "Undoubtedly sustainability measures like this will be a challenge for a growing number of plastics compounders and masterbatchers around the world who are keen to get batches right the first time. A strong colour management program is sure to be a vital part of meeting that goal."

Within the current economic situation, saving resources has become an even more pressing topic, says **Konica Minolta**. However, when selecting colour measuring equipment, the company says there are a number of issues to consider. "As with many things, the application and market demands set the boundary conditions for selecting the correct equipment," says Christian Dietz, Manager Application Technology C&A EMEA.

"While some OEMs demand specific equipment to test the quality of samples as close to visual perception as possible – requiring directional geometries of 45°:0° for example, – everyday tasks like colour quality checks or colour matching ask for more flexible methods to judge the appearance of a sample, and would require diffuse measurement devices such as sphere types. With traditional systems, setting up a colour management workflow is state-of-the-art, and sphere-based spectrophotometers are, together with a decent Colour Matching software, invaluable to control and formulate the correct colour, fast," he says.

Another factor that needs to be taken into consideration is usability of the equipment. "Benchtop spectrophotometers are capable of not only measuring reflection but also transmission, while portable handheld devices are reflectance only but more flexible as to where they are used," says Dietz. "But no matter what type is favoured, this well-established technology helps to cover almost all the needs of a producer in terms of colour quality assurance."

According to Konica Minolta, individualisation and increasing customer demands are driving the colour inspection and appearance business in the car industry, even to the point of unique customisations. For example, in e-mobility the pleasing appearance of the interior for users is becoming more relevant than motor performance. Modern colour inspection embraces these challenges and new automated testing solutions provide a way to satisfy these demands.

Current industry challenges include a decreasing number of experts and greater workload for

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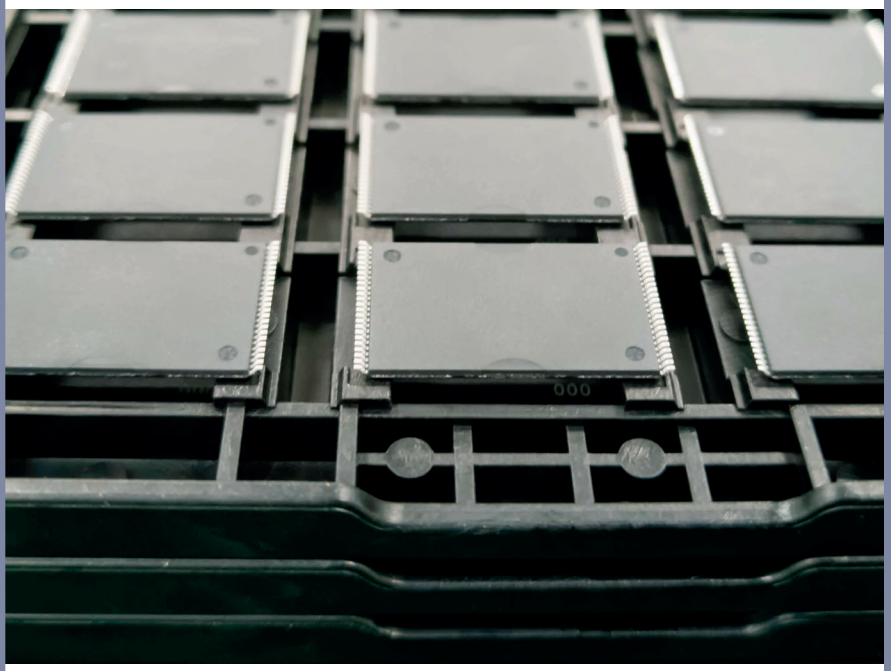

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Elix Polymers secures Renault certification

Elix Polymers has received colour laboratory certification from the Renault design department, which allows the company to self-validate colours according to the car maker's specifications.

Elix says it offers a wide range of pre-coloured ABS and ABS blends for the automotive industry. For interior applications, aesthetics are key to differentiate product value and improve quality perception and the colour harmony needed for different parts to match highlights the importance of meeting strict colour tolerances between different materials and batches.

Elix claims considerable expertise in developing colours based on OEM requirements, including colours and gloss targets using different surface textures. The Elix laboratory in Tarragona, Spain is equipped with twin-screw extruders, moulds with automotive OEM textures, colorimeters, light cabins and a Xenotest weathering chamber.

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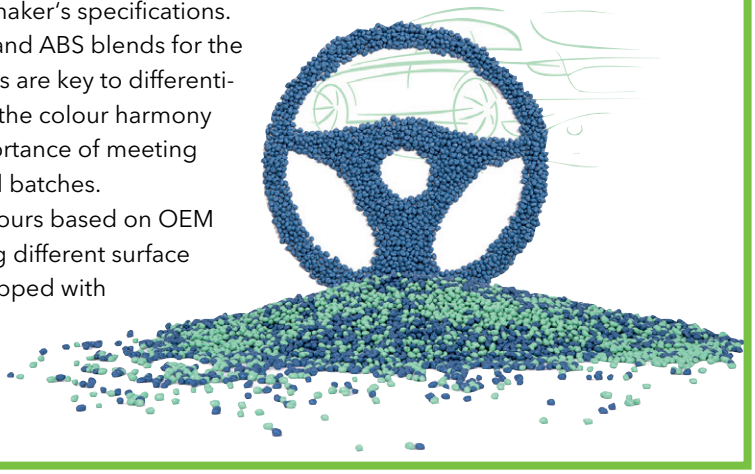

laboratory staff, which requires faster and more automated solutions. "To compensate for reduced human resources, cobotic systems that work alongside humans are becoming increasingly important to perform time consuming tasks," says Dietz. "Another trend is that users want modern systems to cover more tasks with fewer devices and provide increased information about the parts being measured. The industry is working on new solutions for formerly unmeasurable parameters or parts - providing information previously unavailable."

Hyperspectral Imaging (HSI), for example, combines spectrophotometric information and camera machine vision to cover the visible and invisible IR ranges. "Well-established for geological and airborne applications, HSI is now increasingly finding its way into traditional markets, from recycling to new identification possibilities for any kind of material," Dietz says. "Being camera-based, another advantage of these systems is that documentation and communication of part information is much easier than with integrated systems. We are sure to see more developments in this area in the near future."

Below: The CoboSense cobot testing system is designed to handle increased workloads with reduced laboratory manpower

IMAGE: KONICA MINOLTA

The latest development in instrumentation at Konica Minolta is the CM-36dG Spectrophotometer - a benchtop device to combine high accuracy and flexibility for the measurement of colour. It features a built-in ISO compliant gloss sensor to measure both colour and gloss with high accuracy.

The CoboSense cobotic testing system – developed by the Konica Minolta ICW DevOps division with an OEM partner – covers the needs of increased workloads with reduced manpower. It is a collaborative automation platform designed to perform colour quality and appearance analysis in conjunction with surface scratching tests.

Automated labs

Konica Minolta says that cobots cover the industry shift from process to task automation, and from production to laboratory. "Automating the whole process might be demanding on resources and not be efficient or well-advised because some tasks still need human interaction," says Dietz. "In the laboratory, automating just a part of the process under human supervision makes work more accurate, collaborative, reproducible and traceable. Collaborative automation does not replace humans, it assists and frees them for more productive and less repetitive tasks."

Konica Milnolta also supports and distributes the colour management software platform Colibri – developed by **Matchmycolor**. "Colour data must be available globally, where it can be shared with suppliers and customers," says Dr Michael Jakobi, Managing Partner at Matchmycolor. "The trend is towards cloud solutions where colour data can be communicated between systems in an automated way to meet Industry 4.0 requirements. Software must be browser-based and allow for central data management. Interfaces must be available or made available to allow communication and networking with other systems. All this requires a modern software platform and scalable database."

The matchmycolor Hub has been designed to

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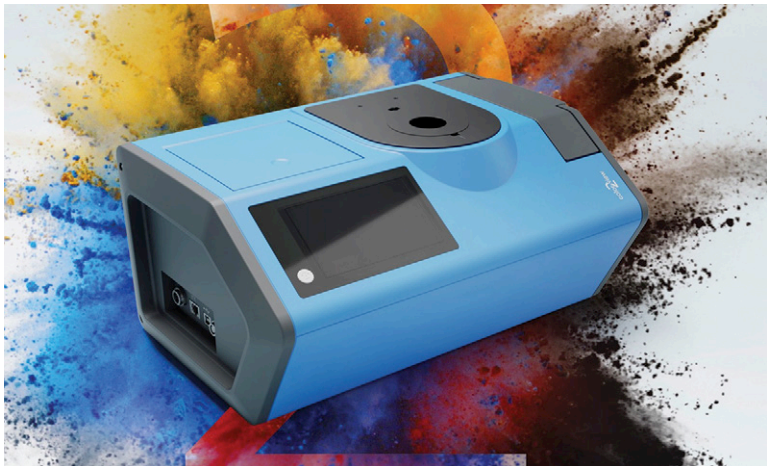
IMAGE: BYK-GARDNER



Above: BYK-Gardner's Color2view is a new benchtop spectrophotometer that includes a fluorimeter to predict light fastness

allow customers to manage product data developed in the laboratory with production and Enterprise Resource Planning (ERP), Manufacturing Execution System (MES) and Laboratory Information Systems (LIMS). Developed as a cloud-based module for the Colibri platform, the matchmycolor Hub centralises and manages master data by allowing the creation of colour products on request from a centralised system, as well as preparation of digitalised collections and shades. It also allows the development and design of master recipes by the laboratory for production, and the correction of recipes from production triggered by production orders.

The matchmycolor Hub has standardised Application Programming Interfaces (API), which allow communication with third party centralised software solutions via custom specific connectors. This makes it suitable for a wide range of industrial applications, including processes where colour plays an important part in the appearance of the final product.

As an example, Jacobi describes the automatic correction of Colibri recipes in production triggered by SAP for a large multinational company that was interested in streaming and automating the colour correction step directly in production. It wanted to start the order process from SAP and send this to the Colibri platform to commence the quality control and correction of the product, if required.

To accommodate the request, a workflow was implemented. A production order (the quantity and recipe to be produced) is sent from SAP to a production workflow component to start the process. A request is sent to the matchmycolor Hub for all colorimetric data required to fulfil the order, which is returned and the quality control job automatically started. If a correction is required, a request is sent to the Colibri platform and the corrected recipe automatically dosed. The final amounts dosed are then returned to SAP. The customer can also perform multiple corrections until the final product meets the order and quality required.

Jacobi adds that future developments in the process will involve artificial intelligence to improve the quality of the recipes produced further, ensuring a perfect match in any location.

BYK-Gardner has introduced a new benchtop spectrophotometer – the Color2view – that uses circumferential illumination at 45° with 0° viewing to measure colour as it it seen. The circumferential illumination from ten directions is said to ensure repeatable measurement results on textured surfaces. Simultaneously with colour, 20° and 60° gloss are measured to clearly differentiate medium gloss and high gloss samples.

Assessing stability

The Color2view also has a fluorimeter integrated to predict lightfastness by quantifying fluorescence – the calculated colour change after fluorescence degradation is displayed with easy-to-understand CIELAB and DE data. The combination of spectrophotometer and fluorimeter is claimed to open new perspectives for controlling colour quality and guaranteeing long-term colour stability.

The Color2view Pro version also offers a Jetness Mode, which is specially designed to measure deep and deepest black with highest accuracy. It features good technical performance, which is also assured for a low reflectance range (R) of less than 0.1%.

According to BYK-Gardner, the system is easy-to-operate, with intuitive navigation. The compact and lightweight instrument can be easily rotated to adapt to the orientation - top or front port - required or to the sample size and shape. Operation via the colour touchscreen is icon-based while an integrated camera presents a live preview of the measurement spot to avoid false readings.

The BYK LED technology provides good short-term, long-term and temperature stable performance while the extra-large measurement spot with homogenous illumination is said to guarantee repeatable and representative readings. Digital standards can be exchanged between benchtop and portable colour instruments without any extra-profiling. Due to good intra-instrument agreement between Color2view and Spectro2guide units, the company claims seamless use of digital standards is possible.

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- **www.x-rite.com**
- **www.datacolor.com**
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IMAGE: SHUTTERSTOCK

Measuring colour during production

*Measuring colour during the compounding process minimises scrap production and reduces costly off-spec material. **Mark Holmes** looks at some available solutions*

Colour measurement is no longer restricted to the laboratory. One of the most significant recent developments in colour measurement technology is the ability to determine colour during the compounding process via inline or online equipment and then using that data to automatically correct the process.

German technology company **ColorLite** says it installed its first inline colour measurement systems around a decade ago and all of them continue to work perfectly, in part due to the use of durable and stable LED technology. Managing Director David Pryor explains the benefits of the technology. "Data can be used to adjust a dosing unit to minimise waste and time because taking a sample after production is not effective," he says.

ColorLite says its inline colour measurement system for strand analysis is able to detect the smallest colour differences during compounding. It uses a spectrophotometer (d/0° geometry) with integrated automatic calibration and an infrared temperature sensor to compensate for thermochromic drift. This reversible colour shift is caused by thermochromic behaviour of the polymer itself, or by additives or interactions between the polymer matrix and incorporated additives. It is an important aspect to be considered when interpreting colour measurement data obtained at elevated temperatures.

The system also includes a guide to ensure that

Main image: Inline colour measurement means faster response to product or process variation, improving quality and cutting cost

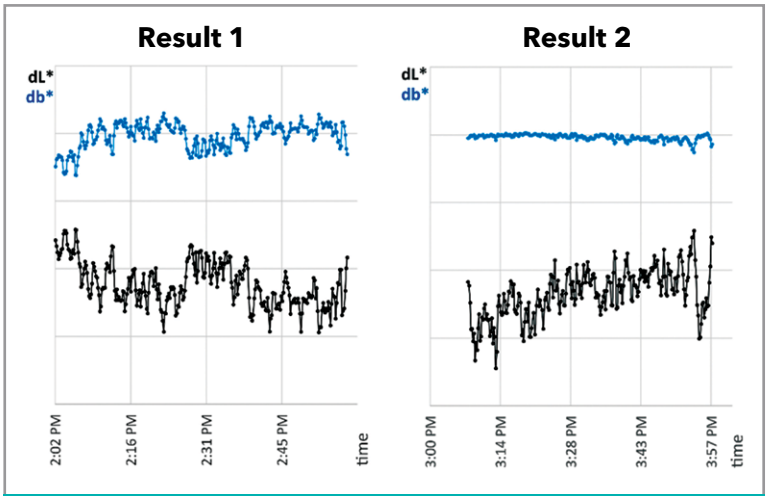


Figure 1: dL* and db* colour value data taken over a one hour period for a masterbatch coloured compound produced in a single screw extruder. Result 1 shows original masterbatch; result 2 the same masterbatch after a second compounding cycle
Source: ColVisTec

the strand is accurately positioned beneath the probe (the technology can also be used for colour measurement of semi-finished products such as cables, pipes, profiles or films). The systems incorporate a modular design allowing them to be configured for reflection and transmission measurement while different probe head variants support contact and non-contact measurement.

In the ColorLite SPH9i system, the external probe head is connected to a PC via an optical fibre, which can be several metres long. In its simplest set-up, the 9i would be connected via an industrial BUS to a process control system allowing it to display and store measured values. The SPH IPM system is equipped with a 7-inch colour touch screen display and does not require connection to a PC module. Measured values, as well as status and alarm information, can be displayed and data trasferred via a number of different interface variants.

ColorLite systems can also be used for reflectance measurement of granules, recycled pellets and flakes. "We have also just modified our pellet measuring equipment, so that the system is more mobile," Pryor says. "The system uses a vacuum to extract samples from the production process into a measuring chamber. These are measured using a specially adapted probe, which can operate over an 80mm wide area. After measurement, the sample falls back into production. The system has been tested in cooperation with the German SKZ Plastics Institute."

The MA80-P probe head's wide range of measurement makes it well suited for applications such as PET recycling, where material colour deviations can be determined directly in the production process and communicated to the colour dosing system via a control loop for automatic adjustment.

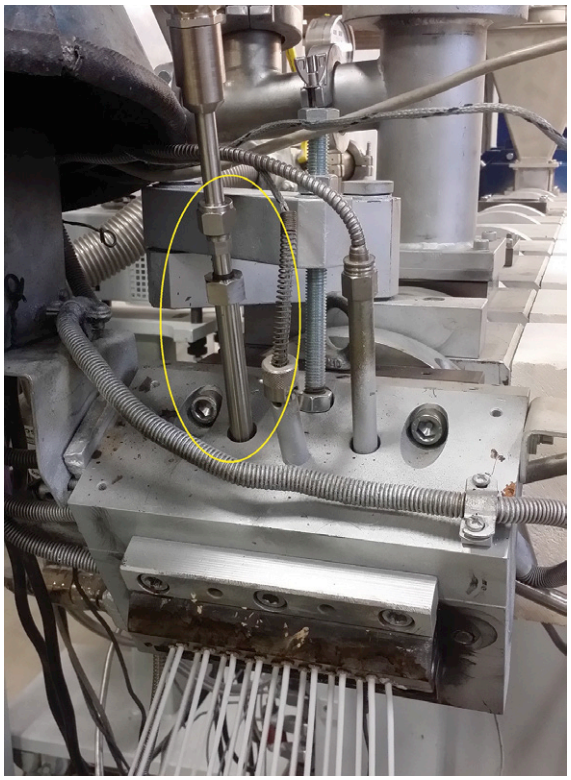
Compound benefits

Germany-based **ColVisTec** also has a long history in manufacture of inline spectroscopic process control solutions. It highlights several examples where its colour measuring equipment can provide benefits for compounders. The first example is to monitor the distribution and dispersion characteristics of a masterbatch without sampling, which can be significantly affected by processing conditions.

The company set-up an experiment using a single-screw extruder to mix a colour masterbatch into a base polymer. It used its InSpectro X spectrophotometer combined with a fibre optic probe in contact with the molten compounded polymer to continuously measure optical properties.

High levels of noise were detected for the colour values dL* (lightness) and db* (blue-yellow colour axis). However, the company says it was not known what was causing these large variations – the measurement system, extruder, feeding system or lack of consistency in the raw materials. One parameter was changed at a time to establish the cause. When

IMAGE: KRAUSSMAFFEI/COLVISTEC



Left: A ColVisTec probe (circled) installed on a KraussMaffei twin screw compounding extrusion die

the process was repeated using undiluted masterbatch that had been re-compounded in a twin-screw extruder a significantly better pigment distribution was achieved, see Figure 1.

ColVisTec says that there are several conclusions that can be drawn from this result. "Every masterbatch pellet is different and how different they are is a measure of the consistency and therefore the quality of the masterbatch," says Fuat Eker, Director of Sales, Marketing and Customisation. "Every compounding and masterbatching operation can be equipped to do these measurements, and tools installed to check the quality of the masterbatch. In addition, masterbatches produced in the laboratory can be checked in the extruder, while colour strength can be determined using residence time measurement."

Inline systems can also provide a much more effective method of ensuring process consistency than traditional sampling. Eker says where samples are used to establish process stability it is important that they are taken at a frequency that will provide a true representation – processes vary throughout a run and that has a direct impact on quality. More samples will mean a more accurate assessment of quality can be made.

However, he says a more appropriate solution is to use continuous inline measurement to detect the spectra and eliminate the need for sampling altogether. The operator is then able to monitor the development of the process in real-time and actively intervene if necessary.

Recycling gains

Recycling, where control of added quantities and dosage is crucial, is a further area where inline measurement can deliver significant benefits. "One of the challenges in polymer recycling is to produce a uniformly coloured polymer with the required colour quality," says Eker. "The starting material is a mixture of different colours in unknown quantities. The addition of the pigment masterbatch plays a major role. The question is how much pigment needs to be added to achieve a consistent colour quality?"

Continuous inline measurement enables enough data to be gathered and processed so the pigment dosing system can be controlled according to the measured colour in the melt. ColVisTec and SKZ (South German Plastics Center in Wurzburg) are collaborating in a joint project to study this. The project involves a setup consisting of a cascade of two single screw extruders producing a white masterbatch in a recycled PP. Each extruder is fitted with a probe to measure L*, a*, b* and ΔE values. The first probe showed the L* value for the recycled PP varied between 35 and 45. The automated pigment dosing resulted in a final compound with a highly consistent L* value of around 62.

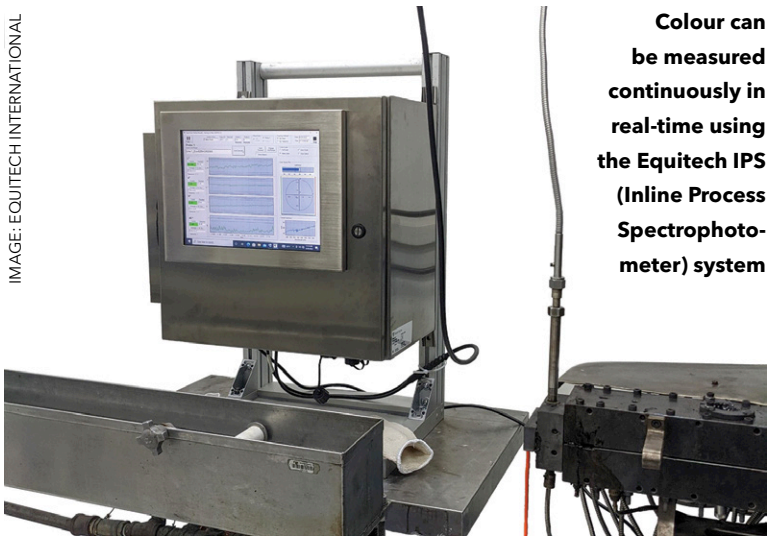
US-based **Equitech International** offers UV-Vis spectroscopy for inline and real-time monitoring of processes where colour and/or chemical composition is critical to product quality and operational productivity (Equitech and ColVisTec had a long-standing licence arrangement until late last year – both now market their technologies independently on a global basis).

"UV-Vis spectrophotometry methods have been used to measure the colour of manufactured products for a long time in laboratory settings under controlled environmental conditions," says

Below: Equitech's IPS system uses ruggedised fibre-optic probes for direct measurement in the melt stream of an extruder

IMAGE: EQUITECH INTERNATIONAL

IMAGE: EQUITECH INTERNATIONAL



Colour can be measured continuously in real-time using the Equitech IPS (Inline Process Spectrophotometer) system

Dr Joseph Golba, Vice-President – Innovation and Implementation at Equitech. "However, modern production technologies, time and materials constraints, and economic pressures are forcing the transfer of these methods to the production lines, demanding that colour be measured as any other process variable, that is inline and in real-time but with the same or more precise results than obtained in the laboratory."

Compounders and masterbatchers can measure colour intermittently during a production, says Golba, using hand-held or benchtop spectrophotometers to measure plaques produced production samples. However, the delay in receiving laboratory results can mean that hundreds of kilos of off-specification material can be produced before the operator is aware of any quality issue, which increases production costs, forces segregation of bad product, or creates a waste disposal problem for the plant.

Direct measurement

Equitech's IPS (Inline Process Spectrophotometer) and ruggedised fibre-optic probes allow measurement to be made directly in the melt stream of the extruder. Golba says the company offer two application tiers. The Alarm is the simplest, easiest to implement, and least expensive option, using the instrument to detect and activate an alarm when some colour or compositional feature, for example stabilising additive, drifts out of specification.

In the Alarm version, it is up to the operator to identify the source of the deviation and act appropriately. It may be a simple, short-term perturbation that is easily identified and can be 'adjusted out' while production proceeds. Alternatively, it may be a more serious issue that requires analysis and a longer time to fix. The second tier is Real-Time Quality Assurance (QA). In combination with the Tier 1 alarm system, the instrument is used to monitor some colour or compositional feature inline and in real-time to assure the quality of the product produced continuously over the entire production run.

Closing the loop

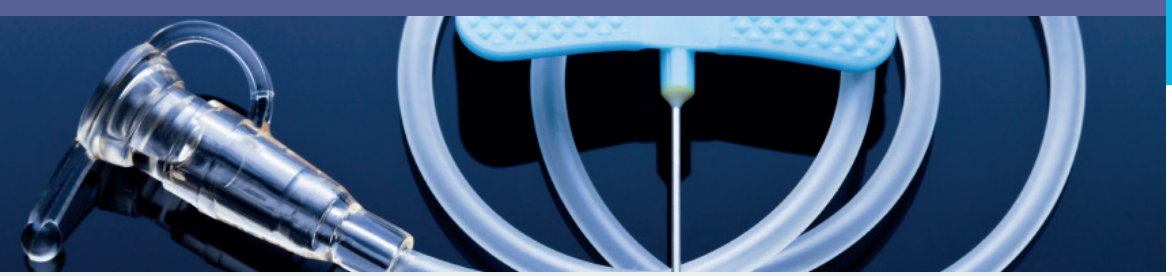
However, closing the control loop for colour is complicated and challenging when using multiple pigments to obtain a colour. Golba highlights an example of four feeders being used to mix blue, yellow, red and black to produce a purple colour. In this case, too much or too little of any one pigment will increase/decrease L* a* or b*. Which pigments are varying can be readily determined in a laboratory, but he says this is a challenging problem to determine inline and in real-time because of the interaction of the pigments with each other, as well as the base resin and because of the influences of the equipment, such as temperature fluctuation and worn out elements in the compounding extruder.

Other factors present challenges to implementing true closed-loop control. "The extrusion equipment market is highly fragmented and there are many different vendors of extruders and feeders for dosing additives, including the pigments used to colour plastics," says Golba. "Extruders may be single, twin or multi-screw and come in a wide range of output capacities. Feeders may be gravimetric or volumetric and allow for multiple colourants to be dosed into the extruder for a specific recipe. Likewise, there are multiple vendors of plant-control software packages to which data and results will need to be communicated."

Last year, Equitech took an 81% stake in US-based optoelectronics hardware manufacturer and software developer CompSol. Golba says this will enable it to improve its control systems and interfaces and enhance its probe redesigns. The company currently offers two probes for use in the plastics industry. Most applicable to compounders and masterbatch producers is the Reflection Polymer Melt Probe (RPMP). This is a contact probe that can measure colour directly in the molten polymer at process conditions up to 5,000 psi and 500°C. It also offers a Large Area Surface Probe (LASP) to provide non-contact measurement of colour in sheet, film and other solid surfaces.

CLICK ON THE LINKS FOR MORE INFORMATION:

- **www.colorlite.de**
- **www.colvistec.de**
- **www.equitechintl.com**



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Lasering in on marking

Increasing concerns over product security, part traceability and counterfeiting protection are driving interest in laser marking. Peter Mapleston investigates the latest additive options

IMAGE: MERCK KGAA

Main image: Laser marking additives provide permanent and durable product identification together with speed and ease of customisation

The way that a plastics compound reacts to laser light can be critical in all sorts of processes and applications. In decoration and marking, for example, lasers create a permanent colour change in the compound. This permanence has made laser marking a popular method of identification – it is much more stable and durable than pad printing. Other laser benefits include the ability to mark a wide variety of surface structures and shapes – even curved designs – plus resistance to abrasion, weather, light and chemicals. A further plus point of laser marking is its flexibility - digital templates can be created quickly and varied easily for applications such as custom or sequential marking.

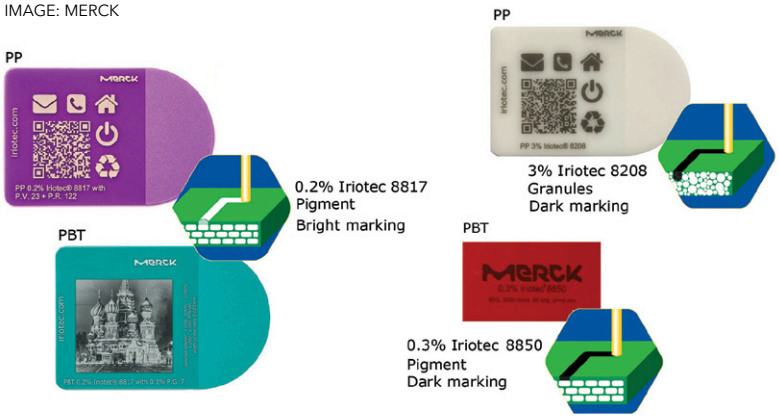
Other laser-based technologies include laser direct structuring (LDS), where the laser is used to create extremely fine tracks in the surface of a part which can then be filled or covered with metal to create electric circuits in moulded interconnect devices (MIDs). Then in laser welding assembly operations, the compound may need to absorb light in a particular part of the spectrum (typically infrared) so that it melts or it be fully transparent to that radiation so the laser beam passes through the component to the weld interface (laser welding developments are covered in a following article in this edition).

One of the global leaders in laser marking additives is Germany's **Merck KGaA** (operating as **EMD Electronics** in the US) with its Iriotec 8000 Series. These additives are based on various chemistries – including iron oxide, modified TiO_2, antimony-doped tin oxide (cassiterite) and mica – selected to suit the application and the compound they are to be incorporated into. The additives can be in the form of a pure oxide, or as a coating on a mica or TiO_2 core.

The company has obtained regulatory clearance via Food Contact Notification (FCN) from the US Food and Drug Administration (FDA) for the majority of its industrial and laser marking pigments in plastic applications. Various Iriotec 8000 Series products now have FCNs, including grades containing antimony-doped tin oxide.

According to Silvia Rosenberger, a laser marking expert in Technical Marketing for plastics applications at the company, the Iriotec 8000 additives were developed specifically for laser marking. This is said to differentiate them for some competitor products where laser printability is a supplemen-

IMAGE: MERCK



Above: Comparison of Merck's Iriotec laser pigment performance at various addition levels in PP and PBT polymers

tary function, alongside other properties such as flame resistance.

The Iriotec additives function through laser absorption, supporting a reaction in the polymer, or through a combination of laser absorption and a colour change within the additive itself. They can create dark marks in light-coloured compounds, or bright marks in dark compounds. All told, there are eight different types within the Iriotec 8000 Series, three of them creating bright markings, and five creating dark markings – two of which are in granular form (encapsulated laser additives) rather than powder. Granules can be sold directly to processors, while the powder grades go almost exclusively to compounders and masterbatchers.

Film developments

One of the most recent developments at Merck has been pigment additives that can be used for laser marking films. The challenge in film marking is for the additive to react sufficiently quickly to enable the marking to be created without burning the polymer. The challenge gets greater as the substrate gets thinner.

Rosenberger highlights the possibility of using laser marking as a sustainable technology for producing "digital passports" on plastics packaging to enhance recyclability. She says Iriotec 8850 is a good choice for marking products such as form-fill-seal bags, where dark markings can be put onto white films, due to its performance and cost in use. An addition rate of around 0.5% is required in the laser-active layer of the film.

Iriotec 8850 can also be used in cable compounds, where it is possible to create markings in-line with extrusion at line speeds said to be higher than any other laser marking product. "Cable companies are now increasingly thinking about marking with lasers instead of printing wheels to provide increased flexibility," says Rosenberger. She says reliability of laser printing compares very well against inkjet printing.

In June, compound producer **Avient** unveiled the Colorant Chromatics UV Laser Marking technology for use in high performance fluorinated ethylene propylene (FEP) wire and cable applications for the aerospace industry. Fluoropolymers such as FEP are capable of withstanding high heat and corrosive environments while also having very good dielectric properties and continuous service temperatures.

"Today, the industry is focused on miniaturisation, resulting in the use of smaller, thinner wires," says Avient. "But laser marking on thinner wire surfaces presents challenges. For example, traditional printing technologies can lead to the mark peeling off or surface damage can result from the use of infrared (IR) laser marking."

The new Colorant Chromatics UV Laser Marking technology enables permanent laser marking with very minimal impact to the thinner wire surfaces. In addition, the formulation enables good processing thanks to reduced lump formation. Anne Hippert, General Manager of the Colorant Chromatics group at Avient, says the technology can allow for a permanent, yet benign, mark on the FEP surface that achieves a 60-80% contrast and meets aerospace industry standards SAE AS4373F and EN-3475-706. It is offered for colours specified by the aeronautics industry, including light red, green, violet, blue, white and grey.

Laser effects

Pigment specialist **Sun Chemical** includes several effect pigment products in its SunMica range that are intended for laser marking. They include SunMica Ultra Fine 286-6000, SunMica LUX Ultra Fine 286-3000, SunMica Sparkle 286-6400, SunMica LUX Fine Black 284-3140, and SunMica Black 284-0246.

"We see a trend for simplifying packaging to improve ease of recycling and customers are seeking a variety of solutions to achieve this target – moving away from labels and creating more mono-material packaging," says Marko Ramp, Global Product Manager for Pearlescent Pigments at the company. "Brand owners are shifting from inks to laser marking to avoid using labels. For Sun Chemical, that means we direct them to different colour solutions. These laser marking additives aid in recyclability by avoiding solvents and labels that can complicate the recycling process in general."

He also points to the increasing use of laser marking on long lifetime products used in harsh environments (automotive components, cables, for example). These applications are often marked with inks, which may be unintentionally removed over extended periods of time. ›

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Right: Fast reacting laser additives are required for film applications to prevent damage to the film itself

Another company active in the area of laser marking additives is **Innocabs** in The Netherlands. It has a portfolio of masterbatches based on commercial and proprietary laser additives under its Inca brand. These provide optimised laser marking functionality and also a customisable laser welding capability.

Innocabs has a 2018 European patent describing a composition that enables fast response and high contrast. The additive comprises a metal oxide based on antimony (antimony-trioxide or antimony-doped tin oxide), a polyol, and a polymer (typically a polyamide or polyester). The company says in the patent that "it is believed that the polyol carbonises during irradiation of the laser marking additive and improves the laser marking of a matrix material."

Referring to earlier patents covering various types of laser marking additives, Innocabs says the technologies described produce various levels of resolution and contrast, but the contrast obtained, "especially at (very) high marking speeds is still relatively low. Moreover, high contrast is mainly obtained while marking with high laser pulse energies. Marking should therefore preferably be performed in focus of the laser beam which limits the marking area per pulse and hence increases marking time."

Many polymer suppliers and compounders now offer products with laser marking capability, but development work continues to improve performance. A typical example is German masterbatch producer **AF-Color**, which says it and its parent company Akro-Plastic have built up many years of experience in developing laser-markable and laser-transparent compounds and masterbatch formulations.

AF-Color says market developments and customer enquiries are showing that the trend towards holistic solutions is steadily increasing.

Right: Laser marking results using combi-masterbatches from AF-Color in a polyamide matrix show the bright contrast on deep black often requested for automotive applications

IMAGE: AF-COLOR

IMAGE: SHUTTERSTOCK/AMPACET

"The quality of laser marking of most polymers is quite poor, leading to a demand of highly effective laser additives," the company says. "The laser-absorbing (LA) product line from AF-Color meets the demand for different polymers and requirements."

Combined solutions

For special applications, combi-masterbatches containing additive and colour are the optimal choice "as they bring maximum flexibility combined with enormous colour strength and excellent contrast," the company says. "Whether dark, light or coloured markings on a natural, black or coloured substrate, almost every combination is possible."

Masterbatch specialist **Ampacet** has developed the LaserMarkFlex portfolio of masterbatches for high definition laser marking on flexible film using Nd:YAG technology. The product range consists of LaserMarkFlex 1081, which is formulated for black/dark grey marking, and LaserMarkFlex 1135, intended for lighter grey marking with broader food approval status (EC and FDA). Both contain no antimony.

Ampacet says LaserMarkFlex, which it says is fully compliant with circular economy design guidelines, enables monochrome permanent and anti-counterfeit marking and provides a robust, waterproof, lightfast and chemical and abrasion-resistant surface. LaserMarkFlex masterbatches are suitable for use in monolayer as well as coextruded film structures and can be used to print logos, barcodes, expiration or best-before dates, and serial numbers on labels and packaging.

The company has also introduced Laser Mark 1001074-E and Laser Mark 1001088-E, which it describes as cost-effective solutions that enable high definition, high contrast laser marking on clear and dark surfaces using NdYAG laser systems. Laser Mark 1001074-E produces sharp dark markings on transparent or light-coloured plastic

parts with an NdYAG laser and does not affect the colour or transparency of the plastic part or article. Once again, it is antimony-free and suitable for food contact applications. Laser Mark 1001088-E is intended for complex projects featuring different colour shades, producing dark or clear markings depending on the colour of the plastic item and the parameters of the laser.

IMAGE: COLLOIDS

Leff: A combination of black and reactive additives from Colloids is used to create the colour effects on these caps

Reactive additives

The L-Tec laser marking masterbatches from UK-headquartered **Colloids** contain a combination of reactive colourants and additives that are highly absorbent of laser wavelengths. Some conduct the heat in a small area to cause ablation or charring on the surface, creating a dark mark. To obtain a light mark, the L-Tec additive rely on a synergist. The interaction with the laser light and its energy are the same, the light marking being created by a foaming effect on the surface.

As with most laser marking additives, the L-Tec additives can influence the colour of the polymer compound. The company says that including too much additive in the formulation will not only add unnecessary cost but also deviate too far from the target colour. Incorporation of colorants alongside the additive, however, improves the quality and contrast of the mark.

Colour can also interact with the laser. Some colours, such as red and blue, reduce the effectiveness of the marking and the contrast is typically low. "These combinations are a single solution that provides a strong consistent colour alongside great marking potential," says Colloids. "It is possible to obtain coloured laser marks: currently Colloids offers these in black with a variety of coloured marks such as greens, reds, purples, blue and yellow. The coloured mark is achieved by using an optimised blend of black and reactive colourants and dispersed in the L-Tec masterbatch."

New or revived trends and styles are constantly emerging both in the packaging and in the design of containers for the cosmetics industry and a metallic look and decorative design using lasers have been very popular for some time, says **Rowa Masterbatch**. It provides its customers with colour masterbatches that are said to ensure metallic looks and laser possibilities without any loss of quality.

"The laser treatment of metallic-looking surfaces used to be associated with a loss of quality, as the laser additives that were required made the metallic look less shiny - at least until now," the company claims. It says it has developed different colour masterbatches that replicate a metallic surface extremely well and that can now be lasered without loss of quality. The masterbatches maintain the rich, brilliant colour tone with a shiny metallic look and are said to be suitable for both light-dark colour changes and for bright colours with a metallic appearance.

Polyamide specialist **Domo Chemicals** says automotive tiers and E&E component makers are increasingly recognising the advantages of laser marking technology for polyamide applications. In the E&E market, it says, around half of all its Technyl customers are now employing laser marking.

Laser marking is also a useful tool for implementing the mandatory unique device identification (UDI) that is required by some medical legislation to protect against counterfeiting. Both the EU's new Medical Device Regulation (MDR) and the US Code of Federal Regulations Title 21 on labelling of medical devices (21 CFR 801 Subpart B) enforce the use of a UDI system on medical devices and their packaging to reduce the risk of counterfeiting, improve traceability and better manage incident reporting, device recalls and other adverse events.

Several medical devices must be directly marked with a unique device identifier – CFR 21 Sec. 801.45 or EU MDR Part C 4.10 specify UDI

IMAGE: ROWA MASTERBATCH

Left: Laser marking metallic masterbatches from Rowa produce parts with high quality finishes for applications such as cosmetics

IMAGE: BUDENHEIM

Above: Budenheim's Budit L50 additive enables sharp delineation of circuit tracks on laser structured moulded interconnect devices

requirements, which generally apply to devices intended to be used more than once and to be cleaned or disinfected before each use.

ABS is widely used to produce external enclosures, covers or shells for reusable devices. **Elix Polymers** says correct laser settings adapted to the ABS material produce acceptable laser marking results but that there may be some limitations since the marking could present an undesired colour, level of contrast or an unexpected resolution. In the medical devices sector this could lead to regulatory non-compliance, it says.

For these reasons, Elix has developed special medical ABS formulations based on M203FC and M205FC materials that optimise laser marking to achieve a specific colour change and a targeted level of contrast over a given colour background that is fully compliant with regulations. The ABS formulations are also said to be valuable when other relevant material properties must be maintained along with laser marking optimisation, such as the biocompatibility requirement of ISO 10993.

Laser structuring

German additives specialist **Budenheim** says its Budit L series wavelength-absorbing ingredients in masterbatch form can be easily dispersed in all polymers. They are appropriate for NIR lasers and result in a change of colour in the polymer itself. Depending on the energy level, different visual effects from bright to dark with various colour shades can be generated on the polymer surface.

A new addition to the product line – Budit L50 – is designed for laser direct structuring for black MID parts. It is designed to act as high efficiency laser-sensitiser and metallization improver, the latter leading to small metallic nuclei initiating the metallization process to provide the final conductivity on the polymer surface.

Budit L50 meets high plating index requirements set by LPKF, a leading provider of laser manufacturing solutions based in Germany, which ensures highly selective metallization deposition. Dielectric properties lead to high edge sharpness resulting in a thin conductive path preventing electrical short circuit; high adhesive strength creates highly durable circuit lines.

In April, **SABIC** introduced LNP Thermocomp OFC08V, a new LDS compound aimed at 5G base station dipole antennas and other electrical/electronic applications. "To help achieve 5G's promise of faster speeds, increased data loads and ultra-low latency, RF antenna manufacturers are revolutionising their designs, materials and processes," says Joshua Chiaw, Director Business Management LNP & Noryl Specialties. "Our latest high-performance LNP Thermocomp compound not only helps streamline manufacturing by avoiding post processing, but it can also deliver exceptional performance across multiple, critical areas."

LNP Thermocomp OFC08V is a glass fibre-reinforced compound based on polyphenylene sulphide (PPS). It features very good plating performance using laser direct structuring (LDS), strong layer adhesion, good warpage control, high heat resistance, and stable dielectric and radio frequency (RF) performance. SABIC says it could enable a new injection mouldable dipole antenna design, offering advantages over traditional printed circuit board (PCB) assembly.

The new compound provides a wide laser processing window and both ease of plating and uniformity in plating line width to help ensure stable and consistent antenna performance. Strong adhesion between the plastic and metal layers avoids delamination, even following thermal aging and lead-free reflow soldering. Claimed improved dimensional stability and lower warpage compared to competitive glass-reinforced PPS grades help achieve smooth fixation of the metal plating during LDS, as well as accurate assembly, says SABIC.

LNP Thermocomp OFC08V has also been listed by LPKF as an approved thermoplastic for LDS with the company's systems.

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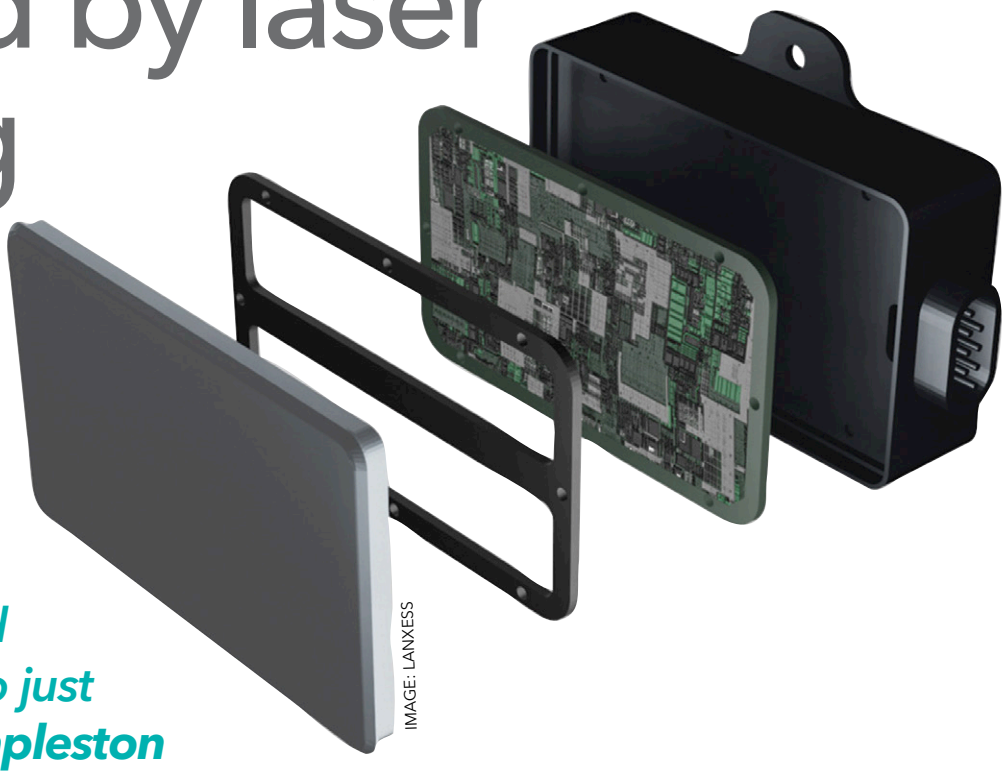


IMAGE: LANXESS

***Many plastics applications today need precise and leak-free joining of complex mating surfaces. Laser weldable compound combinations can do just that, writes* Peter Mapleston**

Main image: Automotive radar sensors are just one emerging application sector where laser welding is delivering results

Precision, speed, flexibility, and reliability are prime considerations for joining plastic parts in many applications today. There are many plastics joining techniques available but laser transmission welding stands out for offering precise and economical energy input, low thermal delay and high weld strength together with the ability to join three-dimensional mating geometries in a single process step.

Laser transmission welding is well suited to cost-effective, low stress production of small components with complex geometries, making it near ideal for the trend toward miniaturised electrical and electronic functions. The technique is simple in principle – a laser beam passes through a laser-transparent component and is absorbed by a second component, usually black-pigmented, beneath. The heat created melts the surface of the second component and, in turn, conducted heat softens the surface of the first. Once cooled, a strong weld seam is formed.

Laser welding is becoming one of the top cost-effective technologies for deep welding polymer materials and many polymer producers and compounders now offer laser-weldable materials. Among them is German masterbatch producer **AF-Color**, which offers optimised and customised additives from its LT (laser transparent) product line to cover the different laser welding process variants.

In the "black-on-black" arrangement, for example, the base component is usually made absorbent by colouring with carbon black. The challenging task is to make the upper part also look black to the human eye while being transparent to laser light. AF Carbon PA 950575 LT black is formulated to meet this requirement.

Sensor opportunities

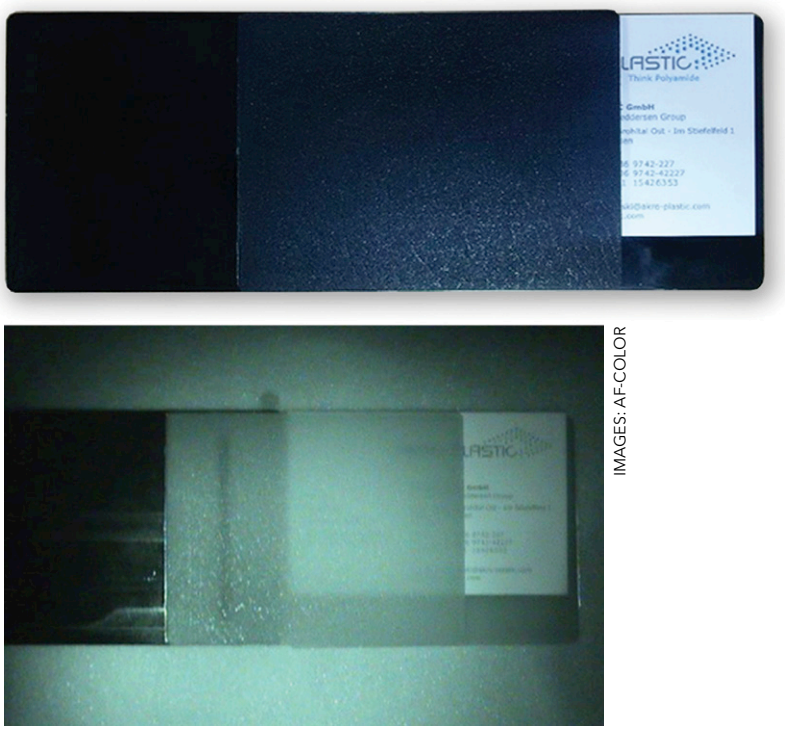
A number of LNP Thermocomp compounds were launched last year by **SABIC** with the aim of improving design options for production of ADAS (Advanced Driver Assistance System) radar covers. The LNP Thermocomp WFC06I and WFC06IXP compounds are said to have been developed for enclosure covers (WFC061 for the front and WFC061XP for the back) for next-generation radar units. The glass fibre-reinforced polybutylene terephthalate (PBT) grades offer a low dissipation factor and dielectric constant to help support the transmission of higher-frequency (>75 GHz) millimetre-wave (mmWave) radar signals. They also feature extra-low warpage to enable production of thinner covers to improve signal transmission.

The LNP Thermocomp WFC06I compound features a laser transmission rate of over 60%, which SABIC says is 20% higher than the nearest competitive product. The company says customers can use its wide laser window and low laser power requirement to potentially increase yield rates. LNP

Thermocomp WFC06IXP acts as the absorbing layer for laser welding.

ADAS sensors is an area that **Lanxess** is also working in. "ADAS radar sensors and their housings in particular are an attractive field of application for our polybutylene terephthalate and polyamide compounds," says Christopher Hoefs, ADAS expert in the company's High Performance Materials (HPM) business unit. "We have a wide product range that meets the desired technical requirements for this area. These include good radar transparency and dimensional stability, good laser welding behaviour and also excellent mechanical properties for fastening the sensors in the vehicle safely and durably."

PBT-based compounds that offer high hydrolysis stability in hot and humid conditions and good laser transparency for laser transmission welding are a specialty as these two material properties are said to be usually mutually exclusive. Lanxess, however, claims to have a number of PBT compounds that successfully reconcile the two requirements. One example is Pocan B3233HRLT (hydrolysis-resistant, laser transparent), which is already being used in a range of large-series applications

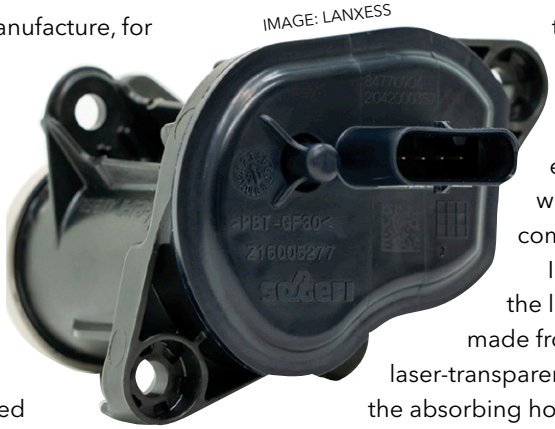


IMAGES: AF-COLOR

Above: "Black-on-black" laser welding calls for one of the two parts to appear black under visible light (top image) but transparent under IR (lower image). AF Carbon PA 950575 LT black from AF-Color meets this requirement

Right: This automotive swirl control actuator is moulded in several pieces in Pocan PBT from Lanxess and assembled using laser welding

IMAGE: LANXESS



and can be employed to manufacture, for example, housings for mechatronic swirl control actuators.

Swirl success

Lanxess says a German automotive manufacturer is equipping several of its diesel engine series with these actuators, which are developed and manufactured by Sogefi Air & Cooling in Orbey, France. The company is part of Italy's Sogefi, which is among the world's leading providers of filter systems, flexible chassis components and air intake and engine cooling systems for vehicles.

Swirl control actuators are part of the air management systems in combustion engines. They are responsible for controlling the air supply to the intake module and, at the same time, ensuring sufficient air turbulence. They help to optimise combustion processes and so play a key role in ensuring that the engine is highly efficient, which is ultimately reflected in high fuel economy and correspondingly low consumption figures.

"Our PBT compound has been chosen because it withstands the high temperatures under the hood in a car, even in very humid conditions," says Jean-Marie Olivé, an application development expert in the High Performance Materials (HPM) business unit at Lanxess. "Our material is also characterised by its low warpage and high dimensional stability, properties that make it ideal for the complex geometries of these compact housings."

Below: Domo Chemicals developed its laser transparent Technyl Star AF 219 V30 black LT for laser welding applications

IMAGE: DOMO CHEMICALS

Olivé says that even though the material is pigmented black, it still offers a high level of transparency in the wavelength range of lasers usually employed for laser transmission welding of plastics. "This ensures stable and efficient welding of the housing components," he says.

In the case of the actuator, the laser-transparent part is made from Pocan B3233HRLT with laser-transparent black colouring, while the absorbing housing half is made from Pocan B3233HR.

Last year, **Domo Chemicals** announced a new product family of PA66 based black plastics suitable for laser welding. Laser transparent Technyl Star AF 219 V30 black LT is now available on the market. "Being such a concentrated heat source, in thin materials laser welding can be carried out at high welding speeds. Thicker materials can produce narrow, deep welds between square-edged parts. Our Technyl Star AF 219 V30 black LT expanded product family will be important for the electric vehicle market where there is a growing demand for sensor boxes, cases and control units", says Vincent de Givry, Marketing Director Engineered Materials at Domo.

"There is the clear trend in the market to go for electro friendly, laser welding compatible materials because this clean welding technology is often used in sensitive corrosion applications. That's why our solutions are also available in electro friendly alternatives, making them suitable for sensitive electrical applications, while offering a cost-efficient solution."

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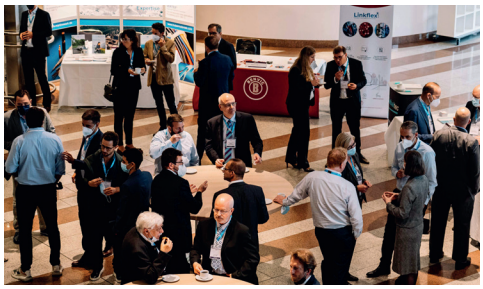

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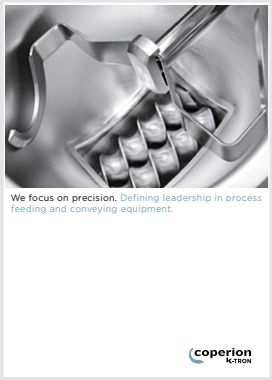

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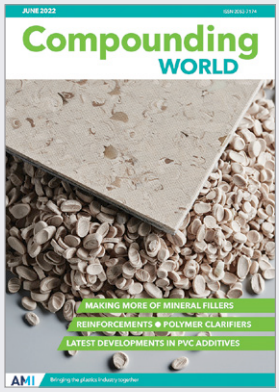

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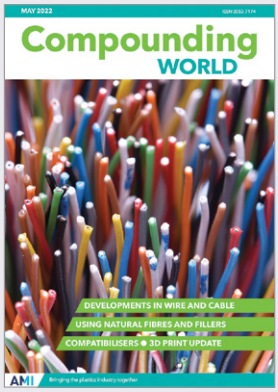

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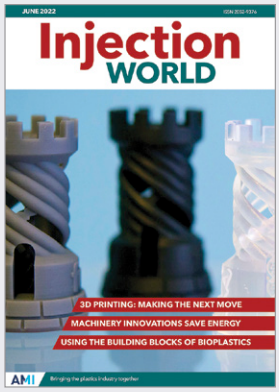

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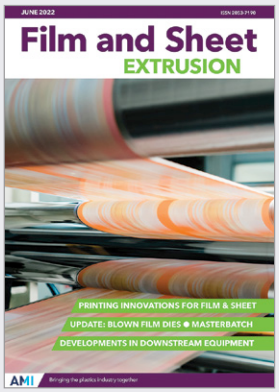

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	17-20 April	Chinaplas 2023, Shenzhen, China	www.chinaplasonline.com
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	5-8 September	Plast 2023, Milan, Italy	www.plastonline.org/en
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