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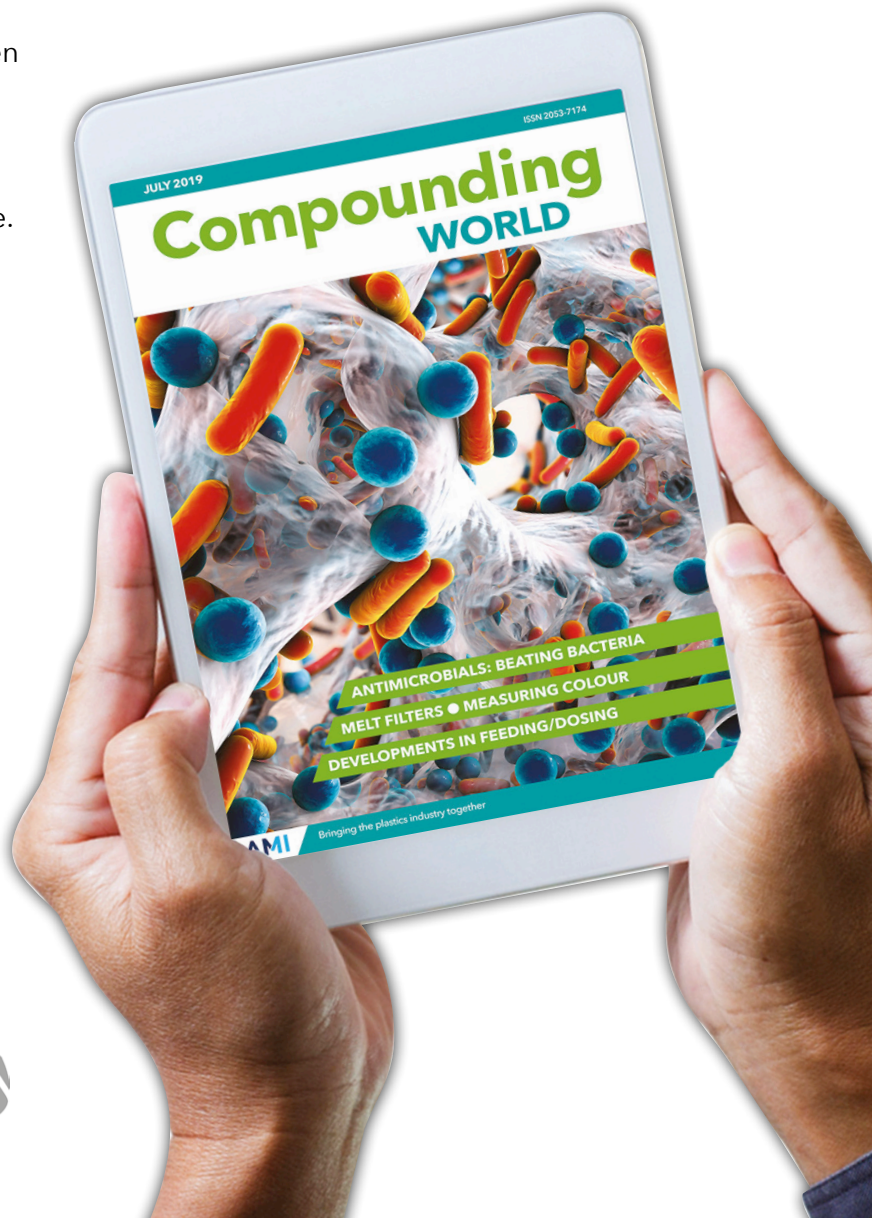

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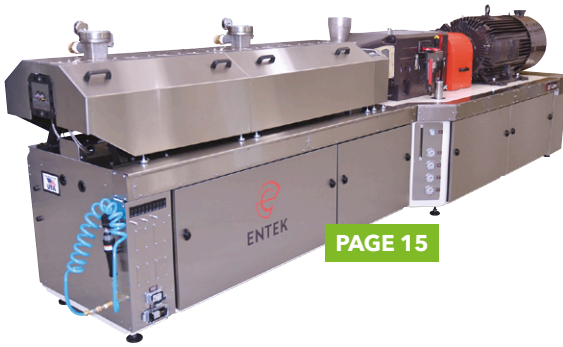

COMING NEXT ISSUE

› Twin-screw extruders › Odour and emissions › Long-fibre thermoplastics › Process simulation

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BASF, Solvay, Domo PA deals completed

The series of transactions through which Solvay has sold most of its Performance Polyamides Business in Europe to Domo Chemicals and the remainder, plus that in the rest of the world, to BASF has been completed.

BASF paid €1.3bn to acquire a large part of Solvay's PA66 business, including eight production sites located in Germany, France, China, India, South Korea, Brazil and Mexico as well as R&D centres and technical consultation centres in Asia, and North and South America. The acquired businesses generated sales of around €1bn last year and will be integrated into BASF's Performance Materials and Monomers divisions.

BASF also acquired Solvay's 50% share in Butachimie, a joint venture with Invista in ADN and hexamethylenediamine, and a 51% share in the new Alsachimie venture with Domo Chemicals to produce adipic acid.

IMAGE: BASF

More than two years in the making, BASF's acquisition of Solvay's PA66 business units is finally completed

BASF said the acquisition gives it broader access to regional growth markets in Asia and the Americas and strengthens its backward integration via direct access to adiponitrile (ADN).

Meanwhile, Domo has completed its acquisition of the former Solvay PA66 operations in France and Poland, its fibre facilities in France, and polymer and intermediates operations in France, Spain and Poland. These employ about 1,000. The businesses had to be sold to gain EU approval for the BASF/Solvay deal.

Domo CEO Yves Bonte described the acquisition an important step in its move "to become a major global service provider to our customers in our key markets of transportation, electrical and electronics, and consumer goods". With the new facilities, he said, Domo is now an integrated producer of both PA6 and PA66.

› **www.basf.com**
› **www.solvay.com**
› **www.domochemicals.com**

Trinseo works with CEDAP

Trinseo said it is working with CEDAP, a specialist in sheet extrusion for the packaging industry, to evaluate the use of chemically recycled PS in food-grade packaging.

The materials firm is also supporting CEDAP in the development of a easy-to-recycle yoghurt container in which pot, lid and label are all 100% PS. This project is being headed by the Citeo consortium, which includes Plastiques Venthenat, Amcor and Triballat.

Trinseo is involved in a number of other initiatives on PS recycling, including a recent announcement that it will build a 'first-of-its-kind' chemical recycling facility for PS in Europe. Its US joint venture, Americas Styrenics, has recently formed a venture with Agilyx to recycle post-consumer PS materials into new products.

› **www.trinseo.com**

Chinaplas postponed due to coronavirus

Organisers of the Chinaplas 2020 plastics trade fair, which was due to take place in Shanghai on 21-24 April, have announced its postponement due to coronavirus health restrictions.

In a statement published on 5 February, show organiser Adsale said: "We sincerely apologise for any inconvenience caused due to the show postponement. Health and safety of all show participants are at our top priority, therefore we have to make this decision."

Adsale said it was closely monitoring the coronavirus situation and would announce new dates in the future.

The annual Chinaplas show is one of the world's biggest plastics exhibitions and has traditionally alternated between Shanghai and Guangzhou. The previous event in Shanghai in 2018 attracted 180,000 visitors.

Adsale said in January it would relocate the Guangzhou show to Shenzhen in 2021 to cope with growing visitor numbers. Dates have been set for 13-16 April 2021, which puts it three weeks ahead of Italy's Plast exhibition and five ahead of the US NPE show.

› **www.chinaplasonline.com**

■ *Compounding World* publisher AMI has announced the cancellation of its Masterbatch Asia conference, which was to take place in Bangkok in Thailand on 3-5 March, also due to coronavirus health and travel concerns. Contact conference organiser Anna Kislingbury for more information: **anna.kislingbury@ami.international**

Akro-Plastic growing in China


IMAGE: AKRO-PLASTIC

Left: Wilfried Jobst, Managing Director of AKRO Engineering Plastics (Suzhou)

Feddersen Group subsidiary Akro-Plastic broke ground at its new 20,000m² compounding plant on the Binjiang Industrial Park in Changzhou, China, last year. Production of the first compounds at the site, which will operate as Akro-Plastic Engineering Plastics (Changzhou), is due to start in 2021.

Akro-Plastic began manufacturing in China in 2005 at Tongli and relocated that to Wujiang in 2010.

With demand growing, the company decided to build a new production site last year. The main customers for the new facility will be in the automotive, electrical and electronics sectors, it said.

"I am convinced that [the new plant] will open another very promising chapter for us in China", said Wilfried Jobst, Managing Director of AKRO Engineering Plastics (Suzhou).

› **www.akro-plastic.com**

Magnifin expansion approved

The board of Magnifin Magnesiaprodukte has approved preparatory work for the construction of a second production site, following completion of a feasibility study.

The company said the new site will produce the same portfolio of magnesium hydroxide products as the existing facility at Breitenau in Austria. It produces grades of coated and uncoated magnesium hydroxide for a wide range of plastic and TPE applications, including data cables, automotive wire and cable, engineering thermoplastics and construction foils.

Magnifin is a 50-50 joint venture between J.M. Huber's Martinswerk subsidiary and Veitscher, which is part of the RHI Magnesita group of companies.

› **www.hubermaterials.com**

Albis adds resources in the US

Germany-headquartered compounder Albis Plastics has added additional product development resources at its US site at Duncan, in South Carolina.

"Investing in our development process here in the US enables us to respond even faster to customer demands for local grades," said Albis Plastics Regional CEO Stefan Fuhlendorf.

The Duncan facility houses a dedicated small lot line for product development purposes and a fully-equipped on-site A2LA and ISO17025 accredited laboratory. The US-based development team will be supported by the company's formulation experts in Germany.

› **www.albis.com**


IMAGE: ALBIS

Albis Plastics Regional CEO Stefan Fuhlendorf

Orbia considering vinyl options

Orbia Advance Corporation – the new name for Mexichem – said it was considering a potential sale of its Vinyl business unit, which includes Vestolit.

"In line with our long-term strategy, Orbia is in the process of analysing potential divestment alternatives or strategic alliances with respect to our Vinyl business, without, to date, having any certainty or approval of the execution of any transaction," the company said in a statement.

The Vinyls unit generated sales of around $2.5bn in 2018.

› **www.orbia.com**

Biffa invests £27.5m in UK PET bottle recycling

Biffa officially opened its £27.5m plastic bottle recycling facility at Seaham in the north east of the UK last month, where it revealed a further £7m investment in a plastic tub and tray recycling unit at nearby Washington.

The Seaham plant can recycle 57,000 tonnes/yr of PET, or 1.3bn bottles, into high-purity pellets suitable for food and beverage packaging and clothing applications. It is expected to generate annual revenues of around £40m.

The new Washington facility will be built in the next 12 months and will be sized to handle about 20,000 tonnes/yr.

› **www.biffa.co.uk**

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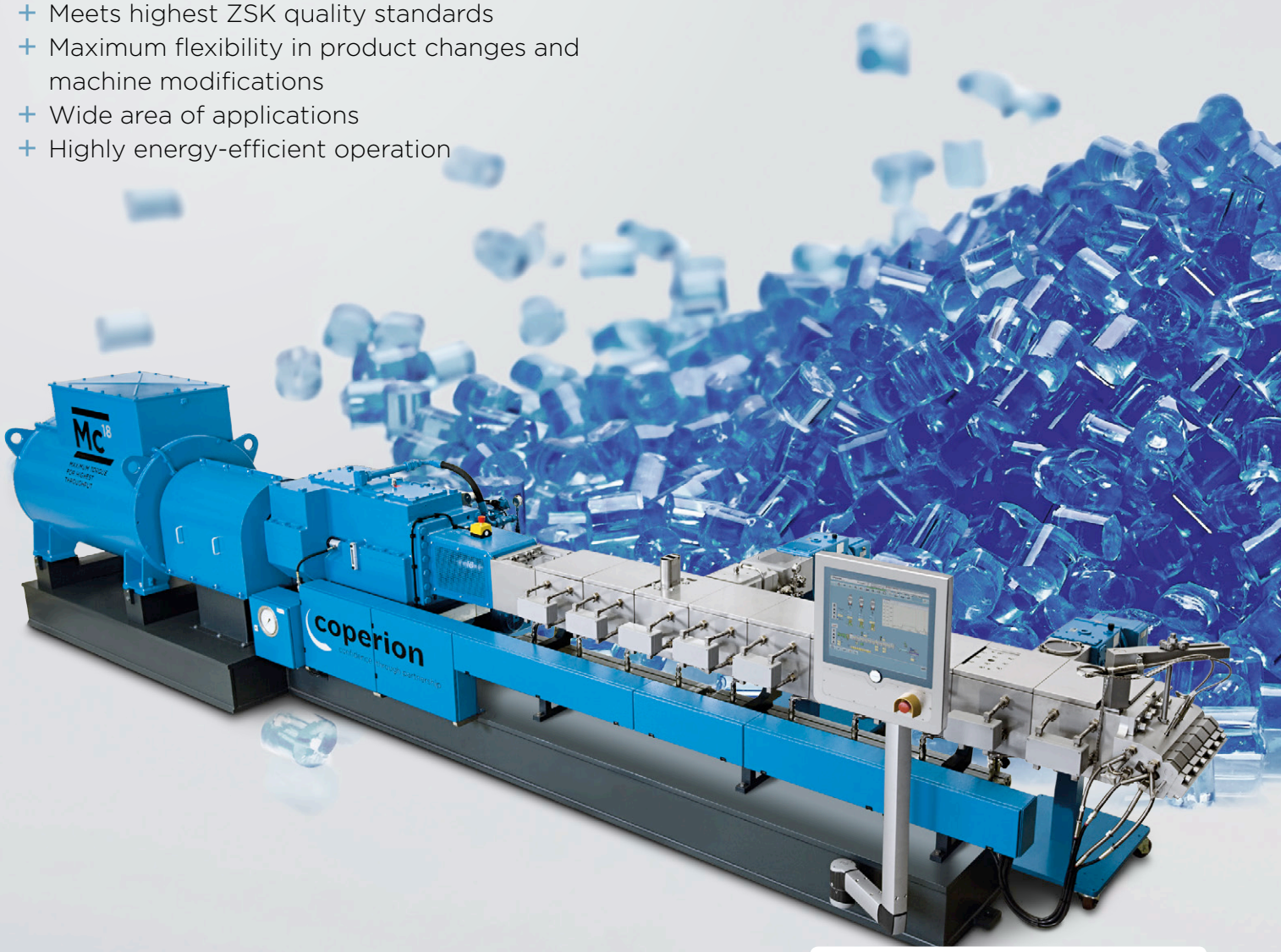

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NEWS IN BRIEF...

Anitmicrobial polymer producer **Parx Plastics** said it has signed a Master Service Agreement with PepsiCo to develop a system to provide high level microbiological reduction in high performance plastics. It said the companies have already carried out testing and sample production.
www.parxmaterials.com

Solvay said its new high molecular weight (HMW) HALS stabiliser capacity at its Willow Island site in the US came online last month. The specialty HMW HALS products join the existing Cynergy and Cyxtra HALS the company produces for PO resins at the site.
www.solvay.com

Chemicals group Italmatch has acquired ICL's RecoPhos Project Technology, including all IP and related assets. It said it aims to develop a route to elemental phosphorous for use in flame retardants, oil additives and pharmaceuticals from waste feedstocks such as sewage sludge ash.
www.italmatch.com

LyondellBasell sales down 11%; Schulman integration on track

LyondellBasell announced 2019 full-year sales of $34.7bn, down 11% on last year's result, with EBITDA down 17% to $5.6bn. The company also said the integration activities related to its acquisition of compounding group A Schulman in 2018 are on schedule, with $130m in forward annual run-rate synergies achieved as of the end of 2019.

"During 2019 LyondellBasell continued to exhibit strong cash generation and remained committed to our disciplined capital allocation strategy," said CEO Bob Patel. The Schlulman acquisition, he added, "demonstrated our capability to derive value from M&A".

The Schlulman business is now part of LyondellBasell's Advanced Polymer Solutions (APS) segment, one of six within the company. APS comprises the Compounding & Solutions line, including PP compounds, engineered plastics, masterbatches, engineered composites, colours and powders; and Advanced Polymers, which consists of Catalloy and polybutene-1.

In 2019, APS saw its EBITDA increase by $24m over 2018, despite a $47m increase in transaction and integration costs related to the acquisition. Compounding & Solutions' results increased by $105m due to new product lines from the acquisition. Advanced Polymers was $40m down, attributed to lower volumes from the automotive and industrial roofing sectors.

› **www.lyondellbasell.com**

SCS to trial Pyrowave process

Styrenics Circular Solutions (SCS), an industry initiative established to increase the circularity of styrenic polymers that counts Ineos Styrolution, Total, Trinseo and Versalis among its members, has signed an NDA to evaluate Pyrowave's catalytic microwave depolymerisation technology for chemically recycling PS.

Canada-based Pyrowave claims to have developed its technology over the past ten years and tailored it to PS, which is relatively easy to convert back to its building blocks.

Dr Norbert Niessner, Global Head of R&D at Ineos Styrolution and chair of the SCS Technology Working Group, said that SCS members "see great potential" in the technology.

"The small, flexible microwave units enable a decentralised approach as they can be installed next to existing local sorting facilities, where the waste feedstock can be found," he said.

› **www.pyrowave.com**
› **www.styrenics-circular-solutions.com**

IMAGE: AMI/C SMITH

US plastic bag manufacturers pledge to lift reuse and recycling rates

Recycling target in the bag

US plastic bag manufacturers and recyclers have renamed their coalition the American Recyclable Plastic Bag Alliance (ARPBA) and signed a commitment to target 95% of plastic retail bags being reused or recycled by 2025.

ARPBA claims the current rate of reuse of plastic grocery bags is 78% with 12% recycled, making a 90% current reuse or recycled rate.

Alliance members say they will also increase the minimum amount of recycled content in their products to 10% by 2021, 15% by 2023 and 20% by 2025.

› **www.bagalliance.org**

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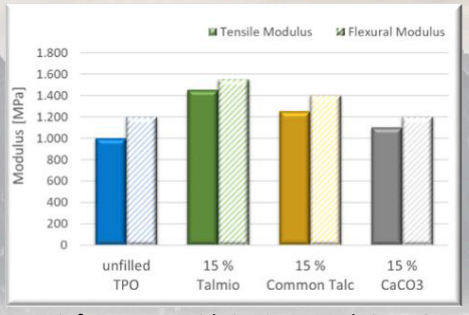

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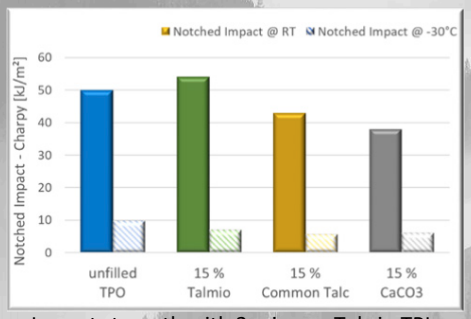

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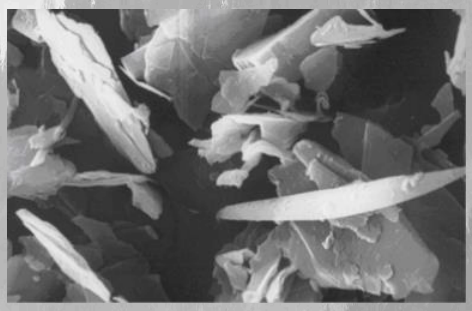
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Experts set to debate future of technical compounding

Speakers have been announced for the Future of the Technical Compounding Industry debate, which takes place at the Compounding World Expo at Messe Essen. It is part of the free-to-attend conference sessions that run across two theatres at the expo in Germany on 3-4 June 2020.

The debate will be chaired by Chris Smith, Editor-in-Chief of *Compounding World* magazine, which is published by expo organiser AMI. It will feature business and technology leaders from major compounding operations across Europe.

Expert participants include: Bernd Sparenberg, Vice President for Technical Compounds at Albis Plastic; Adam Galambos, European Director of Technology at Washington Penn Plastic; Murat Cansever, Technical Director at Eurotec; and Flavio Olivo, Global Sales Director at Sirmax.

The technical compounding expert line-up includes (from left to right) Eurotec Technical Director Murat Cansever, Washington Penn Plastic European Director of Technology Adam Galambos, Sirmax Global Director of Sales Flavio Olivo, and Albis Plastic Vice President for Technical Compounds Bernd Sparenberg

The debate is one of four that will be held over the two days of the expo – the others will focus on the future for masterbatch, cable compounds and regulatory issues. The latter will be hosted by the EuMBC, the European Masterbatchers and Compounders association. The full programme can be downloaded **here**.

Register for your free ticket **here**. It will provide free admission to the Compounding World Expo, plus three exhibitions focused on plastics recycling, extrusion and testing that take place in the adjacent hall at Messe Essen. In total, there will be more than 300 exhibitors and five free conference theatres with 100-plus speakers.

› **eu.compoundingworldexpo.com**

Leistritz working on foamed rPET

German compounding extruder maker Leistritz announced at the Interplastica show in Moscow in January that, together with recycling specialist NGR, film producer Kuhne and Russian company ForPET, it has developed and tested technology to recycle rPET into foamed sheet for carton production.

The idea of using rPET for production of beverage cartons came from Russian firm ForPET. "Our goal was to produce a material that allows recycling without limits," said co-owner Sergey Nikitenko.

ForPET has patented the concept, which produces a 100% recyclable alternative to the composite materials currently used in beverage cartons. This gets around the difficulties of separating layers of different materials at end-of-life.

In the newly developed process, rPET and any additives required are prepared in a Leistritz twin-screw extruder in combination with an NGR liquid state polycondensation reactor to create a pellet or melt for downstream foaming. This is loaded with a physical blowing agent on another twin-screw extruder and then sent to a Kuhne film extruder downstream.

According to Nikitenko, ForPET is "currently working with investors to establish a commercial development centre in Russia". Final development is expected to be completed by the end of 2020.

› **www.leistritz.com**

Left: ForPET's foam rPET films can replace composite carton board

LimnoPlast takes the water

LimnoPlast – a €4.1m EU Horizon 2020 project intended to investigate the impact of plastic on Europe's freshwater resources – was launched at the University of Bayreuth at the end of last year.

The project will research where small particles and fibres in the environment come from and what their effects are on freshwater systems. It is intended to combine natural and social sciences approaches together with environmental engineering.

› **www.limnoplast-itn.eu**

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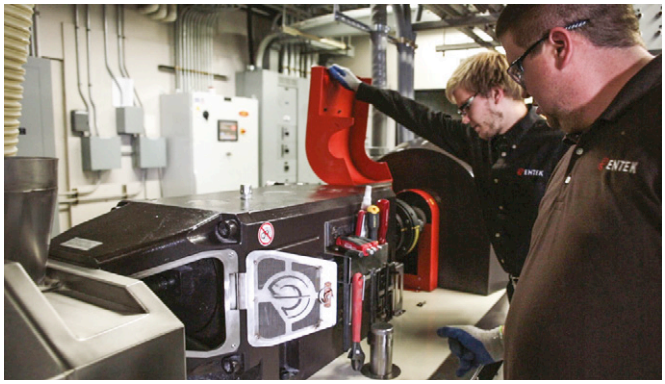

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Specialties pay off for PolyOne

PolyOne reported flat group sales for 2019 at $2.86bn but strong growth in both revenues and operating profit in its Specialty Engineered Materials division.

Robert M Patterson, Chairman, President and CEO, said: "Our investments in composites and other sustainable solutions helped to distinguish our performance, as Specialty Engineered Materials (SEM) led the way in both Q4 and the full year".

SEM increased revenue and operating income by 16% and 20% respectively in 2019. Growth in composites and wire and cable applications more than offset lower sales and operating income in Europe and Asia, which he attributed to weaker automotive demand.

During 2019, PolyOne took two further steps towards achieving its specialities focus by selling its PP&S business and concluding its agreement to buy Clariant Masterbatch. The latter is expected to add $1.15 bn to annual revenues.

› **www.polyone.com**

IMAGE: POLYONE

Right: PolyOne CEO Robert M Patterson

Saipem tests reuse technology

Oil & Gas engineering group Saipem has signed a licence agreement with ITEA to develop its technology for chemical recycling of waste plastic.

Originally designed for oil&gas applications, the ITEA technology is said to be particularly suited to solid urban waste disposal, including unsorted plastic materials. It uses "flameless oxy-combustion" to convert waste to produces water, energy and CO_2 (which can be captured for industrial use).

› **www.saipem.com**

EU vote may end PVC recycling

Members of the European Parliament voted against a derogation proposed by the Commission this month that would have allowed PVC articles to be placed on the market containing controlled levels of "legacy additives", most notably lead-based stabilisers.

The **vote** goes against advice from the European chemicals agency ECHA, which has determined in a five-year **study** that allowing such restricted use was the best waste management option for long lifetime PVC products such as infrastructure pipe and window profiles.

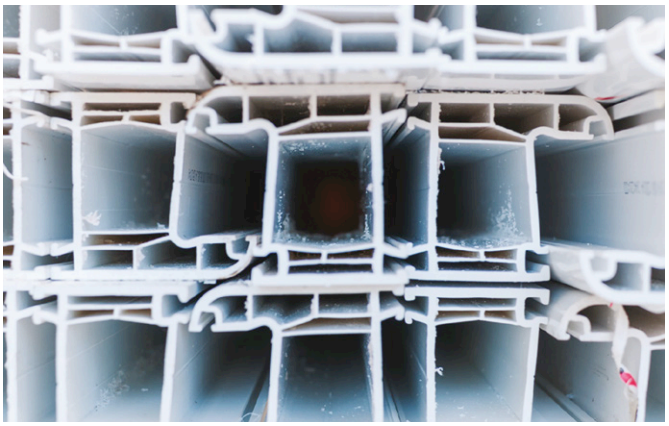

IMAGE: SHUTTERSTOCK

European Parliament vote could block recycling of PVC profiles containing lead stabilisers

Industry association VinyPlus said in a **statement** it "regretted the outcome of today's vote." It added that in the absence of alternative options, it will mean much of the PVC recycled within the EU – nearly 740,000 tonnes in 2018 under its own framework – will be diverted to landfill or incineration.

Lead stabilisers were phased out across EU27 by 2015 but the long service life of many PVC products mean they will be present in the waste stream for decades.

Chroma Color acquires Plastics Color Corp

Speciality US colour and additive masterbatch supplier Chroma Color, based at McHenry in Illinois, has acquired Plastics Color Corporation.

The acquisition includes the Plastics Color Corp sites at Asheboro in North Carolina and Calumet City in Illinois, where the company produces colour, functional additive and custom polymer masterbatch products.

Chroma said that the move will expand its footprint and know-how. "Their presence in medical and pharmaceutical products, food packaging, CPG and construction applications will bring more technologies and know-how to Chroma," said CEO Tom Bolger.

Chroma Color is owned by private equity group Arsenal Capital Partners and combines the former Carolina Color, Breen Color, Hudson Color, Polymer Concentrates and Chroma Corporation businesses.

› **https://chromacolors.com**

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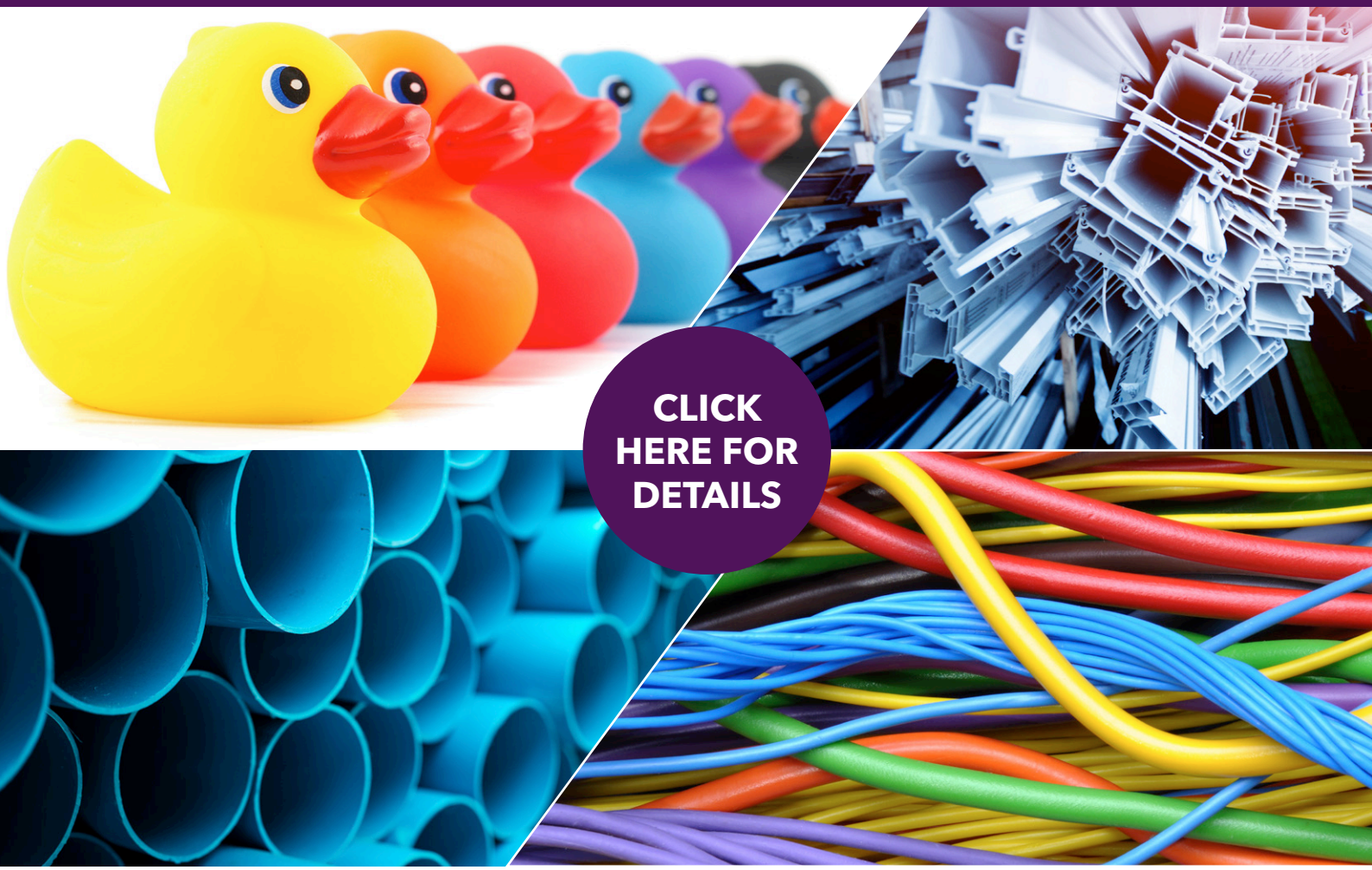

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Make your energy work

IMAGE: SHUTTERSTOCK

*How well do you manage the energy used in your compounding plant? **Mark Holmes** looks at what can be done to make improvements*

Keeping a close control on energy costs in the compounding plant not only makes economic sense, but also helps hit increasingly important sustainability targets. There are a wide range of measures and tools that can be exploited to ensure that the plastics compounding process is energy efficient and managed effectively. However, the starting point is to understand how the plant is functioning as it stands and then to identify where efficiency improvements need to be made.

The first step and perhaps the best way to understand basic energy consumption in the compounding plant is to calculate the Performance Characteristic Line for the site, according to Dr Robin Kent, Managing Director of **Tangram Technology**, a consulting engineer for energy management in the plastics processing sector. "In most plastics processing facilities, electricity is the main energy source. Electricity use is not, as is sometimes thought, fixed and uncontrollable. It is variable and controllable," he says.

"For most sites, electricity use will be directly related to the production volume in a given time period. It is possible to show this by plotting electricity use against production volume – the processed amount of plastic – in a week or month as a scatter chart and finding the linear best-fit for the data. The equation of the line-of-best fit is the Performance Characteristic Line (PCL) for the site. This gives an insight as to how the site functions and can be used for monitoring and targeting as well as for budgeting purposes. The PCL is the 'energy fingerprint' of the facility and varies with every site, providing important information on how it functions," Kent says.

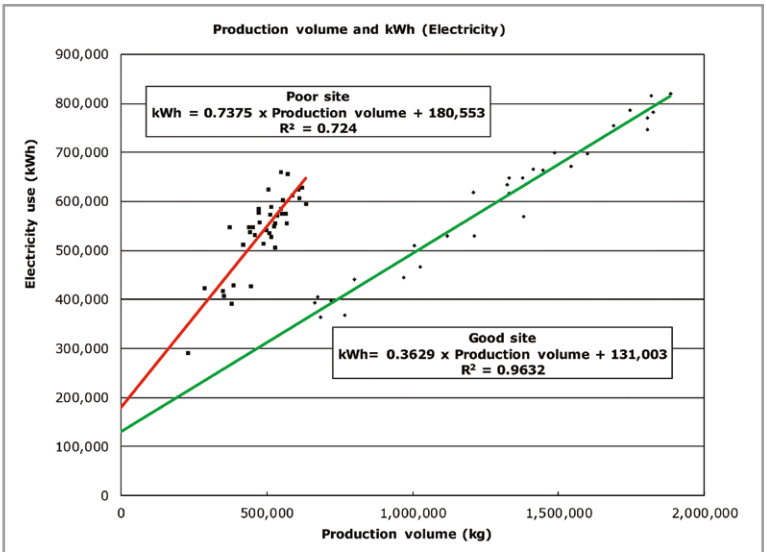
Once energy use in a compounding plant has been assessed there are a number of procedures that can be undertaken to improve energy use. "The

Main image: Use of energy in a compounding plant is neither fixed nor uncontrollable. There are big savings to be made by those ready to take control

Key steps in assessing the energy efficiency of a compounding plant:

- Plot electricity use against production volume - processed amount of plastic – over a month as a scatter chart. Use the spreadsheet to find the equation of the linear line of best-fit and the correlation coefficient (R^2) – see chart below.
- The intersection of the line of best-fit with the electricity usage axis is the 'base load'. This is the energy use when no effective production is taking place but machinery and services are available. This should be approximately 30% of the total load.
- The slope of the linear line of best-fit is the 'process load' for the site and shows the average energy being used to process each kilogram of polymer. The process load varies and is operation specific. For compounding, the value of the process load would be expected to be in the region of 0.4–0.6 kWh/kg.
- A good correlation coefficient (R^2) value is less than 0.7, which indicates good consistency of energy use. This is not the same as good energy management, but indicates that the site is consistent and makes improvement easier to manage.
- A poor correlation coefficient (R^2) is greater than 0.7, which indicates poor consistency of energy use. This is generally the same as poor energy management and indicates that the site is inconsistent and makes improvement difficult to manage.

Source: Tangram Technologies



The Performance Characteristic Line is the starting point for any attempt to improve plant efficiency. Easy calculated, it provides an 'energy fingerprint' of a facility and reveals key insight into how it operates. Here, for example, it can be seen that the poorly managed site has a high process load, a high base load and an acceptable correlation coefficient while the well managed site has a low process load, a lower base load and a very good correlation coefficient. The poor site will accumulate energy costs approximately twice that of the good site for the same production volume. ***Source: Tangram Technology***

Key points to consider in implementing an Energy Policy:

- Create and distribute a formal site Energy Policy.
- Assign clear responsibilities for energy management.
- Gather initial data and convert this into information to manage site energy use.
- Use the performance information to target improvements.
- Publish performance information widely.

Source: Tangram Technologies

PCL gives an insight into how energy is used at a site but there will be no progress in managing energy use unless it is on the management agenda. If energy use is not visible and measured, then there will be no improvement. Every site needs an 'Energy Policy' - a statement of commitment on energy use. This should include short, medium and long-term improvement targets. The policy should be widely distributed to encourage awareness of the costs and benefits of energy management," Kent says.

Driven by production

"Energy management should be the clear responsibility of the production department because it controls most of the energy use. An 'Energy Manager' can only act as the scorekeeper and the process should be driven by production. Funds and time should be allocated to carry out energy management projects. In addition, monitoring and targeting (M&T) are fundamental for energy management. A lot of data is probably already being collected but energy management is not about data, it is about providing information to target improvements. Targeting is the key action - what gets measured, gets done," he adds.

According to Kent, the ideal outcome of a good energy management programme would be a 30% reduction in energy use and costs. "One-third of this would come from management decisions by simply recognising that there is a problem and taking normal management actions. A further third would come from simple maintenance work costing less than £2,000 [US$2,600], while the final third would come from longer term work requiring investment."

Kent says it is important not to forget that energy is a variable and controllable cost and over 30% of

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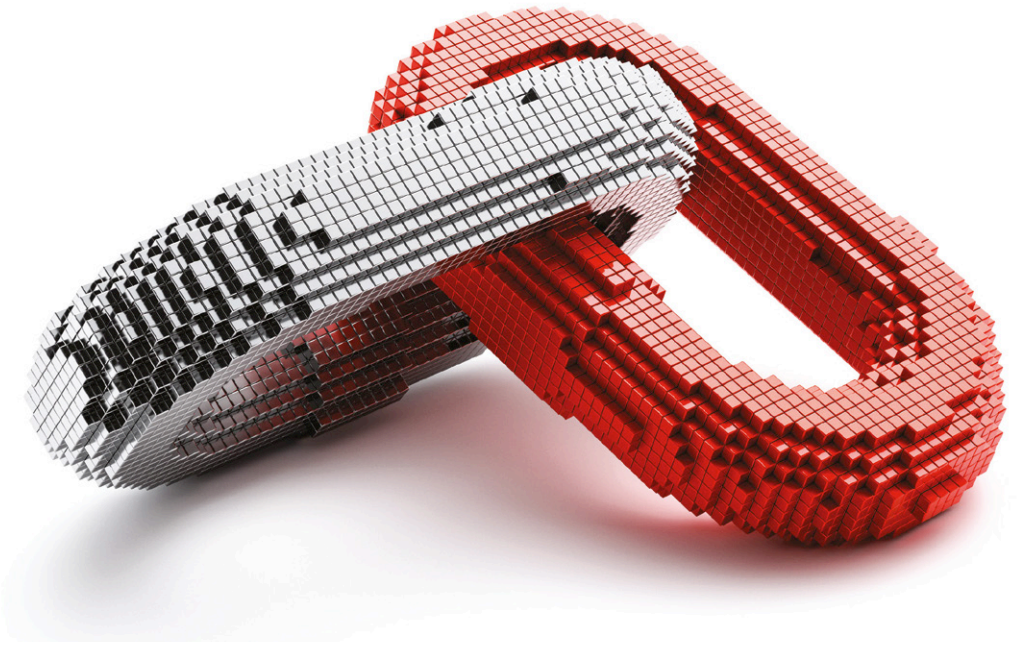

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the energy spend is discretionary. "This means that you choose to spend it either because you do not have the skills or the real desire to do something about it. The actions taken vary depending on where you are in the development cycle. Beginner sites can start with services management and then move on to more complex process-oriented projects. Experienced sites should be looking at process-oriented projects from the start," he says.

Target services

"Services use, such as compressed air and chillers, will be a high proportion of energy use in a compounding plant, but only because the process is quite efficient. These are some of the first places to look for improvements and there are many things that can be done to reduce services use. These include reducing compressed air leakage and the generation pressure, as well as restricting the use of compressed air for drying or product movement. A further option is to increase the chiller operating temperature or eliminating chiller use altogether with air blast cooling. After the services have been checked, the main extruders and process need to be examined for improvements."

Kent says that a major change in extruder operation has been the development of AC + VSD drive systems, which are much more efficient than the older style DC drives. AC + VSD are now being challenged by Permanent Magnet (PM) motors as these are smaller, more energy efficient, have negligible rotor losses and potentially eliminate transmission system losses. However, he points out that it is good people with experience who make the systems and processes work, and says that applies to making older machines more energy efficient and saving money.

The role of experts

There are energy management consultancy specialists available that could benefit compounders, if used well. "Professional energy managers and consultants will never know a compounder's site and process as well as they do," Kent says. "However, the difference is that an energy consultant will know where to look and what to expect, as well as knowing what the important things are and where to make the savings. Nevertheless, there are many people and organisations offering energy consultancy and obviously they are not all equal. If your energy management consultancy focuses on the lights - around 5% of the energy use in a compounder plant - and says nothing about the machines, which account for around 66% of the energy use, then you know that you have got the wrong one," he advises.

"Energy management is not a new task, it has simply risen in importance. Site managers have always been given people, machines and materials and told to make good products. Energy is now simply part of this mix and has a higher priority. It is always possible to see if a plant is well managed by looking at the site, the machines and the people. In a well managed facility, the site and machines are clean, everything is well-maintained and the professionalism and enthusiasm of the people is evident. Sites with good energy management look the same. Conversely, it is also possible to observe that a poorly managed site and one with poor energy management look the same. Energy management is an indicator that says as much about a site's general management capability as about the technical issues of energy management," according to Kent.

Lean manufacturing

US-based producer of twin-screw co-rotating extruders, turnkey production extrusion systems, extrusion wear parts and components **ENTEK** says

Potential extruder energy savings within the compounding plant:

- Always opt for the AC motor + VSD option in new extruders. Motors should be IE3/IE4 rated (or NEMA equivalent). Retrofitting can be examined, with payback likely between 1-2 years.
- Check that the extruder is right for the job and is operating close to the design speed.
- Check the loading on the extruder motors and modify the gear ratios to optimise performance. If pulleys are used, this can be as simple as using pulleys of a different diameter.
- If belt drives are used then optimise the belts. Belt types vary greatly in efficiency and toothed belts are the most efficient. Standard V-belts should be replaced with more efficient belts.
- If a gearbox is used then do not exceed the maximum torque allowance. Use the correct oil and make sure it is at the correct temperature.
- Check extruder controls to make sure that heating and cooling are working efficiently together and not competing against one another.
- Check the barrel heater ammeters. If the heaters are constantly on, then shear heating is not providing all the heating required and insulation could well be beneficial.
- Extrusion dies, transfer pipes, screen changers/melt filters and almost everything downstream of the extruder screw tips can be insulated with either flexible or with board type insulation.
- If using ventilation fans above extruders, then use controls to stop these when the extruder is stopped.

Source: Tangram Technologies

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it prescribes to lean manufacturing. Technical Processing Manager Dean Elliott, Technical Customer Service Matt Ramsdell and Marketing and Business Development Manager Tammy Straw, have identified three key areas of energy wastage in compounding.

Left: Compounding equipment must be correctly specified to operate at its most efficient, says ENTEK

The first of these is equipment energy loss. ENTEK advises the importance of specifying the overall system correctly for the intended application. For example, if the extruder or downstream equipment is oversized or undersized, there is a potential for energy inefficiency (waste). Water cooled motors operate more efficiently than air cooled motors – they already utilise an internal cooling system whereas an air-cooled motor relies on an external blower for cooling. Running motors on VFDs (variable frequency drive) also increases efficiency, as does not running on full speed when not necessary. Finally, the company says an efficient barrel cooling system operates through heat of vaporisation of water and the barrels are internally cooled. Blankets and shroud over blankets help to retain heat in the barrel.

Processing energy loss is a second consideration, according to ENTEK. Most of the energy generated is frictional heat that is provided by the motor of the extruder. This can be minimised through appropriate screw design. The layout should not be overdesigned – the screw configuration should not be too aggressive. For example, if achieving a good quality product requires a specific energy input (SEI) of 0.1 (kW.hr)/kg, a screw design that uses 0.13 (kW.hr)/kg is overdesigned by 30% and is wasting energy. Similarly, operating the extruder with the screw speed too high can increase the SEI unnecessarily. ›

IMAGE: ENTEK

Right: Control HMI's can provide invaluable insight into the process and help take corrective action

The co-rotating twin-screw extruder is an inefficient pump – it is roughly 10-15% efficient. This means an energy loss in restrictive areas such as mixing zones and at the die. Using the best suited pumping elements will increase pump efficiency, minimise the SEI and reduce wasted specific energy. When screws and barrels start to wear, pumping efficiency is reduced. This can force the operator to run at higher screw speeds than necessary, or lower than desired feed rates.

Use your controller

Using the machine's HMI to trend processing under Industry 4.0 helps to maintain optimal running conditions and rapidly take corrective action against upset conditions. Leaving the extruder powered on and/or the screws turning for long periods of time when not producing, for example, results in wasted energy. It also leads to build-up of carbon, which unnecessarily extends purging and clean out time and increases screw and barrel wear.

ENTEK says it is also important to remember that under-utilising equipment is not energy efficient and can cause unnecessary capital equipment expense. Understanding the limiting factors of the process and addressing them sometimes requires only a design change on an existing piece of equipment rather than buying a whole new system. Such options include: improving screw design by breaking up short aggressive mixing zones into longer less aggressive zones; improving moisture removal from the process by adding a vacuum stuffer or a larger vacuum pump or vacuum pump filtration system; adding a melt pump as a more efficient pump; and increasing the hole diameter on the die and/or using a larger mesh screen size if quality allows.

The final area contributing to energy loss is maintenance, according to Entek. This can be minimised by following best practice. For screws and barrels, for example, it is advisable to learn and understand the amount of wear a specific process can tolerate to avoid replacement too early or too late. Meanwhile, the loss of a heater in a zone can result in greater dependence on frictional heating, which in turn effects the SEI. A jammed cooling system valve can allow water to pass through barrels constantly, which means more heat is required than necessary to maintain the set-point. A properly tuned heat/cool system will also provide better control – large temperature oscillation means wasted energy, ENTEK says.

Mapping consumption

According to Markus Schmudde, Head of R&D Compounding & Extrusion, at **Coperion**, a good

IMAGE: COPERION

Right: A consumption map of machines, utilities and other electrical power consumers is a first step in optimising overall energy efficiency of a compounding plant

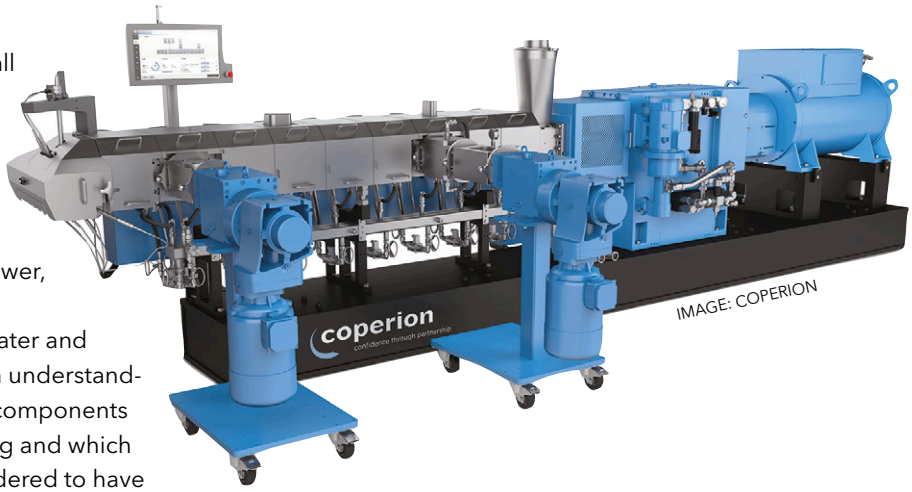

IMAGE: COPERION

Right: Investing in new equipment gives access to the latest energy management technologies

start in assessing the overall energy management efficiency of a compounding plant is to create a consumption map of all machines and consuming equipment of electrical power, as well as utilities such as compressed air, cooling water and nitrogen. "This can help an understanding of which machines or components in a plant require managing and which components can be considered to have no or no significant influence on the energy efficiency of the plant," he says.

"From a technical point of view, the most important aspect for proper energy management is the measurement of energy consumption for the most significant consumers of electricity and utilities. This data needs to be collected and analysed centrally. For each energy or utilities consumer, individual standard values should be set following a plant evaluation. This can then be supported by machine control systems, for example," he says. "One significant outcome of a fully integrated and well managed energy monitoring and management system can be that a plant can control its consumption in a way so that peaks can be avoided. For example, most energy intensive operations can be moved to times when overall energy consumption is low."

Monitor energy

Depending on what has already been implemented in a plant, the first steps will require installation of a monitoring system for all equipment consuming energy. "In the short term, machine control systems can be updated to avoid energy consumption peaks," Schmudde says. "Coperion has already installed such systems to improve the energy management of the extruder heating up procedure. Longer term actions can include connecting machines from different production steps, such as material handling, extrusion and packaging. By collecting all the data in a centralised platform, the overall energy consumption can be managed and peaks leveled out. Combined with an OEE [overall equipment effectiveness] Tool, such as the one that Coperion demonstrated at the K show, single machines that waste energy can be identified and procedures for optimisation can be developed."

Coperion says it will launch this new OEE Tool this year. After identifying machines not operating efficiently, the software will offer solutions for improvement. Ultimately, by improving the operation procedures of each machine, overall energy efficiency will increase.

From a hardware point of view, Schmudde says it is always beneficial to invest in the latest machinery. "Often old machines cannot run processes in the most efficient way due to their lack of power or other features," he says. "In addition, developing optimised screw configurations for a compounding process can lead to a significant reduction in energy consumption, particularly because the extrusion process is one of, if not the most, energy consuming production step in a compounding plant. Such optimisation can also lead to an increase in output, which is an additional benefit for a plastics producer."

Schmudde says Coperion uses its own test laboratory to carry out optimisations. He says these have shown that improvements of 10-20% in energy consumption are not out of reach and can often be achieved through relatively minor changes in the machine configuration.

Optimise potential

"Energy resources and environment topics are increasingly discussed and therefore require that a plant is operated at its optimum level," he says. "It is always necessary to know the current state of a compounding plant in order to target the potential for reaching optimum performance with the lowest consumption of any utilities, principally energy. As well as energy, loss of material, reduction of off-spec material and highest levels for OEE will also automatically optimise energy consumption. Unused energy, such as heat convection losses, can also be used to reduce the total energy consumption of a plant. For example, hot water and steam can be used to heat offices or buildings efficiently."

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IMAGE: SHUTTERSTOCK

High friction results in increased wear, reduced efficiency and unwanted noise in many sliding plastics applications. Peter Mapleston learns how to solve the problems

Geared up for better wear performance

Plastics offer many advantages over metals in technical applications but one area where they can fall short is their resistance to wear. It is not just that plastics are typically not as hard as metals, but also that the entire physics of how plastic materials wear is not well understood. Tribology – the science of wear, friction and lubrication – is very well understood in the world of metals. However, when it comes to plastics the science is hardly out of its infancy. There is much is still to be learnt.

In terms of learning, the Wear-Resistant Plastics Conference in Dusseldorf last December (which was organised by *Compounding World* publisher AMI) provided a useful classroom. Dr Marcel Meuwissen, Senior Scientist Mechanical Properties at the **DSM Materials Science Centre** in The Netherlands, opened the event by pointing out that Amonton's law of friction, which holds that the Coefficient of Friction (CoF) in any given system is constant, is just not true. Down at the level of single asperities (surface irregularities) he said CoF may increase or decrease with increasing force, depending on how much load is applied and over how big an area, for example.

Meuwissen took a deep dive into surface science as he discussed the company's research into understanding abrasive wear of engineering plastics, especially polyamides. He concluded by saying that the links between intrinsic properties of polyamides and wear rate are simply not yet understood. "Wear and friction [are] strongly dependent on conditions at contact (pressure, temperature, surface topology, ...)," he said. "Indications are that wear is linked to toughness and fatigue, depending on testing conditions."

High-performance solid lubricants based on synthetic metal sulphides significantly improve friction and wear characteristics of engineering thermoplastics, according to lubricant supplier **Tribotecc**. Christian Schmied, who works in Development, Application Technology and Analytics at the company, provided an overview of

Main image: High friction surfaces contribute to wear and noise in plastic gear systems. Careful lubricant selection can minimise both

its products at the Dusseldorf event.

He explained that metal sulphides such as molybdenum disulphide (MoS_2), tungsten disulphide (WS_2) and tin sulphide (SnS_2) are good lubricants because they have a layer lattice structure, with layers of atoms bonded together by relatively-weak Van de Waals forces able to slide across each other easily.

Schmied illustrated his point with test results on various ETPs, including PPA, PPS, PEEK, and PI (polyimide). These results show how critical it is to match the additive to the polymer, but also provide evidence that when the system is optimised, improvements in tribological properties can be considerable. In a compound based on PEEK containing a new synthetic lubricant – SLS 22, based on tin disulphides and phosphates – it was possible to reduce average (over time) coefficient of friction (CoF) by as much as 40% and to also reduce wear by a similar amount.

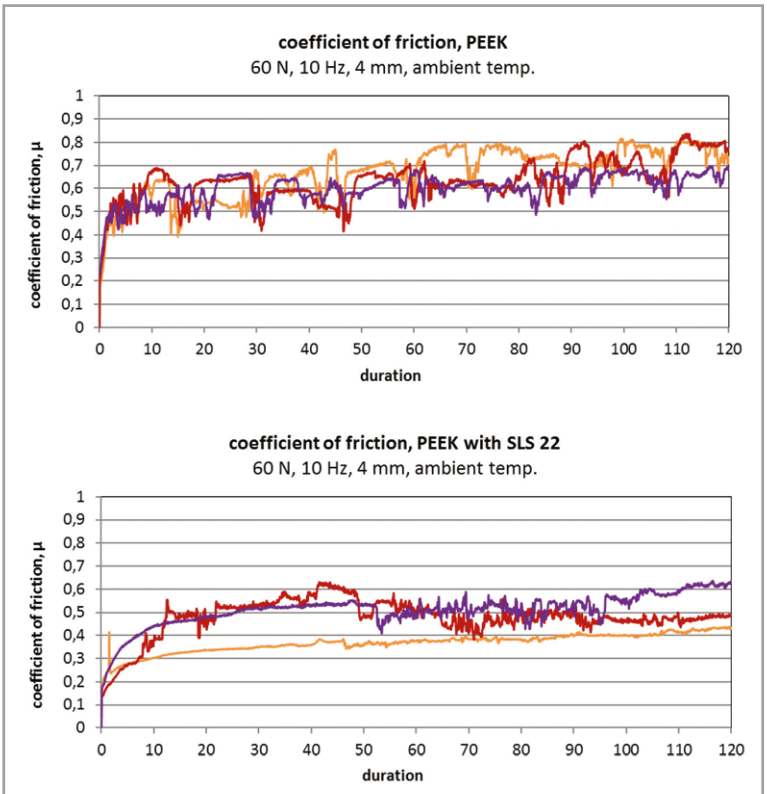

Figure 1 and 2: Effect of synthetic lubricant SLS 22 on CoF in various samples of PEEK (pin-on-disc tests)
Source: Tribotecc

Optimised selection

Graphite and other solid lubricants for improving friction and wear were discussed by Klaus Rathberger, Managing Director of **Georg Luh**, which specialises in graphite and mica additives. He compared the effects of MoS_2 with boron nitride and graphite and emphasised that selection of the optimum solution must be made according to the needs of the application (taking into account electrical and thermal conductivity, cost, colour, etc). "Graphite has high potential for modification according to specific application needs and combination of properties – lubrication + electrical and thermal conductivity," he said.

Researchers and students at **Luleå University of Technology**, in Sweden, are investigating the effect of various forms of nano-carbons on the tribological properties of high-performance plastics. Professor Nazanin Emami reported on some of the results, which showed a clear correlation between friction and wear reduction (Figures 3 and 4).

Slippery problems

Turning to the topic of lubricant combinations, Cayetano Espejo Conesa, a Teaching Fellow at the UK's **University of Leeds**, explained that one plus one does not always equal two when it comes to the use of internal and external types. In plastics-metal systems, polymers can be inherently self-lubricating due to the formation of a thin polymer-based transfer layer on the metal counter-face that improves tribological properties. Polymer self-lubricant properties can also be enhanced through internal lubrication, using such additives as MoS_2, graphite, silicones, nanophases, and also ionic liquids.

However, there is a potential problem when

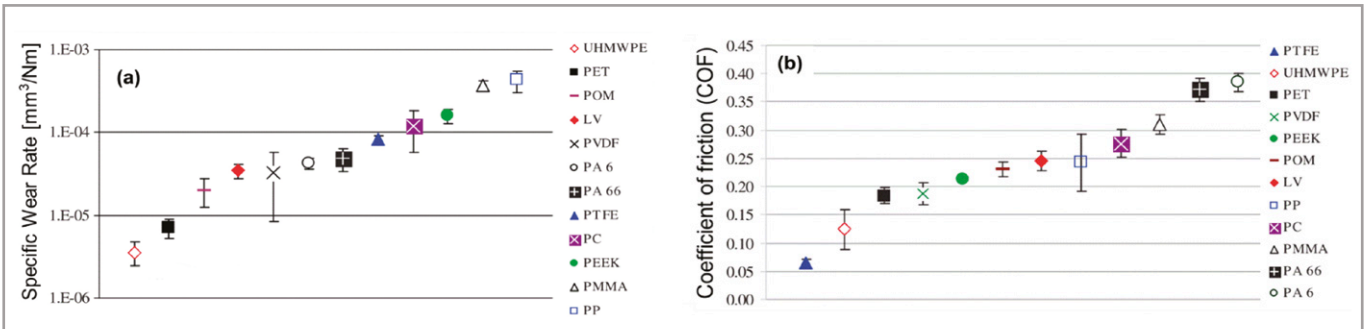

Figure 3: Averaged CoF and specific wear rates over a test period of 20 hours in water-lubricated conditions for a number of different polymers (Luleå University of Technology)
Source: Luleå University of Technology

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these lubricants combine. "Internal lubricants must have a synergistic effect with the transferred layer," he said. Equilibria can be affected by external lubrication, which may dissolve the transfer layer and/or replace it with a less effective lubricant layer. This can actually increase the CoF and accelerate wear, according to Espejo Conesa, who also discussed self-healing in polymer systems through phenomena such as viscoelastic recovery, migration of fillers, other particles in a matrix, and even induced polymerisation.

Omya OML is a new coated mineral processing aid from **Omya International** that is claimed to combine the value of a functional additive and mineral carrier. Franck Baradel, Market Manager Technical Polymer Applications describes it as a synergist for new technical compounds that can improve heat dissipation and flame retardancy as well as tribological properties. "Omya OML may partially substitute expensive lubricants in wear and abrasion resistant compounds (PTFE micropowder, MoS_2, silicone) while eliminating the break-in period, optimising processing (compounding, converting, demoulding) and limiting the fluoro-polymer content in the recipe," he says.

Tackling noise

Witcom, a supplier of high-performance engineering plastics compounds, has developed a range of internally lubricated thermoplastics that are particularly effective at keeping noise levels low. "Noise is caused by high frequency vibrations which in turn are the result of high speed fluctuation of the coefficient of friction over time. Our new compound formulations ensure that friction

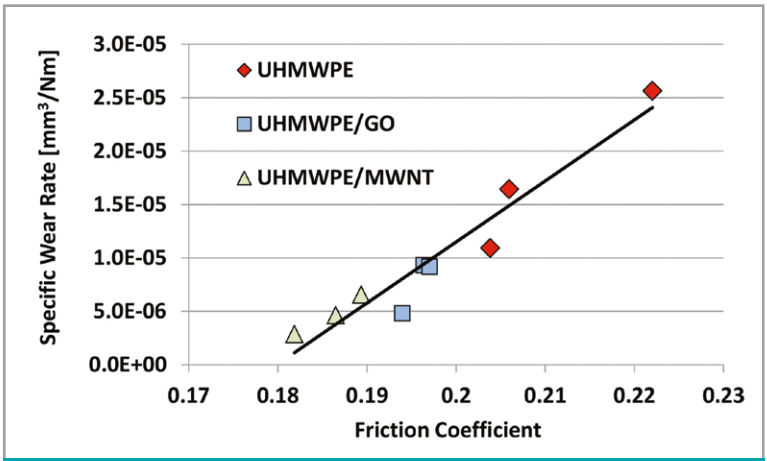
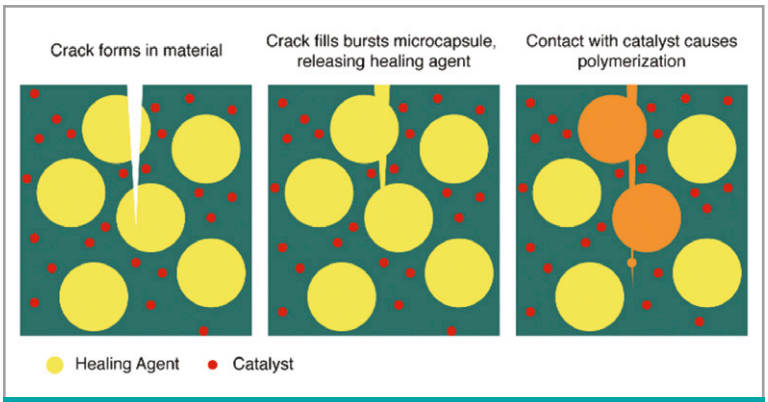


Figure 4: Graph showing the effect of multiwall carbon nanotubes (MWNT) and graphene oxide (GO) on wear and friction in ultra-high molecular weight polyethylene. The results show a simultaneous reduction of friction and wear with a direct correlation between the two. Measurements from pin-on-disc tests.
Source: Dr A Golchin at Luleå University of Technology



Cracks caused by wear can be "healed" by induced polymerisation, one of a number of self-healing micro-encapsulant mechanisms under investigation at the University of Leeds
Source: University of Leeds

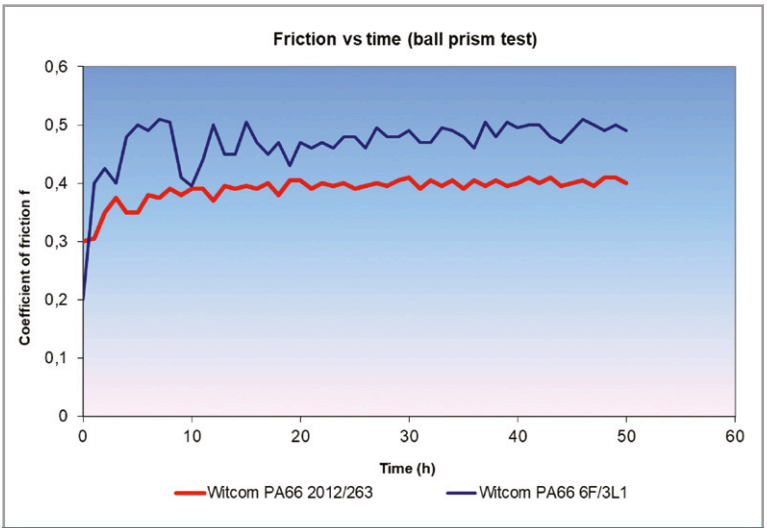


Figure 6: Witcom is working on improving the CoF over time of compounds as making CoF more stable reduces noise for both gears and bearings
Source: Witcom

remains extremely constant. This ensures very smooth-running bearings which are extremely silent," says Business Development Manager Christine Van Bellingen. The product range, recently extended, includes grades based on a wide range of polymers.

"Demand for these products has skyrocketed over the last few years, particularly because the automotive interior for electric vehicles is much quieter than before," Van Bellingen says. "The noise of an internal combustion engine would drown out sounds which have now become clearly audible."

Another growth area for Witcom is gear materials. Pieter Janssen, Chief Scientist Lubricated Materials, says: "Unlike traditional solutions, gears manufactured out of these materials have extremely low wear when paired against themselves. This means the entire gear train can be made out of a single material, reducing manufacturing cost and simplifying design."

Gear designers do need to be careful, though. As was noted several times at the AMI conference, POM components do not perform so well when paired with other POM parts in such applications.

Shifting a gear

Adnan Hasanovic, Technical Manager for Gear Actuators at **DSM**, explained recently in a blog how plastic gears can help to cut weight in vehicles. "For decades, scientists and engineers have focused on improving the materials used for gears while attempting to overcome several challenges, such as gear teeth breaking at the root due to fatigue, wear of the teeth at the flank, local overheating, too much noise, shock loading or hard stops, and noise vibration issues," he says.

"Today sintered metal gears are being replaced with high-performance plastic gears in automobiles because (of) the demand to lightweight vehicles and increase fuel efficiency (…) driven by meeting new and upcoming legislation to reduce emissions – so the research and testing to improve gear design continues."

Hasanovic cites the start-stop motor as an important application. These may perform as many as 350,000 starts over the lifetime of a vehicle, or up to 45m load cycles per annulus gear tooth. "DSM's Stanyl (PA46) meets these tough material requirements across a range of power ratings," he says.

To understand the theoretical and practical relationship between the application and the material's wear and friction properties, DSM runs various interfacial and environmental temperature tests. Its onsite gear tester validates material performance at an application level and correlates it with basic material properties, such as tensile strength, fatigue resistance and tribological properties.

Eurostar Engineering Plastics has been working with French automobile group PSA and with research outfit Cetim to minimise gear noise. Alexis Chopin, Technology Engineer at the company, explained at the AMI conference how "auto-lubrified" polymers can help reduce airborne noises in vehicles, which are typically generated by vibration of the surfaces as they rub against each other in, for example, mechanical joints. The sound waves are produced by variation in the frictional force generated at the contact between two surfaces.

"The variations in force of each contact and the number of contact asperities as a function of space and time are specific in the resulting friction force," said Chopin. "In the case where the other parameters are fixed, these variations are therefore

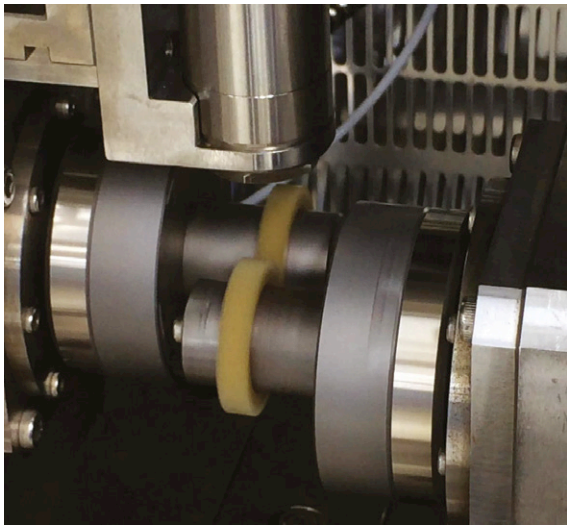


IMAGE: DSM

Right: Gear testing on DSM's test rig allows materials and gear wheel design to be optimised

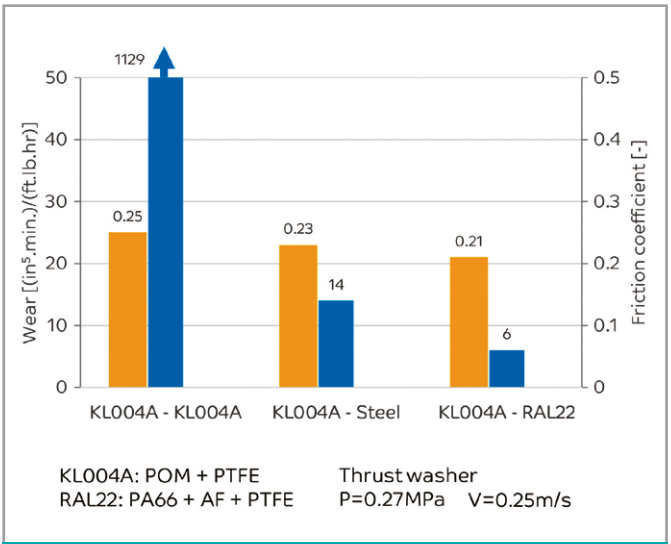


Figure 7: Wear results from tests depend considerably on what a material is rubbing against
Source: SABIC

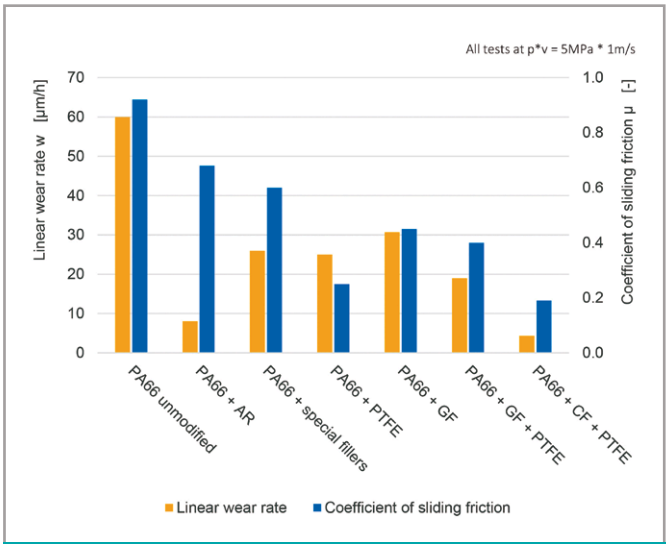


Figure 8: Typical wear and CoF performance for different additive and PA66 resin combinations
Source: Albis

characteristic of a pair of materials under given tribological loading conditions. The amplitude of these variations is defined as the excitation power." Eurostar and its partners wanted to evaluate the noise potential of different material pairings to avoid the risk of noise at the design stage of a shaft/bearing system.

Chopin says Eurostar has put considerable effort into adjusting wear and friction properties in its Star-L range of products, with a particular goal being to meet PTFE-free trends and developing REACH PTFE regulatory requirements. "One key patented innovation has been the development a new range of compounds based on halogen-free permanent lubricant based high molecular weight polymers," he said. The PTFE-free concept is said to have generated a great deal of interest and is now being requested by some E&E players for new developments to the EN50642 standard for Cable Management Systems.

"For certain products, PTFE remains a strategic raw material to enable low coefficient of friction. It is well known that PFOA (perfluorooctanoic acid), although not used as an intended raw material, may be detected in PTFE micropowders. REACH legislation taking effect on July 4 2020 requires less than 25 ppb PFOA level. Eurostar EP already anticipated this requirement and is already able to propose fully REACH-compliant Star L products," Chopin said.

Beating wear

LNP, a division of **SABIC**, has long been a player in wear resistant compounds. Erik Schwartz, Lead Scientist LNP copolymers T&I, explained that its Lubricomp grades are traditionally lubricated compounds providing wear and friction solutions, while its Lubriloy compounds use a proprietary, fully-compatibilised alloy lubrication system to provide non-halogenated solutions based on PA 66, PC, PPO, PPA and POM. The latter compound family offers various benefits over PTFE-filled materials, the company claims, including improved impact and lower density.

Wear and friction data for gears is usually based on plastic-steel contact measured in a standardised thrust washer test, which runs at room temperature with constant pressure and velocity, Schwartz said. The problem is that, with plastics, wear and friction coefficients are influenced by many parameters, including external lubricant, surface roughness, temperature, contact pressure, sliding velocity, and more. For this reason, and this was a message repeated by several speakers at the AMI conference, materials for wear applications need to be chosen on a case-by-case basis.

Albis is another compounder offering a wide range of options in wear and friction properties. Karolina Smrczkova, Product Specialist for the company's Business Line Specialties, spoke about the different effects of various additives in PA66 compounds. Generally, among Alcom WP compounds for gears, she said aramid fibres improve wear properties, glass fibres improve wear and friction, silicones and PTFE have a positive impact on wear and friction coefficients, and carbon fibres reduce wear rate significantly (this is summarised in Figure 8).

Providing some general indications for the use of plastics in wear applications, Smrczkova advised:

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Figure 9: Typical performance of different polymers in wear applications

Polyoxymethylene (POM)	Polyamide (PA6, PA66)	Polyphenylene sulphide (PPS)
■ Lower thermal stability than PA	■ **Dimensional change** of PA due to swelling has to be considered	■ Dimensionally stable
■ **High shrinkage**, but dimensionally stable	■ Compatibility of PA towards lubricants has to be checked	■ Shrinkage depends on crystallinity and operating temperature
■ Glass fibres **bond poorly** in matrix	■ Higher thermal stability than POM	■ Very little water absorption
■ Fibres breaking out on surface cause higher abrasion		■ Works **very well** in and under water, especially combined with carbon fibres
		■ Appropriate for applications in medium, very good chemical resistance

Source: Albis

crystalline thermoplastics are more suitable for wear applications; pairing of the same polymers in dry running applications should be avoided; smooth metallic surfaces are suitable for POM; rough metallic surfaces are more suitable for PA; glass fibre reinforcement increases abrasion on the sliding partner; electrical conductivity has to be considered when using carbon fibre.

Braking innovation

Independent compounder **Lati Industria Termoplastici** has a range of low friction and wear resistant grades branded Latilub. Luca Posca, Technical Assistance & Marketing Director with the company, says its Latilub 62-02M compound based on a modified PA6 containing MoS_2 and proprietary lubricants has proved superior to a PA12 containing MoS_2 in a cable coating for a new drum brake for Continental Brakes Italy. The 62-02M grade has been shown to offer better heat resistance and also costs less.

Below: Squeaks in air vents can be prevented using new modified ABS-based grades from ELIX Polymers

IMAGE: ELIX POLYMERS

Last year, **ELIX Polymers** introduced some new anti-noise materials for key applications, mostly but not exclusively in automotive interiors. The specialty grades of regular and high-heat ABS, PC/ABS and ABS/PC are said to reduce squeak and rattle generated by the contact of plastic parts with other plastics parts, as well as with leather and other products. Typical auto parts affected by this include door handles, seating, cup holders, and air vents, according to Fabian Herter, Industry Manager Automotive at the company.

The new grades have been submitted to stick-slip tests according to VDA 230-206 at several automotive OEMs. These were conducted with different forces (10N, 40N) and speeds (1mm/s and 4mm/s) at several temperatures. Results are given on a 10-point scale, where 10 is the worst behaviour, and all grades scored 1.

Herter says the new compounds provide the same key performance and processing properties as regular grades, so new approvals at OEMs are not needed. Significant cost savings are possible, he says, because fabrics or grease that have in the past been added to component systems afterwards to reduce squeak and rattle are no longer needed.

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IMAGE: SHUTTERSTOCK

Electrically conductive plastics far from static

As electronics penetrate further into every aspect of modern life demand for electrically conductive polymer compounds is on the rise. Peter Mapleston looks at latest developments

Electrically conductive thermoplastic compounds now play an important role in industries where static accumulation, electrostatic discharge (ESD), or electromagnetic interference (EMI) are critical for the safety and performance in the applications they enable. Examples include high-end packaging, electronic and electrical equipment, automotive systems, or medical technology components. To address the specific requirements in those applications, various conductive fillers – including carbon black, carbon nanotubes, and carbon fibres as well as metal flakes and whiskers – have been used in a wide range of compounds, with electrical properties tailored to specific needs.

Nanocarbon technology is becoming a key enabler in development of technologies to improve electrical conductivity in thermoplastic compounds, and we look at some of the latest developments below. But not everything is nano. In the era of the Circular Economy, scraps from production of continuous carbon fibre reinforcements for composites are being put to good use in new applications – and one important example could be conductive compounds. And in the antistatic area, interesting progress can also be seen in the use of hydrophilic thermoplastic elastomers.

Graphene nanotubes (also known as single-wall carbon nanotubes, or SWCNTs), produced by **OCSiAl** under the Tuball brand, can deliver a unique combination of conductivity, colour and strength to polymers. This is due to their ability to connect with each other to create a conductive, flexible and strong 3D network inside the polymer. This effect comes at nanotube addition levels as small as tenths or even hundredths of a percent in the overall compound.

OCSiAl's SWCNTs are 100 times stronger than steel, very conductive (comparable with copper, but five times lighter) and highly flexible. The company claims to be the world's largest producer – its current production capacity stands at 75 tonnes/yr and it plans to start up what it says will be the world's largest graphene nanotube synthesis plant in Differdange, Luxembourg, in 2023. It already has two Tuball technical centres in China and Russia, with the next Tuball Centre due to open in Luxembourg around now.

The company says Tuball nanotubes are finding their way into applications as an anti-static and reinforcing additive in epoxy, polyester, vinyl ester, silicones, rubbers and thermoplastics. It cites glove coating, conveyor belts, flexible ventilation ducting, artificial leather, and electrostatic dissipative (ESD) flooring. "Adding 0.25-2.0 wt% of Tuball Matrix 814 beta nanotube concentrate to a PVC plastisol formulation results in stable and homogenous

Main image: Electrically conductive plastics provide essential protection to electronic equipment and avoid potentially catastrophic device failure

IMAGE: OCSIAL

Right: OCSiAl's conductive additives promise to make the playground less or a hair-raising experience

surface resistivity of 10^9-10^5 Ohm/sq while maintaining colour and mechanical properties of the final product," says a company spokesperson.

Another recent application for graphene nanotubes is in polyethylene rotomolded products, such as containers for flammable liquids and powders, children's slides, and oil separators where permanent and uniform anti-static or conductive properties are essential for safety reasons. The standard working dosage in such applications is typically around 0.5-1.0% of nanotube concentrate for achieving 10^6-10^9 Ohm/sq surface resistivity.

OCSiAl says it is also in the development phase with a number of new product grades, including some suitable for engineering polymers, that can meet the requirements of injection moulded conductive parts typically needed by the large volume automotive and electronic industries.

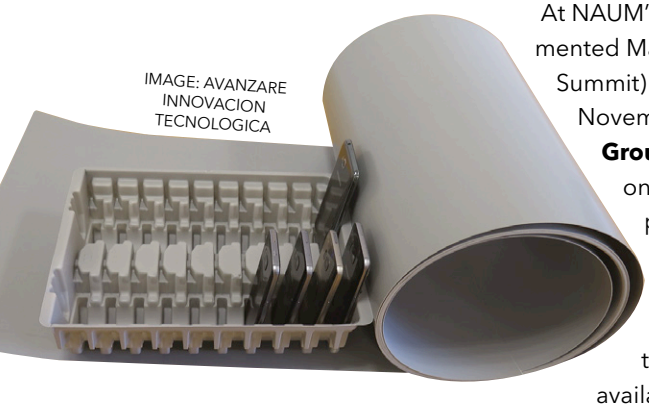

IMAGE: AVANZARE INNOVACION TECNOLOGICA

Above: This electronic packaging tray in HIPS was developed by Portuguese company VFplas using Avanzare additives

At NAUM'19 (the Nanoaugmented Materials Industry Summit) in Kyoto, Japan, last November, the **LehVoss Group** presented results on improving the performance of PA6, PA12, PPS and TPU with graphene nanotube formulations that are now available on a commercial scale. The company claims, for example, to be the first to offer an electrically conductive TPU for 3D printing that retains its flexibility and mechanical properties. Materials are available for both power bed fusion and FFF 3D print technologies. "If you think about applications, these are carriers, trays, housings, switchers, containers and medical equipment," says Marco Burth, LehVoss Group Product Development Manager.

Nano masterbatches

Nanotechnology company **Avanzare Innovacion Tecnologica**, which is based at Navarrete in Spain, says it is paving the way in developing nano-additive masterbatches that enable high electrical and thermal conductivity in thermoplastic components. It offers a complete series of colourless permanent antistatic additives and masterbatches suitable for applications such as packaging, electronics, technical flooring, and ATEX parts.

IMAGE: LEHVOSS

Right: Checking an electrically conductive Luvocom PEEK compound produced by LehVoss

The company cites its Avandiss-232 masterbatch for HIPS and PS as an example. It is said to be suitable for production of non-black electronic components or packaging materials with a range of electrical resistivity from 10^9-10^6 Ohm/sq.

Another example is its range of electrically conductive (10^{-1}-10^1 Ohm/sq) EVA thermoplastics that also provide thermal management. These solutions are based on "graphene related" materials, which are processed by Avanzare into masterbatches. The company also produces heatable compounds that can be employed for flooring using low voltage current. "The use of this low voltage and the very low electrical resistance of the developed plastic allows the generation of heat and the transfer of this to the tile and therefore generate a radiant floor of low consumption," says Javier Perez, CCO at Avanzare. Heat dissipation from a hot element has also been demonstrated.

Another supplier with long experience in nano additives is **Nanocyl**. It says that over the past five years, electrically conductive compounds containing its Plasticyl NC7000 multiwall carbon nanotube (MWCNT) masterbatch "have become the market technical benchmark in various industry segments." It says market share of the materials have significantly increased in automotive (fuel systems and exteriors), electronic packaging (HDD trays) and industrial applications.

"More recently, the demand for electrically conductive solutions has surged in new market environments," says Michaël Claes, Chief Technology Officer at Nanocyl in Sambreville, Belgium. "Most notable ones are harsh environment dedicated products (ATEX regulation), specialty cables and additive manufacturing."

He also points to developments in the area of

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Right: Cabot says its CNS compounds are less dusty and easier to process than traditional CNT alternatives

3D printing. Interest in filament-based 3D print technologies (such as FDM and FFF) has boomed over the past few years but Claes says the conductive market is still in its infancy, mostly because of dispersion issues and degradation of mechanical properties. Nanocyl now has products targeted at this market that he says exhibit superior dispersion and properties (high electrical conductivity level at low loading, good mechanical properties, and very good processability).

Meanwhile, in more traditional markets such as specialty cables NC7000-based solutions are being used to replace the conductive (copper) or dissipative layer, imparting better flexibility, lightweight and increased manufacturing throughputs, says Claes.

"With the strengthening of ATEX standards, electrically conductive materials are now a must-have for more and more industrial applications – physical grounding is less and less accepted by the standards and therefore a truly conductive material is now necessary. NC7000 based compounds are a unique solution to impart such properties without affecting any other performances," he says.

Alternative structures

Cabot Corporation recently expanded its portfolio of advanced carbons to include Athlos carbon nanostructures (CNS), a family of materials the company claims are unique and which consist of a network of crosslinked carbon nanotubes manufactured using a proprietary process it acquired from Lockheed Martin back in 2018. It says they enable an optimal balance of electromagnetic interference (EMI) shielding, conductivity, mechanical strength and processability.

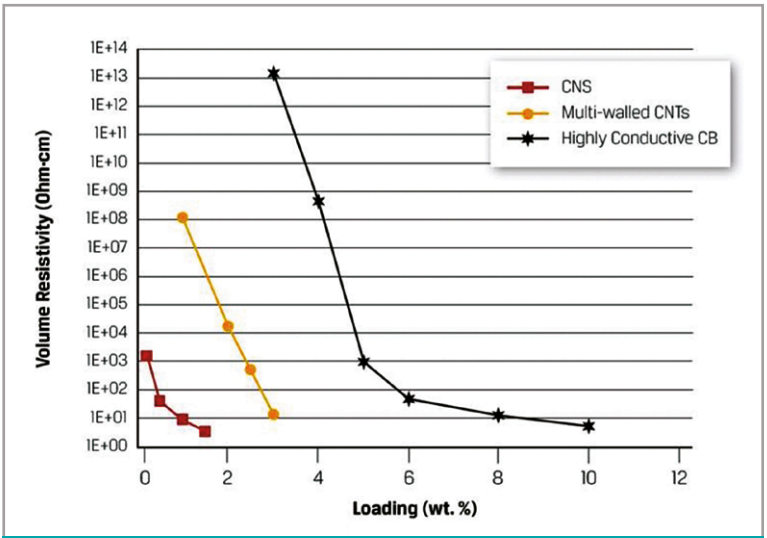

Figure 1: Chart showing typical compound volume resistivity at various loadings of highly conductive carbon black (CB), multi wall carbon nanotubes (MWCNTs), and carbon nano-structures (CNS)
Source: Cabot Corporation

IMAGE: CABOT CORP

"Athlos CNS deliver unmatched EMI shielding performance relative to other carbon additives," the company says. "The addition of Athlos CNS to EMI shielding solutions enables significant lightweighting and miniaturisation advantages by replacing or reducing the loading of traditional metal-based alternatives. Additionally, using Athlos CNS can improve industrial hygiene compared to other conductive carbon additives by reducing dust contamination during processing."

CarbonX, which makes a conductive porous carbon material of the same name, says it has experienced "exponential" growth over the past 12 months. After ramping up accessible capacity from 50 to 200,000 tonnes/yr, it says it has now entered a commercial phase with five key grades currently on offer. These grades differ in terms of basic properties such as surface area (ranging from 44 to 189 m^2/g) and pore size. CarbonX has also partnered with carbon black production facilities in China and the US.

The material, developed within the chemistry laboratories of Delft University of Technology in The Netherlands, enables lightweight, isotropically electrically and thermally conductive solutions for plastic materials. Compared to "regular" carbon black, CarbonX says its particles are smaller and display a narrower size distribution while aggregates have higher pore strength.

Carbon-X materials comprise chemically-linked nano-fibres formed into a 3D-network, which the company says allows for good mixing and a good interaction with many polymers. The materials are said to provide similar strength levels as glass fibres in formulated compounds.

"We believe more and more challenges in the thermoplastic market will come from the implementation of the Industrial Internet of Things and automobile electrification," says Roberto Calderone, Head of Marketing at the company.

The rapid development cycles typical of these

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IMAGE: PROCOTEX

Right: Milled carbon fibre produced by Procotex from composite waste

industries are already leading to a tension between design parameters that a multifunctional material such as CarbonX has the potential to solve, Calderone says. Key material properties such as high crystallinity, strong pores and excellent processability is said to result in an unusual combination of reinforcement and conductivity features in the compound. "At the same time, processability is never compromised, so for example conductive films with a thickness down to 20 µm can be fabricated," he adds.

Calderone says that, together with its commercial partners, CarbonX has recently developed some new applications in the field of EMI shielding. "For example, when mixed with CarbonX, PA6 compounds can achieve shielding effectiveness of 60dB in the range 1-10GHz, while reinforcement is 50% better than when using other conductive carbon fillers."

Recycling ideas

Hans Miltner is Senior Consultant and Business Development Manager with **Procotex** in Dottignies, Belgium, which specialises in processing recovered carbon fibres. "Today, conductive polymer compounds are believed to be on the verge of a much wider global utilisation, with volume demand forecast from mainstream markets and applications in the near future," he says. "Especially the automotive industry is now rapidly driving their adoption, as the ongoing electrification and the development of autonomous driving are putting new requirements to the materials that are used."

Carbon fibre as a reinforcement offers unrivalled mechanical performance and durability with low weight for critical applications that include aerospace structures, he says, but the manufacturing of carbon fibre composites and parts also comes with a significant amount of production waste. Close to a third of all carbon fibre produced ends up as waste in the form of trim in composite production, and much of that ends up in landfill.

Miltner says recycled carbon fibre will mainly target markets other than aerospace where the favourable performance/cost ratio provides a better value proposition compared to incumbents, including virgin carbon fibre. "Compared to alternative conducting fillers, recycled carbon fibre can offer equivalent electrical and superior mechanical performance, up to competing with virgin carbon fibre at 30-50% lower cost. Its overall CO_2 footprint is lower than that of any of the virgin alternative solutions, including carbon black," he says.

Data for a PA66 compound with a recycled carbon fibre content as low as 10% shows property levels typical for a 30% glass-filled material but with a 15% lower density and additional antistatic or static-dissipative behaviour (depending on the type of fibre used). "Further increasing the carbon fibre content to 30% results in a 150% higher specific stiffness and a 65% higher specific strength than an equivalent glass-filled compound, but with conductive or EMI-shielding behaviour," Miltner says.

Future developments at Procotex are dedicated to improving handling of the recycled carbon fibre products, as well as maximising achievable performance levels in polymer compounds. "To comple-

PolyOne's Surround family of conductive compounds are designed to shield sensitive electronics from both electromagnetic (EMI) and radio frequency interference (RFI), minimising the risk of "cross talk" between electronic components. The company says the compounds (formerly marketed under the ElectriPlast name) weigh up to 60% less than aluminium or copper and provide greater design freedom. They can be formulated with either stainless steel or nickel-coated carbon fibres.

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IMAGE: POLYONE/THINKSTOCK

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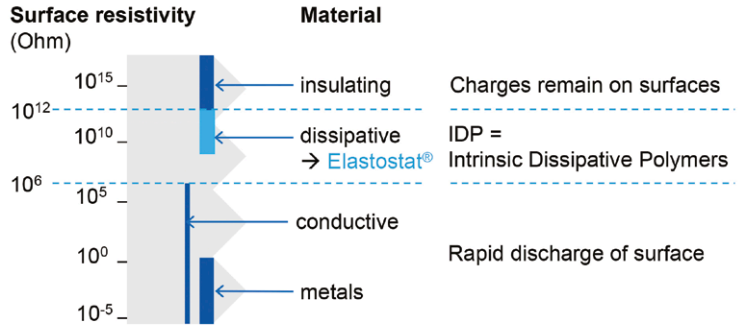

BASF's Elastostat antistatic masterbatches can achieve surface resistivity levels of 108-109 Ohm
Source: BASF

ment the current 300µm range, Procotex is now also developing granulates with a carbon fibre length of 1mm to offer even higher conductivity and improved reinforcing capacity along with accurate, dust-free handling and high filler dispersibility," he says.

With the automotive industry in mind, Procotex also plans to offer carbon fibre products with a sizing developed specifically for a polypropylene matrix. "Initial study results not only show increased stiffness, strength and electrical conductivity of the reinforced materials, but also highlight the remarkable retention of low-temperature impact performance," Miltner says.

Polymeric antistats

As already demonstrated, there are numerous ways to achieve antistatic properties in compounds and it is not always through the use of particulate additives. An alternative option involves addition of thermoplastic elastomers such as the Pebax polymers from **Arkema**. These thermoplastic elastomers comprise a hard polyamide segment and a soft polyether segment. Grades for antistatic modification use a polyether that is hydrophilic – picks up water – which increases its electrical conductivity.

Traditional Pebax grades are made with a hard segment in PA6 or PA12. A new antistatic grade, however, contains PA11 sourced from castor plants, making it partially (41%) bio-based. It was introduced at the Conductive Plastics 2019 conference organised by *Compounding World* publisher AMI last October in Vienna.

The new Pebax RNew 30R51 grade is suitable for use in biobased polymers such as PLA, says Market Development Manager Clio Cocquet. It also has the extra benefit that its refractive index has been tuned so it can be used in acrylic (PMMA) without affecting transparency. Typical applications include cosmetic packaging, furniture and lighting, where the additive helps reduce the attraction of parts to dust.

Arkema is currently ramping up capacity for bio-PA11. It is building a world-scale bio-based production plant in Asia, which will provide it with substantial extra capacity for making the new antistatic Pebax. The new plant should come on stream in late 2021.

BASF also has a TPE-based antistatic offering, but in its case it is a polyurethane – Elastostat 10-02 – which it supplies in masterbatch form. Current applications include PP buckets for chemical waste, HDPE intermediate bulk containers, and polystyrene transport trays for microchips. Future possible applications include blown film. A more recent development, Elastostat 15-01, is for use in other TPUs. One application is hoses that require EU food contact approval, but BASF is also targeting transportation belts and shoe soles.

Serving up ideas

Carlos Caro is Project Leader at **Grafe Polymer Solutions** in Blankenhain, Germany. "For two decades we have been serving the market in the field of electrically conductive compounds for the production of things like storage boxes in automatic warehouse systems where sensitive parts are handled or where unexpected electric discharges need to be avoided for safety reasons," he says.

"In the last years we have been seeing a switch for two kind of applications : either for low cost products or for high performance ones. In order to improve the mechanical properties of the whole compound low cost electrically conductive compounds contain a certain amount of recycled and/or regranulated resins paired with new, virgin polymer. The quality of this recycled material and the ratio of new resin are crucial for the quality of the whole compound influencing the final price of the product," he says.

The volumes for these relatively low-cost compounds are high but the competition is tough, says Caro. "Our job as a compound producer is, therefore, to find the perfect balance between material costs and quality in terms of mechanical properties."

Meanwhile, although the quantities and consumption in high performance applications are smaller in comparison to low-cost ones, Grafe's flexible middle scale production and laboratory capacities allow it to develop and produce customised materials for many projects in a faster way, Caro claims.

Masterbatch specialist **Colloids** has undertaken a development programme to improve the performance characteristics of its E-Tec range of electrically conductive products. E-Tec grades, based on both commodity and engineering polymers, offer customers enhanced electrical

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IMAGE: COLLOIDS

Right: Colloids has been optimising performance of its E-Tec range of electrically conductive products

performance for film, sheet and profile extrusion, injection moulding, vacuum forming and closed cell foams.

The programme was initiated to establish where and how improvements could be made to all aspects of the product development cycle. The aim was to improve performance in terms not only of electrical conductivity, but also customer product manufacture and functionality, mechanical property retention, and economics.

The additive system used in the E-Tec range is mainly carbon based; selection determined by the level of permanent electrical conductivity required, base polymer and end application. Each product in the E-Tec range has been targeted at particular polymer conversion processes and market application areas.

New additions to the range include bespoke electrically conductive polymer specific concentrates formulated to individual customer's requirement as well as synthetic and graphite-based, graphene conductive compounds.

Formulations were developed based on the need to ensure easy manufacturing, including good dispersion of the conductive additive. Emphasis was not only placed on the selection of a conductive additive with the correct functionality on the particle surface, but also on the additives required to assist dispersion, as well as stabilise the compound. Developing and retaining the mechanical characteristics of the base polymer, with the possibility of rheology modification, was also considered.

"The compounding phase is critical to the success of the electrically conductive compound," says Shazia Akhtar, Senior Analytical Chemist at Colloids. "During the development process, the choice of main compounding method, control of shear development by adjusting mixing screw geometries and feed characteristics, along with other processing factors such as residence time, were established for each individual formula."

Akhtar says formulation and compounding technology are critically important.

"Conductive additives need to be dispersed to an optimum level to reach the percolation threshold at the lowest concentration for a given electrical conductivity requirement. The lower the concentration of conductive additive, the less of a detrimental impact it will have on the mechanical characteristics of the final product. The dispersion characteristics must be carefully monitored to ensure that the conductive network is not destroyed by excessive mixing."

Specialty compounder **Witcom** claims one of the broadest range of carbon powder-modified conductive compounds, based on polymers ranging from polyolefins to high temperature plastics. Recent additions include PES and PBT. Christine Van Bellingen, Business Development Manager Conductive Materials says: "The key breakthrough here was to come up with formulations that have sufficient impact strength."

Van Bellingen sees considerable opportunity in the growth of radar-based autonomous driving technologies in the automotive sector, such as adaptive cruise control and collision detection. She says Witcom, part of the Wittenburg Group, has been at the forefront of radar-absorbing materials for more than 10 years. New developments at the company include materials that offer thermal conductivity as well as radar absorption, and materials that offer absorption over a wider frequency range.

IMAGE: GRAFE

Below: Grafe's conductive range includes antistatic masterbatches to prevent dust build-up

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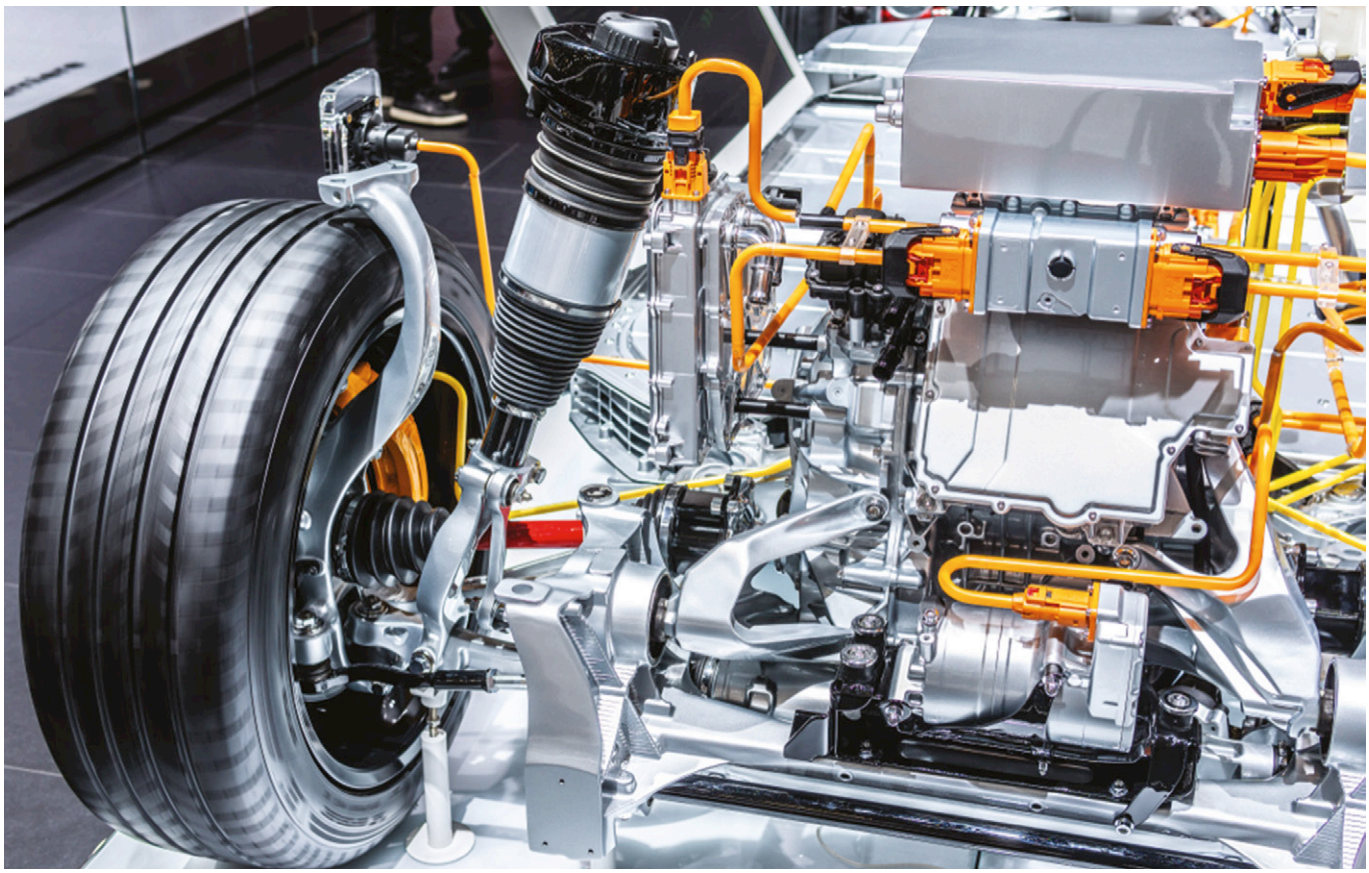

IMAGE: SHUTTERSTOCK

Preparing PA for a new age

Alternative drive technologies in automotive and the move to high powered connectors in E&E mean polyamides are facing ever more stringent demands, writes ***Jennifer Markarian***

Polyamides are entering a New Age in terms of application. This versatile family of polymers is already a key option for satisfying demand for lightweight and high performing thermoplastics in sectors such as automotive and electrical and electronic (E&E). These demands continue to intensify, while a growing focus on sustainability and the dawn of the Circular Economy means recycled polyamides must be upgraded to match virgin polymers and bio-based materials are being considered.

End-users are looking for ways to improve their sustainability profile and suppliers are obliging them. Bio-based polyamides sourced from castor bean oil – examples include Arkema's Rilsan PA11 and DSM's EcoPaXX PA410 – have been used for many years, but these product lines are being expanded. **DSM**, for instance, announced at K2019 that it will offer a full range of alternatives to its existing engineering plastics products containing at least 25% bio and/or recycled-based materials by 2030. One of the company's first moves in this direction is Stanyl PA46, a high-performance aliphatic polyamide manufactured using a mass-balance approach of bio-based feedstock and available with the ISCC Plus sustainability certification (mass-balance apportions bio-based feedstocks to the process to give a claimed bio-content in the final product). Another example is it's Akulon RePurposed, a PA6 sourced from discarded fishing nets.

Ford Motor Company, which has researched the use of natural fibre composites and bio-based foams over many years, is pushing towards the use of recycled PA6 or 66 as more sources become available, says Alper Kiziltas, Ford's Technical Expert for Sustainability and Emerging Materials. The company is also investigating use of biobased PA610. A collaborative project between Ford and

Main image: Cars of tomorrow will use different drive systems and that means a whole new set of material demands. Polyamides are stepping up to the mark

Right: Clariant is using bio-derived feedstocks from Neste in its Exolit OP Terra additives

the Department of Mechanical Engineering at the University of Michigan-Dearborn in the US is looking at the damping behaviour of melt-compounded graphene or cellulose reinforcements in PA610.

Upcycling opportunities

"Upcycling" of polyamides – recycling into performance applications – is possible through the use of a targeted combination of additives, including heat stabilisers, processing stabilisers, flow enhancers, nucleating agents, and others, according to additive supplier **Brüggemann**. These are needed because polymers that have already seen multiple heat histories and processing steps may not have the optimal viscosity for their next intended use. Appropriately selected additives can be used to either increase viscosity (to lengthen chains and increase molecular weight) or decrease viscosity.

Chain-extension additives compensate for the reduction in molecular weight resulting from degradation in use and reprocessing. Brüggemann's Bruggolen M1251 allows linear chain extension to occur during compounding and is claimed to be able to improve the mechanical properties of the recyclate to match those of prime material. Bruggolen M1253 is a smaller pellet size version of the same additive that is easier to dose during compounding.

The company's Bruggolen TP-M1417 additive, meanwhile, can be used to shorten excessively long molecular chains in high viscosity polyamide waste such as films or cast nylon. This decreases the viscosity to bring the resins back to the injection moulding viscosity range. The final viscosity can be accurately controlled by adjusting the quantity added. Compounds produced using this modifier "exhibit excellent mechanical properties and are suitable for the same applications as prime materials of similar viscosities. This removes the need to blend the recyclate with prime polymers," says the company.

IMAGE: NESTE

A place for FRs

A recent collaborative project between **Clariant**, **Fraunhofer LBF** and **PINFA** showed that glass-fibre reinforced polyamide containing Clariant's HFFR Exolit OP1400 flame retardant could maintain a UL 94 V-0 rating after being recycled multiple times. The results showed that while mechanical properties dropped after multiple cycles, the formulas containing OP 1400 were comparable to those containing no flame retardant, indicating that it does not negatively affect properties. The property decrease was rather attributed to loss of glass fibre length; flame retardancy was maintained. The results are important for companies looking to make use of production scrap and post-consumer recyclate, according to Clariant.

PA recyclates containing bromine-based FRs also fared well in studies. **ICL-IP** says it has investigated the suitability of its bromine-based flame retardants for production of PA66 compounds intended to be recycled. After five cycles of injection moulding followed by mechanical recycling, with each subsequent cycle comprised of a 50/50 blend of virgin and recycled compound, the PA66 compounds containing brominated FRs exhibited higher Izod impact strength initially and displayed a lesser decline on recycling compared to compounds containing a halogen-free FR,

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IMAGE: SHUTTERSTOCK

Above: Electric vehicle parts may need to meet the same fire standards as home appliances

according to the company's studies.

The concept of bio-based polymers is becoming fairly well established; now additive suppliers are turning their attention to more sustainable products. **Clariant**'s Vita range of additives are based on non-food competing rice bran wax feedstocks. They are designated as products from natural origin with at least 98% renewable content – meaning a 0.98 renewable carbon index (RCI). Licocare RBW 360 TP Vita, for example, is a multifunctional additive suitable for lubrication and nucleation in polyamides and other engineering plastics, so providing potential cycle time reduction opportunities.

The company's new EcoTain-labelled dispersing agent, Ceridust 1060 Vita, which is also based on rice bran wax, is said to improve pigment dispersion in plastic parts made with PA and other polar engineering thermoplastics.

Automotive moves

In addition to the drive for sustainability, technology trends in the automotive market are also affecting polyamide additives. Ongoing changes in automotive technology – such as the move to electric power trains – will lead to higher requirements in terms of flame retardancy, thermal conductivity, and shielding from electromagnetic interference (EMI), according to Tamim Sadiki, Global Marketing Director for **DSM Engineering Plastics**.

EMI shielding is independent of the polymer matrix and depends only on the additive type, its amount, and its alignment in the polymer, says Sadiki. However, although the polymer type does not affect EMI function, the interface between the polymer and additive does have a major effect on the mechanical strength of the compound, he adds.

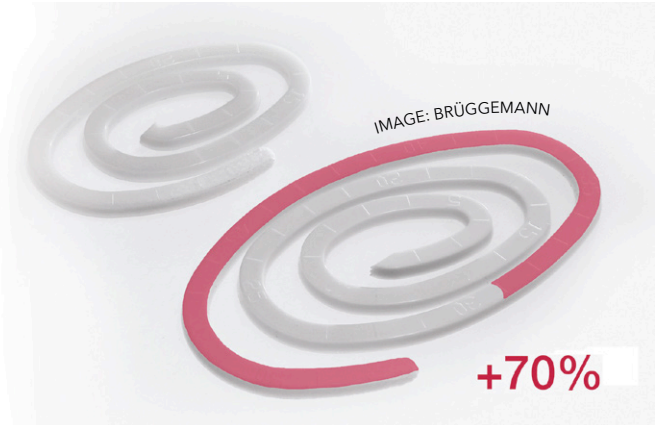
While flame retardancy requirements in passenger cars are not as stringent today as some other areas of transportation (notably railways and aircraft), the car of the future will be different, resulting in more use of flame retardants, predicts Sadiki. "With the move towards electrification in combination with high voltage charging, people will increasingly charge their cars in the garage at home, typically overnight. A car should be treated similarly to an unattended appliance product, which needs to meet UL94-V0 requirements. My expectation is that all parts which are in the high voltage charging path of an electrical car will change to UL94-V0 in the future."

He acknowledges that the drawbacks of such a change would be the potential for increased cost and weight and more challenges to mechanical performance. "The industry will need to find a balance between economics of design and safety/reliability aspects. My bet is that safety will win," Sadiki says.

Lightening up

Increasingly stringent carbon dioxide emission standards and the introduction of electrical drives and heavy batteries are driving further lightweighting moves, which will be met by switching from metals to plastics or by making current plastic components even lighter, according to Dr Klaus Bergmann, Head of Polymer Additives at **Brüggemann**. "High performance flow enhancers and heat stabilisers are paving the way for aliphatic polyamides achieving these high demands in applications that were previously reserved for metals and special resins such as PA46 or polyphthalamides," he says.

A new flow enhancer from the company, Bruggolen TP-P1810, is designed for semi-aromatic polyamides while Bruggolen TP-P1507 is already used for aliphatic polyamides, including PA6, PA66 and PA12. Supplied in pellet form for dosing during compounding or injection moulding, the additives are claimed to improve melt flow while retaining mechanical properties in finished components. In trials carried out for Brüggemann by independent process and testing specialist RJG Technologies, TP-P1810 was found to enable a greater than 20% cycle time reduction during moulding. Spiral flow of a semi-aromatic polyamide



Right: Bruggemann's Bruggolen TP-P1810 dramatically improves flow in semi-aromatic PA grades

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Right: BYK-MAX CT 4260 FR allows HFFR flame performance to be met at reduced filler levels

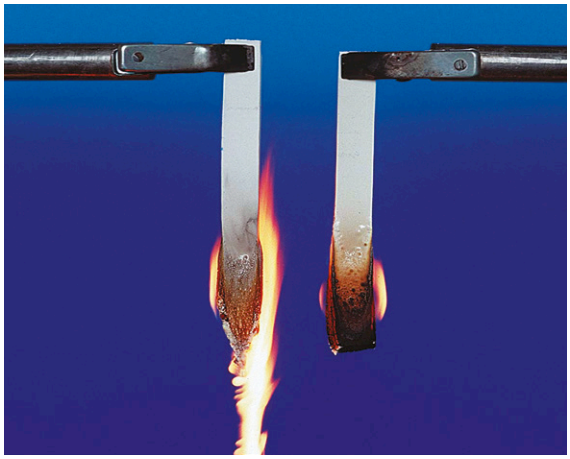


IMAGE: BYK

reinforced with 50 wt% glass fibre was extended by 70% using a 1.5% addition of the flow enhancer, with a resulting improvement in the ability to flow in complex shapes.

Brüggemann's heat stabilisers include TP-H1805 for higher temperatures, such as found in turbocharged engine applications, and TP-H1607 and TP-H1803 for longer mechanical performance retention times at different temperatures. Bruggolen TP-H1803 Phenolic Plus is a new heat stabiliser for polyamides designed for applications where the part is primarily exposed to temperatures below 150°C but that reaches short-time peak temperatures of up to 180°C, says Bergmann. Its ability to withstand these higher peak temperatures is an advantage over conventional stabiliser blends produced with hindered phenolic antioxidants and organic phosphites, he says.

Phenolic Plus is supplied as easily dosed and dispersed, dust-free pellets. According to Brüggemann, it can be used at lower dosages than conventional phenolic/phosphite blends to achieve the same level of effect. Applications with continuous exposure to temperatures above 150°C do call for the use of copper-based stabilisers, says Bergmann.

Burning issues

Joerg Garlinsky, Head of Global Enduse Thermoplastic Industrial Applications at **BYK**, says that the trend towards hybrid engine technology, which uses downsized combustion engines that result in higher heat generation, increases the need for performance additives in the engine compartment. He adds that in the long-term, if e-mobility becomes established as expected, demand may shift to additives for battery housings, which also have high requirements for stability.

Flame retardancy is already critical for many polyamide end-uses, including transportation and electrical and electronic (E&E) applications. New synergists aim to improve halogen-free formulations. BYK's flame-retardant synergist BYK-MAX CT 4260 FR is said to improve flame retardant properties and allow reduced levels of aluminum or magnesium hydroxide fillers to be used in HFFR compounds. This reduced filler loading improves processing, physical properties, and weight. BYK says that in HFFR formulas, the synergist improves dropping behaviour and crust formation.

The additive is an organoclay based on a montmorillonite mineral with an organic surface treatment. It is easily dispersed in polyamides with standard compounding equipment, according to Garlinsky. In addition to improving fire retardancy properties, it can also enhance barrier to oxygen, water vapour, and hydrocarbons, the company says.

A mineral filler synergist for phosphorous-based flame retardants in polyamides is also in development at **HPF The Mineral Engineers**, a division of Quartzwerke. Its kaolin and wollastonite combination can save cost by reducing the amount of flame retardant required while improving some properties, such as tensile elongation, modulus, and HDT.

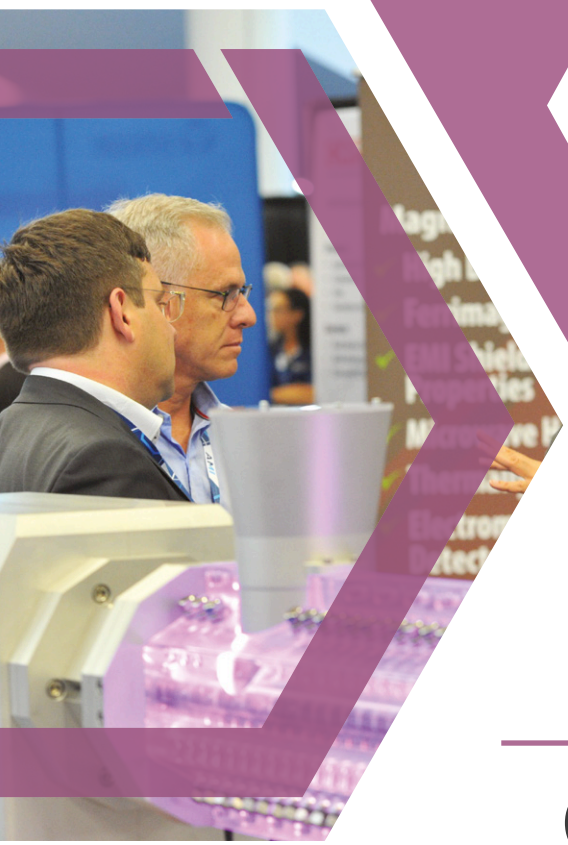
Below: The higher power handling of today's USB-C connectors requires improved flame retardance

IMAGE: SHUTTERSTOCK

Making connections

Changes in the electrical and electronics market will also affect polyamide materials and additives, **DSM**'s Sadiki said in a presentation at AMI's Performance Polyamides conference in the US last year. USB-C connectors, for example, handle more power than previous generations so high comparative tracking index (CTI) and V0 flame retardancy at narrow wall thickness is needed for product reliability (the higher CTI reduces the risk of connector failures due to arcing and short circuits).

The challenge for a flame retardant compound in this application, says Sadiki, is to achieve a UL94-V0 formulation down to 0.18 mm wall thickness while still delivering a combination of high material flow, high mechanical strength, low warpage and high CTI (600V). He said DSM's testing has shown that a PA46 compound with a



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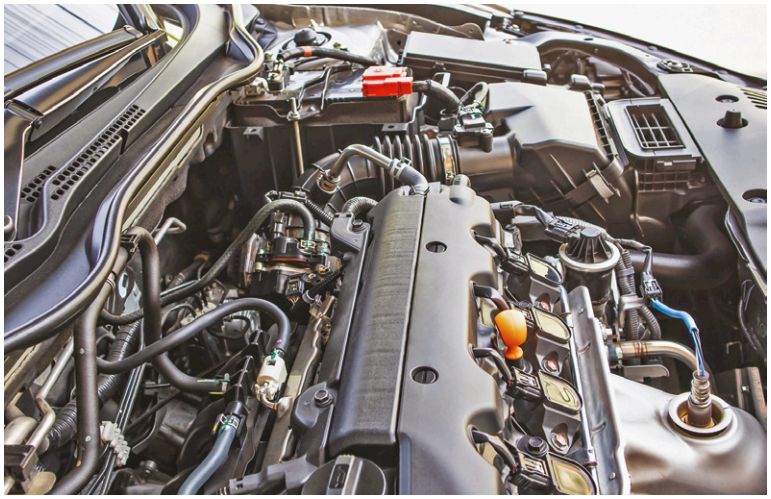

Above: Creamid P PA6 compounds from Teknor-Apex can provide an alternative to PA66

phosphorous-based halogen free flame retardant displays better tracking resistance than an LCP (liquid crystal polymer) in such an application.

In connectors that are to undergo a high-temperature reflow soldering process, he says, DSM's ForTii aromatic PPA is preferred as it displays much lower moisture absorption than the aliphatic Stanyl PA46. "The low moisture absorption together with its intrinsically high surface tension avoids the formation of so-called 'blisters' during the high temperature SMT [surface mount technology] reflow soldering process," he explains. "In addition, the high moisture absorption of PA46 would deteriorate the signal integrity of high speed FAKRA [automotive] and HSD [high-speed data] connectors."

Brüggemann's Bergmann says that E&E markets are also increasingly demanding metal and halogen-free additive packages to avoid the risk of electrochemical corrosion in sensitive applications. He said the company plans to launch such a stabiliser system this year.

Matching PA66

Due to the recent and ongoing shortages of PA66, users are looking to upgrade the performance of PA6 to provide an alternative. "Tailor-made additives assist compounders and users in making this move, mainly by increasing long term heat stability and productivity," says Bergmann. "Bruggolen TP-H1805 extends the heat stabilisation of PA6 up to 200°C. Combinations of Bruggolen P22 or TP-P1401 nucleating agents with TP-P1507 flow enhancer will lift PA6 to the productivity levels of PA66, as PA6 modified this way will match the short injection moulding cycle times of PA66. In addition, small amounts of TP-P1507 allow for increasing the glass fibre content by just 5% to make PA6 grades reach the same mechanical properties as PA66 without any sacrifice in flow properties," he says.

BYK's Garlinsky says making a switch from PA66 to PA6 is not always possible but can be done in some cases through the smart addition of functional additives. He says the company's SCONA impact modifiers and coupling agents for polyamide and polyamide blends can help improve the physical properties of PA6 while its BYK-MAX HS organic and inorganic heat stabiliser concentrates can improve thermostability at high temperature conditions, such as found in automotive under-the-hood applications.

The new Creamid P series of PA6 compounds from **Teknor-Apex** have been formulated for lower moisture uptake. The new compounds "absorb nearly one-third less water at saturation than standard grades, provide 15-25% improved tensile properties in the conditioned state, and exhibit higher flow and better surface characteristics, even in highly glass-filled formulations," the company claims. The technology used to lower moisture uptake can also be used in PA6/66-based compounds. An advanced heat stabilisation formulation extends continuous use temperature.

"The improved tensile properties of Creamid P compounds enable them to meet the demands of certain structural applications where, traditionally, PA6 compounds did not perform due to high moisture uptake," said Markus Krippner, Director of New Business Development ETP. "In some cases, they may provide a practical alternative to polyamide 66 compounds as well." The company introduced the first two Creamid P compounds, with 30% and 50% glass fibre content, last year.

Designed to improve impact resistance and dimensional stablility of PA6 and 66 compounds, Olebond 7403 in one of a line of maleic anhydride-grafted PE-based polymer additives from **Tisan**. The three grades are formulated for operation at temperatures of -50°C, 0°C and ambient and are used at addition levels of 3-25%. They can be used in unfilled, filled and fibre reinforced compounds. The company says tests show the Olebond 7403 IM-C low temperature grade can increase impact strength of unfilled compounds by up to five times at a 10% addition level.

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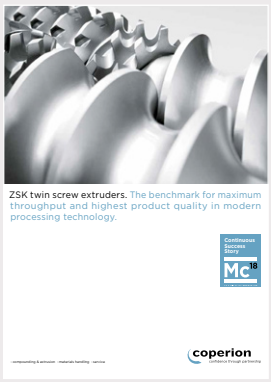

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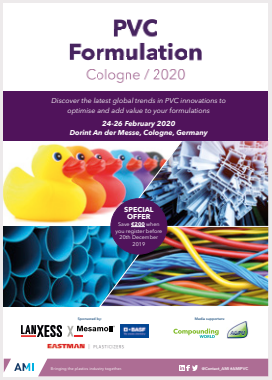

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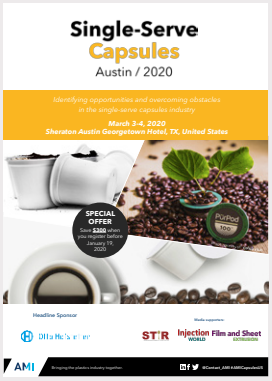

The 3rd edition of AMI's international Single-Serve Capsules conference in North America, on March 3-4, 2020 in Austin, Texas, brings together industry-elite speakers to evaluate and discuss the trends, challenges and opportunities facing the sector.

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LSR INNOVATIONS

AMI's LSR Innovations conference returns to Neuss, near Dusseldorf, in Germany on 4-5 March 2020. The event brings together materials and processing technology experts, processors and end-users to explore the latest LSR solutions and trends.

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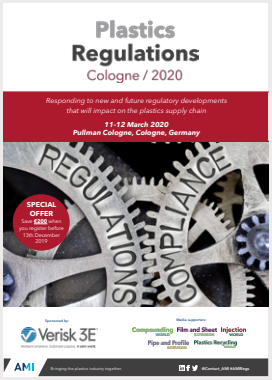
PLASTICS REGULATIONS EU



The 4th edition of Plastics Regulations provides advice on a range of compliance issues at one event. The event takes place on 11-12 March 2020 in Cologne, Germany. The conference provides an ideal environment for regulatory updates.

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GRASS YARN & TUFTERS FORUM

The 14th edition of AMI's Grass Yarn & Tufters Forum takes place in Barcelona in Spain on 23-25 March 2020. The event examines technical and commercial developments shaping the future for the synthetic turf industry.

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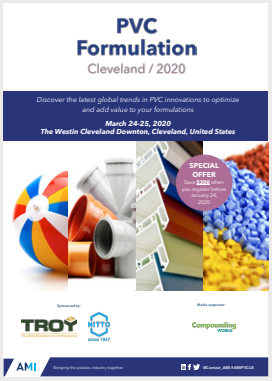
Learn more about AMI's upcoming conferences

Click on the relevant brochure cover or link to download a PDF of the full conference programme

PVC FORMULATION USA



The 2020 edition of AMI's North American PVC Formulation conference will be held in Cleveland, Ohio, USA, on 24-25 March 2020, providing a forum for formulators, compounders and suppliers to identify future material and processing trends.

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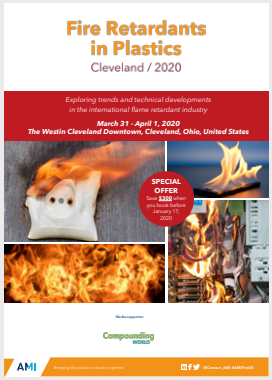
FIRE RETARDANTS IN PLASTICS



The 10th edition of AMI's Fire Retardants in Plastics conference moves to Cleveland, Ohio, USA. Taking place on 31 March-1 April, the event explores the regulatory and technical developments shaping the North American fire retardants market.

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POLYMERS IN FOOTWEAR USA

The second edition of AMI's North American Polymers in Footwear conference takes place in Portland, OR, USA, on 7-8 April 2020, presenting a comprehensive analysis of the latest advances in footwear materials and processing technologies.

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PLASTIC PIPES IN INFRASTRUCTURE

The 8th Plastics Pipes in Infrastructure conference focuses on the latest technical developments plastic pipes for water, gas, drainage and district heating applications. The conference runs on 28-29 April 2020 in Hamburg, Germany.

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PERFORMANCE POLYPROPYLENE EU

The third edition of AMI's European Performance Polypropylene conference come to Cologne in Germany on 29-30 April. Learn more about the use of this versatile polymer in demanding markets such as automotive appliances and construction.

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POLYMER SOURCING & DISTRIBUTION

The AMI event specifically created for companies involved at every stage of the European polymer supply, Polymer Sourcing & Distribution, takes place in Hamburg on 12-14 May 2020, reviewing recent trends in sourcing options for both commodity and engineering resin grades.

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Compounding World January 2020
The first edition of Compounding World in 2020 explored the latest developments in additives for film materials. It also looked at some of the most recent innovations in pelletisers and polymer analysis equipment.

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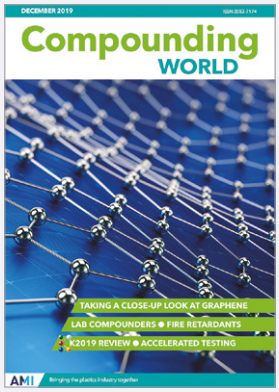

Compounding World December 2019
The December edition of Compounding World looked at the potential opportunities for graphene in plastics. It also reviewed the latest developments in flame retardants, laboratory compounding and weather testing.

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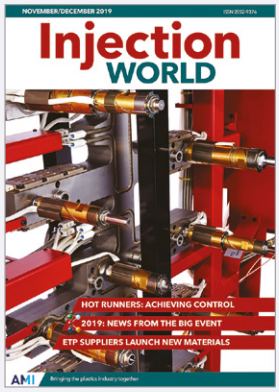

Injection World November/December 2019
The November/December edition of Injection World takes explores new developments in hot runners and engineering thermoplastics. It also examines some of the latest automotive applications and details innovations on show at K2019.

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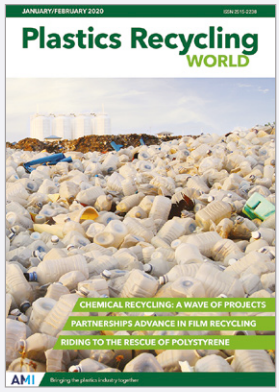

Plastics Recycling World January/February 2020
The January-February of Plastics Recycling World takes a deep dive into chemical recycling, with features on the many technologies being developed for polyolefins and polystyrene. Plus the latest on film recycling technology and projects.

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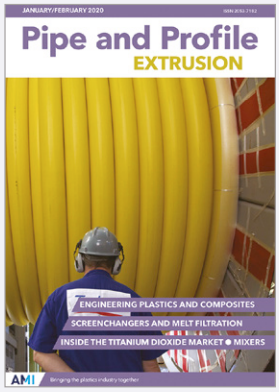

Pipe and Profile January/February 2020
The January-February issue of Pipe and Profile Extrusion looks at applications using engineering plastics and composites, provides updates on mixing technology and melt filtration and delves into the titanium dioxide market.

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Film and Sheet January/February 2020
The combined January/February edition of Film and Sheet Extrusion examines the latest developments in film technology, plus new polymer analysis equipment and some innovative medical materials and applications.

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Compounding WORLD
Film and Sheet EXTRUSION
Pipe and Profile EXTRUSION
Injection WORLD
Plastics Recycling WORLD

GLOBAL EXHIBITION GUIDE

2020	**3-5 March**	JEC World, Paris, France	www.jec-world.events
	9-11 March	Plast Alger, Algiers, Algeria	www.plastalger.com
	11-12 March	PlastExpo Nordic, Helsinki, Finland	www.plastexpo.fi
	11-13 March	Expo Plasticos, Guadalajara, Mexico	www.expoplasticos.com.mx
	21-24 April	Chinaplas – **POSTPONED**	www.chinaplasonline.com
	7-13 May	Interpack, Dusseldorf, Germany	www.interpack.com
	19-22 May	Plastpol, Kielce, Poland	www.targikielce.pl
	3-4 June	Compounding World Expo Europe, Essen, Germany	www.compoundingworldexpo.com/eu/
	8-11 June	Argenplas, Buenos Aires, Argentina	www.argenplas.com.ar
	29 Sep-1 Oct	Interplas, Birmingham, UK	www.interplasuk.com
	13-17 October	Fakuma, Friedrichshafen, Germany	www.fakuma-messe.de
	4-5 November	Compounding World Expo USA, Cleveland, USA	www.compoundingworldexpo.com/na/
	8-11 November	Pack Expo, Chicago, USA	www.packexpointernational.com
	23-26 November	All4Pack, Paris, France	www.all4pack.com
	2-4 December	Plastic Expo, Tokyo, Japan	www.plas.jp/en-gb.html
2021	**4-7 May**	Plast 2021, Milan, Italy	www.plastonline.org/en
	17-21 May	NPE 2021	www.npe.org

AMI CONFERENCES

24-26 February 2020	PVC Formulation Europe, Cologne, Germany
3-4 March 2020	Single-Serve Capsules USA, Austin, TX, USA
3-5 March 2020	Cables 2020, Dusseldorf, Germany
11-12 March 2020	Plastics Regulations Europe, Cologne, Germany
24-25 March 2020	PVC Formulation USA, Cleveland, OH, USA
31 March-1 April	Fire Retardants in Plastics, Cleveland, OH, USA
28-29 April 2020	Plastic Pipes in Infrastructure, Hamburg, Germany
29-30 April 2020	Performance Polypropylene EU, Cologne, Germany
12-14 May 2020	Polymer Sourcing & Distribution, Hamburg, Germany

For information on all these events and other conferences on film, sheet, pipe and packaging applications, see

www.ami.international

PLASTICS RECYCLING WORLD EXPO

POLYMER TESTING WORLD EXPO

3 - 4 June, 2020

ESSEN, GERMANY

PLASTICS EXTRUSION WORLD EXPO

COMPOUNDING WORLD EXPO

4 - 5 November, 2020

CLEVELAND, OHIO

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