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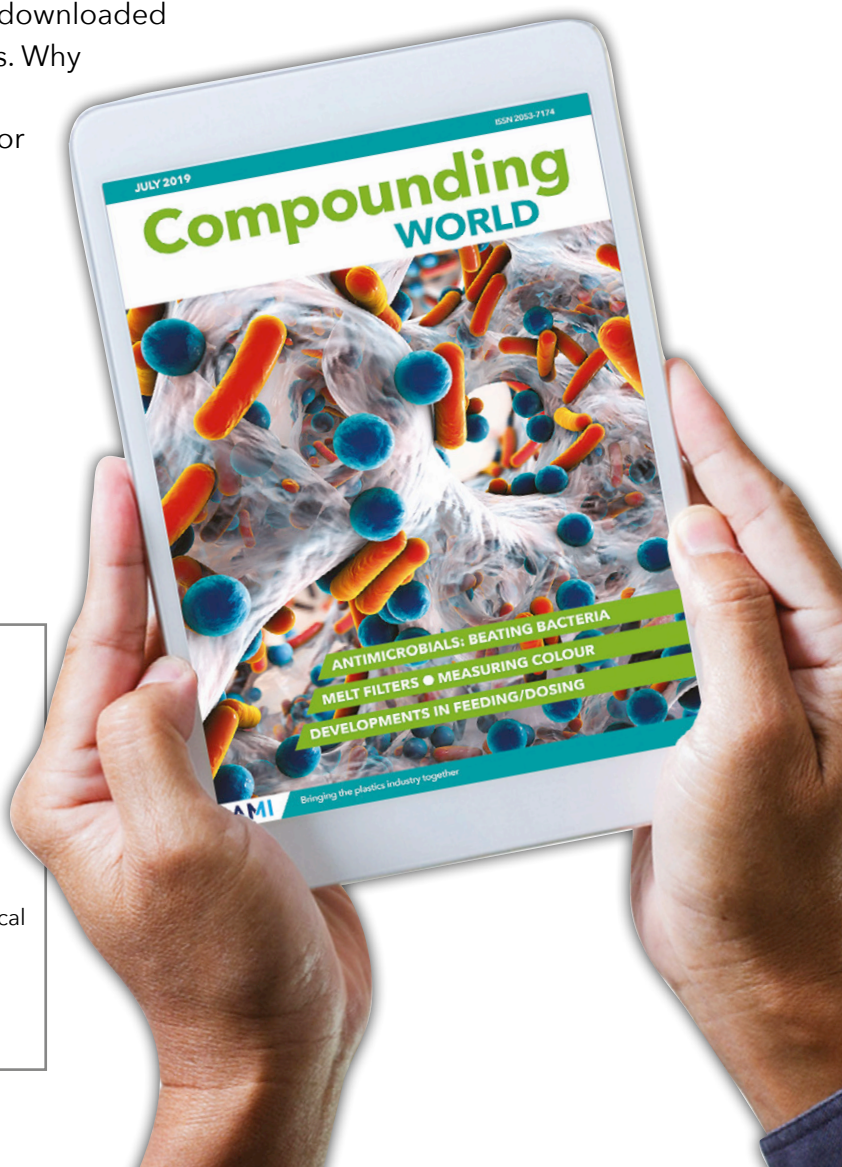


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Compounding WORLD

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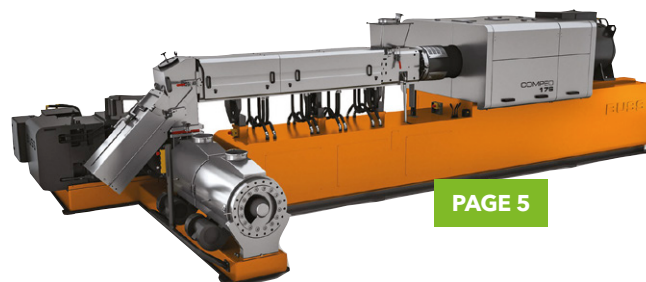
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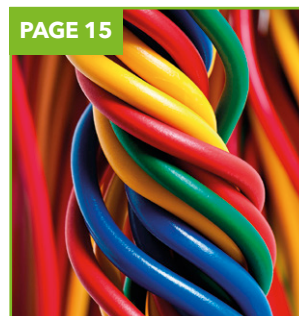
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Colloids grows in China

Colloids has acquired an additional 4,000 m² unit next to its current factory in the Changshu Economic & Technological Development Zone in Jiangsu province, which is located about two hours north-west of Shanghai in China.

The company said the move will enable it to add additional masterbatch production lines and to increase its capacity to 18,000 tonnes/year.

Colloids opened its first manufacturing plant and R&D facility in China in 2016 and reports strong growth



Above: Colloids is to build a second plant in China

in recent years. The production plant mainly supplies engineering masterbatches to the automotive and

electronic industries in China and across the Asian region.

➤ www.colloids.com

Americhem cuts virtual ribbon

Americhem held a virtual ribbon cutting ceremony last month to mark the completion of a plant expansion dedicated to clean compounding for medical devices at its Morrisville facility in Pennsylvania, US.

Carrying ISO 13485 certification, the Americhem Engineered Compounds (AEC) Customer Design Centre "gives AEC unique

capabilities to produce compounds that meet the most stringent medical device requirements", the company said.

The 585m² centre includes a 186m² clean compounding area that will house six new compounding lines, as well as pilot-scale production to assist new product design and small lot qualification.

"Our clean compounding facility is the largest of its kind and includes an air lock with a positive pressure environment, HEPA-filtered air exchange with humidity and temperature controls, epoxy coated floors to allow for easy cleaning, and sealed and polished warehouse floors," said Jim Figaniak, AEC General Manager.

➤ www.americhem.com

RadiciGroup ups global capacities

RadiciGroup's High Performance Polymers division is to build a 25,000m² plant at Suzhou in China that will increase its production capacity in the country by 20,000 tonnes/year.

The move recognises the company's strong growth expectations for China and the Asia region and is the final element in a more than €35m spending in new production capacity spanning three continents.

This investment has seen the Italian company open a new 20,000m² site in Mexico and expand operations in the US, adding a total of 20,000 tonnes/year of capacity. A further 15,000 tonnes/year capacity is currently being added in Germany, complementing the enhancements made at the Radici Novacips facility in Italy over the past two years.

➤ www.radicigroup.com

Arkema's PA11 investment plans on track

Arkema said last month that, despite some challenges due to the Covid pandemic, it remains on track to start production of Amino 11 and Rilsan PA11 at its site at Jurong Island, Singapore, in the first half of next year.

The new plant, first announced in 2017, will increase the company's global PA11 capacity by 50%. It will be the world's largest integrated biofactory dedicated to high performance polymers (PA11 is produced from

castor beans), according to the company. Total investment, including additional downstream polymer capacities in China, amounts to around €450m.

Applications for PA11 are expected in new energy vehicles, 3D printing, consumer goods, electronics, and sports and lifestyle applications. Demand is said to be particularly strong in these sectors in the Asian region.

➤ www.arkema.com

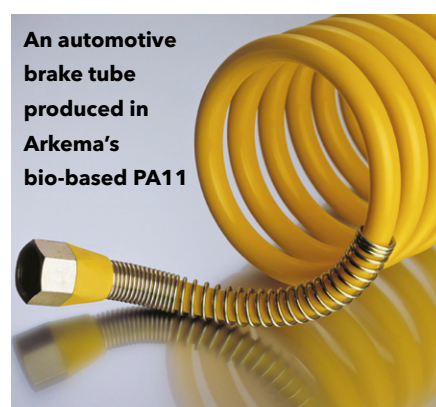


IMAGE: ARKEMA

IN BRIEF...

Austria's **Starlinger**

Viscotec said last month its installed base for PET recycling systems worldwide has reached a combined capacity of 2m tonnes. The firm specialises in extrusion systems for recycling of PET packaging waste into food-grade quality material for use in food and beverage packaging.

www.viscotec.at

Lanxess has added two new inorganic yellow pigments to its range of pigments for heat-resistant, high-performance plastics. Colourtherm Yellow 26 and 30 are based on iron oxide and zinc ferrite respectively and are designed for cost-effective colouration in the temperature range 220-260°C.

www.lanxess.com

Borealis and Stena plan chemical recycling unit

Borealis, together with Stena Recycling, has initiated a feasibility study for construction of a chemical recycling unit at its site at Stenungsund in Sweden.

Depending on the outcome of the study and a final positive investment decision, operations could begin in 2024 with products supplied under the Borcycle C brand. The unit would be managed by Borealis, which said the proposed project would be the first chemical recycling facility to be integrated into a cracker.

Part-funded by a grant from the Swedish Energy Agency, the study will look at the optimal technology for the unit and its integration into the Borealis cracker. Stena's role in the



Above: Borealis plans to build a chemical recycling unit at its Stenungsund site in Sweden

project is to supply the waste material from its mechanical recycling sorting operations.

Borealis said that it will also co-operate independently with Fortum Recycling & Waste on a further project involving the

sourcing of plastic waste for the new unit. Fortum will apply for public funding for a feasibility study to define technical requirements for pre-treatment of plastics, quality control and sourcing of suitable materials.

➤ www.borealisgroup.com

European PLA site at engineering stage

Total Corbion PLA, a 50/50 joint venture between Total and Corbion, has begun front-end engineering design for its previously announced 100,000 tonnes/year PLA plant, which it will build at Grandpuits, France.

The company said it has contracted NextChem, a subsidiary of Italy's Maire Tecnimont, to carry out the design work.

Due to be operational in 2024, the plant will be the first of its kind in Europe and

will make Total Corbion PLA the global market leader in PLA, the company claims. It already has a 75,000 tonnes/year facility in Thailand, which started production two years ago.

Total Corbion makes PLA

resins under the Luminy brand from renewable lactic acid supplied by Corbion. Applications include packaging, food service ware, durable consumer goods, 3D printing and fibres. PLA resins can be mechanically or chemically recycled, as well as being compostable and degradable.

The PLA production unit is part of a €500m investment Total is making to 2024 in its 'net zero' strategy, which will see Grandpuits converted to a zero-crude platform.

➤ www.total-corbion.com



The Total site at Grandpuits in France is to be the location for the new Total Corbion PLA plant

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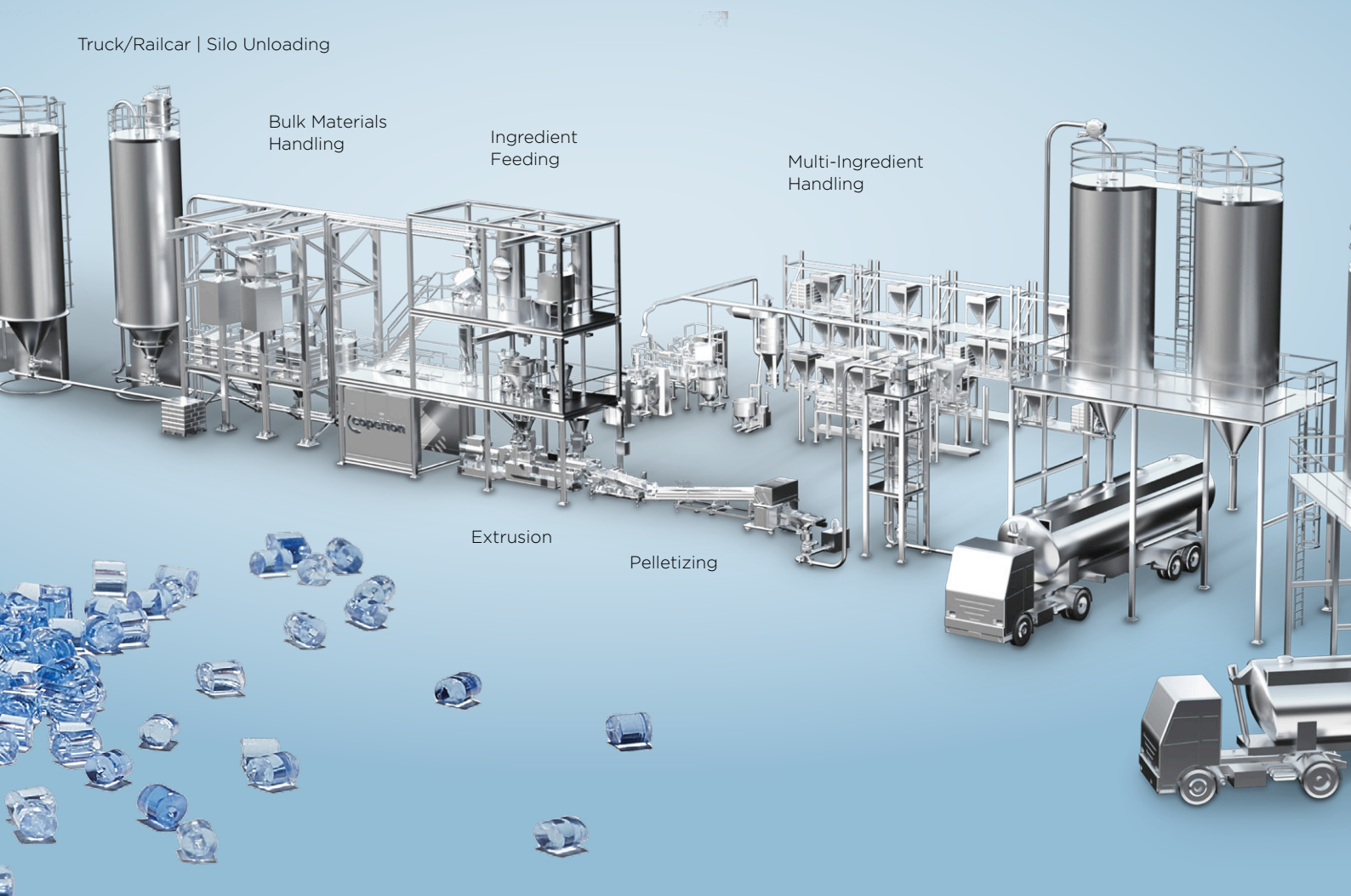
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Feeding

Multi-Ingredient
Handling

Extrusion

Pelletizing



Polykemi to invest €10m to manufacture in US

Polykemi is to invest close to €10m to set up its first production plant in the US. The plant, which will be located at Gastonia in North Carolina, will start up in 2022 and will be the Swedish compounder's largest ever single investment.

The company has been active in the US market since 2013 working with toll compounding partners but the long term plan has always been to have its own production capacity. "The whole time, our goal has been to start up production in the US, and we have now reached that milestone. The new plant is geographically close to our existing customers, which gives us a clearer presence and even

IMAGE: POLYKEMI



Above: Polykemi's planned US production site is its largest ever investment

stronger customer relationships," said Johan Hugoson, CEO of the US business.

The new facility will initially cover 4,600m² but the site will allow expansion to 9,200m². It will start production with two production lines – 75mm and 90mm – ramping up to a full complement of six. The

intention is to produce virtually all the compounds it currently manufactures at its sites at Ystad in Sweden and Kunshan in China.

Polykemi Group recorded sales of around €140m for 2019 and had a capacity of around 65,000 tonnes globally.

➤ www.polykemi.se

Black PA for laser welding

Domo Chemicals has launched Technyl Star AF 219 V30 Black LT, a laser-transparent PA66 that is suitable for laser welding. The new grade will shortly be joined by a glass fibre-reinforced PA6.

The company says laser welding is increasingly used to join thermoplastic components, especially complex and small shaped parts.

Light transmission tests at a wavelength of 940nm have shown the new PA66 grade is suitable for use at up to 3mm thickness. According to Vincent de Givry, Marketing Director for Engineered Materials at Domo, Technyl Star AF 219 V30 Black LT "will be important for the electric vehicle market where there is a growing demand for sensor boxes, cases and control units."

Domo's Technyl PA resins are currently available only in Europe.

➤ www.domochemicals.com

Romira adds recycled carbon fibre

Rowa Group subsidiary Romira has developed a series of lightweight, high strength PA compounds based on reprocessed post-industrial carbon fibre.

The compounds are said to offer mechan-

ical properties comparable to 20% glass fibre-reinforced PA6 together with a significant reduction in weight and reduced carbon footprint.

➤ www.romira.de/en

Sulzer/Borealis pair up in ePP technology

Fluid engineering specialist Sulzer Chemtech and polyolefins producer Borealis have completed development of a process for extrusion of ePP beads that they claim will cut manufacturing costs by up to 60%.

The process uses extrusion with direct gas impregnation instead of conventional autoclave methods. This, Sulzer claims, means foam moulders can implement their compounding line to greatly reduce costs associated with

material supply, warehousing and intermediate transportation.

Additional claimed benefits include improved control over ePP properties such as bulk density, closed cell content and bead size distribution, and greater flexibility in fine-tuning the recipes. The beads can also be processed at standard pressure in steam chest moulding machines.

Sulzer is to set up a new production line to support large-scale adoption of the technology.

➤ www.borealisgroup.com

➤ www.sulzer.com



Left: Sulzer claims its new direct gas impregnation ePP process cuts costs by up to 60%

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IN BRIEF...

Repsol, Canadian technology provider **Enerkem**, and waste management firm **Agbar** are to build what they claim will be the first waste-to-chemicals plant – Ecoplanta Molecular Recycling Solutions – on the Iberian Peninsula at Repsol's petrochemical complex at Tarragona in Spain. Pending a final investment decision the plant should start operation in 2025.

www.repsol.com

The European Chemicals Agency (**ECHA**) said Norway has submitted its proposal to restrict the manufacture, use and placing on the market of the flame retardant Dechlorane Plus due to its persistence and bioaccumulation characteristics. ECHA's RAC and SEAC committees will evaluate the proposal for compliance with REACH prior to initiating a consultation.

www.echa.europa.eu

SI Group to make 705 antioxidant in China

Additives producer SI Group will start production of its proprietary Weston 705 food contact liquid antioxidant at its plant at Danyang in China next month.

The company currently exclusively manufactures the additive, which it describes as "strategic" for its business, at its plant at Morgantown, in West Virginia in the US.

Vice President Plastics Solutions Chuck Reardon said the decision to produce at a second location would

secure supply for customers and underlined its commitment to the Chinese region. "We see continuing growth in the China market and we want to be part of that," he said.

SI Group Senior Vice President and CCO Joey Guillion described the investment as "significant" and said that it pre-empts expected demand growth for the product from polyolefin producers globally.

"Our Morgantown facility

is not yet out of capacity but we felt it necessary to have another point of manufacture to support capacity coming on line in Asia and in the Gulf [of Mexico]," he said.

Weston 705 was introduced in 2014. It is a liquid phosphite secondary antioxidant that offers improved processing and colour performance at low dosage levels and carries global food contact approvals.

> www.siigroup.com

Renewable plasticisers from BASF

BASF has launched a family of mass-balance renewable plasticisers: Hexamoll DINCH BMB, Palatinol N BMB, Palatinol 10-P BMB, Plastomoll DOA BMB, and Hexamoll DINCH Cycled.

The BMB grades use renewable feedstocks such as bio-naphtha or biogas from organic waste or vegetable oils. The Hexamoll DINCH Cycled grade uses

pyrolysis oil derived from plastic waste obtained from BASF's partners in the ChemCycling project.

All the grades carry third-party REDcert2 certification of renewable content using a mass balance approach and are claimed to offer a lower carbon footprint than conventional plasticisers.

> www.basf.com

Clariant opens Chinese stabiliser JV

Clariant and Beijing Tiangang Auxiliary have opened their process and light stabiliser production JV in the Cangzhou Coastal-Port Economy & Technology Development Zone, which is located in China's Hebei province.

Clariant said China is a key market for high-end process and light stabilisers such as its Nylostab S-EED multifunctional hindered amine light stabiliser for PA polymers.



"As a leader in high-end additive solutions, we are very excited to extend our production footprint and

step up local access to high-performing, sustainable solutions," said Francois Bleger, Global

Left: The Clariant/Tiangang light stabiliser plant at Cangzhou is now in operation

Head of Clariant's Business Unit Additives.

The new plant is a continuation of the joint venture Clariant signed with Tiangang in September 2017 aimed at combining the technology and process technologies of both companies.

> www.clariant.com

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Buss adds cascade option for PVC

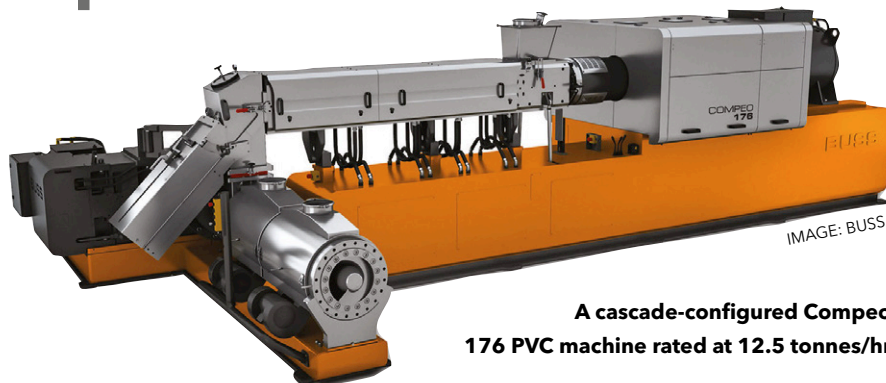


IMAGE: BUSS

A cascade-configured Compeo 176 PVC machine rated at 12.5 tonnes/hr

Buss says it can now supply its larger modular Compeo plasticised PVC compounding systems in a two-stage cascade configuration, which reduces residence time for thermally sensitive formulations.

The new configuration is available on 137-sized machines and larger. By decoupling the discharge and pelletising unit from the compounder, back-pressure build-up is avoided at the transition so the risk of exposing the compound to extreme temperatures is reduced. A further benefit is that the free-fall connecting tube and diverter valve can be operated and

cleaned without tools.

The single-screw discharge unit, which generates the pressure required for pelletisation, is arranged at right angles to the compounder, helping to keep the overall system compact. Screw lengths of 4 or 6 L/D are possible, according to Buss.

"When it comes to compounding plasticised PVC, the decoupled configuration has particular advantages over our usual conical twin-screw discharge unit," said Buss Head of Development and Design Dino Kudrass.

➤ www.busscorp.com

LyondellBasell unveils its Circulen brand strategy

LyondellBasell has launched the Circulen brand to bring together its recycled and renewable polymers, which are initially available in Europe with the North America and China regions to follow.

The company said the new branding represents the next step in "delivering on its sustainability goal of producing and marketing two million tonnes of recycled and renewable-based polymers annually by 2030".

The Circulen family comprises three ranges of polymers: CirculenRecover grades are made from mechani-

cal recycled material from its Quality Circular Polymers joint venture; CirculenRevive grades are made using the company's MoReTec plastic-to-feedstock chemical recycling process; CirculenRenew grades are made from renewable feedstocks such as used cooking oil.

Circulen products are already being used commercially in the latest Samsonite Magnum Eco suitcase line and in some types of garden equipment, such as watering cans, Lyondell-Basell said.

➤ www.lyondellbasell.com

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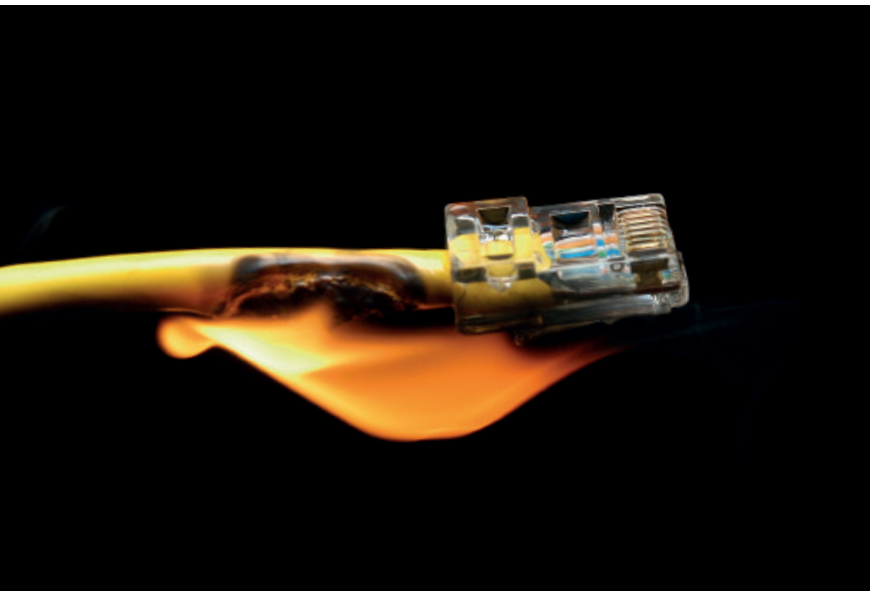




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HFFR demands drive cable innovation

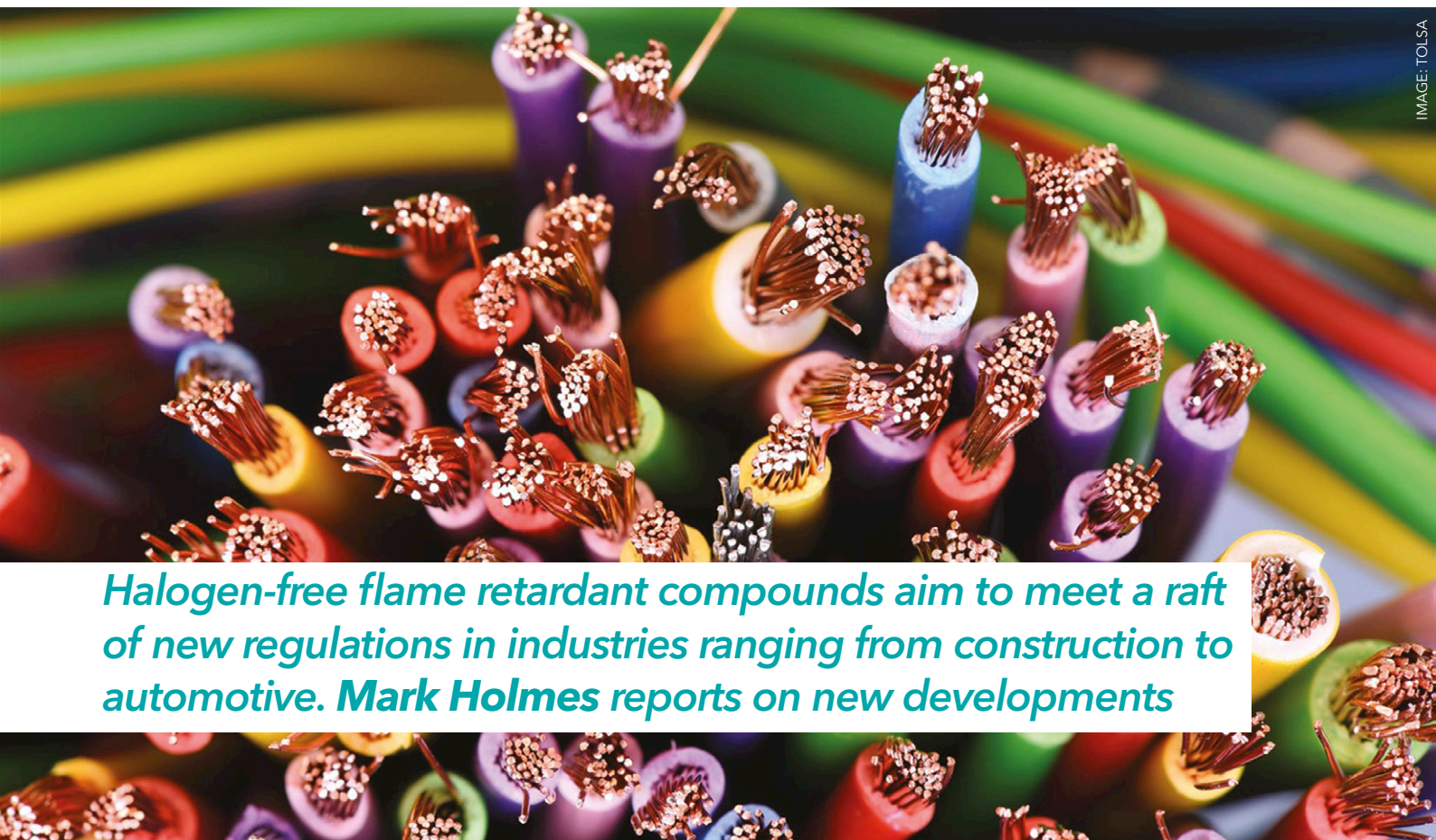


IMAGE: TOLSA

Halogen-free flame retardant compounds aim to meet a raft of new regulations in industries ranging from construction to automotive. Mark Holmes reports on new developments

Demand for wire and cable compounds is high and requirements are becoming increasingly challenging across industries as diverse as construction, automotive, electrical and electronic, and telecommunications. Wire and cable compounders are looking for flame retardant solutions that are halogen-free while continuing to meet the stringent regulations applied in these sectors. Meanwhile, productivity in cable production remains a top priority and solutions are being introduced that allow streamlining of manufacturing processes. This is particularly evident in the growth area of crosslinkable halogen-free flame retardant compounds.

Wire and cable is an important application sector for Swiss compounding machinery maker **Buss**. Despite a 2020 slowdown – almost exclusively attributable to Covid-19 – the company reports that it is now observing strong growth in demand for its kneader extruder machines in the field of halogen-free flame retardant (HFFR)

materials, especially for crosslinkable compounds.

“The steady expansion of photovoltaic technology, as well as electric mobility, are contributing to the increasing demand for crosslinkable HFFR cable compounds. Construction Products Regulation (CPR) or specifications for automotive cables always require high performance materials. In turn, this drives further development of better performing compounds and more efficient compounding technologies,” says François Loviat, Head of Process at the company.

“Several applications require the use of crosslinked materials, for example, where superior temperature, wear or oil resistance is demanded. This is typically the case in the automotive and photovoltaic industries. The main drawback of most crosslinked polyolefin-based cable materials is that they have a tendency to ‘drip’ when burning. This contributes to the spread of fire and limits the performance of crosslinkable compounds during

Main image:
Flame retardance - increasingly using halogen-free systems - is a key growth area in cable applications

Right: A Buss Compeo 55 kneader extruder configured in an HFFR compound version with single screw discharge

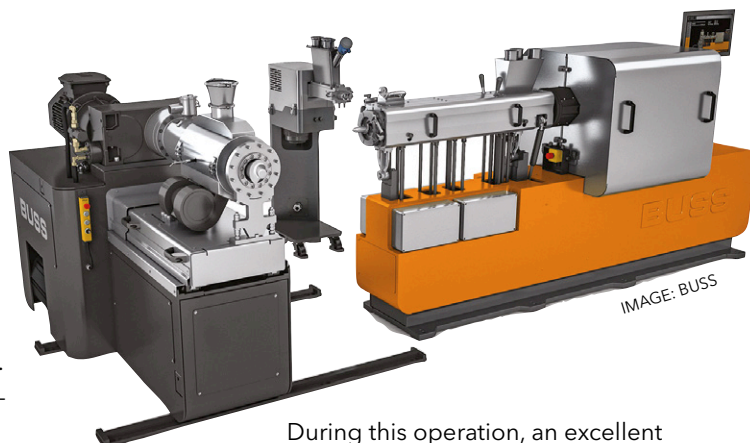
flammability tests," he says.

"Traditional HFFR compounds perform better during flammability tests but are typically characterised by lower oil and wear resistance and mechanical performance in general. These limitations can be overcome by replacing traditional crosslinkable or HFFR cable compounds by crosslinkable flame retarded alternatives," according to Loviat.

Production of crosslinkable flame retardant cable materials has traditionally been a two-step process. In the first step the base polyolefin polymer is grafted with a reactive silane, then in the second step the grafted material is compounded with a flame retardant additive/filler. This well-established process works, but Buss says it is inefficient and cost-intensive because the material has to be melted and pelletised twice. This either requires two compounding machines or the use of alternate production cycles on a single machine.

Buss has developed what it believes is a more efficient process allowing crosslinkable HFFR compounds to be produced in one step and this is already being used on an industrial scale at some of the main global producers of crosslinked HFFR compounds. The company claims it provides a significant competitive advantage in terms of productivity, product quality and energy consumption.

The one-step Buss production process requires fast mixing of the grafting chemicals and good temperature control of the process. "From this point of view, the Buss kneader is tailor-made for this application," Loviat claims. "A minimum temperature of 170-190°C must be reached in the first section of the machine to perform the grafting successfully. The flame retardant material - typically aluminium or magnesium hydroxide - is then added and mixed with the grafted compound.



During this operation, an excellent dispersion of the flame retardant and accurate temperature control are crucial in order to achieve good mechanical properties while not exceeding the degradation temperature of the flame retardant, which is around 200°C."

Loviat claims the flexible modular design of the latest Buss Compeo allows it to be fine-tuned for this application. "The Compeo - the latest generation of Buss kneader - combines three and four flights kneading elements within the same machine and allows further optimisation of the production process of xl-HFFR compounds. The four flight kneading elements in the first section of the machine melt and heat-up the resin quickly and at a high throughput, while the three flight kneading elements in the second section of the machine provide an ideal combination of good flame retardant dispersion and temperature control."

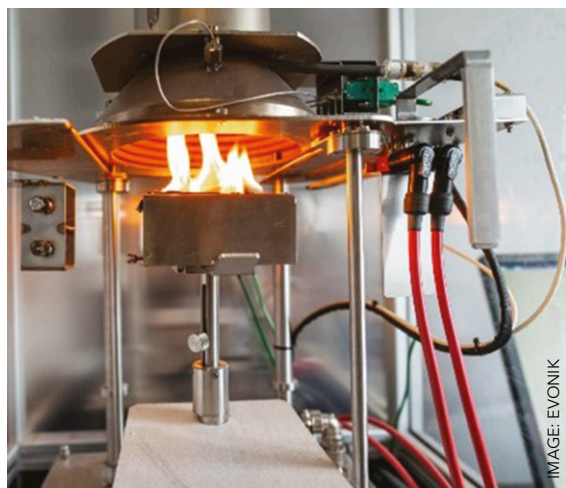
Additive innovation

Wire and cable is also a key market for **Evonik**, which offers a number of additive products designed for the development of new cable compounds that meet the highest standards. "We have invested in new laboratory capabilities, such as cone calorimetry, which allow us to evaluate the heat release and smoke density of compounds using our additives during burning that ultimately helps us to develop safer additives," says Dr Ido Offenbach, Americas Segment Manager, Polymer Specialties.

"There are a number of new regulations that are the main driver for growth in wire and cable compounds. For example, the new EU Construction Products Regulation (CPR) - EN 45545 - for fire protection of railway vehicles requires elevated flame retardancy performance with low smoke and heat release," says Offenbach.

He also sees a variety of different development trends emerging in wire and cable compounding, explaining that these vary depending on the type of compound. For example, thermoplastic compounds need improved flame retardance performance with minimum impact on mechanical

Right: Evonik's cone calorimeter fire testing equipment helps speed development of wire and cable compound formulations



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performance while operators of larger extruders need to increase output. Maintaining and improving performance in oil and water environments and enhancing the hydrophobicity of compound formulations are also among the top priorities.

High loading levels of hydroxide-type flame retardants are important to achieve better performance. However, such high loading levels typically compromise mechanical and electrical performance. There is a need, therefore, for additives that can improve loading levels without compromising performance. Evonik has developed a number of organo-modified siloxane additives – including its Tegomer V-Si 4042 and Tegopren 6879 grades – that make it possible to increase the maximum loading levels of hydroxide-type flame retardants while achieving homogenous dispersion in the polymer matrix so that mechanical properties of the wire or cable compound are not negatively affected and good processability is maintained.

Evonik's organo-modifier siloxanes (OMS) are available in liquid and solid form. "We are also introducing a dry crosslinker in peroxide and e-beam crosslinking compound formulations to improve crosslinking efficiency," says Offenbach.

"These additives are based on silane, trialkyl and triallyl functionality. We also have organic porous carrier technology – Accurel XP – based on EVA, HDPE and LLDPE, which allow customers to transfer liquid additives into solid masterbatches for convenient dosage on all extrusion lines. In addition, we have developed Accurel XP for PA6 and PA12 polymer compounds for demanding cable applications, such as tunnel operations."

Future wire and cable developments at Evonik will include the introduction of a dry silane series of additives. The dry silane products will offer easier and more precise dosage than standard liquid silanes while, due to their solid nature, help keep the production site cleaner.

Halogen-free

According to **Tolsa**, significant growth continues in the area of halogen-free cables due to the emergence of new and tougher regulations and growing demand for high-performance cables. The company's Adins additive products can help meet these requirements, according to its Special Additives Business Unit team.

Adins additives are used mainly in medium and



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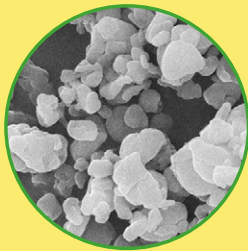
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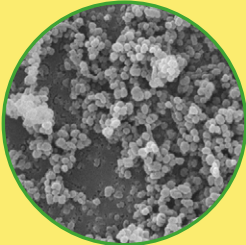
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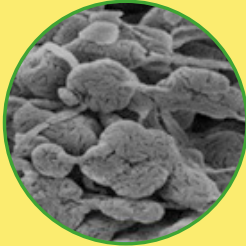
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Right: Tolsa sees a clear demand for safer flame retardant systems across the cable industry

low voltage cables, although the Adins Fireproof line can also be used in high voltage cables. HV cables, together with submarine and telecommunications, are among the applications where the company sees the fastest growth within the cable industry at present. Electric vehicles are another important area of growth and development due to the requirement for flame retardance performance and high-speed charging, as well as the need to recycle flame retardant compounds.

Tolsa says that alongside the trend towards halogen-free materials, it continues to see environmental concerns over antimony trioxide (ATO) and says alternatives are being actively sought. Other trends evident in the wire and cable industry include a desire to increase the use of recyclable or environmentally-sustainable materials, as well as the need to prepare for more stringent international health and safety regulations. From a technical perspective, other challenges include achieving higher capacity in optical cables, improving underwater cables for renewable energy duties, and generally enhancing mechanical properties and heat resistance.

According to the Tolsa Special Additives Business Unit team, there is a clear demand for

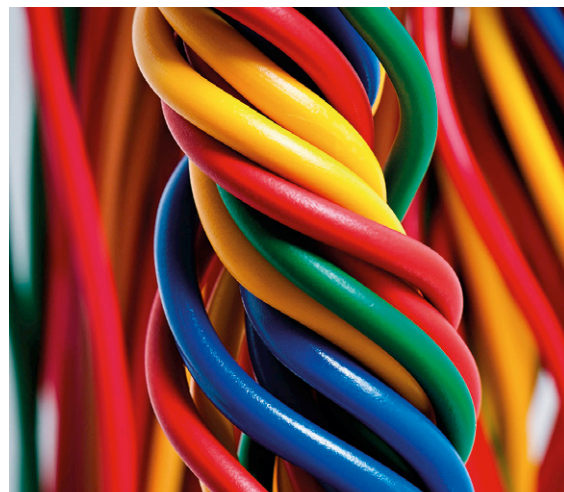


IMAGE: TOLSA

safer flame retardant additives and synergist systems that enhance functionality but reduce the dosage needed without impacting on the processability and the desired physical and chemical properties. Tailored additives to comply with specific end-user requirements are also in demand, as well as new solutions for ceramifying tapes. In addition, improvements in cable anti-dripping performance are under development.

The latest developments at Tolsa include the

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*Melissa Jensen-Morgan
Design Engineer, ENTEK Extruders*



Adins range of flame-retardant synergist additives, which are based on a new technology using natural silicates. The company says these offer tailored performance benefits and make it possible to replace part of today's highly-loaded flame retardant systems.

The Adins Clay range includes Adins Clay 20, Adins Clay 80T and Adins Clay Sil-1. Adins Clay 80T, in particular, has demonstrated a strong impact in smoke and heat release and is currently marketed for thermoplastic matrices and rubber in cable applications. Adins Clay Sil-1 is used in silicone and PVC formulations to deliver reduced heat release and smoke suppression and can allow levels of antimony trioxide (ATO) to be reduced. Another new product for ceramifying cable materials is Adins Clay G1, which is based on natural silicates and low melting glass.

Tolsa says the Adins Clay and Adins Fireproof additives are based on surface-modified silicates (Adins Fireproof is a ceramifying additive doped with low melting glass). The synergists can be used in combination with several commonly used flame retardants, including metal hydroxides, intumescent systems and halogenated flame retardants. The products are compatible with a range of polymers including EVA, PVC, PP, PE and PA, as well as rubbers such as EPDM. Even at low dosages, the company says the Adins Clay and Adins Fireproof additives deliver high performance,

including anti-dripping effect, improved char mechanical properties, reduced heat release and smoke suppression.

Tolsa says that its technology allows the silicate to be functionalised with different modifiers, compounds or particles to improve the efficiency of the system so that improved performance can be achieved with less flame retardant additive. The company says it is working closely with leading wire and cable manufacturers to develop new applications in the automotive and electrical/electronic industries, for example, as well as developing specific additives for PA and silicones.

Lifting performance

Germany's **Nabatec** developed its Actilox PA-B2 additive masterbatch for producers of HFFR cable compounds. Described as a flame retardant booster, it is claimed to reduce pressure build-up during compounding and extrusion without compromising mechanical performance and ageing characteristics. It is said to be easy to blend with any mineral-based fillers and shows synergistic effects with ATH in terms of flame retardancy (Nabatec offers a range of ATH fillers in its Apyral product line).

Minimising the negative impact of the high filler loadings on processing in HFFR cable formulations is also the goal of **Innospec Leuna**, which has developed an organic processing aid that it claims improves the dispersion of ATH and MDH, as well as carbonates and silica-based nano-materials. Viscospeed is a polar additive that is intended to improve wetting and dispersion of the inorganic filler particles and prevent re-agglomerating during processing. The company adds that the additive preserves elongation at break and ageing characteristics, while flame retardance is enhanced through improved char formation and reduced dripping tendency.

Europiren – the distributor of Brucite+ high purity magnesite products from the Russian Mining Chemical Company – has investigated ethylene butyl acrylate (EBA) copolymer as a new base for halogen-free flame retardant (HFFR) cable compounds. Similar to an ATH-EVA combination, EBA and magnesium hydroxide (MDH) display close thermal decomposition points – 300-330°C for MDH and greater than 350°C for EBA.

Europiren's polymer laboratory has studied a series of HFFR formulations based on EBA filled with Ecopiren MDH. The first step included full replacement of EVA by EBA in a classic cable sheathing compound. Ecopiren 3.5 treated with stearic acid (C), alkylsilane (NP) and without surface treatment

Table 1. Basic properties of an ethylene butyl acrylate (EBA) copolymer cable sheathing compound containing different Brucite+ Ecopiren magnesium hydroxide (MDH) flame retardant fillers

Formulation	1	2	3
Polymers	%	%	%
EBA	24	24	24
mLLDPE, MFI 3.5	5	5	5
LLDPE-g-MAH	5	5	5
Fillers			
Ecopiren 3.5	63		
Ecopiren 3.5C		63	
Ecopiren3.5NP			63
Processing aids and stabilisers	3	3	3
TOTAL, %	100	100	100
Properties			
MFI at 190°C, 21.6 kg, g/10min	4.1	0.8	2.5
LOI, O ₂ %	49	45	50
Tensile strength, MPa	13.5	11	14
Elongation at break, %	71	67	77
Source: Europiren			

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Table 2. Basic properties of a copolymer cable sheathing compound based on ethylene butyl acrylate (EBA) and different ULDPE polymers containing Brucite+ Ecopiren magnesium hydroxide (MDH) flame retardant fillers

Formulation	4	5
Polymers	%	%
EBA	15	16
ULDPE, MFI 1	10	16
mLLDPE, MFI 3.5	5	4
LLDPE-g-MAH	5	4
Fillers		
Ecopiren 3.5	62	58
Processing aids and stabilisers	3	2
TOTAL, %	100	100
Properties		
MFI at 190°C, 21.6 kg, g/10min	4	7
LOI, O ₂ %	42	38
Tensile strength, MPa	11	11
Elongation at break, %	110	150
Source: Europiren		

was used as the filler. Mechanical properties, melt flow rate and LOI were tested (Table 1).

The formulations based on 100% EBA base polymer were found not to provide appropriate mechanical properties. Stearic acid, as expected, lowered both the LOI value and mechanical properties. However, despite the low mechanical properties, the expected high LOI level for the HFFR sheathing was achieved due to the close thermal decomposition points of MDH and EBA. An attempt to improve the mechanical properties using ULDPE was made in a second series of formulations (Table 2).

The introduction of ULDPE improved mechanical properties without sacrificing too much LOI. However, the desired mechanical properties were only achieved by reducing the total filler content. Although the development work is at an early stage, Europiren's researchers say the results for EBA-brucite compounds in HFFR cable formulations are promising. Like ATH-EVA combinations, it says synergetic behaviour is observed in combinations of MDH-EBA and natural MDH (hexagonal particles) provides better flame retardant performance.

Power performance

Polyolefins specialist **Borouge** has introduced Borlink LS4201S for power cables in high stress, high

voltage applications of up to 230kV. The company says the new grade is produced under clean conditions and is able to perform at a maximum operating stress of 10kV/mm. The compound is claimed to offer XLPE cable producers the benefits of design flexibility, good scorch security and reliability for long production runs.

According to the company, the significantly improved scorch safety lowers the risk of insulation defects and reduces degassing time, which means cable manufacturers can further optimise production cycles and running times without losing overall safety and reliability. Borlink LS4201S has successfully completed a type test in accordance with IEC62067 international standards.

Hexpol TPE has recently launched a comprehensive portfolio of wire and cable compounds based on high performance materials, such as VMQ advanced silicone elastomers, traditional elastomers, and thermoplastic elastomers (TPE). The company says electrification trends and an increasingly connected population means the demand for power and telecom products is expanding rapidly. Alongside this growth comes the introduction of stricter regulations and industry standards to protect people and infrastructure.

"To help industry meet these demands we have put our experience and know-how into developing one of the most comprehensive portfolios in the market. We offer a unique position, taking a polymer neutral approach to supply customers the optimal solution for their requirements," says Ralph Wolkner, President Hexpol Compounding Europe/Asia.

The range includes silicone rubber materials, CPE, EPDM, NBR+PVC, CR rubber compounds, pigment and additive masterbatch, as well as thermoplastic, EVA, TPE and TPV technologies. Typical properties include halogen-free flame retardancy, low smoke and low toxicity. Materials are RoHS, SVHC and REACH compliant, with grades designed to meet international cable standards such as EN50363 or IEC 60811.

Bedding, insulation and sheathing materials are all part of the portfolio. Application areas include locations containing expensive or sensitive equipment, such as hospitals, airports, train and transport hubs, communication exchanges, power generation facilities and offshore platforms.

Grades are also available for telecommunication and electric cables ranging from high-to-low voltage.

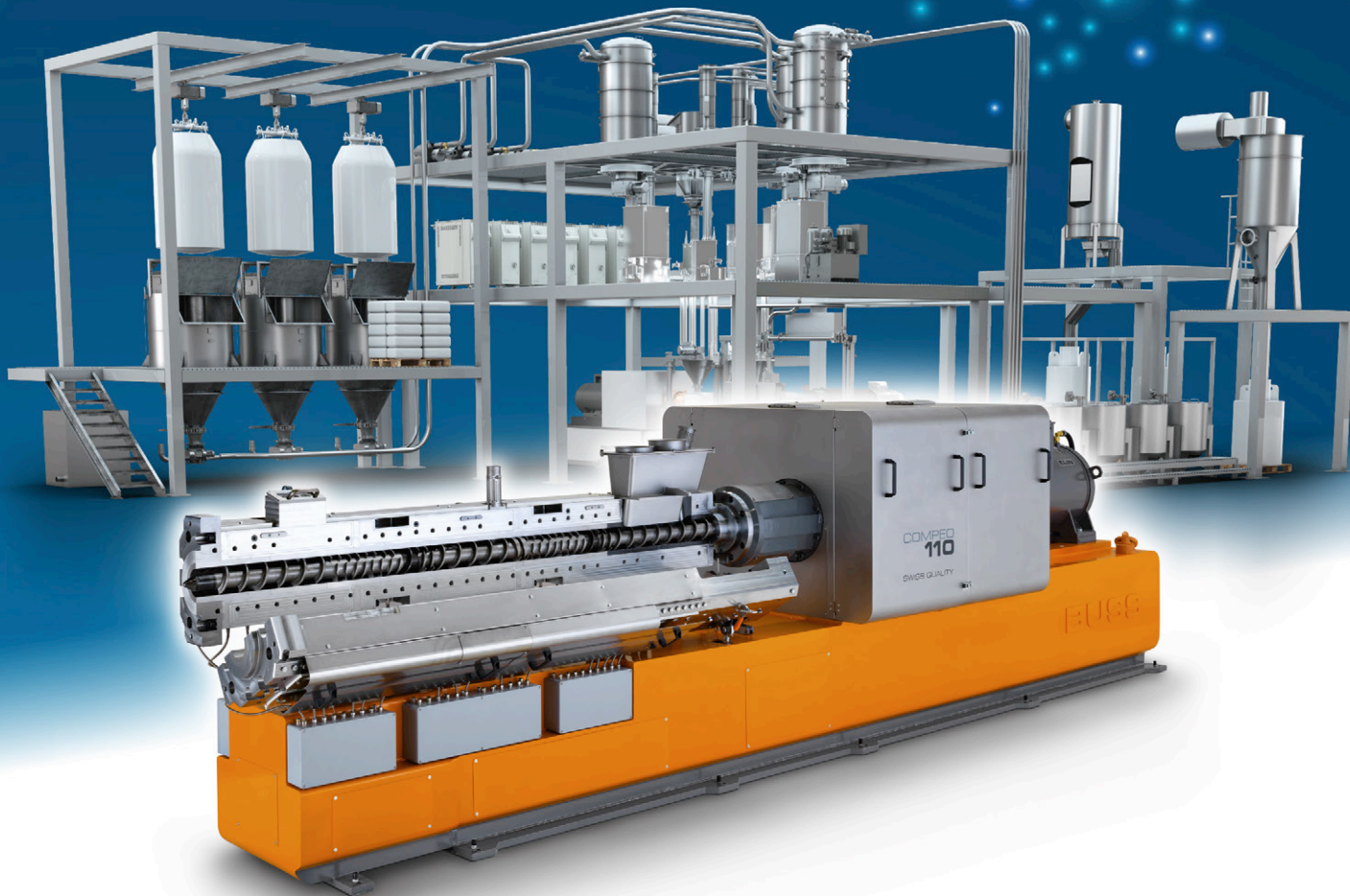
Alphagary has developed a TPE compound for use in charging station cables for electric vehicles that it claims is durable, efficient and

Right: Borouge is aiming its Borlink LS4201S XLPE grade at HV power cables



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environmentally friendly. Garaflex is intended to provide an alternative to thermoset rubber and has been tested by leading charging station manufacturers. The company says it can withstand punishing weather conditions while performing to the UL safety standards and maintaining toughness.

The company has also developed Megolon – a halogen-free flame retardant compound – for cable applications that meet the European Union's Construction Product Regulations (CPR). The compounds are tailored for applications such as fibre optic and copper data and power cables. Alphagary says that it has also focused on ease of processing.

Colour options

Avient has developed OnColor WC Choice, a new line of colorants that reliably achieve the performance levels required in a range of wire and cable applications. Compatible with EVA and PE, the portfolio of 12 standard colours is said to be cost-effective and allow for reduced minimum order quantities and shorter lead times. It says the products are suitable for use in telecommunications, energy and power, and automotive applications.

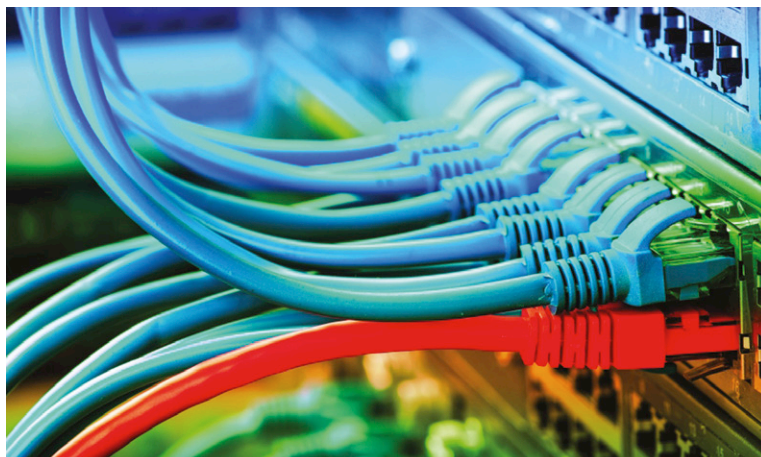


IMAGE: AVIENT

The company has also introduced new specialised polymer grades with enhanced chemical resistance and improved productivity for optical fibre cables (OFC). With processing speeds up to 1000m/min and a much lower melting point than PBT (a traditional OFC jacketing material), the new Ecco grades are said to enable faster processing and reduced energy use during manufacturing. In addition, they maintain performance at reduced wall thickness and are easily colourable.

As global demand for internet connectivity and

Above: Avient says its new OnColor WC Choice colorant line meets the needs of cable producers

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Right: Benvic describes its Linkflex HF polyolefin cable compounds as cost-effective LV cable grades

data transmission capacity continues to rise, fibre optic cable is rapidly replacing traditional copper communication cables. Avient says Mordor Intelligence, for example, forecasts the optical fibre cable market will see a 12.5% compound annual growth rate (CAGR) by 2025. This growth will, in turn, drive the demand for high performing wire and cable materials.

The Eccoh LSFOH 6153 UV and 6154 UV grades extend Avient's low smoke, fume, zero halogen portfolio, which is focused on applications where smoke mitigation is of particular concern, including communication and data cables. The new grades are intended primarily for gel-filled loose tubes, micro-modules, and tight buffered optical fibre cable applications. Suitable for dry as well as wet applications, Avient says the materials offer good chemical and UV resistance, and are compatible with a variety of filling compounds and gels used to protect optical fibres.

Primarily known for its PVC products, **Benvic** is now extending its polymer slate and has developed the Linkflex HF series of polyolefin HFFR compounds for the manufacture of cables and sheathing. The materials are said to provide full compliance with the latest Construction Product Regulations (CPR) currently being implemented in Europe.

Strongest demand for Linkflex HF products is currently coming from the low voltage cable market in building and construction, according to Benvic. "Pricewise this is a very challenging marketplace and so we are delighted to already be making inroads and proving our cost-competitiveness with these buyers," says Vinceç Mercade, the company's Marketing Manager for New Products.

The mechanical, chemical resistance and climatic characteristics of the new Linkflex HF materials are said to have been optimised for flexibility and ease of use in installation and service. Particular care has been taken to optimise Linkflex HF for cost-effective cable manufacturing, primarily by lowering the amounts of polymer compound used while also improving the processing stability.

"Because Benvic's core PVC business made us a relative latecomer to this market, we were able to offer it a completely fresh pair of eyes," Mercade says. "We made sure to recruit experts from the cable industries and from the related plastics processing sectors. In this way the Benvic focus was always on creating value in the supply chain - making processability easier and more competitive, speaking the same language as the customers and OEMs and backing our compounds with customer support and all in a completely halogen-free package. Indeed, all in the building and electrical

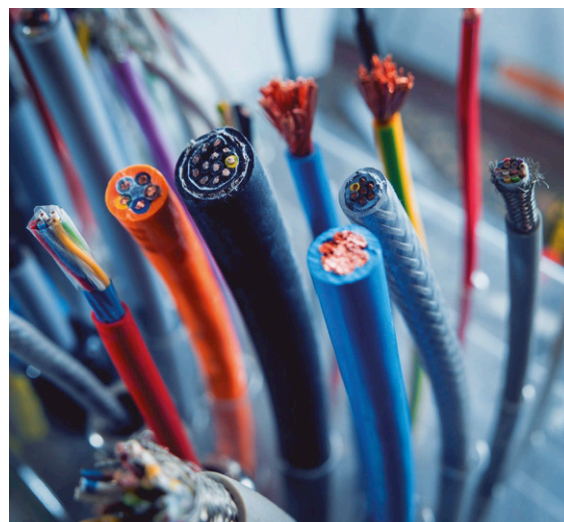


IMAGE: BENVIC

industries now need to stay in line with legislative and regulatory requirements, such as CPR."

The current Linkflex HF range is currently based on supplying low voltage applications in buildings and data communications, but the company plans to extend this to industrial, utilities and heavy-duty applications. Looking further ahead, Mercade says the company will also offer crosslinked versions of the Linkflex HF compound.

Italian compounder **Padanaplast** has extended its products for the electric vehicle sector with a new experimental flame retardant cross-linked HFFR compound Cogegum GFR 1709-27 T4. "The surging development of complex hybrid, all-electric and fuel cell vehicles demand advanced automotive wires and cables to meet a range of voltages and performance criteria," says Antonello Casale, R&I & Technical Service Chief Manager at the company.

Cogegum GFR 1709-27 T4 is a silane cross-linked polyolefin specifically developed for production of high voltage ultra-flexible battery cables requiring very good thermal and mechanical performance and resistance to automotive fluids.

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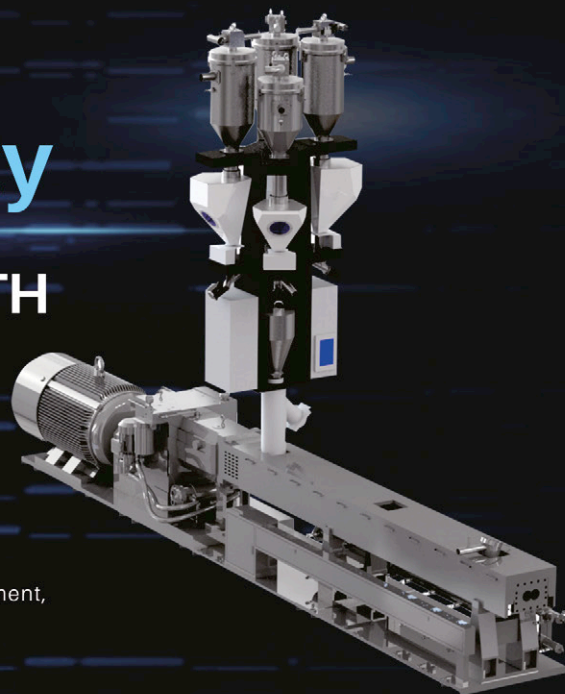
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Sustaining progress in natural fibres

Natural fibre reinforcements and fillers are proving effective options for reducing the environmental impact of plastic products. Peter Mapleston looks at the latest developments

The availability and performance of fibres from all sorts of renewable resources continues to improve, helping compounders and processors that serve many markets to home in on targets for carbon footprint reduction, degradability, and overall sustainability. Much of this demand results from growing environmental concerns and increasingly restrictive regulatory requirements being imposed or threatened on the use of many plastics-based materials, particularly in the consumer goods sector.

Looking just to Europe, almost 150,000 tonnes of biocomposite granulates were produced across the continent last year, according to nova-Institute in Germany. It estimates that more than half of this volume contained cork, close to a third were wood-plastics composites, and near 10% used flax, hemp, or kenaf fibres. Some 4% of the compounds contained cellulose fibres (pulp or paper based) and the remainder were derived from a mix of sources comprising meadow grass, straw, nut shells, and other renewables. They are used for various reasons – not only for sustainability – with improved mechanical properties, aesthetics and weight reduction cited as prime goals.

Building materials company Alloc and research outfit **RISE PFI**, both based in Norway, earlier this year started a new project called “BioComp” with two industrial partners in the country. The project is

centred on a new injection mouldable biocomposite system based on wood fibres (by-products of flooring production) and bioplastics, which are being implemented on a new compounding line that could eventually be used for commercial production. The BioComp initiative is a continuation of the FiberComp and ValBio3D projects previously discussed in *Compounding World* (see the May 2020 edition). Other partners in the BioComp project, which is partly funded by the Research Council of Norway, include **Norske Skog Saugbrugs** and **Plasto**.

“The bio and circular economy focuses on biobased materials, reduction of material consumption, increment of the product-lifetime and recycling of industrial side-streams, thus closing the loop of material utilisation,” says Gary Chinga Carrasco, Lead Scientist in the Biocomposite area at RISE PFI. “This was one of the driving forces behind the project.”

Chinga Carrasco says the project will develop new biocomposite products and covers the whole value chain from biocomposite production (the specialism of Norske Skog Saugbrugs), injection moulding (Plasto) and interior building materials (Alloc), all working in close collaboration with RISE PFI, which is responsible for biocomposite R&D.

Dag Molteberg is Senior Development Manager at Norske Skog Saugbrugs. He says the company’s

Main image:
A growing variety of natural fibres and fillers are being developed for production of reduced carbon footprint and lightweight polymer compounds



Above: Norske Skog Saugbrugs is building a new plant for production of its Cebico wood fibre-based biocomposite pellets at its Halden site in Norway

main business is in the production of printing paper, but it also develops new green products based on its fibre resources and knowledge. "Saugbrugs has run several R&D activities related to biocomposites over the last ten years, but we are now taking this to an industrial and commercial level with the building of a new plant for production of biocomposite pellets."

The brand name chosen for the pellets is Cebico. They will be produced on the demonstration plant at the Norske Skog Saugbrugs plant at Halden in Norway, which will consist of a line for preparation of wood fibres, together with the compounding and pelletising line. Start-up capacity will be around 300 tonnes/yr. "The fibre source will be TMP (thermo mechanical pulp) spruce fibres, which we produce. Thermoplastics will be PE and PP, virgin and recycled. We will also investigate bio-based materials," Molteberg says.

Molteberg says the company sees large market opportunities within construction materials, consumer goods and packaging, among others. "We seek customers using conversion techniques like injection moulding, extrusion, hot pressing and 3-D printing."

Right: Aimplas is exploring the use of fillers derived from olive stones in the Oliplast project

Moulding expertise

Plasto Project Manager Runar Stenerud says its role in the project is to provide injection moulding expertise. The company operates highly automated injection moulding facilities that run 24/7 with unmanned production over night and during week-ends. "Participation in BioComp project is important for us to further strengthen our value proposition," he says. "Solving complex problems in the most cost-effective and sustainable manner possible."

Alloc's goal is to ensure its interior building products meet the environmental expectations of its customers. "As a producer of interior building

materials, Alloc has an environmental obligation to the market," says Leif Kåre Hindersland, Alloc's R&D Manager. "We need to make every effort to find better, lower-energy ways to produce, using sustainable and environmentally sound raw materials. We look at this project as a door-opener to a changing market with more and more demanding end users regarding the circular economy. There will also be an increased demand from governments around the globe that force every producer to go in the right direction."

RISE PFI has many years of experience in research and production of sustainable biocomposite materials based on several different polymers and tailor-made fibres and nanofibres, according to Chinga Carrasco. "We are pleased to be contributing to the industrial realisation of biocomposite products in Norway, with our extensive know-how and state-of-the-art equipment within the wood fibre processing, biocomposites and 3D printing areas."

Moving to southern Europe, Spanish research organisation **Aimplas** is looking at the use of the residues from olive cultivation in plastics. It is starting out from the premise that the main crops in the Mediterranean basin that generate lignocellulosic residues – potential raw material for composites and particleboards – can be woody crops such as olives, almonds, citrus fruits, and vines and cereals such as rice.

Global olive oil production has tripled over the past 60 years. For the 2019/20 growing season, global production amounted to 3.14m tonnes – close to 40% of it in Spain – according to data from the International Olive Council. It is an industry that creates considerable volumes of waste material – pruning of olive trees generates a large amount of biomass, which is made up of leaves (25% in dry weight) and branches. The olives themselves





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Right:
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hemp fibre in
PE or PP

amount to 85% pulp and 15% stone (production of olive oil in Spain alone generates some 360,000 tonnes of olive stones annually).

All of these lignocellulosic residues of olive cultivation – leaves, branches, and stones – can be recovered to obtain composites, according to Aimplas. Together with Spanish olive oil producer Olivarera los Pedroches, it is working on a project in which the stones are recovered to develop novel bio-based, biodegradable, and compostable compounds.

“A new possibility for this by-product is the incorporation of olive stones as a reinforcing material in plastic materials providing a wood-like appearance, which can provide an alternative to plastic products in the packaging and household goods sector,” Aimplas says. A new material, which has been named Oliplast, incorporates this filler/reinforcement derived from olive stones in a bioplastic matrix.

The process of preparing the olive stone fibres for incorporation into plastics compounds is not straightforward and requires various treatments. The stones must pass through a number of cleaning and grinding steps before separation into different fractions depending on the particle size obtained. These different particle sizes produce compounds with differing characteristics. Aimplas says that all products made with Oliplast can be treated as conventional organic waste and, in a particularly circular process, they could even be used to produce compost to fertilise the olive grove itself.

Growth continues at **APM** (Automotive Performance Materials), the hemp-filled compounds production joint venture between the automotive



IMAGE: APM

Tier One Faurecia and agricultural cooperative Interval. It says it will supply a newly developed grade, NAFILean Stiff, for use in the new Peugeot 308 model (other APM NAFI products were used on the previous model). Based on PP containing 20% hemp, the NAFIlead Stiff compound is said to be lighter than glass fibre reinforced PP but has a similar tensile modulus of 3.5GPa. It will be used to produce injection moulded structural instrument panel parts amounting to more than 5kg per vehicle.

Beyond automotive

APM is also pursuing applications outside automotive. The company now offers the NAFIBOOST line of 60% hemp-filled concentrates, which are intended for mixing with PE or PP to obtain materials incorporating 10 to 20% hemp according to the end use requirements. It says this new strategy is expected to aid take-up of composite materials containing hemp. “APM’s goal is also to limit the over-cost and make the technology affordable to

Naturally sparkling appliance design



IMAGE: UPM BIOCOMPOSITES

Left: The
Mysoda range
of domestic
sparkling drink
machines are
produced in a
wood fibre
filled PP
compound
from UPM
Biocomposites

UPM Biocomposites worked with Finnish company Mysoda to create its line of domestic sparkling water machines. Launched last year, the appliances are made from UPM’s Formi EcoAce biocomposite, which is manufactured from wood fibre and renewable mass balance PP produced from UPM BioVerno naphtha. All the raw materials are by-products of the wood and pulp industry.

The UPM Formi EcoAce compound is claimed to provide similar material properties to fossil-based alternatives and can be processed using industry-standard methods

such as injection moulding and extrusion. The surface finish, however, provides a more wood-like appearance due to the fibre content.

The appliance was created for Mysoda by Helsinki, Finland-based Pentagon Design. “Striving for more sustainable solutions is a fundamental element of good design,” says Creative Director Arni Aromaa. “For the design team it was natural to look for alternatives for fossil-based material in this home carbonation market, which is a sustainable solution in itself.”

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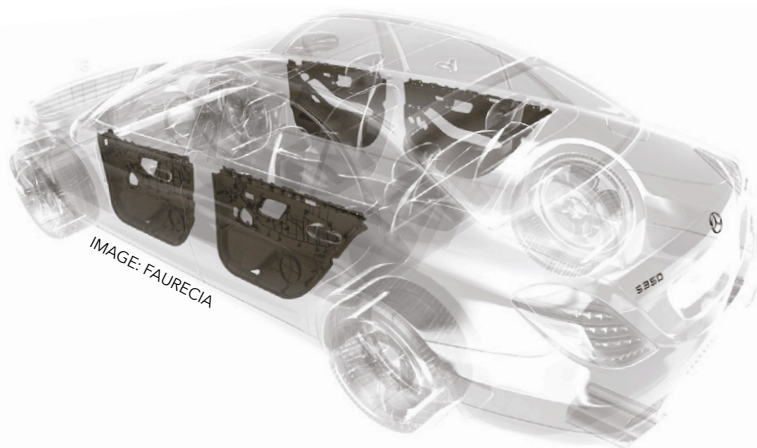
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new areas," says Jean-Marie Bourgeois-Jacquet, in sales & business development at the venture.

Faurecia, meanwhile, says innovation in sustainable materials is taking place across all of its business groups. The company says its aim is to reduce the CO₂ footprint of materials used for interior applications by 87% by 2030. Faurecia Interiors introduced its first NAFILean hemp-based products in 2008 and the company says it is building on this to develop other interiors products that have reduced CO₂ emissions.

"A number of plants are suitable for use as bio-composites in plastic products – linen and bamboo, for example," says Laurence Dufrancatel, who is Innovation Materials Manager and part of the Sustainable and Smart Product Line team member at Faurecia Interiors. "For use in automotive interiors parts, hemp meets OEMs' performance and safety requirements."

The NAFILean range has grown from one product to four today, with a next generation grade said to be in the development pipeline. "Each of these improves on the 'parent product' by lowering CO₂ emissions, reducing weight, or opening possibilities for more uses. The original NAFILean



products are on average 25% lighter than their conventional counterparts and save around 28% in CO₂ emissions," says Dufrancatel.

"NAFILean Stiff and NAFILite develop on the existing range, offering more uses," he says. "NAFILean Stiff makes for a tougher part that can be used in different settings while still saving 52% of CO₂ emissions. And NAFILite has a microcell structure with 29% reduction in weight and 43% in CO₂ emissions before its use phase. NAFILean R, which uses a 100% recycled plastic matrix, saves

Above:
NAFILean
components
are used on
17 production
vehicles,
including the
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Class



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108% of associated CO₂ emissions."

Faurecia is now producing NAFILean products for 17 vehicle models and the products can be found in around 13m cars. The next generation of NAFILean will be a high performance version – NAFILean Perf. It will offer even higher reductions in weight and CO₂ emissions at 41% and 58% respectively, according to Dufrancatel.

Current NAFILean products are manufactured by injection moulding but Dufrancatel says Faurecia is now developing its NFPP family, which comprises a new range of interior component options for compression moulding technology. The first generation of this series is said to be already in serial production. "Compression presents opportunities to develop natural fibre composites using other plants such as flax and kenaf and expand the uses of our solutions in visible parts, for example," he says.

Agricultural sourcing

Hungarian compounder **Inno-Comp** has been involved in research sponsored by the European Union and the Hungarian government on the development of what it says is a new biocomposite product family. "On a degradable PLA or non-de-

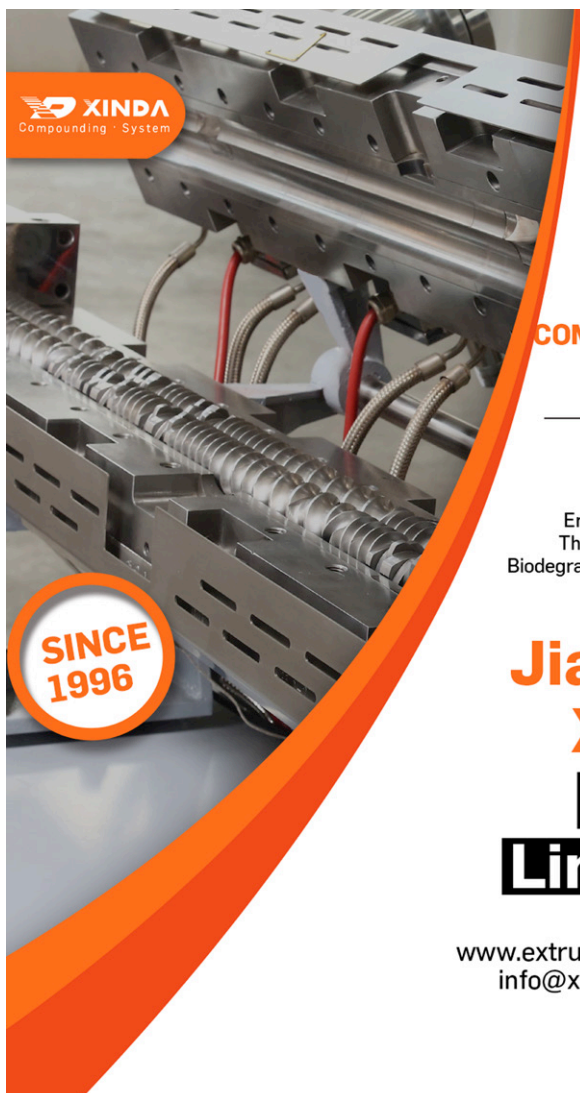


IMAGE: INNO-COMP/VILHEMP

gradable, mainly PP, polymer basis, our compounds are manufactured from natural materials that originate from domestic agriculture. But they are not intended to be reused there, for example grind of apricot shells, walnut shells, almond shells, and hemp fibre," says Sales Engineer Balázs Kugler.

"Blending PLA with hemp fibres improves the quality of the produced material in multiple ways: apart from its natural appearance, its physical properties and compostability are also much more

Above:
Vilhemp is using hemp reinforced PLA compounds from Inno-Comp to produce compostable cutlery



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IMAGE: FRAUNHOFER WKI



Above: Fraunhofer Institute researchers have produced a range of flame-retardant bio-filaments for 3D printing

improved compared to the plain PLA," says Kugler.

Inno-Comp is working with start-up end-product manufacturer **Vilhemp** and an undisclosed global wholesale company. Vilhemp is using the PLA-based compound for the production of cutlery that can be composted after use. Under industrial conditions, visible decomposition begins after 28 days.

The materials are being produced on a production line based on a Theysohn TSK032HV/46D type two-screw extruder equipped with an Econ underwater pelletising system. It was installed and commissioned in July last year. "This tailor-made machine was configured in a way to be suitable for producing high quality specialties such as natural-filler filled biocomposites and flame retarded compounds," Kugler says.

Below: Testing the tracking resistance of a PLA biopolymer compound formulated for electrical applications at Fraunhofer WKI

Electrical compounds

At the **Fraunhofer Institute** for Wood Research (WKI), a team headed by Dr Arne Schirp working together with various partners has embarked on a new project called BioFla, which is looking into how bioplastics and biocomposites can be

produced for electronics and logistics applications. The aim is to develop flame retardant products using halogen-free systems while also providing the necessary resistance to heat and impacts.

"The biomaterials currently available on the market do not fully satisfy these requirements," says Schirp. "We are developing materials which have the necessary properties, and which can be processed by means of injection moulding and FDM additive manufacturing. Products such as light switches, sockets, motion detectors, cable ducts or charging stations for electric vehicles could soon be produced from biomaterials."

As a first step, Fraunhofer WKI is working in collaboration with the Fraunhofer Institute for Applied Polymer Research IAP on the development of a halogen-free bio-flame retardant based on organophosphoric acid ester. In a second step, this will be reactively bound to polylactide (PLA). The binding of the reactive flame retardants and the partial crosslinking of the PLA is achieved through electron irradiation.

Compounds will contain wood fibres and impact modifiers. Schirp says that research indicates that, possibly contrary to expectation, the wood fibres have a positive effect on heat resistance and flame retardancy. "Thermoplastics have a relatively high heat of combustion and burn without charring. By adding wood, charring is induced. Replacing a certain percentage of the thermoplastic with wood particles changes the fire behaviour by decreasing the heat of combustion of the volatiles. In addition, residue formation is increased due to the wood particles," he explains.

Parallel to the developments with self-synthesised flame retardants, the team is also using commercially available flame retardants. Other thermoplastics, both bio and non-biobased, are also being examined.

All the compounds are processed by means of



IMAGE: FRAUNHOFER WKI/HAGER ELECTRO

injection moulding and FDM filament-type additive manufacturing to form test specimens for subsequent testing. The materials are evaluated for their UL94 fire performance rating, heat resistance, glow-wire test, tracking resistance, tensile strength and modulus of elasticity, impact resistance, water absorption and swelling.

"During the first year of the project, it was possible to develop PLA-based formulations, extrude them into filaments and print them, thereby achieving the UL94 V-0 classification at a test-specimen thickness of 1.6 mm," says Schirp. "Flame-retardant PLA as well as a flame-retardant wood fibre-reinforced PLA/PBS blend successfully withstood the glow-wire test at 960° C. With regard to tracking resistance, the flame-retardant, wood fibre-reinforced PLA/PBS blend achieved at least 175V; in one test, 200 V and 250 V were also achieved."

In the second year of the project, research will involve investigations with PHB and PET, as well as the new bio-flame retardant. In addition, and in cooperation with project partners from industry, the formulations will be compounded on a larger scale and processed for applications in electrical engineering and electronics (E&E) and logistics.

Cellulose research

Natural fibre interest does not stop at Europe's borders. In North America, **Performance BioFilaments**, a Canadian producer of nanofibrillated cellulose, recently completed an investigation in collaboration with the National Research Council of Canada's Automotive and Surface Transportation Center to determine and evaluate material prop-



Above: The Prima chair, widely used throughout Finland's schools, is now available in a compound based on cellulose reinforced recycled PP

Back to school for Prima

A collaboration between Finnish furniture company Isku and Fortum (probably best known as a clean power generation company but which has also developed plastics based on post-consumer recyclates) has led to the introduction of a new version of Isku's Prima school chair. Used in schools around the world since the 1990s, this new version of the classic design is made from recycled plastics, mostly consumer packaging collected from Finnish households, reinforced with cellulose fibre.

"Fortum Circo PP FC recycled plastic is a new type of material specifically developed to meet the requirements of a highly durable product," says Mikko Koivuniemi, Fortum's Product Line Manager, Plastic Recycling.

The compound was developed in collaboration with a third Finnish company Elastopoli, which has been working on development of natural fibre reinforced composites for 14 years, and is based on a patented process technology. "The material has qualities on par with virgin plastic, but its environmental impacts are significantly smaller," says Koivuniemi.

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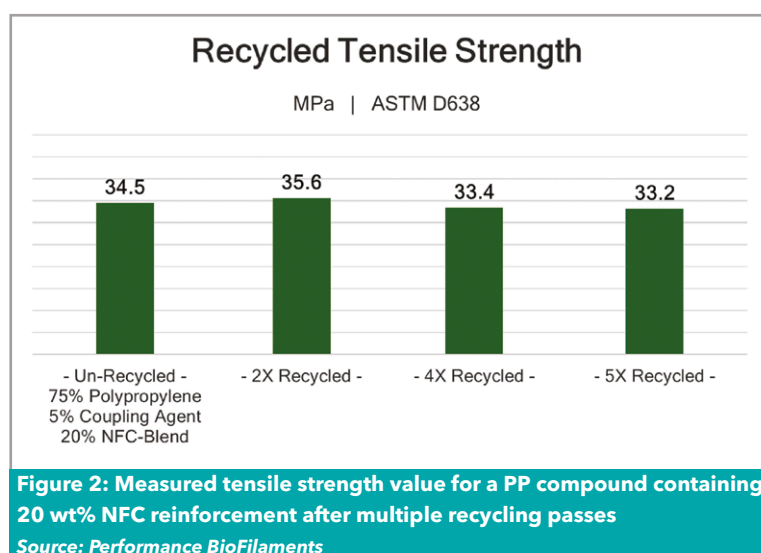
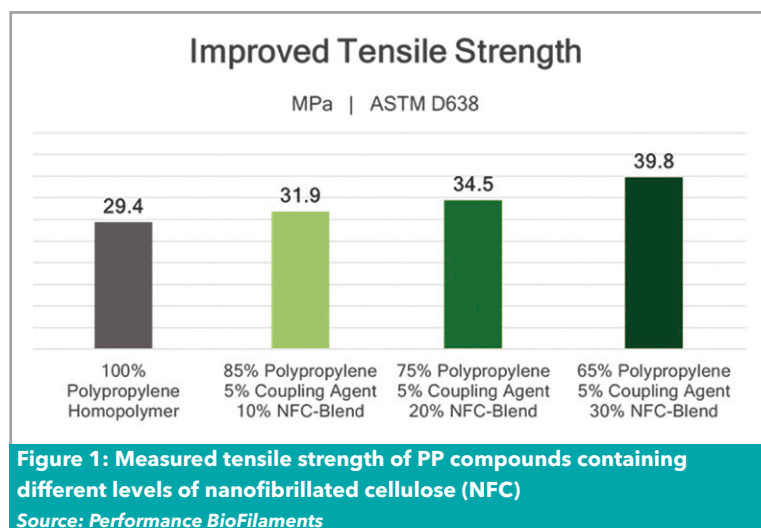


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erty gains and recyclability of natural fibre reinforced thermoplastics.

Geoff Fisher, Director of Business Development at Performance BioFilaments, says the investigation involved compounding of nanofibrillated cellulose (NFC) derived from wood fibres via mechanical refining into diverse polymers, including PP and PLA, and testing these compounds for gains in strength (Figure 1). The compounds were then put through multiple re-grind/extrude cycles to see how those gains obtained from the fibres persisted after being recycled.

Tests showed that NFC cellulose can deliver increases of more than 30% in tensile strength and more than 75% in tensile modulus with loadings of up to 30 wt% in PP and PLA. Interestingly, it was found that these properties changed little after being recycled five times (tensile strength results are presented in Figure 2).

Meanwhile, Georgia, US-based **Attis Innovations** recently entered the plastics market with a portfolio of biobased fillers as well as polymeric materials and

resin extenders. Targeted feedstocks under consideration include black liquor, woody biomass, crop stover, nut hulls and shells, grasses, and numerous other renewables.

Attis formed a strategic partnership three years ago with Alpharetta, US -based **Genarex**, which extracts otherwise low-value materials from corn ethanol by-products and uses them as bio-additives in plastics. It says it now has the ability to service customers with "a versatile array of materials" which bring value and cost savings to a variety of applications.

"Attis Innovations' primary product for the plastics space is a unique, melt-flowable lignin, a bio-additive that brings unparalleled cost savings and performance to common resin systems," says Bob Montgomery, VP Product Development at the company.

Bio-based fillers

Attis also markets a suite of bio-fillers called Bylox through its strategic partnership with Genarex. These fillers are said to differ greatly from existing bio-filler options in that the material is primarily protein-based, which Montgomery claims gives it superior ductility and particle size.

"Bylox LT has shown great success with many film applications, including agricultural mulch film and yard and pet waste bags," he says. "Bylox HT is a more thermally stable product that is capable of processing in conjunction with higher temperature products without creating anisotropic shrinkage issues or significant loss of mechanical properties. Bylox Clean is an outstanding product with lower base colour and odour, and in addition to working in films has shown the ability to substitute some plasticiser used in the production of flexible PVC for a significant cost reduction."

In a separate development, Montgomery says Attis Innovations is also currently pursuing the development of a fully bio-based, 100% lignin-borne carbon fibre product.

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3D print developments target volume markets

Large volume custom manufacturing is on the horizon for 3D printing processes and new developments in compounds are playing a major role. Mark Holmes reports

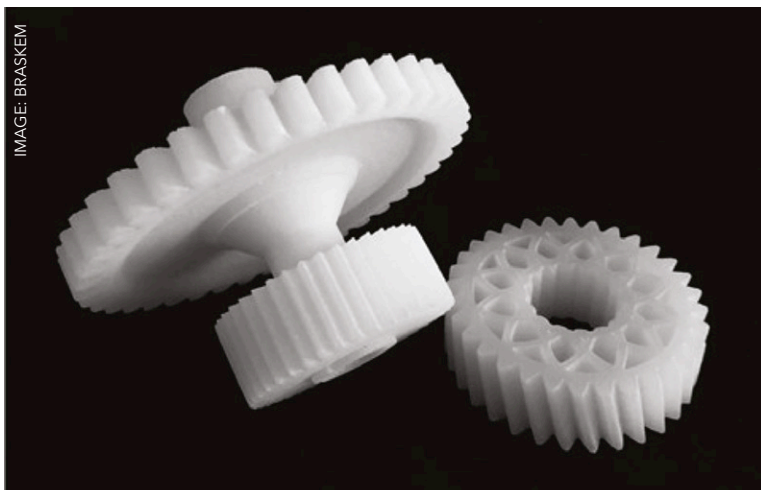
The range of compounds suitable for 3D printing – or additive manufacturing – continues to grow and formulations are increasingly being developed with specific 3D print production processes in mind. Many compound producers are collaborating with specialist suppliers of 3D printing materials and with machinery manufacturers to optimise the performance and processing of new materials. A great deal of this development work is intended to take 3D print manufacturing technologies to the next level, supporting the move from the prototyping environment through to production of one-off and customised products and, ultimately, to high volume tailored manufacturing.

LyondellBasell, for example, has recently launched Beon3D, a range of polypropylene (PP) compounds intended for production of complex,

high quality 3D printed objects in one step. The company says the Beon3D materials are intended to advance the adoption of additive manufacturing in markets such as transportation, industrial and consumer goods, building and construction.

While often associated with the production of single items, 3D print technologies are also suitable for large-scale custom manufacturing. However, the choice of polymers has been restricted due to processing challenges. PP compounds, for example, are the material of choice for many industrial-manufactured parts due to their good mechanical properties, scratch and chemical resistance, light weight, as well as resource efficiency. But the polymer is not easy to process in extrusion-based 3D print processes such as fused deposition modelling (FDM) and fused filament fabrication (FFF).

Main image: 3D print compounds are increasingly being developed for volume production and specific production techniques. The latest Repsol introductions are pitched at FDM and FFF equipment



Above:
Braskem is working with Advanced Laser Materials to develop PP powders for SLS manufacturing systems

"The key challenges in extrusion-based additive manufacturing of common PP are the typically pronounced warpage and adhesion problems of PP on common printing substrates," says Joan Miravittles, Marketing Manager at LyondellBasell. "The Beon3D range is specifically designed for 3D printing to overcome these challenges. Therefore, we offer industrial customers solutions for the additive manufacturing of PP that enable fast, precise, and reliable manufacturing at the highest level."

The Beon3D product family is currently focused on extrusion additive manufacturing techniques that use filament materials. "Our materials are specifically designed to be processed with all common printer systems and also to allow reliable scaling for customers," Miravittles says.

"Extrusion-based additive manufacturing is a robust and cost-competitive technology that allows the application of various polymers, and especially polymer compounds, to produce functional multi-colour and multi-material parts in a single process step. Additionally, extrusion-based additive manufacturing is exceptionally flexible in producing customised parts over a wide size range and in any quantity. Consequently, it is complementary to conventional processing techniques and allows for a unique integrative combination for tailored mass production," he says.

LyondellBasell claims that its Beon3D products provide fast, precise and reliable processing even at high volumes. "Beon3D products are chemical and temperature resistant and create durable, low-density parts," says Miravittles. "It is due to our expertise in various industrial markets such as transportation, electrical and electronics, as well as building and construction, that we are able to bring the Beon3D product family to our customers providing them with innovative and efficient 3D printing solutions."

Bright future

While the use of PP compounds in the 3D print sector is still emerging, leading additive manufacturing industry experts predict a bright future for the polymer. According to Prof Dr Rolf Muelhaupt, additive manufacturing expert at the University of Freiburg in Germany, the combination of materials such as LyondellBasell's Beon3D PP compounds with current additive manufacturing technologies will enable new material properties previously unthinkable in the sector. "Producing sustainable finished products in one-step has become a reality through the combination of design, digitisation and manufacturing," he says.

Spain's **Repsol** has also expanded its range of PP compounds for 3D print applications, with two new grades formulated for production of high mechanical performance components using FFF and FDM techniques introduced this year. The compounds join the current three grades launched in 2020.

Isplen P3D820FM is a highly mineral filled medium flow PP that offers high rigidity and dimensional stability and low warpage together with good impact performance and optimal surface appearance. It is UV stabilised and is said to offer good scratch resistance, making it suitable for outdoor use. Repsol Isplen P3D630FV is a glass fibre reinforced PP indicated for applications that require very good impact resistance, high rigidity, and low deformation and shrinkage. It is also UV stabilised.

Also targeting PP but in the different area of powder-based technology, **Braskem and Advanced Laser Materials (ALM)**, a leader in materials development for additive manufacturing, have introduced a PP powder for selective laser sintering (SLS) industrial 3D printing. The two companies began their partnership in 2018, focusing specifically on the development of polyolefin-based powders for SLS. The new PP powder is the first commercial product launched under the joint collaboration.

SLS uses thermal energy from a laser to selectively sinter polymer powder layer-by-layer to produce a three-dimensional, solid geometry. It is used in industrial applications in automotive, aerospace, packaging and consumer goods. The launch of the new PP powder is said to bring a number of enhanced benefits to the SLS additive manufacturing process. These include lighter weight, moisture resistance, durable living hinge capabilities, improved recyclability, chemical resistance and enhanced processing stability, as well as an elongation at break and flexibility that is comparable to injection moulding PP grades. ➤



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Thinking big

Bioplastics producer **Natureworks** has long held a foothold in the 3D print space, where its PLA-based Ingeo polymers have proven to run well on filament-type production systems. The latest addition to its offering is Ingeo 3D700, an amorphous grade formulated for large-format 3D print applications where the company says high rates of polymer deposition can result in excessive warpage with materials such as ABS or significant shrinkage with polyolefins or "general-purpose" PLA grades.

"As the 3D printing space expands into larger, more complex applications, we are seeing an increased need for printing materials that are tailored for a specific application or process," says Dan Sawyer, Business Development Leader for NatureWorks. "With significant growth in large-format additive manufacturing for industrial applications, we saw the opportunity to develop a new Ingeo biopolymer grade specifically designed to minimise the loss of time and material due to failures in large format prints."

Part warpage in large parts is typically controlled by using compounds containing mineral fillers or glass, carbon, or cellulosic fibre reinforcement, which can make processing more challenging. Natureworks says that because the Ingeo 3D700 resin has been designed for low shrinkage, it is possible to use less reinforcing content and still achieve quality large-format parts.

In trials carried out by extruder and large-format printer component maker Dyze Design, Ingeo 3D700 showed significant shrinkage and throughput improvements over Ingeo 3D850, an existing Natureworks 3D print grade. "Our tests showed

that a large-format part printed using Ingeo 3D850 demonstrated a shrink rate of 1.25%. In comparison, the same part printed with Ingeo 3D700 had a shrink rate of less than 0.25%," said Dyze CTO Philippe Carrier. "Because Ingeo 3D700 also has a higher throughput rate, we were able to successfully print at the lower temperature of 190°C without seeing shrinkage or warping in the part."

Natureworks says Ingeo 3D700 is available for use as pellets for direct resin-to-print processes or as filament for the FFF process in the US, Asia, and Europe.

The latest additive manufacturing development from **Evonik** is a 3D printable filament based on PEEK. This high-temperature and chemical-resistant ready-to-use material is said to be particularly well suited for additive manufacturing of demanding industrial plastic parts due to the high-performance polymer's suitability for processing in common

extrusion-based 3D printing technologies such as fused filament fabrication (FFF) or fused deposition modelling (FDM).

Evonik has launched the new filament under the Infinam PEEK 9359 F name. The natural-coloured PEEK filament, which has a diameter of 1.75mm, is wound on 500g spools suitable for direct use in standard FFF/FDM 3D printers for PEEK materials. Its properties include high mechanical strength, hydrolysis resistance and inherent flame retardancy. The company adds that it is well suited to production of lightweight and high-performance 3D parts for the aerospace, automotive, and the oil and gas industries.

Compared to stainless steel, 3D parts made of Infinam PEEK 9359 F are said to be approximately 80% lighter and 30% tougher. They also offer very good fatigue resistance and this combination of properties makes the compound a good option for metal replacement in demanding lightweight applications. The new resin also offers good wear resistance and low sliding friction and can withstand long term exposure to temperatures of 250°C or short term exposure to temperatures of more than 300°C.

Flexible option

Together with HP, Evonik has developed a 3D-printable thermoplastic elastomer for the latter's Multi Jet Fusion technology. The elastomer is a flexible high-performance speciality powder based

Right: Infinam PEEK 9359 F is a new 3D printable filament based on PEEK from Evonik



IMAGE: EVONIK

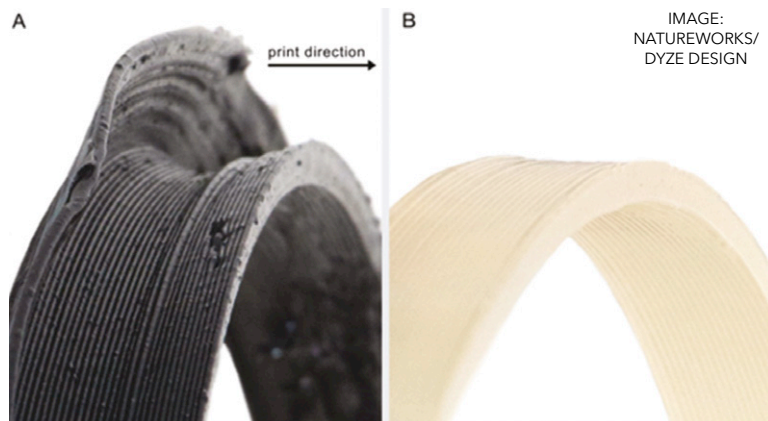


IMAGE: NATUREWORKS/DYZE DESIGN

Images show the difference in side wall warpage in the same part produced in black PP (left) and Ingeo 3D700 (right) from Natureworks

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Right: Evonik and HP have developed a 3D-printable thermoplastic elastomer for HP's Multi Jet Fusion technology

on a thermoplastic amide (TPA). The two companies have a long-standing industry partnership and this new elastomer is optimised for the Multi Jet Fusion technology.

The new TPA powder is a flexible, lightweight-construction material with a low density of 1.01 g/cm³ and a Shore A hardness of 91. The high-performance powder is intended for production of functional high-tech 3D plastic parts – prototypes as well as series products – that require high extensibility and energy return; Evonik cites sports equipment and automotive components as prime examples.

Underlining its commitment to additive manufacturing, Evonik recently opened a new technology centre for 3D printing in Austin, Texas, US. The company says the site will play a key role within its global innovation network in the development of ready-to-use materials for powder bed fusion based on the Structured Polymers technology it acquired in 2019.

The new Centre for Structured Polymers Technology comprises an application technology laboratory with 3D printers and a processing area, a research and development laboratory, production rooms and associated office areas, as well as meeting rooms.



IMAGE: EVONIK

The Structured Polymers technology is based on polymer granulate that is processed into fine powder material in various steps. Polymer powders can be produced in controlled particle sizes with a diameter range of 0.1-400 microns. The first ready-to-use powder materials

– two thermoplastic elastomers based on copolyesters – were introduced to the market in late-2019. Both products exhibit high elasticity and flexibility combined with good resilience, remain tough and flexible after printing, and are said to yield good surface quality.

In a separate move, Evonik has acquired a minority stake in Chinese company UnionTech through its Venture Capital unit. The Shanghai-based company is active in the field of stereolithography (SLS) 3D printing. In the SLS process the part is “pulled” from a bath of light-curing liquid resin with a laser or display light source curing the photopolymer layer-by-layer to create a three-dimensional product. Using this method, it is possible to produce complex workpieces with a much smoother structure than with other 3D print processes. Typical markets include automotive and aircraft manufacturers as well as industrial parts or special footwear products.

Maintaining filament consistency

The Liad Smart ColorSave-Micro from **Ampacet** is a gravimetric colour and additive feeder designed to meet the needs of companies producing filaments for the 3D printing industry.

The company says filament producers face a common challenge in maintaining consistent colour quality during extrusion, which can

lead to high scrap rates or customer complaints. This can be due to use of short screws without mixing elements or not using micro pellets or quick melt colour masterbatches, but also due to inaccurate hand mixing.

According to the company, the Liad Smart ColorSave-Micro gravimetric feeder provides precise feeding of

colour masterbatches to eliminate the inaccuracies of hand-mixing resin and colour or additive masterbatches. In addition, it avoids the possibility of segregation of colour and virgin resin during the feeding process.

The feeder uses a single vibrational-protected inner channel to eliminate exterior vibration and consistently deliver an accurate dose. It operates in a continuous extrusion mode and ensures a consistent let-down ratio of the colourant relative to the extruder throughput rate.

The ColorSave-Micro can accurately dispense materials – including flowable, non-dusty powders or granules and micro pellets – at rates as low as 0.1%.

➤ www.ampacet.com



IMAGE: AMPACET

Left: The filament format is one of the most popular for 3D print materials but production raises specific challenges dosing for formulators and producers, according to Ampacet

PEEK performance

Another key player in the high performance additive manufacturing sector is **Victrex**. The company says that incumbent PEEK materials used in most 3D print applications are based on grades originally designed for conventional manufacturing methods such as machining and injection moulding, while its Victrex AM 200 filament is specifically developed for this new production technology.

Victrex says that while the good mechanical properties of PAEK are in demand for high-performance 3D printed parts these could often not be realised with existing PEEK and PEKK choices. The company says repurposing injection moulding PEEK into filament fusion additive manufacturing, for example, typically results in weak parts because of poor interlayer bonding. Its new material is designed to address this weakness.

The first 3D printing equipment supplier to offer Victrex's new AM PAEK filament is China-based Intamsys. It reports that in its manufacturing equipment the Victrex AM 200 filament delivers higher Z-axis strength and has shown up to 80% strength in the X-Y direction with a better fused filament forming (FFF) printing adaptability than existing PAEK materials.

"Our test results to date have shown that the Victrex AM 200 filament has a better interlayer adhesion than other PAEK materials on Intamsys machines," says Charles Han, Founder and Chief Executive Officer of Intamsys. "Compared with unfilled PEEK, it is designed with slower crystallisa-



IMAGE: VICTREX

tion, lower melt temperature and a viscosity fine-tuned to the filament fusion process, such as easier flow in the build chamber after leaving the nozzle. Higher flow in open air (low shear rates) also promotes interlayer bonding and stability during printing. All of this

contributes to an improved interlaminar adhesion, easier printing (less shrink and warp), and a better suitability for FDM 3D printing, compared to other similar options, based upon the testing we have done at Intamsys up to this point."

The Intamsys tests were performed on a number of different printers including its smart dual nozzle Funmat Pro 410 3D Printer. This industrial-grade, high-temperature 3D printer can print parts up to 305mm by 305mm by 406mm and can handle a variety of complex structures. It can print a number of materials, including PEEK, carbon fibre reinforced PEEK-CF, PEKK, PC, PC-ABS.

Intamsys is also part of Victrex's filament fusion network, which aims to facilitate the use of high-performance Victrex AM materials based on PAEK

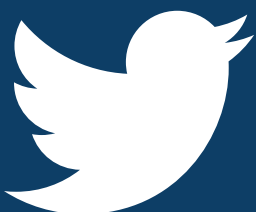
Left: An engineering component produced in Victrex AM 200 PAEK filament

Below: This shoe insole was printed by SLS using a partially bio-based thermoplastic polyurethane from Covestro



IMAGE: COVESTRO

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Emery Oleochemicals has developed binder systems for metal and ceramic 3D print part production



IMAGE: EMERY OLEOCHEMICALS

Additive manufacturing – more than just plastics

3D printing is not all about plastics. Emery Oleochemicals' Green Polymer Additives business unit has developed a binder system for 3D printing of sinterable metals and ceramics using extruded filaments and FDM machinery.

The company's technical group developed its first binder system for metal injection molding in the early 1990s. Since then, applications have developed from powder injection molding (PIM) and powder extrusion to the current stage of additive manufacturing using filaments made from sinterable feedstock. These filaments typically contain more than 80 wt% of metal or ceramic powder.

According to the company, the metal or ceramic feedstock filaments can be processed using a standard FDM printer with just a modified print head. After filament 3D printing, parts go through several post-processing steps involving solvent removal and thermal treatment steps to create finished full metal or ceramic components.

According to Emery, its binder and feedstock systems provide parts with improved part strength and lower shrinkage. The company says the same binder system can be used for both 3D print prototyping and volume powder injection moulding.

➤ <https://greenpolymeradditives.emeryoleo.com/3dprinting>

polymers. These materials are designed for use in applications requiring high temperature resistance and good mechanical properties. Victrex says the materials also offer good resistance to wear, fatigue and chemicals.

Sustainable ideas

The latest additions to the **Covestro** 3D print materials line up are focused on sustainability and include pellets and filaments containing recycled content, including some post-industrial waste from the company's manufacturing facilities. One of these new additions is a polycarbonate blend suitable for applications that require high temperature resistance.

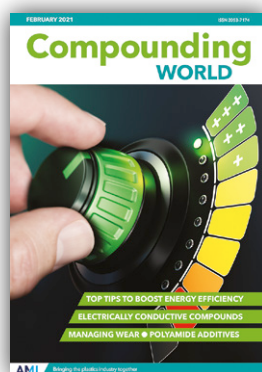
Covestro is also developing partially bio-based products for 3D printing in which almost 50% of the carbon content is derived from biomass. One such material is a TPU that has already been used to print a shoe insole using selective laser sintering (SLS). Other building blocks for sustainable TPU materials include the Cardyon polyols, which are partly-derived from CO₂.

Lubrizol Corporation has introduced three Estane 3D TPU grades for fused filament fabrication (FFF) 3D printing applications for users of Ultimaker equipment. The new grades include Estane 3D TPU F94A-055 or HH PL, Estane 3DP TPU 98A and Estane 3DP TPU F70D. Ultimaker offers a material library called the Marketplace in Ultimaker Cura, which allows partner raw material suppliers to upload profiles for grades that are compatible with Ultimaker printers. Lubrizol's three latest Estane 3D TPU grades meet requirements for printing industrial jigs and fixtures, prototypes, end-use parts, and flexible parts such as orthopaedic insoles.

Three new **Kimya** ABS compounds have been qualified for the Method X 3D printer from Maker-Bot, which is a subsidiary of Stratasys. The new materials include Kimya ABS Kevlar for parts requiring high strength, abrasion resistance, and

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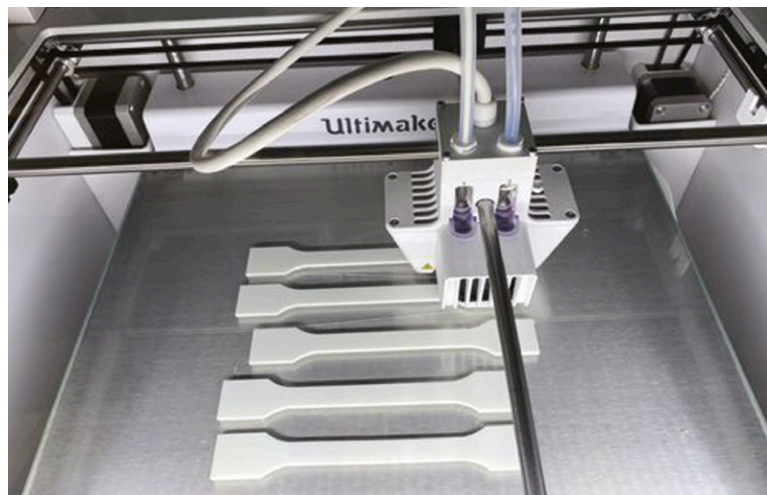
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IMAGE: LEHVOSS GROUP



Above:
TÜV Süd has certified the combination of Luvocom 3F filament from Lehvoss Group and Ultimaker printing technology

dimensional stability; Kimya ABS-ESD, which protects against electrostatic discharges; and Kimya ABS-EC, which is electrically conductive.

Kimya says that cost savings of up to 80% have been demonstrated compared to traditional manufacturing methods by 3D printing tools and fixtures using the ABS Kevlar material in its own production facilities. With a heated build chamber that can maintain temperatures up to 110°C and that provides the ability to control the speed at which parts cool during the printing process, Method machines are claimed to be able to print high strength manufacturing-grade parts from advanced engineering materials more successfully than traditional desktop 3D printers. The company says users can also produce parts that have internal structures or complex geometries on Method machines when printing with Stratasys SR-30 soluble supports.

The new Kimya materials are designed to print on the Method X 3D printer equipped with MakerBot's new Labs Gen 2 Experimental Extruder. This is optimised to handle more abrasive third-party composites and polymers and features a number of upgraded components, including hardened gears and a metal filament switch designed to reduce wear.

Performance PA

MakerBot has also added a PA 12 carbon fibre reinforced grade to its range. The material offers very good physical and thermal properties and can be used to print metal replacement parts for some applications. It is described as a resilient carbon fibre-reinforced PA that is optimised for high strength and stiffness. Compared

to PA6 and PA66, the PA12 base polymer offers a lower moisture absorption and, as a result, it better retains its performance in high moisture environments.

The PA12 carbon fibre grade has been formulated to process well in MakerBot's 3D print equipment. With a tensile modulus of 6000MPa, it is said to be suitable for applications that require high rigidity, such as automotive brackets or inspection gauges, functional prototypes, and lightweight parts for the aerospace, manufacturing, and automotive industries.

Commissioned by **Lehvoss Group** and Ultimaker, German testing house TÜV Süd has certified the 3D printing combination of the former's Luvocom 3F PA^{HT} 9825 NT filament and Ultimaker printer. The certification is based on TÜV Süd's Reproducible 3DP Construction process test specification, which references existing and emerging 3D printing standards.

The specification includes material property analysis and production of test specimen parts – including dimensional tolerances – as well as the manufacture of the filament. In addition, emissions are measured during the printing process. According to TÜV Süd, the combination of the LehVoss material and Ultimaker printing process meets the requirements in all respects. The Luvocom 3F PA^{HT} 9825 NT unreinforced high-performance PA and Ultimaker S5 Pro Bundle is the first FFF system to be certified by TÜV Süd.

On the basis of its current range of more than 30 FFF materials, Lehvoss Group is now supplying four materials as its own filament. Work is underway on certification of all four variants, with the focus on development, production and distribution of materials that can be marketed in filament form by established manufacturers under their own brand names.

"This is an important step for the industrialisation and scalability of FFF," says Dr Thiago Medeiros Araujo, Business Development Luvocom 3F.

"The certified system increases reliability in parts production and is intended to accelerate the use of 3D printing to put it on a par with already established production processes, such as injection moulding."

Right: A bottle mould produced using the new xPEEK147-Black grade from Henkel on Nexa3D's NXE 400 machine



IMAGE: HENKEL

Photo finish

In the photopolymer area, **Arkema** has expanded its Sartomer specialty resins product offering



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in 3D printing with the acquisition of Colorado Photopolymer Solutions. The company, which is based at Boulder, Colorado, US, specialises in photopolymer formulation for 3D printing in areas such as medical, composites, construction and consumer goods sectors.

Arkema has also strengthened its partnership with Continuous Composites, creator of the Continuous Fiber 3D Printing technology (CF3D). This US-based start-up aims to advance development of 3D composite manufacturing technologies for production of lightweight structures and offers a complete solution that includes software, hardware, material and motion platforms. Through its Sartomer Business Line, Arkema is developing a new generation of solutions for the CF3D process. Following the signing of a Joint Development Agreement in 2019, the two companies say they have hit some key milestones with the development of N3xtDimension photocurable resins for the process.

Adaptive3D is another US start-up that Arkema has invested in. The company sells photopolymer resins to enable additive manufacturing of tough, strain-tolerant, tear-resistant rubbers. Adaptive3D printable photo-resins are optimised for high-throughput manufacturing of functional complex three-dimensional plastic and rubber parts in a wide range of applications in the consumer goods, healthcare, industrial, transportation and oil and gas markets.

A collaboration between **Henkel** and Carbon aims to develop and validate the former's Loctite-branded formulations for use with Carbon's additive manufacturing process. As part of the collaboration, the newly introduced Loctite 3D IND405 Clear material is immediately available to Carbon customers.

The partnership agreement allows industrial customers to access Henkel's single-component (1K) technologies for use with the Carbon Digital Light Synthesis (Carbon DLS) 3D printing process. The Loctite 3D

IND405 Clear grade certified for Carbon printers is a clear, tough, semi-rigid, 3D printable material. The one-part liquid is said to be easily printed and is suitable for applications including enclosures and housings, light pipe prototypes, bottle prototypes, and jigs and fixtures.

Henkel is also working with Nexa3D, which makes production photopolymer-based 3D printers, and has developed three new functional polymers for durable prototype, production tooling and functional end-use parts with extended UV weathering stability. The partnership aims to move additive manufacturing towards mass production of functional parts across multiple industries using Nexa3D's NXE 400 manufacturing process.

The new photopolymer materials include xPP405-Black, which is a tough semi-rigid high-strength plastic resin providing a modulus similar to PP, 130% tensile elongation at failure and good UV weathering stability as characterised by ASTM G154 testing. xPP405-Black has an industrial black finish and is suitable for production of end-use parts such as piping, large housings and enclosures. The xPP405-Clear grade combines clarity, toughness and impact strength with a heat deflection temperature between 50-60°C. It can be finished for clarity and is suitable for production of packaging, light guides and luminaire components, and micro-fluidics.

The xPEEK147-Black grade is a tough material with good surface finish and dimensional stability and a high heat deflection temperature. It is suitable for production of tooling and functional end-use parts for automotive under-the-hood applications. xPEEK147 provides a temperature resistance of up to 230°C together with high stiffness and dimensional stability, long term thermal stability, and good solvent resistance.

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Right: Fluid ducts printed in Henkel's Loctite 3D IND405 Clear grade using the Carbon DLS process



Additional reporting by Chris Smith

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The Compeo is the latest generation of kneader extruder from Buss and is designed to provide the utmost flexibility in application. This 12-page brochure details key features and model specifications.

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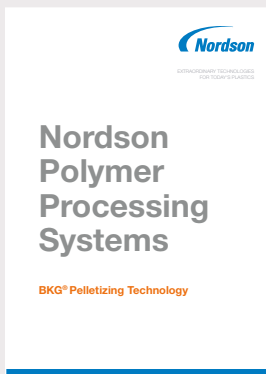
LEISTRITZ: MASTERBATCH SYSTEMS



Additive and colour masterbatch production places specific demands on compounding equipment. This 16-page brochure from Leistritz explains how its ZSE 35 iMAXX masterbatch twin screw extruder rises to the challenge.

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NORDSON: BKG PELLETISERS



The BKG range of pelletisers from Nordson Polymer Processing Technology includes underwater, water-ring and strand systems suitable for almost any thermoplastic pelletising application. Find out more in this six-page brochure.

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STRUKTOL: CREATIVE RECYCLING



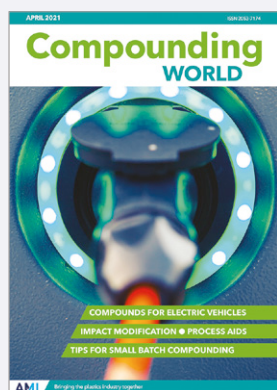
Struktol offers a full range of additives to enhance performance of recycled compounds. This brochure details its extensive range of lubricants, PP viscosity modifiers, homogenisers and odour control products.

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

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Compounding World April 2021

Features in the April issue of Compounding World cover compounds for electric vehicles and impact performance, along with small batch compounding, process aids, a preview of Chinaplas 2021 and an interview with PVC compounder Benvic.

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Compounding World March 2021

The March issue of Compounding World reports on the latest twin-screw extruders and their ability to handle recycled materials and low bulk density natural additives. Other features cover special effect pigments, compounding simulation software and odour reduction.

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Injection World April 2021

The April issue of Injection World looks at how the Covid-19 pandemic is stimulating greater use of robots and cobots by injection moulders. Features also cover the latest in caps and closures and a ramp-up in recycled compound offerings.

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Plastics Recycling World March/April 2021

The March/April edition of Plastics Recycling World magazine takes a look at the latest innovations in melt filtration. It also explores the use of additives to enhance recycle quality and reviews some of the newest developments from the PET recycling sector.

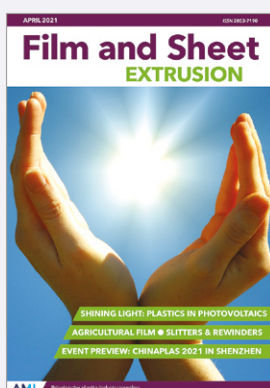
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Pipe and Profile May 2021

The May edition of Pipe and Profile Extrusion magazine takes a look at innovation in pipe die design. It also reviews some of the latest developments in medical tubing, pipe joining technology, standards and testing.

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Film and Sheet April 2021

The Film and Sheet Extrusion April edition has features covering advances in photovoltaics, agricultural film and slitters and rewinders. There is also a preview of Chinaplas 2021, the first major plastics exhibition to take place in over a year.

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Injection
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Plastics Recycling
WORLD

GLOBAL EXHIBITION GUIDE

2021	15-18 June	FIP, Lyon, France POSTPONED	www.f-i-p.com
	22-25 June	Plast 2021, Milan, Italy POSTPONED	www.plastonline.org/en
	10-12 August	Feiplar, Sao Paulo, Brazil NEW DATE	www.feiplar.com.br
	14-18 September	Equiplast, Barcelona, Spain NEW DATE	www.equiplast.com
	29-30 September	Compounding World Expo Europe, Essen, Germany NEW DATE	www.compoundingworldexpo.com/eu/
	12-16 October	Fakuma, Friedrichshafen, Germany	www.fakuma-messe.de
	3-4 November	Compounding World Expo USA, Cleveland, USA NEW DATE	www.compoundingworldexpo.com/na/
	8-12 November	Plastico Brasil, Sao Paulo, Brazil NEW DATE	www.plasticobrasil.com.br
2022	15-18 November	Arabplast, Dubai, UAE NEW DATE	www.arabplast.info
	25-28 January	Interplastica, Russia, Moscow	www.interplastica.de
	17-21 February	PlastIndia, New Delhi, India NEW DATE	www.plastindia.org
	8-10 March	JEC 2021, Paris France NEW DATE	www.jec-world.events
	8-11 March	Plastimagen, Mexico City	www.plastimagen.com.mx
	5-8 April	FIP, Lyon, France NEW DATE	www.f-i-p.com
	19-26 October	K2022, Dusseldorf, Germany	www.k-online.com

AMI CONFERENCES

25-27 May	Grass Yarn & Tufters VIRTUAL SUMMIT
27-29 July	Smart Packaging VIRTUAL SUMMIT
14-16 September	Cables Europe, Cologne, Germany
27-28 September	Chemical Recycling, Dusseldorf, Germany
4-6 October	Polymer Sourcing & Distribution Europe, Hamburg, Germany
20-21 October	Plastics Recycling Technology Europe, Vienna, Austria
30 Nov-2 Dec	Fire Resistance in Plastics Europe, Dusseldorf, 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

29 - 30 September, 2021
ESSEN, GERMANY

PLASTICS EXTRUSION
WORLD EXPO

COMPOUNDING
WORLD EXPO

3 - 4 November, 2021
CLEVELAND, OHIO

www.ami.international/exhibitions