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Image: SGL Group has introduced a carbon fiber with a high Young's modulus, making it suitable for aerospace applications. Sigrafil C T50-4.8/280 can also be used to make pressure vessels, drive shafts, profiles, and sheet molding compounds (SMCs), as the fiber meets high mechanical requirements due to its high stiffness and strength. (Photo courtesy SGL Group)

REINFORCED *plastics*

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RP Rewind

Liz Nickels leafs through past issues of Reinforced Plastics to find out what was happening in the RP industry of the past

Five years ago...

'The move towards lighter weight vehicles on our roads continues at great pace and developments in composites are at the forefront of this,' affirmed editor Mark Holmes. The magazine reported on a new method developed by DSM for automotive applications that could reduce the density of SMC moldings and new developments at Airbus and Boeing.

However, while the use of carbon fiber can contribute to the lightweighting of end use applications, the manufacturing process can generate a number of unpleasant and hazardous by-products, according to an article in this issue by Richard Grzanka, vice-president of business development for Anguil Environmental Systems. 'Manufacturing carbon fiber can have serious environmental ramifications and pose immediate danger to humans if careful consideration is not given to emission control at the production phase of these materials. The oxidation and carbonisation furnaces and industrial ovens have the potential to emit hydrogen cyanide (HCN) and ammonia (NH₃) which are immediately dangerous to human health in small quantities. Carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxide (NO_x) and volatile organic compounds (VOCs) are other pollutants of concern for carbon fiber producers, not only for their harmful effects on the environment but also their direct correlation to energy consumption at each plant. Tar residues and silicone from the manufactur-



Twenty years ago, a futuristic use of composites was the Sparrow single-seat electric commuter car.

ing process further complicate the destruction devices used on these applications.'

10 years ago...

'The advanced composites market has not escaped the effects of the global recession,' noted editor Amanda Jacob. Slowing demand for carbon fiber prompted Mitsubishi Rayon to postpone the start-up of its new carbon fiber plant in Japan until 2010. But the carbon fiber market was still growing; just not as fast as in past years – and its potential was still enormous. According to an article in this issue from

author Richard Stewart, once the domain of aerospace, auto racing and high-end sporting goods, carbon fiber reinforced plastic (CFRP) composites were increasingly being used in a host of new manufacturing applications where material cost is secondary to performance, high strength and reduced weight considerations.

At the time, aerospace was the largest segment of the market for carbon fiber at 21%, according to aerospace consultancy AeroStrategy LLC. In 2008, CFRP constituted 37% of aerospace composite demand, compared to 35% for glass fiber

reinforced plastics (GRP). Other major consumers of CFRP were the industrial (15%), sporting goods (14%), wind energy (11%) and automotive (10%) sectors.

20 years ago...

'Composites tend to be seen by much of the general public as materials of the future – a tag which both promotes and harms their image,' explained consulting editor Amanda Weaver. 'The downside is that people perceive that using the same materials as those employed in Stealth

bombers and Formula 1 racing cars in everyday applications is both unnecessary and expensive. The good side is that people associate them with things futuristic and advanced. And in the current climate all things futuristic are once again fashionable as we approach the year 2000 and the 3rd millennium [...] So what will the next millennium hold for composites?' Author Vicki McConnell forecasted that in the next five years there will be several production cars with a 80–90% composite construction, including the Sunrise elec-

tric saloon car, the Sparrow single-seat electric commuter car [100 beta versions of which will be exclusively on sale in 2018 – see sparrowcar.com/beta for details] and the Paradigm saloon car. 'For an industry only just over 50 years old which started life making caravans, truck cabs and a range of other commonplace products which now look positively antique this is significant progress,' said Amanda.

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Applications

World's first 3D printed yacht features CFRP

Lehvoss has partnered with Italian boat builder, Livrea Yacht, to build what it says is the world's first 3D printed sailboat.

The yacht, called the Mini 650, has been built for the 2019 solo transatlantic yacht race, called the Mini-Transat, which starts in France and ends in Brazil.

It has been made using a direct extrusion 3D printing technology and a material deposition strategy using 3D printing materials and supplied by Lehvoss based on thermoplastic polymers reinforced with carbon fibers. The materials have also been modified to yield an improved layer strength with no warping of the printed parts.

Lehvoss; www.lehvoss.de

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.014>



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Thermoplastic composites could drive aerospace build rates

Using thermoplastic to make a composite part could reduce manufacturing time by 20–30% compared to metals or other polymer materials, according to materials specialist Victrex. 'The aircraft industry has forecast that over 35,000 new aircraft will be required within the next 20 years,' it said in a press release. 'Meeting this kind of escalating demand clearly calls for new approaches and new technologies. As a consequence, thermoplastic composites are expected to play an increasingly important role in accelerating future aircraft construction.'

The company says it is partnering with aerospace OEMs and research centers, using its Victrex AE 250 composites product range and related technology while last year Victrex announced it was



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'Supply chain and capacity are important criteria for increasing the amount of

thermoplastic composites in future aircraft programs,' said Tim Herr, director at Victrex. 'When using high-performance polymers, the initial costs for thermoplastic composites may be much higher. However, when we consider total costs, the

equation immediately looks much different.'

Victrex; www.victrex.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.013>

Solvay named new USA bobsled partners

Carbon fiber companies Solvay and deBotech have formed partnership with USA Bobsled and Skeleton. Solvay is one of the team's technology partners and suppliers of carbon fiber composite materials, while deBotech, Solvay's customer and USA Bobsled and Skeleton's preferred carbon fiber manufacturer, has been a team partner for 15 years.

Solvay's prepregs are developed to improve strength while remaining lightweight, and can create distinctive complex shapes, giving performance equipment improved aerodynamic efficiency.

'At deBotech we have worked with Solvay's materials for years across a wide range of high performance applications,' said Hans deBot, deBotech president and

founder. 'It is that experience coupled with our deep understanding of carbon fiber composite properties that enabled us to partner with USA Bobsled and Skeleton since 2002.'

Solvay; www.solvay.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.012>

Pultrusion conference attracts record numbers

The recent World Pultrusion Conference attracted 150 delegates, a record number, according to the European Pultrusion Technology Association (EPTA), which organized the event.

Taking place in Vienna, Austria on 1–2 March the conference covered growth drivers for the pultrusion industry, potential in existing and emerging applications, and the latest developments in materials, testing and standardisation.

According to the EPTA, pultrusion is one of the few continuous processes for manufacture of composite parts and enables the high volume manufacture of structural profiles with improved mechanical properties and consistently high quality. Pultruded composites have found a role in numerous industries including construction, transportation, consumer goods, and the electrical and chemical sectors.

'The record number of 150 participants, coming from North and South America, Europe, India and South Africa, indicates a clear and growing interest in pultrusion globally,' said Dr. Elmar Witten, Secretary, EPTA. 'The high level of technology and application development activities showcased in the wide-ranging conference programme is evidence of a strong



Pultruded composites have found a role in numerous industries including construction.

determination to improve the competitiveness of pultruded products and pursue growth opportunities.'

The World Pultrusion Conference is a biennial event and the largest forum for the pultrusion industry in Europe. The

next conference will take place in March 2019.

EPTA; www.pultruders.org

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.011>

NTPT to provide prepregs for watch manufacturer

North Thin Ply Technology, which makes lightweight prepreg materials has signed a new long-term agreement with watchmaker Richard Mille. The companies have been working together since 2013.

The new multi-year contract is for NTPT to develop lightweight thin ply materials for watches, jewelry and luxury stationery items.

As part of the agreement, NTPT will upgrade its R&D and production facilities

at the company's headquarters in Renens, Switzerland. It plans to create a large clean room production area for a new prepreg line, ATL machine and autoclave. The new facility will help develop quartz based blocks for composite components.

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'The Thin Ply carbon and quartz materials developed and supplied by NTPT are instrumental in helping us to provide the finest watches and luxury accessories that

combine the best technical innovation, the best of artistry and architecture and the best techniques in watch making with hand finishing,' said Richard Mille.

NTPT; www.thinplytechnology.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.010>

Hockey sticks feature nonwoven veils

Technical Fibre Products (TFP) have provided lightweight glass veil to help make a range of ice hockey sticks.

The company's Optiveil range features an even fiber distribution that provides a low-tack surface on the uncured parts

and an improved surface finish after molding. The high porosity of the veil also minimizes microporosity, according to the company. When incorporated in either the interlaminar or surface regions, the veil serves as a flow media

and helps reduce porosity, part weight and scrap.

TFP; www.tfpglobal.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.009>

Henkel resin could replace aluminum

Henkel has introduced Loctite MAX 5 matrix resin for carbon fiber reinforced composite wheels. The new technology is designed to replace aluminum in chassis applications and follows the company's development of Loctite MAX 2 for use in glass fiber reinforced leaf springs.

The new resin has temperature resistance, toughness and long-term durability

as well as rapid mold filling, thorough fiber impregnation and high curing rates for cost-efficient large volume production, the company said.

'There is an ongoing strong trend for further light weighting in automotive, with a clear focus on chassis components and integrated multi-substrate designs engineered to meet the

industry's strict fleet fuel consumption and CO₂ regulation targets,' said Konrad Brimo Hayek, senior business development manager – Chassis, ADAS and Safety for Henkel.

Henkel; www.composite-lab.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.008>

Graphene composites improve auto part

Applied Graphene Materials (AGM), which makes graphene materials, has worked with plastic composite manufacturers to help develop a supercar tailgate.

The company worked with Magna Exteriors and prepreg specialist SHD Composites to develop the W Motors Fenyr SuperSport tailgate using AGM's graphene-improved epoxy prepreg. This development follows the launch of a range of AGM graphene-improved prepreg materials by SHD in March 2017, with SHD subsequently developing the MTC9810 epoxy prepreg system.

According to the companies, the prepreg offers increased torsional stiffness, interlaminar shear strength and laminate fracture toughness, in addition to improved surface finish, in-service fatigue life and improved properties under hot and wet conditioning.

'We are confident that AGM's graphene can deliver significant benefits to the composites sector and we are pleased to be making progress towards application in a number of end industries through our



The company developed graphene prepreg to make the W Motors Fenyr SuperSport tailgate.

valuable collaborations with industry partners such as SHD and Magna,' said Jon Mabbitt, CEO of AGM.

Applied Graphene Materials; www.appliedgraphenematerials.com

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The company worked with Magna Exteriors and prepreg specialist SHD Composites to develop the W Motors Fenyr SuperSport tailgate using AGM's graphene-improved epoxy prepreg. This development follows the launch of a range of AGM graphene-improved prepreg materials by SHD in March 2017, with SHD subsequently developing the MTC9810 epoxy prepreg system.

According to the companies, the prepreg offers increased torsional stiffness, interlaminar shear strength and laminate fracture toughness, in addition to improved surface finish, in-service fatigue life and improved properties under hot and wet conditioning.

'We are confident that AGM's graphene can deliver significant benefits to the composites sector and we are pleased to be making progress towards application in a number of end industries through our



The company developed graphene prepreg to make the W Motors Fenyr SuperSport tailgate.

valuable collaborations with industry partners such as SHD and Magna,' said Jon Mabbitt, CEO of AGM.

Applied Graphene Materials; www.appliedgraphenematerials.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.007>

'The Thin Ply carbon and quartz materials developed and supplied by NTPT are instrumental in helping us to provide the finest watches and luxury accessories that

combine the best technical innovation, the best of artistry and architecture and the best techniques in watch making with hand finishing,' said Richard Mille.

NTPT; www.thinplytechnology.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.010>

Hockey sticks feature nonwoven veils

Technical Fibre Products (TFP) have provided lightweight glass veil to help make a range of ice hockey sticks.

The company's Optiveil range features an even fiber distribution that provides a low-tack surface on the uncured parts

and an improved surface finish after molding. The high porosity of the veil also minimizes microporosity, according to the company. When incorporated in either the interlaminar or surface regions, the veil serves as a flow media

and helps reduce porosity, part weight and scrap.

TFP; www.tfpglobal.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.009>

Henkel resin could replace aluminum

Henkel has introduced Loctite MAX 5 matrix resin for carbon fiber reinforced composite wheels. The new technology is designed to replace aluminum in chassis applications and follows the company's development of Loctite MAX 2 for use in glass fiber reinforced leaf springs.

The new resin has temperature resistance, toughness and long-term durability

as well as rapid mold filling, thorough fiber impregnation and high curing rates for cost-efficient large volume production, the company said.

'There is an ongoing strong trend for further light weighting in automotive, with a clear focus on chassis components and integrated multi-substrate designs engineered to meet the

industry's strict fleet fuel consumption and CO₂ regulation targets,' said Konrad Brimo Hayek, senior business development manager – Chassis, ADAS and Safety for Henkel.

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Composite lightpoles for future cities

Pultrusion company Exel Composites has developed a range of composite laminates for the LuxTurrin5G project, which is aimed at making bigger data capacity available for companies and users through a network of smart light poles. Exel is collaborating with partners including Nokia Bell Labs to develop the composite lighting poles designed to create a telecommunications network for urban environments.

According to Exel, the higher frequency 5G signals required by companies may not travel as far as current signals and a dense network of antennas will be needed to boost the 5G signal locally. Integrating these thousands of antennas unobtrusively into city infrastructure could be a major challenge and as a result, the composite poles will incorporate integrated miniaturized 5G base stations to create a high-capacity 5G data transmission network. A pilot project is currently underway in the Finnish city of Espoo.

Longer life

The composite pole functions as mast, architectural casing, weather protection and radome for the 5G antenna. The pole tubes are manufactured from glass fiber reinforced polyurethane resin using the pultrusion process. The laminate structure



The composite pole functions as mast, architectural casing, weather protection and radome for the 5G antenna.

is designed to minimize the attenuation of the 5G millimeter-length radio waves as they travel through the pole wall. The composite pole also offers easy assembly and a longer life compared with steel and wood alternatives, Exel says.

'Telecommunications and infrastructure are key markets for Exel Composites and with LuxTurrin5G we have the

unique opportunity to unite our proven expertise in these sectors to create a new solution for the future urban environment,' said Kari Loukola, senior vice president at Exel Composites.

Exel Composites;
www.exelcomposites.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.006>

Glass fiber composite 'ribbon' incorporates foam core

A shopping center in Perth, Western Australia features a 3.5×2.5 m core composite spiral ribbon representing a company logo.

The ribbon was made by Mouldings Design based in Henderson, Western Australia and consists of Divinycell Matrix IPN foam core from Diab with stitched E-glass skins using a vinylester resin. The ribbon weighed in at 72 kg and the total sculpture at 155 kg.

According to Diab, the design of the logo as a helical ribbon, although simple in concept, proved difficult to manufacture in more traditional materials. The use of sandwich composites allowed the complex shape to be easily achieved by the team. An added advantage of the core material was the resulting light weight of the logo. This minimized the



The ribbon consists of Divinycell Matrix IPN foam core from Diab with stitched E-glass skins using a vinylester resin.

impact on the shopping center structure, which a heavier construction may have caused.

Diab; www.diabgroup.com

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Lightweight composites for Spanish bank

Diab says that it has supplied a lightweight PET core for the new corporate headquarters of Spanish banking group Banco Popular Español, SA.

The building includes an auditorium with a special box for interpreters designed using glass and the PET core. Two cases were manufactured, one forming the ceiling of the box and the other the floor. Each was

formed by three panels of glass fiber reinforced plastics of curved geometry and with a length of 7.50 m and a width of 1.10 m. The panels were made of Divinycell PET 60 with a thickness of 55 and 12 mm using resin infusion technology. They weigh less than 120 kg and offer fire-retardant properties (BS2d0), reportedly meeting all fire, smoke and toxicity requirements.

The pieces for the box were manufactured by Carbures, a company which specializes in the manufacturing of composite parts and structures.

Diab; www.diabgroup.com

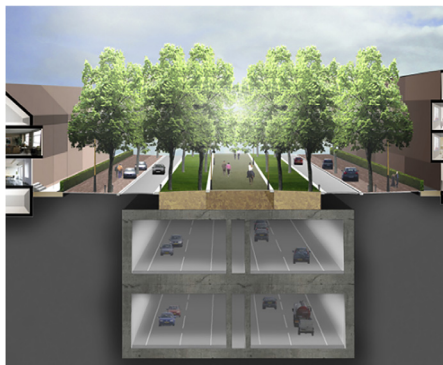
0034-3617/<https://doi.org/10.1016/j.repl.2018.04.004>

Composite fire system improves tunnel safety

Aliancys has supplied a range of resin system for a firewater system forming part of a new motorway multi-level road tunnel in Maastricht, the Netherlands.

The system provides a reliable availability of firewater for potential fire situations inside the tunnel. While it was originally intended to be constructed in stainless steel, after project kick-off it was found that total system cost would be too high, that there was a high risk of corrosion pitting of the welds, and that there were major issues with steel pipe raw material availability potentially delaying the entire A2 tunnel project timeline.

As a result, composite pipe company Verstedden provides a range of pipes for the new firewater system. The main part



Verstedden supplied 4.2 km of piping using a Atlac resin system supplied by Aliancys.

between the main traffic tubes. In total, Verstedden supplied 4.2 km of piping using a Atlac resin system supplied by Aliancys.

‘Aliancys and Euroresins have helped us to fine-tune resin formulation and provide support in promoting our GRE piping systems,’ said Peter Bogers, managing director of Verstedden. ‘With the support of both companies we can much better promote the benefits of composites solutions, and convince key stakeholders about the attractive economics and long-term reliability of firewater systems in these materials.’

Aliancys; www.aliancys.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.003>

Airbus delivers first A350-1000

Airbus has reportedly delivered the first A350-1000 to Qatar Airways, following successful FAA and EASA Type Certification on 21 November.

This stretched version of the aircraft is 7 m longer than the A350-900 and carries an additional 40 seats.

The company was congratulated by Hexcel, a major supplier of materials for the A350 XWB program including its Hex-

cel’s HexPly M21E/IMA carbon fiber/epoxy prepreg which has been used to manufacture all composite primary structures of the aircraft, including the fuselage panels, keel beam, wing and empennage. The lower wing cover is the biggest single civil aviation part ever made from carbon fiber and spans 32 m long. Carbon fiber reinforced plastics has also been used in other structural components such as the

pylon upper spar and door surround. For the first time on an Airbus aircraft, Hexcel’s HexMC carbon fiber/epoxy molding compound has also been used for the A350-1000 fuselage crutches.

Hexcel; www.hexcel.com

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formed by three panels of glass fiber reinforced plastics of curved geometry and with a length of 7.50 m and a width of 1.10 m. The panels were made of Divinycell PET 60 with a thickness of 55 and 12 mm using resin infusion technology. They weigh less than 120 kg and offer fire-retardant properties (BS2d0), reportedly meeting all fire, smoke and toxicity requirements.

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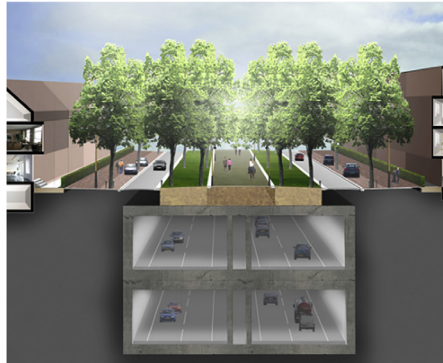
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of the system is a 125 mm diameter composite pipe network installed inside the tunnel emergency tubes located in

between the main traffic tubes. In total, Verstedden supplied 4.2 km of piping using a Atlac resin system supplied by Aliancys.

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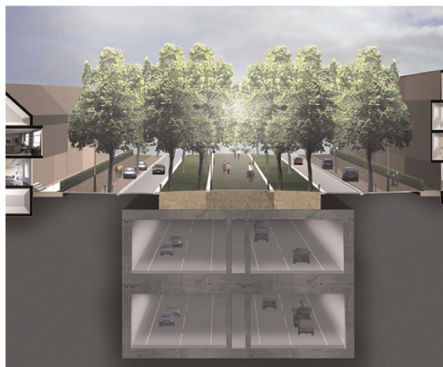
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Business

Velox signs distribution agreement with Life Material Technologies

Velox GmbH, which provides raw materials for the composite industry, has formed a new distribution partnership with Thailand-based Life Material Technologies Limited, a manufacturer of antimicrobial additives and treatments for the plastics, coatings and textile industries.

Velox will be the exclusive distributor of the country in the DACH, Benelux and Nordics regions.

'With this new partnership, Velox is extending its existing antimicrobial portfolio and is able to address new target markets for compounding, extru-

sion and injection molding applications,' said Stefan Rokitta, product manager at Velox.

Velox; www.velox.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.041>

New distribution company formed

GRP Solutions Ltd and advanced composite experts Andrew Pointon and Michael Stevenson have formed Total Composite Solutions (TCS) Ltd, a UK-based composite service, solutions and product distribution business.

The new business will use the combined business and distribution expertise from the two entities and will focus on providing market development, technical and engineering support along with pro-

duct distribution within the resin, adhesives, fiber and prepreg markets.

GRP Solutions Ltd will continue to focus on its current core business activities, the company said.

'We are delighted to have now completed the formation of the new company alongside GRP Solutions,' said Andrew Pointon, managing director and shareholder of TCS. 'We see a strong strategic fit and a fantastic customer focused team

at GRP which will help support our goal to provide our customers and partners with a full solution approach to their business growth. We will operate within the advanced composite sectors where we see strong organic growth and many exciting new projects.'

Total Composite Solutions; totalcompositesolutions.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.040>

Total and Microtex form partnership

Total Composite Solutions (TCS) Ltd, a composite product distribution business and Microtex Composites Srl, a weaving and prepreg manufacturer have signed a long-term partnership agreement for the UK and Ireland markets.

'We are delighted to have concluded the contract with Microtex and to be associated with the brand and company,' said

Andrew Pointon, MD of TCS. 'Microtex have a strong R and D culture and current market leading products, which we firmly believe aligned with our service proposal and capability will add real value to the UK market.'

The UK and Ireland markets are strategic for our company and TCS have a great commercial potential in this area,' said Sil-

vio Campigli, business development manager of Microtex Composites Srl. 'We believe that this will be the beginning of a strong and long-term cooperation.'

Total Composite Solutions; totalcompositesolutions.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.039>

Spirit AeroSystems to grow fabrication and defense segments

Spirit AeroSystem has unveiled plans to grow in fabrication and defense, each of which it says could exceed US\$1 billion over the next five years.

Spirit already produces more than 38,000 unique parts to support its current aerostructures business, the company says.

'There is a huge market for these detailed parts, delivering them directly to original equipment manufacturers,' said Spirit CEO Tom Gentile. 'Fabrication is a



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Andrew Pointon, MD of TCS. 'Microtex have a strong R and D culture and current market leading products, which we firmly believe aligned with our service proposal and capability will add real value to the UK market.'

The UK and Ireland markets are strategic for our company and TCS have a great commercial potential in this area,' said Sil-

vio Campigli, business development manager of Microtex Composites Srl. 'We believe that this will be the beginning of a strong and long-term cooperation.'

Total Composite Solutions; totalcompositesolutions.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.039>

Spirit AeroSystems to grow fabrication and defense segments

Spirit AeroSystem has unveiled plans to grow in fabrication and defense, each of which it says could exceed US\$1 billion over the next five years.

Spirit already produces more than 38,000 unique parts to support its current aerostructures business, the company says.

'There is a huge market for these detailed parts, delivering them directly to original equipment manufacturers,' said Spirit CEO Tom Gentile. 'Fabrication is a



Business

Velox signs distribution agreement with Life Material Technologies

Velox GmbH, which provides raw materials for the composite industry, has formed a new distribution partnership with Thailand-based Life Material Technologies Limited, a manufacturer of antimicrobial additives and treatments for the plastics, coatings and textile industries.

Velox will be the exclusive distributor of the country in the DACH, Benelux and Nordics regions.

'With this new partnership, Velox is extending its existing antimicrobial portfolio and is able to address new target markets for compounding, extru-

sion and injection molding applications,' said Stefan Rokitta, product manager at Velox.

Velox; www.velox.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.041>

New distribution company formed

GRP Solutions Ltd and advanced composite experts Andrew Pointon and Michael Stevenson have formed Total Composite Solutions (TCS) Ltd, a UK-based composite service, solutions and product distribution business.

The new business will use the combined business and distribution expertise from the two entities and will focus on providing market development, technical and engineering support along with pro-

duct distribution within the resin, adhesives, fiber and prepreg markets.

GRP Solutions Ltd will continue to focus on its current core business activities, the company said.

'We are delighted to have now completed the formation of the new company alongside GRP Solutions,' said Andrew Pointon, managing director and shareholder of TCS. 'We see a strong strategic fit and a fantastic customer focused team

at GRP which will help support our goal to provide our customers and partners with a full solution approach to their business growth. We will operate within the advanced composite sectors where we see strong organic growth and many exciting new projects.'

Total Composite Solutions; totalcompositesolutions.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.040>

Total and Microtex form partnership

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'There is a huge market for these detailed parts, delivering them directly to original equipment manufacturers,' said Spirit CEO Tom Gentile. 'Fabrication is a

good margin business where Spirit has unmatched capability and capacity for both commercial and defense customers.'

The company has developed centers of excellence in Wichita, Kansas for complex parts and chemical processing. The company also has established a center at its Oklahoma, facility and is expanding its Malaysia site. Spirit anticipates developing a US\$1 billion annual business within the next five years by insourcing parts, supplying other tier-one suppliers and expanding business with its current commercial and military customers. Spirit has named Kevin Matthies as senior vice president of Global

Fabrication, reporting to Ron Rabe, senior vice president of Fabrication and Supply Chain. Kevin will work with Alan Young, vice president of Wichita Fabrication, to grow the new business.

Defense segment

In defense, Spirit is supporting the Lockheed/Sikorsky CH-53K helicopter, the Bell Helicopter V-280, the Boeing KC-46A (a military derivative of the 767), the Boeing P-8A (a military derivative of the 737), and has been named as a supplier on the Northrop Grumman B-21 Raider program. Spirit says that the defense segment is

expected to be a US\$1 billion annual business within the next five years and account for about 10–15% of Spirit's revenue.

The company has appointed industry veteran Krisstie Kondrotis as senior vice president of defense programs and business development, reporting to Duane Hawkins, senior vice president/GM Boeing, defense, business/regional jet programs and global customer support.

Spirit Aerosystems;
www.spiritaero.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.038>

Solvay and Boeing sign materials agreement

Solvay says that it has signed an agreement with Boeing to supply composites and adhesives in support of the 777X airplane production. Solvay will be supplying a range of material technologies including out-of-autoclave structural carbon fiber epoxy prepreg, flame resistant interior phenolic prepreg, lightning strike protection surfacing film and structural bonding adhesive.

These materials will be used applications across the 777X plane including the vertical and horizontal stabilizers, the nacelle, landing gear doors, wings and interior structures.

'Boeing is one of Solvay's key strategic partners and the signature of this agreement demonstrates our ability to develop material solutions that meet Boeing's

technical, supply and cost challenges,' said Carmelo Lo Faro, president of Solvay's composite materials global business unit.

Solvay; www.solvay.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.037>

New fiber placement center established

Carbon fiber company SGL Group and Fraunhofer IGCV have founded the joint Fiber Placement Center at SGL's plant in Meitingen, Germany. System manufacturers Compositence GmbH and BA Composites GmbH have also joined the companies to develop the center.

The center will feature over 500 m² of lab space with different machines, making it possible for engineers to develop production concepts and demonstrate their feasibility by prototyping. In event of a demonstrated cost benefit, SGL Group may also implement an industrial production of fiber-reinforced parts. Both dry and pre-impregnated fibers with or without thermoplastic matrix systems will be processed, SGL says.

Bilateral projects with aerospace companies for secondary and primary structural parts in various aircraft types have already been put in place at the center, along with development projects in collaboration with various automotive parts manufacturers worldwide.

High flexibility

'Fiber placement enables a high degree of automation in production, while offering

high flexibility and extremely efficient material utilization,' said Andreas Wüllner, head of the composites – fibers and materials business unit at SGL Group. 'These technologies, which are already established for aerospace applications, will be transferred into other industrial sectors for highly efficient large-scale production. For many of our customers, this is a promising opportu-

nity to exceed existing process capabilities for serial production of components made from fiber-reinforced plastic.'

'The Fiber Placement Center clearly reflects the mission of the Fraunhofer Society, to provide substantial support in knowledge transfer to the industry by means of applied research and to advance the industrialization of fiber-reinforced



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SGL carbon sells share in joint venture SGL

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SGL Group says that its production of composites and composite components will now be concentrated at five sites in Germany and Austria, while the existing business relationship with Kumpers for the supply of carbon fibers will be continued.

The joint venture was founded in early 2007 for the production of materials such

as fabrics and braids based on carbon and glass fibers.

According to SGL, this move allows it to concentrate its expertise in the processing of carbon and glass fibers for composites and composite components within its Composites – Fibers & Materials (CFM) business unit at five sites. These are the three German sites in Meitingen, Wackersdorf (both Bavaria), and Willich (North Rhine-Westphalia), plus Ried and Ort in Austria's Innkreis region.

The transaction is part of the strategy to consolidate all key activities in the value chain, from carbon fibers and materials to components, under the roof and thus under the overall responsibility of SGL Group. The company recently announced its complete takeover of the former joint ventures SGL Automotive Carbon Fibers (SGL ACF) and BENTELER-SGL with the aim of expanding its capabilities.

SGL; www.sglgroup.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.035>

Adhesives gain ClassNK approvals

Scott Bader says that various products in its adhesives range have received ClassNK approvals for steel and glass fiber reinforced plastic applications in the ship building industry.

Crestabond M7-05 and M7-15 have gained NK's certificate of approval for applications involving the bonding of steel, while for GFRP bonding applications, Crestomer 1150PA, 1151A, 1152PA

and 1153PA have all gained NK's certificate of approval.

Nippon Kaiji Kyokai, known as ClassNK or NK, is a ship classification society which offers the survey and classification of ships and marine structures and is one of the world's largest classification societies in terms of gross tonnage under class.

'Gaining ClassNK approval is a significant step forward for the growth of our

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Scott Bader; www.scottbader.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.034>

Sabir expands capacity for resin production

Chemicals company Sabir has announced projects in Asia and the Netherlands to increase global capacity for two of its engineering thermoplastic materials, Ultem and Noryl resins.

To increase capacity for Ultem resins, a polyetherimide material, the company plans to expand its existing footprint in Singapore where it currently has compounding operations, pending final government clearance. The planned new production facility in Singapore is expected to go online

in the first half of 2021. When fully operational, the Singapore facility is expected to increase capacity by 50% over a 2018 baseline.

The company also plans to recommission operations at its Bergen op Zoom PPE resin plant in the Netherlands by the end of 2019 to produce polyphenylene ether (PPE), the base resin for its line of Noryl resins and oligomers. When operational, the Bergen op Zoom facility is expected to add more than 40% global capacity over a 2017 baseline.

'Increased customer demand, especially in Asia, prompted the further capacity expansion plans,' said Ernesto Occhiello, executive vice president. 'While interim capacity gains for both Ultem and Noryl resins have been achieved, global demand for both product lines has increased significantly.'

Sabir; www.sabir.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.033>

Global carbon fiber market could reach US\$4650 million by 2022

The global carbon fiber market could reach US\$4650 million in the next four years, according to a report published by Reportbuyer.com.

The market was valued at US\$1980 million in 2015, and is anticipated to reach US\$4650 million by 2022, growing at a CAGR of 11.1% during the forecast period. In

terms of volume, the market is anticipated to reach 143 kilotons by 2022, growing at a CAGR of 13.0%, researcher say. The demand for carbon fiber has increased owing to its increased use in wind turbines, automotive, sailing/yacht building, marine, and aerospace and defense industry.

The market is split into pan-based and pitch-based and rayon-based carbon fiber, and pan-based carbon fiber segment is projected to grow at the highest CAGR in the future, while continuous carbon fiber dominated the market in 2015, and is also projected to register the highest growth rate. Aerospace and defense, sports/leisure,

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The transaction is part of the strategy to consolidate all key activities in the value chain, from carbon fibers and materials to components, under the roof and thus under the overall responsibility of SGL Group. The company recently announced its complete takeover of the former joint ventures SGL Automotive Carbon Fibers (SGL ACF) and BENTELER-SGL with the aim of expanding its capabilities.

SGL; www.sglgroup.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.035>

Adhesives gain ClassNK approvals

Scott Bader says that various products in its adhesives range have received ClassNK approvals for steel and glass fiber reinforced plastic applications in the ship building industry.

Crestabond M7-05 and M7-15 have gained NK's certificate of approval for applications involving the bonding of steel, while for GFRP bonding applications, Crestomer 1150PA, 1151A, 1152PA

and 1153PA have all gained NK's certificate of approval.

Nippon Kaiji Kyokai, known as ClassNK or NK, is a ship classification society which offers the survey and classification of ships and marine structures and is one of the world's largest classification societies in terms of gross tonnage under class.

'Gaining ClassNK approval is a significant step forward for the growth of our

structural adhesives in the ship building industry,' said Jonathan Stowell, Scott Bader's global adhesives director. 'We are delighted to offer industry leading ClassNK approved structural adhesives to the ship building industry worldwide.'

Scott Bader; www.scottbader.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.034>

Sabir expands capacity for resin production

Chemicals company Sabir has announced projects in Asia and the Netherlands to increase global capacity for two of its engineering thermoplastic materials, Ultem and Noryl resins.

To increase capacity for Ultem resins, a polyetherimide material, the company plans to expand its existing footprint in Singapore where it currently has compounding operations, pending final government clearance. The planned new production facility in Singapore is expected to go online

in the first half of 2021. When fully operational, the Singapore facility is expected to increase capacity by 50% over a 2018 baseline.

The company also plans to recommission operations at its Bergen op Zoom PPE resin plant in the Netherlands by the end of 2019 to produce polyphenylene ether (PPE), the base resin for its line of Noryl resins and oligomers. When operational, the Bergen op Zoom facility is expected to add more than 40% global capacity over a 2017 baseline.

'Increased customer demand, especially in Asia, prompted the further capacity expansion plans,' said Ernesto Occhiello, executive vice president. 'While interim capacity gains for both Ultem and Noryl resins have been achieved, global demand for both product lines has increased significantly.'

Sabir; www.sabir.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.033>

Global carbon fiber market could reach US\$4650 million by 2022

The global carbon fiber market could reach US\$4650 million in the next four years, according to a report published by Reportbuyer.com.

The market was valued at US\$1980 million in 2015, and is anticipated to reach US\$4650 million by 2022, growing at a CAGR of 11.1% during the forecast period. In

terms of volume, the market is anticipated to reach 143 kilotons by 2022, growing at a CAGR of 13.0%, researcher say. The demand for carbon fiber has increased owing to its increased use in wind turbines, automotive, sailing/yacht building, marine, and aerospace and defense industry.

The market is split into pan-based and pitch-based and rayon-based carbon fiber, and pan-based carbon fiber segment is projected to grow at the highest CAGR in the future, while continuous carbon fiber dominated the market in 2015, and is also projected to register the highest growth rate. Aerospace and defense, sports/leisure,

plastics,' added Dr. Klaus Drechsler, head of chair of carbon composites at the Technical University of Munich. 'Fiber placement processes are well suited for future

applications due to their high level of automation and material efficiency. These developments benefit significantly from industry-oriented research activities.'

SGL; www.sglgroup.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.036>

SGL carbon sells share in joint venture SGL

Carbon company SGL Group has sold its 51% shareholding in the SGL Kumpers joint venture to fabric manufacturers Kumpers GmbH and its MD, Franz-Jürgen Kumpers.

SGL Group says that its production of composites and composite components will now be concentrated at five sites in Germany and Austria, while the existing business relationship with Kumpers for the supply of carbon fibers will be continued.

The joint venture was founded in early 2007 for the production of materials such

as fabrics and braids based on carbon and glass fibers.

According to SGL, this move allows it to concentrate its expertise in the processing of carbon and glass fibers for composites and composite components within its Composites – Fibers & Materials (CFM) business unit at five sites. These are the three German sites in Meitingen, Wackersdorf (both Bavaria), and Willich (North Rhine-Westphalia), plus Ried and Ort in Austria's Innkreis region.

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The aerospace and defense segment was reportedly the largest revenue contributor in 2015, but the wind turbine segment is

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Owens Corning recognized for leadership in climate and water

Glass fiber company Owens Corning has been named one of 25 global companies on a list for both climate and water. This achievement recognizes actions completed in 2016 to manage environmental risks, cut carbon emissions, and enhance water stewardship.

The list has been put together by non-profit company CDP, formerly known as

the Carbon Disclosure Project, which works to reduce greenhouse gas emissions and safeguard water resources and forests.

'Being awarded a position on CDP's A Lists for both climate and water highlights the progress we've made on our 2020 sustainability goals, specifically the greenhouse gas emission and water consump-

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Owens Corning;
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Michelman and Engineered Fibers Technology LLC (EFT), which provides consulting services, have announced they will be partnering to develop innovative solutions for specialty fibers composites.

'This partnership takes advantage of Michelman's leading position as a sizing

and surface treatment expert and leverages that expertise with EFT's portfolio of advanced fiber technologies,' said Michelman in a press release. 'Both companies recognize that by working closely together they can accelerate the pace of new and advanced product inno-

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Metyx secures 50% investment to expand company

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The combined investment funds will be used to expand the existing facilities at a site in Kaposvár, a city in the southwestern part of Hungary, over the next five years, increasing its production capacity for weaving glass and carbon fiber textiles and expanding its fabric and core kitting service.

Metyx Hungary employs 155 people and currently operates four production lines, with three additional lines being installed in 2018. With the new investments, the total annual capacity at Metyx Hungary will reportedly increase from 3000 to 8000 tons for technical fabrics, along with an expanded glass and core kit cutting service. The company expects the numbers of employees in Hungary to reach 200 by the end of this year, with additional people needed by the end of 2020.

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New investments

'We look forward to working closely with HIPA and other Hungarian government agencies going forward to make our expansion plans a reality,' said Uğur Üstünel, co-director of Metyx Group. 'Being located in

wind turbines, molding compounds, automotive, pressure vessels, civil engineering, marine, pultrusion, consumer, and sailing/yacht building are the various end-use industries for this market, Reportbuyer.com says.

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Uğur Üstünel, co-director of Metyx Group, speaking at a press conference in Budapest.

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Metyx Hungary employs 155 people and currently operates four production lines, with three additional lines being installed in 2018. With the new investments, the total annual capacity at Metyx Hungary will reportedly increase from 3000 to 8000 tons for technical fabrics, along with an expanded glass and core kit cutting service. The company expects the numbers of employees in Hungary to reach 200 by the end of this year, with additional people needed by the end of 2020.

The fabrics and kits manufactured by Metyx Hungary are aimed at producers of composite parts used building and construction, boatbuilding, automotive, transportation and wind energy.

Metyx; www.metyx.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.028>

Kordsa makes record number of patent application

Kordsa, an affiliate of Sabanc Holding, says that it registered a record number of patent applications in 2017. It did the same in 2016.

The company's patent portfolio has grown by 60% in 2017 and its number of

patent applications now totals 664 together with 167 inventions and 168 granted patents globally by the end of the year. Kordsa's number of inventions also increased by 14% in 2017.

Kordsa; www.kordsa.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.027>

JEC World 2018 welcomes more than 40,000 visitors

The organizers of JEC World says that it had more than 1300 exhibitors and 42,445 visitors from 115 countries.

'The ability of JEC Group to gather the whole composites industry under one roof over three days lies in the fact that we always initiate new precursory programs to the service of composites professionals,' said Frédérique Mutel, JEC group president and CEO.

This year JEC initiated new programs such as the Composite Challenge, allowing 10 PhD students to pitch their thesis in front of the industry, the Start Up

Booster and Innovation Award Programs to accelerate relations between innovative companies with investors or established enterprises.

Dirk Ahlborn, CEO of Hyperloop opened the Startup Booster ceremony by supporting the spirit of ingenuity in the industry, while Dayton Horvath, additive manufacturing consultant, presented his vision of how to apply artificial intelligence to composite materials and manufacturing.

A first at the show this year was the introduction of public votes to elect favor-

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0034-3617/<https://doi.org/10.1016/j.repl.2018.04.026>

New UK distributor for composite production company

A newly formed company, iSpec Limited, has been appointed sole UK and Ireland distributor for Techni-Modul Engineering.

Techni-Modul designs production solutions for the composites industry featuring complete automated robotic production

cells unifying multiple machines and processes with integrated advanced SCADA/PLC control systems and produces its own composite production machines including, hot drape formers, composite presses, handling tools and molds. iSpec

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'We are very pleased and honoured to intensify and reinforce our long-standing partnership with Elbe Flugzeugwerke,' said Stefan Gautschi, general manager at Gurit. 'This new contract provides both parties and our partners with continuity and reliability for the future.'

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Evonik plans new polyamide 12 plant

Evonik is planning to build a new plant to produce polymer polyamide 12 (PA 12), aiming to increase its overall PA 12 capacity by more than 50%. Polyamide 12 is made for growth markets such as the automotive industry, oil and gas pipelines, and in 3D printing.

Evonik plans to invest approximately €400 million in the PA 12 complex at its largest site, Marl Chemical Park in North Rhine-Westphalia, Germany. The existing

PA 12 production will have additional manufacturing facilities for the polymer and its precursors. The complex is expected to become operational in early 2021.

'This investment is a perfect fit to our strategy of consistent focus on specialty chemicals since polyamide 12, as a high-performance polymer for specialty applications, is an important part of our strategic Growth Engine Smart Materials,' said

Christian Kullmann, chairman of the Evonik executive board.

The PA 12 market is posting annual growth rates exceeding 5% worldwide, outpacing the global gross domestic product. In the specialty application of 3D printing, growth rates reach double digits, the company said.

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selection of a composite product based on its overall life cycle performance.

The Eco Impact Calculator was launched in July 2016, and the number of users of the tool – including designers, manufacturers and end-users of composite

products, materials suppliers and researchers – has been increasing and feedback has been positive, according to the association. The survey will help EuCIA identify future industry needs and direct its long term development program for the tool. The

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'We are very pleased and honoured to intensify and reinforce our long-standing partnership with Elbe Flugzeugwerke,' said Stefan Gautschi, general manager at Gurit. 'This new contract provides both parties and our partners with continuity and reliability for the future.'

Gurit; www.gurit.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.024>

Gurit appoints new CTO

Gurit has appointed Dr. Emiliano Frulloni as CTO and member of the executive committee.

Dr. Frulloni has many years of technology and leadership experience in the advanced composites industry and holds an MBA from Manchester Business School and a PhD in Materials Science and Technology from University of Perugia, Gurit says. Dr. Frulloni joins Gurit from Solvay

where he holds the position of global r&d director composite product development.

Dr. Damian Bannister, current CTO of Gurit, will take on the position of director of innovation composite materials where he will reportedly focus on the development and improvement of the company's base formulations as well as new material technologies for Gurit's prepreg and formulated products ranges.

'I am very excited to appoint Emiliano as our new Group CTO and happy to retain Damian with his rich know-how as director innovation composite materials as the combined innovation power will make Gurit stronger in the market,' said Rudolf Hadorn, CEO of Gurit.

Gurit; www.gurit.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.023>

Evonik plans new polyamide 12 plant

Evonik is planning to build a new plant to produce polymer polyamide 12 (PA 12), aiming to increase its overall PA 12 capacity by more than 50%. Polyamide 12 is made for growth markets such as the automotive industry, oil and gas pipelines, and in 3D printing.

Evonik plans to invest approximately €400 million in the PA 12 complex at its largest site, Marl Chemical Park in North Rhine-Westphalia, Germany. The existing

PA 12 production will have additional manufacturing facilities for the polymer and its precursors. The complex is expected to become operational in early 2021.

'This investment is a perfect fit to our strategy of consistent focus on specialty chemicals since polyamide 12, as a high-performance polymer for specialty applications, is an important part of our strategic Growth Engine Smart Materials,' said

Christian Kullmann, chairman of the Evonik executive board.

The PA 12 market is posting annual growth rates exceeding 5% worldwide, outpacing the global gross domestic product. In the specialty application of 3D printing, growth rates reach double digits, the company said.

Evonik; www.evonik.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.022>

EuCIA launches eco survey

The European Composites Industry Association (EuCIA) is launching a survey to look into the next stage of development of its Eco Impact Calculator for composites. The online resource is being used by companies to support the business case for the

selection of a composite product based on its overall life cycle performance.

The Eco Impact Calculator was launched in July 2016, and the number of users of the tool – including designers, manufacturers and end-users of composite

products, materials suppliers and researchers – has been increasing and feedback has been positive, according to the association. The survey will help EuCIA identify future industry needs and direct its long term development program for the tool. The



VDL Fibertech Industries plans to employ EuCIA's Eco Impact Calculator in determining the LCA of its composite container to demonstrate that composites offer a more sustainable solution than steel.

survey, which can be found on the EuCIA website, is open to all composites industry professionals.

'Communicating the sustainability of composites is a long term strategy for EuCIA and the Eco Impact Calculator is an important component of this,' said Roberto Frassine, EuCIA's president. 'It is a 'living' tool which must continue to develop as composites technologies advance and business and legislative landscapes evolve. We encourage all interested parties to submit their feedback and opinions so that we can determine the future path for this resource and further increase its value to the composites industry.'

EuCIA; www.eucia.eu

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ELG Carbon Fibre accelerates UK expansion plans

ELG Carbon Fibre, which specializes in recycled carbon fibre materials, has announced plans to increase the capacity of its UK facility.

It will focus on increasing its capacity to recover fibre from uncured prepreg and laminate feedstock and the commercialization of the company's Carbisio MB product line for reinforced thermoplastic compounds.

ELG's existing UK facility currently houses highly reclamation and conversion equipment that supports the manufacture

of recycled carbon fibre products to be reintroduced into the supply chain.

In 2016, to promote the use of recycled carbon in the composites industry, ELG installed a custom built, nonwoven production line to make carbon fibre and hybrid thermoplastic mats in aerial weights from 100–500 gsm and widths up to 2.7 m. These products are currently being used in production automotive programs.

ELG is also upgrading its pyrolysis furnace to increase its output capacity beyond the current 1,000 tonnes of carbon fibre per

year. This upgrade will be completed in the fourth quarter of 2018, after which the company says it will be able to deliver 1,700 tonnes of carbon fibre products to its customers from the Coseley plant each year.

'We are very focused on investments that offer customers a viable, high volume alternative to costly virgin carbon fibre,' said Frazer Barnes, managing director ELG Carbon.

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ELG and Sanko Gosei formalise technical partnership

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SET and Sanko Gosei have developed designs using polymers reinforced with ELG's recycled carbon fiber. This combination of technologies has facilitated the extension of injection molded plastics into structural applications, providing weight savings compared with other reinforced plastic materials or metals, according to ELG.

SET's manufacturing expertise makes it possible for structural parts to be manufactured with cycle times under one minute.

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0034-3617/<https://doi.org/10.1016/j.repl.2018.04.019>

DSM appoints new president

Science company Royal DSM has appointed Wilfrid Gambade as president of DSM Dyneema.

Gambade joined DSM in 2009 and was responsible for the composite resins business in Europe. From 2011 moved into the role of president of composite resins and synthetic resins. Over the past three years, he turned around DSM's personal care business and integrating DSM's aroma



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Dyneema; www.dyneema.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.018>



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Aliancys announces price increase

Aliancys has announced a price increase of €100 per ton for its unsaturated polyester resin product portfolio sold in Europe, the Middle East and India.

‘The pricing of our key raw materials has been sharply increasing in recent weeks,’ said Fons Harbers, marketing and sales director of Aliancys. ‘This leaves us no choice

but to raise the prices of our products as a result.’

Aliancys; www.aliancys.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.017>

Composite production to run fossil-free

Composites manufacturer says that it plans for its production plant in Laholm, Sweden to obtain 100% of its energy from fossil free sources 2019.

The plant in Laholm, which today uses fossil natural gas as its energy source, will have changed entirely to biofuel by January 2019, the company says. This energy transformation is expected to reduce the company’s carbon footprint by 6000 tons of carbon dioxide annually.

‘When we evaluated our own climate impact, it became clear that a large part of our carbon footprint could be linked to the energy use in our factories,’ said Per Hökfelt, EVP sustainability. ‘With the new energy solution in Laholm, we are taking a big step forward in our effort to deliver products for a future sustainable society.’

A biofuel plant will be established next to Diab’s production facility in Laholm. In addition to the biofuel boiler system, a heat pump plant will be installed, making

it possible to use 20–30% of the waste heat generated in the production plant, heat that can be reused in the factory.

The project also receives investment support from Swedish governmental initiative Klimatklivet (The Climate Leap). Some 45% of the energy conversion project in Diab’s production facility in Laholm has been funded by Klimatklivet.

Diab; www.diabgroup.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.016>

ACMA calls for infrastructure investment

The American Composites Manufacturers Association (ACMA) says that it has met with over 100 Members of Congress and their staffs to advance legislation to increase government investment in composites transportation, water and energy infrastructure.

President Trump has called for a US\$1.5 trillion plan to repair the US’s infrastructure. ‘While ACMA applauds this administration’s commitment to infrastructure, we need to ensure we are not wasting taxpayer dollars on failing, outdated technology that will not provide the solutions our

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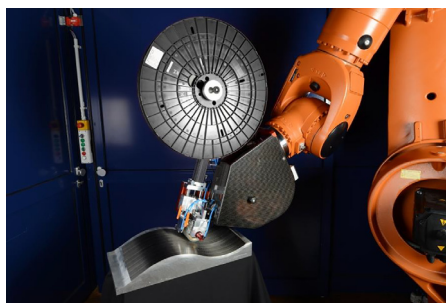


Technology

New tape winding system

Conbility GmbH and Fraunhofer IPT have partnered to develop a placement and tape winding system.

The new PrePro 2D machine system allows for the automated tailored tape placement of UD laminates which can be used for subsequent thermoforming or as stiffening structures in injection molding processes. The machine comprises a rotating and translational table which is moved relatively to the applicator station. The applicator station can be equipped with a



The new PrePro 2D machine system allows for the automated tailored tape placement of UD laminates.

single or with multiple spool applicators and because of the large process area, a 9 kW IR heater is used for the in-situ-consolidation process.

The 3D system can be used for laser-assisted thermoplastic tape placement, IR-assisted thermoset prepreg placement and dry fiber placement.

Fraunhofer IPT;
azl-aachen-gmbh.de

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.066>

Spirit develops new manufacturing technology

Spirit AeroSystems's Advanced Technology Centre based in Prestwick, Scotland, has reportedly developed an improved method for manufacturing composite parts.

In collaboration with the University of Strathclyde and the Scottish Innovation Centre for Sensor and Imaging Systems (CENSIS), Spirit has developed an intelligent heated tool for curing composite components. The new technology can cure composite parts 40% faster at half the cost and supports a range of composite components across industries, from wind turbine blades to the next generation of composite aircraft.

'Instead of curing components at a standard temperature for hours at a time, we can now tailor the cycle time to match individual part geometries,' said Stevie Brown, lead engineer at the center. 'The



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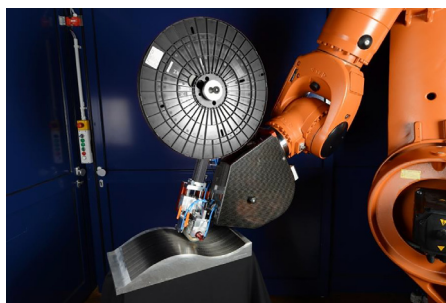


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autoclave has been a bottleneck in manufacturing lines, and removing it will reduce cycle times for components, cut production costs and decrease energy consumption.'

Curing process

Typically, high-performance composite materials are layered on a specially formed surface, or tool, and then placed in an autoclave, where a combination of heat

and pressure accelerate the hardening of the material. Spirit's new technology introduces a multi-zone heated tool, reportedly removing the need for an autoclave. The tool enables control of the curing process through real-time monitoring and feedback.

According to Spirit, CENSIS supported the collaboration with funding and provided project management expertise while the University of Strathclyde provided

technical support and developed the control algorithm and software for the intelligent tool. The collaboration will continue through 2018, and Spirit has begun applying the technology in research and manufacturing projects.

Spirit AeroSystems;
www.spiritaero.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.065>

Solvay launches vacuum channel for resin

Solvay has developed Vac-Ply VMS3, a multi-layer microporous vacuum channel for resin infusion.

The channel has been designed to maximize air removal during resin infusion processes, thus improving impregnation and avoiding dry spots. It is suitable for

the infusion of large structures such as boat hulls or wind turbine blades, where maintaining vacuum over long distances is important.

Vac-Ply VMS3 reportedly has reduced witness mark on the laminate surface, improved linear adhesive bond line, thin-

ner overall construction and has been designed for serial production to meet global demand.

Solvay; www.solvay.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.064>

Carbon fiber suitable for aerospace

SGL Group has introduced a carbon fiber with a high Young's modulus, making it suitable for aerospace applications. Sigrafil C T50-4.8/280 can also be used to make pressure vessels, drive shafts, profiles, and sheet molding compounds (SMCs), as the fiber meets high mechanical requirements due to its high stiffness and strength.

The high Young's modulus based on a 50 k fiber (50,000 individual filaments) is unique to the market, SGL claims. Previously, only fibers with lower numbers of filaments (e.g. 12 k or 24 k) achieved these high mechanical properties (4800 MPa, 280 GPa).

'With the new Sigrafil 50 k carbon fiber, we can now offer aerospace industry cus-

tomers attractive material solutions for various component classes,' said Andreas Erber, head of the aerospace segment at SGL Group.

SGL Group; www.sglgroup.com

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Sicomin earns USDA certified product label

Sicomin, which makes epoxy resin systems, has earned a US Department of Agriculture (USDA) Certified Bio based Product label for its SR GreenPoxy 56/SD GP 505V2 product.

The following Sicomin products have earned the label:

- SR GreenPoxy 33/SD 4999 with 26% bio based content.
- SR GreenPoxy 56/SD Surf Clear with 36% bio based content.

- SR GreenPoxy 56/SD GP 505V2 with 52% bio based content.
- SR Surf Clear EVO/SD EVO MEDIUM with 30% biobased content.

The USDA Certified Bio based Product label displays a product's bio based content, which is the portion of a product that comes from a renewable source, such as plant, animal, marine, or forestry feedstocks.

'Products from Sicomin are contributing to an ever-expanding market place that adds value to renewable agriculture commodities, creates jobs in rural communities and decreases our reliance on petroleum,' said Kate Lewis from the USDA BioPreferred Program.

Sicomin; www.sicomin.com

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Innovation Award for SGL

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The project was run by the Technical University of Munich with partners Airbus, BASF SE, BMW, SGL Group, Foldcore,

Neenah Gessner, Neue Materialien Bayreuth and Hofmann.

Currently, producing sandwich structures takes time, making it expensive, the partners says. In traditional processes, producing a standard generic component could take a cycle time of up to one day. This project has revealed that these long cycle times can be reduced drastically to five minutes for a comparable component

in the aerospace industry and to 2.5 min for a similar component in the automotive sector due to improved integration of the different components, including fusion bonded thermoplastic materials between the core and skins. The companies have also developed a production sequence using the three techniques of thermoforming, injection molding and fusion bonding in a primarily automated working facility.

autoclave has been a bottleneck in manufacturing lines, and removing it will reduce cycle times for components, cut production costs and decrease energy consumption.'

Curing process

Typically, high-performance composite materials are layered on a specially formed surface, or tool, and then placed in an autoclave, where a combination of heat

and pressure accelerate the hardening of the material. Spirit's new technology introduces a multi-zone heated tool, reportedly removing the need for an autoclave. The tool enables control of the curing process through real-time monitoring and feedback.

According to Spirit, CENSIS supported the collaboration with funding and provided project management expertise while the University of Strathclyde provided

technical support and developed the control algorithm and software for the intelligent tool. The collaboration will continue through 2018, and Spirit has begun applying the technology in research and manufacturing projects.

Spirit AeroSystems;
www.spiritaero.com

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Solvay launches vacuum channel for resin

Solvay has developed Vac-Ply VMS3, a multi-layer microporous vacuum channel for resin infusion.

The channel has been designed to maximize air removal during resin infusion processes, thus improving impregnation and avoiding dry spots. It is suitable for

the infusion of large structures such as boat hulls or wind turbine blades, where maintaining vacuum over long distances is important.

Vac-Ply VMS3 reportedly has reduced witness mark on the laminate surface, improved linear adhesive bond line, thin-

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SGL Group partnership helps with separation technology

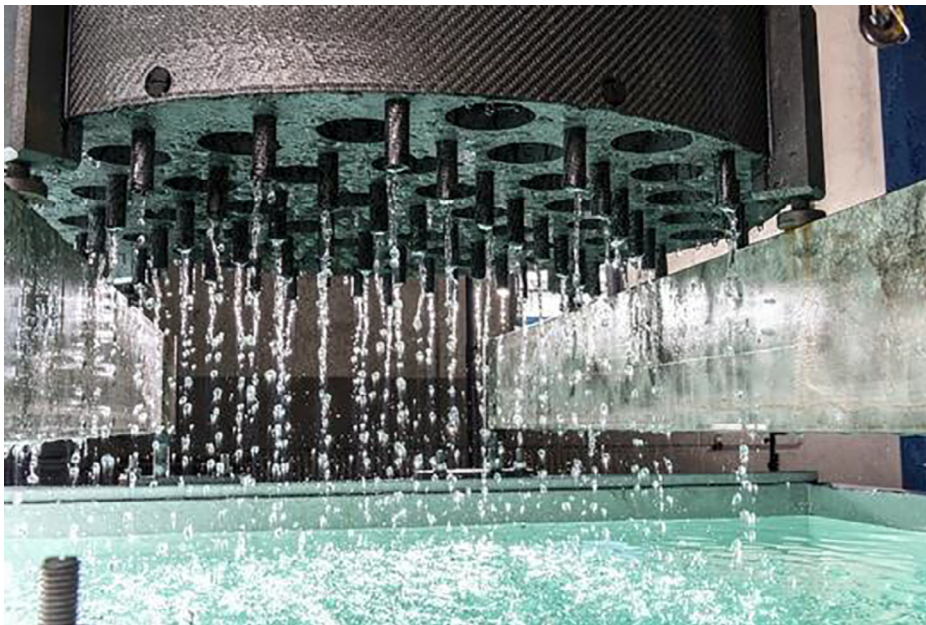
Carbon fiber specialist SGL Group has formed a partnership with Sulzer Chemtech, which provides separation and mixing technology to provide carbon fiber composite materials (CFC) for column internals.

The column internals now feature liquid distributors, collectors and feed pipes made of Sigrabond composite material.

'The new column internals, introduced under the brand name MellaCarbon, are as corrosion-resistant as graphite liquid distributors used to date, but are at the same time lighter, stronger, stiffer, more rigid and more temperature resistant than plastics and have lower cost than special metals,' said Ralph Spuller, SGL project manager for the cooperation project. 'An innovative connection system enables the realization of larger diameters and allows cost efficient production.'

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Scott Bader launches new products

Scott Bader has launched two new brands, Crestafire and Crestafix. Crestafire covers all products that offer fire, smoke and toxic fume (FST) performance for manufacturing fire retardant (FR) composite parts to fire standards required in many building and construction, passenger rail, and land transport applications. The Crestafire range includes: FR gelcoats and intumescent topcoats, FR structural adhesives and a variety of FR rated open and closed mold,



A lightweight CRFP roof custom designed using Scott Bader Crestapol 1260 resin.

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The Crestafix range of rapid cure bonding pastes are reportedly strong, light and tough, developed for a range of markets including marine, automotive and land transportation.

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Crestabond M1-10 reportedly has a working time of 8–12 min and a fixture time of 16–23 min. It has improved fatigue and impact resistance, good gap filling capability and requires minimal surface preparation prior to bonding, the company said.

M1-10 is suitable for bonding a wide variety of substrates including glass fiber reinforced plastic, stainless steel, aluminium, abs, acrylic and polycarbonate. It is black in colour which makes it a suitable adhesive for colour sensitive bond lines, for instance with carbon fiber or black ABS parts.

'This latest addition to our Crestabond range allows us to offer further bonding

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Assessment focuses on hybrid car doors

Sabic has released the results of a recent lifecycle assessment of passenger car side

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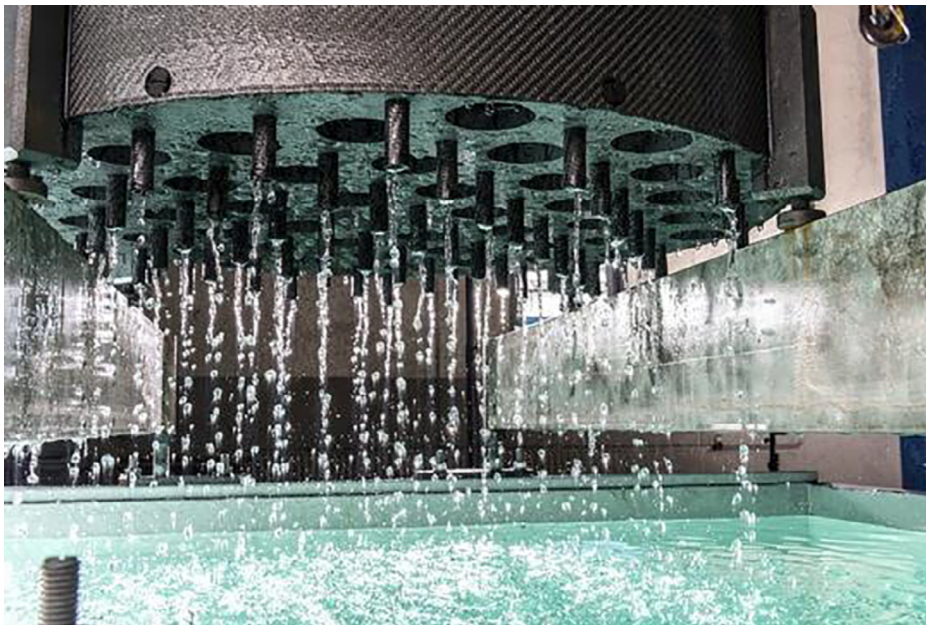
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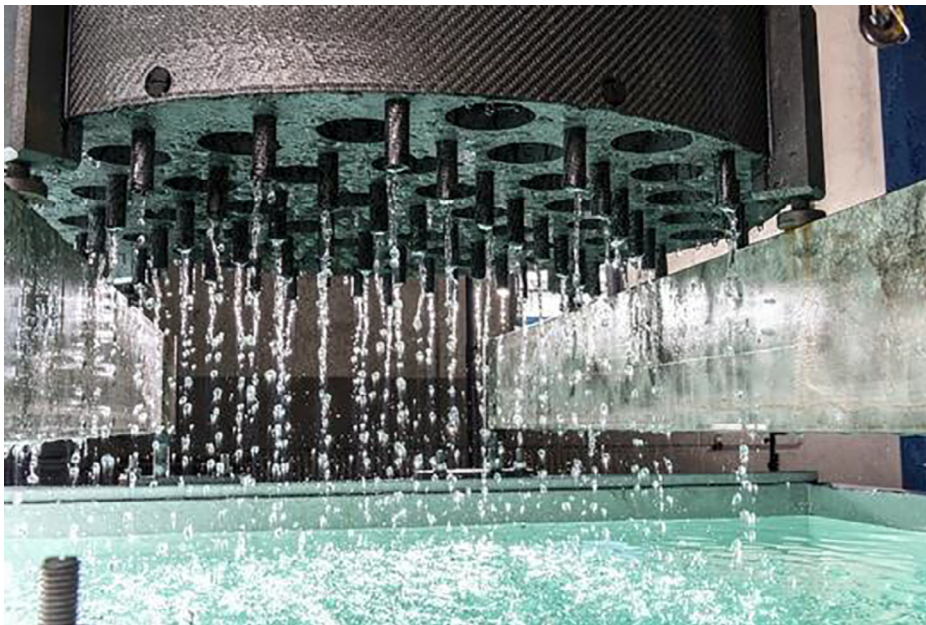
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M1-10 is suitable for bonding a wide variety of substrates including glass fiber reinforced plastic, stainless steel, aluminium, abs, acrylic and polycarbonate. It is black in colour which makes it a suitable adhesive for colour sensitive bond lines, for instance with carbon fiber or black ABS parts.

'This latest addition to our Crestabond range allows us to offer further bonding

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Scott Bader; www.scottbader.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.058>

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Components with a sandwich structure are suitable for secondary structures such as floor paneling or interior lining of

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SGL; www.sglgroup.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.061>

SGL Group partnership helps with separation technology

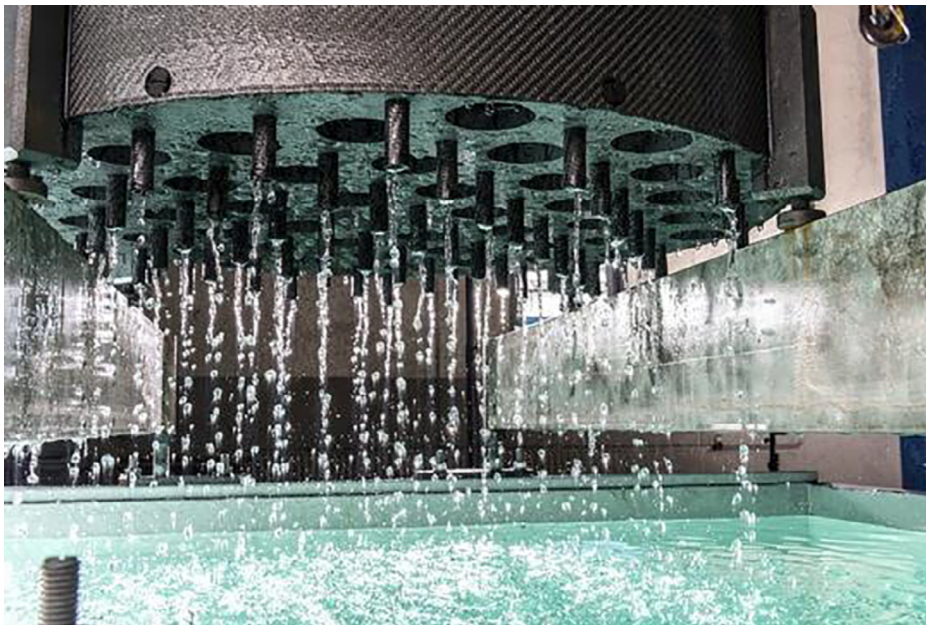
Carbon fiber specialist SGL Group has formed a partnership with Sulzer Chemtech, which provides separation and mixing technology to provide carbon fiber composite materials (CFC) for column internals.

The column internals now feature liquid distributors, collectors and feed pipes made of Sigrabond composite material.

'The new column internals, introduced under the brand name MellaCarbon, are as corrosion-resistant as graphite liquid distributors used to date, but are at the same time lighter, stronger, stiffer, more rigid and more temperature resistant than plastics and have lower cost than special metals,' said Ralph Spuller, SGL project manager for the cooperation project. 'An innovative connection system enables the realization of larger diameters and allows cost efficient production.'

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Scott Bader launches new products

Scott Bader has launched two new brands, Crestafire and Crestafix. Crestafire covers all products that offer fire, smoke and toxic fume (FST) performance for manufacturing fire retardant (FR) composite parts to fire standards required in many building and construction, passenger rail, and land transport applications. The Crestafire range includes: FR gelcoats and intumescent topcoats, FR structural adhesives and a variety of FR rated open and closed mold,



A lightweight CRFP roof custom designed using Scott Bader Crestapol 1260 resin.

pultrusion and filament winding resins, compatible with glass, carbon and aramid fiber reinforcements.

The Crestafix range of rapid cure bonding pastes are reportedly strong, light and tough, developed for a range of markets including marine, automotive and land transportation.

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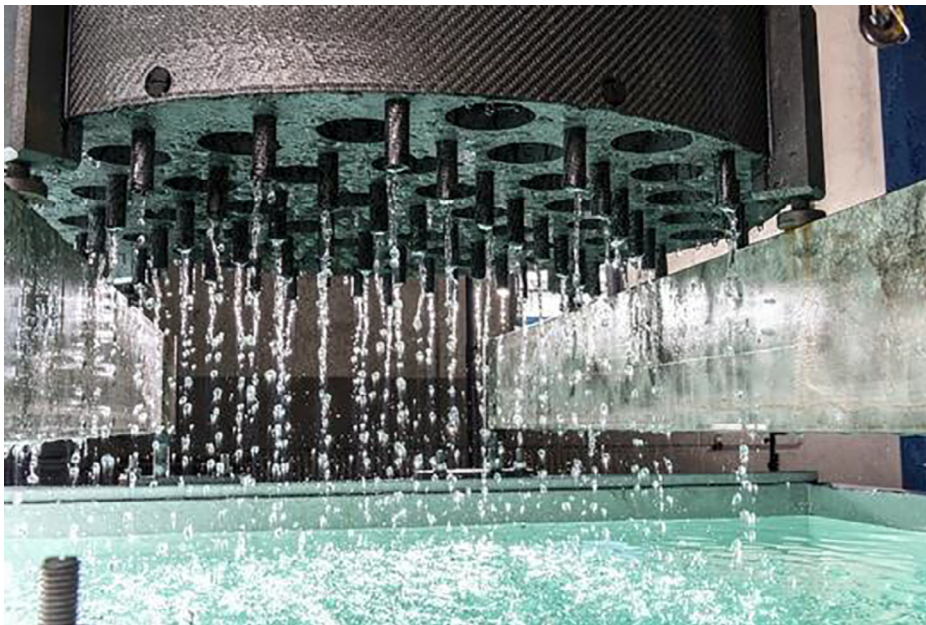
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The company says that material system has been conceived to help improve compliance with stringent energy and emissions regulations.

The life cycle assessment (LCA) found that doors made with the glass fiber polypropylene-reinforced composites outperformed metal car doors with regards to global warming potential and cumulative energy demand. The CFRTC parts weigh less than steel, aluminum and magnesium and deliver improved strength, corrosion resistance and the ability to be produced in high volumes using injection molding.

The assessment, performed in compliance with ISO 14040/44, compared a side door of a passenger car (a typical sedan) made with thermoplastic matrix composites comprising of UDMAX GPP 45–70 tape combined with an injection-molded grade of glass-filled thermoplastic resin, to identical doors made of steel, aluminum

and magnesium. The UDMAX tapes were converted into a laminate and then overmolded onto both sides of a substrate using Sabic's STAMAX glass reinforced polypropylene product, creating a hybrid material system. Parameters for vehicle operation were based on three powertrains – internal combustion (no adaptation), plug-in hybrid and electric – operating over a lifetime of 200,000 km using the New European Driving Cycle.

Vehicle emissions

The results for the internal combustion powertrain showed that the thermoplastic composite doors achieved lower global warming potential than any of the three metal doors: 26% lower than steel, 21% lower than aluminum and 37% lower than magnesium. These numbers were slightly different for the hybrid and electric powertrains.

For cumulative energy demand, the thermoplastic composite doors also achieved lower numbers than the metal doors: 10% less than steel, 13% less than aluminum and 26% less than magnesium for the internal combustion powertrain. Again, the results were slightly different for the hybrid and electric powertrains.

'Many countries, including China, Japan and several across the European Union, have announced they will tighten vehicle emissions regulations in the near future,' said Scott Fallon, global automotive leader, Sabic. 'These impending changes add urgency to the need for advanced new material solutions that can reduce part weight without sacrificing performance.'

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Sabic introduces new composite tape

Sabic has launched UDMAX GPE 45–70, a glass-filled high-density polyethylene composite tape suitable for applications in the water distribution and oil and gas sectors.

It can be used to reinforced industrial pipes, boilers and storage tanks, helping increase strength performance while reducing weight. 'This new material is

designed for use on industrial pipes and vessels and it can deliver excellent mechanical properties,' said Hans Warmerdam, commercial director.

Sabic's tapes feature a high-pressure fiber impregnation technology (HPFIT) that enables the spread and combination of thousands of glass or carbon fibers with a thermoplastic matrix. 'The result is a

resin-rich surface containing a high density of continuous fibers, minimal void content and fewer broken fibers,' said Joris Wismans, technology director. UDMAX tapes are available in different slitted sizes in rolls of up to 4000 m.

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New dry fiber range from Porcher

Porcher Industries has developed the Dry Fiber range, which offers a new way of processing materials out-of-autoclave (OOA).

Dry Fiber is a range of carbon fiber with a binder interface which is suitable for automated fiber placement (AFP)-made preforms for thermoset resin infusion or injection. The material can provide similar component properties to conventional prepreg stacking, enabling the high-speed production of complex shaped parts with improved buy-to-fly ratio, the company says.

The technology uses a one-step-process to impregnate the fiber so can be produced in flat calibrated width for AFP or rounder non-calibrated formats for winding, with a variety of different fiber aerial weights, binder chemistries and binder rates available.

Other features include 100% continuous fiber with no splices that has improved steering in high curvature AFP lay ups, no need for paper or film interleaves which means less waste and risk of fuzzing, improved epoxy resin compatibility and a long shelf life.

Porcher Industries says that it has also added a non-combustible line of Flamline glass fabrics for construction. Flamline fabrics can be used when the highest levels of fire, smoke and toxicity protection are required in textile applications such as acoustical insulation panels, stage curtains, and upholstery interliners for furniture.

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Short fiber thermoplastic compounds

Polymer Company Piper Plastics has developed the KyronMAX series of structural short fiber thermoplastic compounds.

According to the company, the compounds could outperform the mechanical strength of long fiber thermoplastic (LFT) materials.

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LFT compounds, the company said. The technology enables complex parts to be molded with improved mechanical performance and consistency. Very complex parts can be molded with wall thicknesses down to 0.015 inch (0.038 cm), according to Piper.

Competitive structural compounds use high fiber loadings and long fiber lengths to achieve the desired mechanical performance, but the performance of these mate-

rials often do not translate into the molded parts, due to weld line strength loss and fiber length reduction during processing, the company added. In contrast, KyronMAX technology can outperform all other thermoplastic compounds using short fiber technology and much lower filler loadings. 'The lower filler content results in a tough, structural plastic that can be utilized in extremely aggressive applications, yet is still processing friendly

and does not require specialized molding equipment,' said Wilkinson.

The material has tensile strengths above 51,000 psi (352 MPa) and flexural modulus above 6,500,000 psi (44,816 MPa) and is available in various thermoplastics including PA, PPA, PPSA, PEI, PEEK, with more in current development.

Piper Plastics; piperplastics.com

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New research to develop discontinuous composite tubes

NTPT, the Ecole polytechnique fédérale de Lausanne and other partners, plan to implement a research project to improve discontinuous carbon fiber tubes.

NTPT has been producing the tubes using a patent pending method with Thin Ply prepreg materials since 2016. The technology makes it possible to position fiber plies at any angle and at any point in the tube's length or thickness.

The four-year research will focus on improving the potential of tubular discontinuous fiber composites by creating design rules, improving the material and looking at the cost effectiveness of the process, helping NTPT to better communicate its advantages to the performance market sectors, and to expedite the initial stages of new projects and product development.

Carbon fiber composite tubes can be used in various market sectors and applications such as thin wall tubes in the aero sector as struts or control arms, automotive drive shafts, masts and booms in the marine sector, rollers and cylinders for industrial applications and the performance sports sector, in particular golf. On a larger scale the technology may be applicable to the automated manufacture of wind turbine spar and root components. Two components will be developed through the course of the study. One short term project is a windsurf mast which will be developed over an 18-month period in conjunction with professional windsurfer Tristan Algret, and the other is a three-year project with a leading aerospace company to develop tubular structures for UAVs.



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'We are embarking on an exciting project that is the obvious next step in our research and development into high performance composite tubes,' said James Austin, CEO, NTPT. 'We have established a sound platform from which to launch our parts business, and we are excited about the progress made this year. Now is the time to move into this next stage of

research, which will allow us to more easily provide customer-specific responses to new applications and enquiries, and enable us to move into the prototyping stage of new products more quickly.'

NTPT; www.thinplytechnology.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.053>

Composite/metal hybrid improves hollow profiles

Lanxess says that it has now extended the use of its plastic/metal hybrid technology to make hollow profiles with round or rectangular cross sections.

This hybrid technology makes use of glass fiber reinforced polyamide 6 for injection molding as well as a steel or aluminum sheet as metal component.

'Compared to sheet metal, hollow profiles show significantly higher dimensional stability as well as increased torsional strength and stiffness,' said Lukas Schröer,

LFT compounds, the company said. The technology enables complex parts to be molded with improved mechanical performance and consistency. Very complex parts can be molded with wall thicknesses down to 0.015 inch (0.038 cm), according to Piper.

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and does not require specialized molding equipment,' said Wilkinson.

The material has tensile strengths above 51,000 psi (352 MPa) and flexural modulus above 6,500,000 psi (44,816 MPa) and is available in various thermoplastics including PA, PPA, PPSA, PEI, PEEK, with more in current development.

Piper Plastics; piperplastics.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.054>

New research to develop discontinuous composite tubes

NTPT, the Ecole polytechnique fédérale de Lausanne and other partners, plan to implement a research project to improve discontinuous carbon fiber tubes.

NTPT has been producing the tubes using a patent pending method with Thin Ply prepreg materials since 2016. The technology makes it possible to position fiber plies at any angle and at any point in the tube's length or thickness.

The four-year research will focus on improving the potential of tubular discontinuous fiber composites by creating design rules, improving the material and looking at the cost effectiveness of the process, helping NTPT to better communicate its advantages to the performance market sectors, and to expedite the initial stages of new projects and product development.

Carbon fiber composite tubes can be used in various market sectors and applications such as thin wall tubes in the aero sector as struts or control arms, automotive drive shafts, masts and booms in the marine sector, rollers and cylinders for industrial applications and the performance sports sector, in particular golf. On a larger scale the technology may be applicable to the automated manufacture of wind turbine spar and root components. Two components will be developed through the course of the study. One short term project is a windsurf mast which will be developed over an 18-month period in conjunction with professional windsurfer Tristan Algret, and the other is a three-year project with a leading aerospace company to develop tubular structures for UAVs.



The technology makes it possible to position fiber plies at any angle and at any point in the tube's length or thickness.

'We are embarking on an exciting project that is the obvious next step in our research and development into high performance composite tubes,' said James Austin, CEO, NTPT. 'We have established a sound platform from which to launch our parts business, and we are excited about the progress made this year. Now is the time to move into this next stage of

research, which will allow us to more easily provide customer-specific responses to new applications and enquiries, and enable us to move into the prototyping stage of new products more quickly.'

NTPT; www.thinplytechnology.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.053>

Composite/metal hybrid improves hollow profiles

Lanxess says that it has now extended the use of its plastic/metal hybrid technology to make hollow profiles with round or rectangular cross sections.

This hybrid technology makes use of glass fiber reinforced polyamide 6 for injection molding as well as a steel or aluminum sheet as metal component.

'Compared to sheet metal, hollow profiles show significantly higher dimensional stability as well as increased torsional strength and stiffness,' said Lukas Schröer,

LFT compounds, the company said. The technology enables complex parts to be molded with improved mechanical performance and consistency. Very complex parts can be molded with wall thicknesses down to 0.015 inch (0.038 cm), according to Piper.

Competitive structural compounds use high fiber loadings and long fiber lengths to achieve the desired mechanical performance, but the performance of these mate-

rials often do not translate into the molded parts, due to weld line strength loss and fiber length reduction during processing, the company added. In contrast, KyronMAX technology can outperform all other thermoplastic compounds using short fiber technology and much lower filler loadings. 'The lower filler content results in a tough, structural plastic that can be utilized in extremely aggressive applications, yet is still processing friendly

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project manager for lightweight structures. 'We believe that this new hollow profile hybrid technology enables the manufacturing of components such as cross car beams, which up until now were not resilient enough using classic plastic metal hybrid technology.'

Lanxess developed a one-step process to make the part where the metal inserts can be automatically placed into the injection molding tool. Due to their production pro-

cess, these metal inserts exhibit dimensional tolerances, which can damage the tool. In case of undersized inserts leaks in the tool system may result and to avoid the profile collapsing due to the high levels of melt pressure during the injection molding process, the metal insert has to be supported. Another challenge for the company was to create a long-lasting, form fitting bond between the plastic and the metal in all directions.

The company says that the technology could be used to make seat structures, front ends, tail gates, and mirror brackets in truck as well as furniture, ladders and strollers. It is currently working on expanding hybrid technology to make die-cast or extrusion molding inserts.

Lanxess; www.lanxess.com

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New materials from Gurit

Composites specialist Gurit has launched Ampreg 30, a new low toxicity epoxy laminating system and Balsaflex Lite, a balsa core material.

Balsaflex Lite has a coating system that is capable of reducing the resin uptake in infusion processes by up to 50% for rigid panels and by up to 40% for flexible balsa wood sheets. It is reportedly compatible with epoxy and polyester resin infusion processes used by the industry.

Gurit Balsaflex Lite is supplied in standard sheet size of 610 × 1220 mm (2×4ft), thickness from 6 mm up to 50

mm and in the existing Balsaflex density range.

Ampreg 30 can be used in the manufacture of large composite structures in the marine, wind and construction industries. It has been made with a focus on the health and safety of hand lay-up and vacuum bagging production techniques.

Gurit Ampreg 30 features a resin matrix resulting in improved mechanical and thermal properties of laminates produced at ambient temperature cures and moderate temperature post-curing processes.

The laminating system is available with a range of hardener speeds from fast to slow.

It is also available in a LRT (Light Reflective Technology) version, an optional addition to the resin matrix that enables the inspection of contamination by means of UV light after each work period to reduce workers' exposure to chemicals and without changing the mixing and handling properties of the laminating system or cured resin performance.

Gurit; www.gurit.com

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New testing method improves composites understanding

The Fraunhofer Institute for Structural Durability and System Reliability LBF has developed a new testing method for carbon fiber composites which combines mechanical and radiographic examination.

The method can be used to characterize materials, and reportedly makes it easier to assess inclusions or damage to raw material based on their influence on the durability and service life. Fraunhofer LBF says this can lead to better understanding of material behavior and material characterization.

Using the method, the tested component remains in the X-ray equipment during the mechanical load. As a result, the exact location in the material can be observed and analyzed throughout the entire load duration. Previous concepts were not able to achieve the necessary precision of just a few micrometers with the alternating insertion and removal of the sample with intermittent radiological examination, Fraunhofer says.

'Understanding how damage occurs to the material of a component while is placed under realistic mechanical loads is one of the key questions in materials science, and was previously not possible,'

said Oliver Schwarzhaupt, scientific employee in function-integrated lightweight construction at Fraunhofer LBF. 'The new process represents a huge advance in regards to detail resolution and precision, as well as the retrievability of possible causes of damage.'

While scientists subject the component to a mechanically dynamic service life load, they can use the radiological examination in this cycle to observe and illustrate the occurrence and progress of the damage. With forces in the test machine of up to 250 kilonewtons, even high-strength components made of carbon fiber like those used in aircraft construction can be examined, the scientists say. 'There is still a great need for examination to understand the failure mechanisms in carbon fiber-reinforced plastics,' said Schwarzhaupt.

Damage origin

With most modern imaging processes, cracks and damage in material can be illustrated vividly and in three dimensions, opening up many possibilities for analysis. With the use of a microfusion pipe, the X-ray equipment in the Fraunhofer LBF

has a high resolution capacity of just a few micrometers. In this way it is possible to detect the smallest signs of damage even as it begins to occur, or determine that the slightest irregularities in the material are the point of origin for the damage. In the area of fiber-reinforced plastics in particular, the occurrence of damage on the fiber level can be studied.

With this knowledge about the cause of the error and the error sequence, developers, designers, and manufacturers can now improve their materials, components, and manufacturing processes even before a crack is macroscopically visible. 'Our new concept makes a great contribution on the topic of material understanding and is clearly better able to meet customer-specific requirements in the area of material failures at an early stage,' ensures Schwarzhaupt.

Fraunhofer Institute for Structural Durability and System Reliability;

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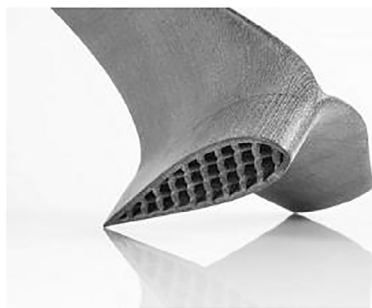
New plastic composite materials for 3D printing

3D printing company EOS is now offering European distribution of three polymers for additive manufacturing (AM) from ALM, a wholly owned subsidiary of the company.

The following fiber reinforced materials are now available:

ALM HP 11-30, a carbon fiber-reinforced polyamide 11 material with high strength, impact resistance, and an increased elongation at break. The material is suitable for components subject to mechanical wear that require a minimum level of toughness, including automotive industry applications, particularly for motorsport.

ALM PA 640-GSL, a polyamide 12 material filled with lightweight glass micro-



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spheres, providing practically the same properties as a normal glass filled polyamide, but with reduced weight (com-

ponent density: 0.82 g/cm^3). With a microsphere and carbon fiber filling, ALM PA 640-GSL is suitable for applications that require extremely low weight, high strength, and rigidity in one product. It also features increased thermal resistance and improved surface quality. Application fields include the aerospace, shipping, sports, model making, and motorsport sectors.

ALM FR-106, a flame-retardant polyamide 11 suitable for use in the aerospace industry, is also available.

EOS; www.eos.info

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.048>

Implementation of adhesive-free bonding

RWTH Aachen's Aachen Centre for Integrative Lightweight Production (AZL) says that it has implemented adhesive-free bonding of thermosetting and thermoplastic fiber reinforced plastic for the first time in large-series production with cycle times of less than three minutes. The

demonstrator made of carbon fiber reinforced epoxy resin shell element and glass fiber reinforced PA6 ribbed structure was derived from the current BMW i3.

The process took place as part of the OPTO-Light research project in cooperation with BMW AG, KraussMaffei

Technologies GmbH, ARGES GmbH, Precitec GmbH & Co KG, Sensortherm GmbH and Zeiss Optotechnik GmbH.

AZL; www.azl.rwth-aachen.de

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.047>

Ashland launches new resin

Ashland has launched Derakane Signia, part of an existing resin line.

According to the company, the new formula has 'an undeniable detection system to verify the integrity of designs' of corrosion-resistant glass fiber reinforced plastic (FRP) pipes and tanks. It also has corrosion

resistance, mechanical properties and improved processing.

Ashland says that the resin can improve manufacturing efficiencies and lower emissions due to its styrene suppressant technology. The resins are formulated to provide a no-prep surface, increased

secondary bonding and reduced gassing for faster consolidation and less processing time and labor.

Ashland; www.ashland.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.046>

New resins from Aliancys

Aliancys has introduced two new resins.

The Daron 8150 resin is suitable for automotive applications and carbon sheet molding compound (SMC) applications. The resin features improved wetting of both glass and carbon fibers which makes it possible to obtain elevated strength and stiffness in light-weight molded components. It is suitable for high volume manufacturing and molded parts have demonstrated ultra-low emissions.

Aliancys is also launching the new Neomold 2017-S-1 resin for manufacturing composite tooling. The resin makes it possible to make molds that mirror the surface and dimensions of the plug. The thixotropic nature of the resin allows for improved application on vertical surfaces without sagging. Although the through-cure is fast, the exothermic heat is low. The resin is highly suitable for making thick parts in one go.

The company has also helped develop light-weight passenger bus components for VDL Bus & Coach. These components are made by applying a foaming resin formulation using resin from Aliancys.

Aliancys; www.aliancys.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.045>

New sandwich foam core for automotive

3A Composites Core Materials says that it has developed structuralAIREX, a new foam core platform for lightweight, high-volume automotive applications that can

be processed in high-temperature, high-pressure, short-cycle production methods.

Weight reduction has become a major focus in the automotive industry. Com-

posites, particularly sandwich designs, have a proven track record of delivering weight saving solutions, the company says. However, composite sandwich parts

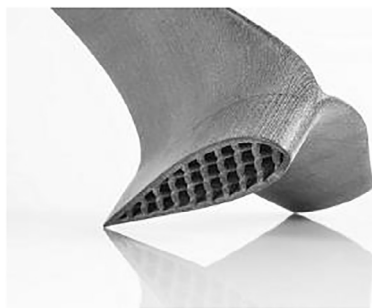
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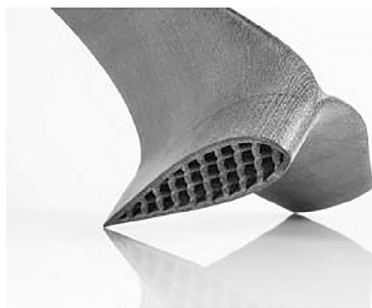
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EOS; www.eos.info

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.048>

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Technologies GmbH, ARGES GmbH, Precitec GmbH & Co KG, Sensortherm GmbH and Zeiss Optotechnik GmbH.

AZL; www.azl.rwth-aachen.de

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Ashland launches new resin

Ashland has launched Derakane Signia, part of an existing resin line.

According to the company, the new formula has 'an undeniable detection system to verify the integrity of designs' of corrosion-resistant glass fiber reinforced plastic (FRP) pipes and tanks. It also has corrosion

resistance, mechanical properties and improved processing.

Ashland says that the resin can improve manufacturing efficiencies and lower emissions due to its styrene suppressant technology. The resins are formulated to provide a no-prep surface, increased

secondary bonding and reduced gassing for faster consolidation and less processing time and labor.

Ashland; www.ashland.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.046>

New resins from Aliancys

Aliancys has introduced two new resins.

The Daron 8150 resin is suitable for automotive applications and carbon sheet molding compound (SMC) applications. The resin features improved wetting of both glass and carbon fibers which makes it possible to obtain elevated strength and stiffness in light-weight molded components. It is suitable for high volume manufacturing and molded parts have demonstrated ultra-low emissions.

Aliancys is also launching the new Neomold 2017-S-1 resin for manufacturing composite tooling. The resin makes it possible to make molds that mirror the surface and dimensions of the plug. The thixotropic nature of the resin allows for improved application on vertical surfaces without sagging. Although the through-cure is fast, the exothermic heat is low. The resin is highly suitable for making thick parts in one go.

The company has also helped develop light-weight passenger bus components for VDL Bus & Coach. These components are made by applying a foaming resin formulation using resin from Aliancys.

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New sandwich foam core for automotive

3A Composites Core Materials says that it has developed structuralAIREX, a new foam core platform for lightweight, high-volume automotive applications that can

be processed in high-temperature, high-pressure, short-cycle production methods.

Weight reduction has become a major focus in the automotive industry. Com-

posites, particularly sandwich designs, have a proven track record of delivering weight saving solutions, the company says. However, composite sandwich parts

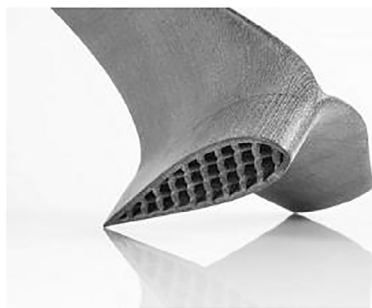
New plastic composite materials for 3D printing

3D printing company EOS is now offering European distribution of three polymers for additive manufacturing (AM) from ALM, a wholly owned subsidiary of the company.

The following fiber reinforced materials are now available:

ALM HP 11-30, a carbon fiber-reinforced polyamide 11 material with high strength, impact resistance, and an increased elongation at break. The material is suitable for components subject to mechanical wear that require a minimum level of toughness, including automotive industry applications, particularly for motorsport.

ALM PA 640-GSL, a polyamide 12 material filled with lightweight glass micro-



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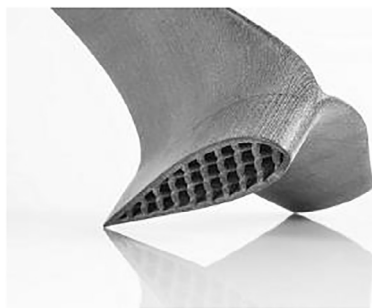
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used in a car must fulfill very diverse requirements. The material mix and the manufacturing technology must both be specifically tailored to the individual part and its expected series volume.

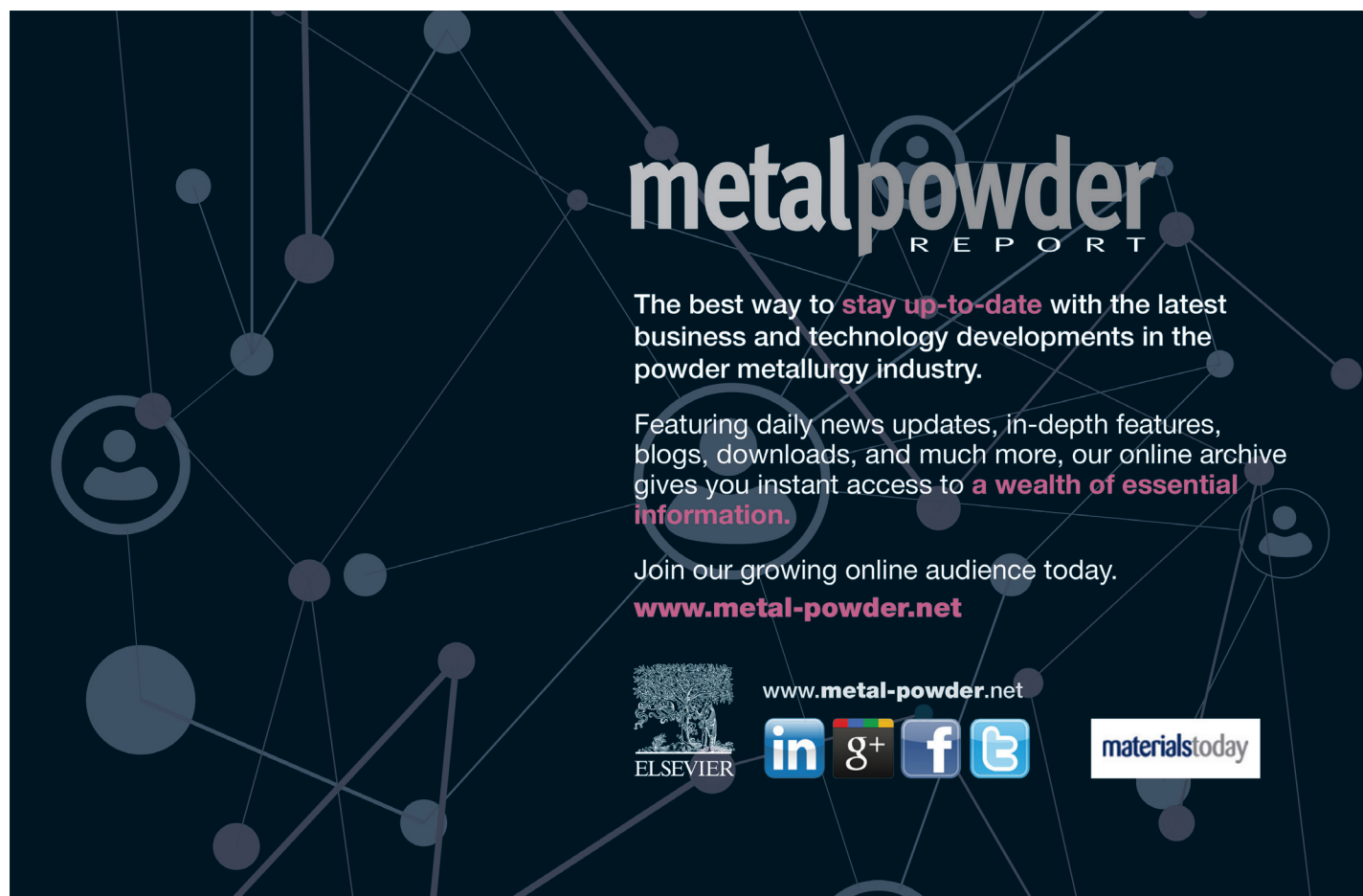
'Our goal is to support the automotive industry in its strive toward weight

reduction, and to deliver a sustainable and cost-efficient sandwich solution to accelerate the growth of structural sandwich parts in high volume car production,' said Eric Gauthier, president of global key accounts of 3A Composites Core Materials.

3A Composites;

www.airexbaltekbanova.com

0034-3617/<https://doi.org/10.1016/j.repl.2018.04.044>



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REPORT

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Interview with Gino Francato

Lewis Fowler*, Gino Francato

Reinforced Plastics spoke with Gino Francato from SABIC (Saudi Basic Industries Corporation) about composites manufacturing and current trends in the composite industry.



Q: Please can you start by introducing yourself, telling us about your background and that of SABIC?

I'm the Global Business Leader Composites at SABIC which ranks among the world's top petrochemical companies. I have been working for SABIC since May 2013 and I am responsible for the global composites platform and for new business development of advanced composites in Europe.

SABIC is a global leader in diversified chemicals headquartered in Riyadh, Saudi Arabia. We manufacture on a global scale in the Americas, Europe, Middle East and Asia Pacific, making distinctly different kinds of products. SABIC supports customers in identifying and developing opportunities in key end markets such as construction, medical devices, packaging, agri-nutrients, electrical and electronics, transportation, and clean energy.

Q: Could you tell us about the technology you specialize in and its impact?

Our main focus at JEC Composites World 2018 is accelerating the adoption of high quality thermoplastic composites. At SABIC

we believe thermoplastic composites are the next generation of lightweight-enabling materials, with adoptions and developments growing in industries from electronics to automotive to aerospace.

We will also be highlighting our capabilities in predictive engineering and process modeling.

Examples:

SABIC's UDMAX tapes

SABIC's UDMAX tapes are unidirectional Continuous Fiber Reinforced Thermoplastic Composites (CFRTCs) that offer exceptionally lightweight and high strength as a replacement solution for metal, plywood and other traditional materials. They feature a proprietary high-pressure fiber impregnation technology (HPFIT™) that quickly and precisely enables the spread and combination of thousands of glass or carbon fibers with a thermoplastic matrix. The result of the process is a tape with a resin-rich surface containing a high volume fraction of continuous fibers, minimal void content and fewer broken fibers. UDMAX tapes are available in different slitted sizes in rolls of up to 4000 running meters.

A superior replacement to traditional materials, CFRTC tapes can offer important benefits to many different industries.

In automotive, UDMAX GPP 45–70 tape can help OEMs and designers reduce part weight to reduce fuel consumption and emissions to comply with current and upcoming regulatory requirements. For light commercial vehicles, UDMAX GPP tape can be used in sidewalls, floor and roof panels, replacing steel, wood or thermosets to provide lighter weight, toughness and durability.

For the Aircraft industry, weight saving is of paramount importance. SABIC developed a seat back prototype constructed from CFRTC of carbon fiber and ULTEM™ resin meeting Federal Aviation Regulation (FAR) compliance in the United States for flammability, smoke density and heat release. The prototype

* Corresponding author.

application features an integral, hollow channel design that delivers high strength-to-weight ratio and is lighter than aluminum.

The energy sector can also benefit from CFRTCs. Used to reinforce oil, gas and water pipes, UDMAX GPE 46–70 tape helps withstand high pressure, corrosion and enables longer pipe sections to be produced compared to pipes made out of metal.

As consumer electronics devices become increasingly lighter and thinner, device covers made with thermoplastic composites can contribute to weight-out, cost effectiveness, mass productivity, recyclability and design flexibility more effectively than thermoset and other materials.

A digitized composites manufacturing system for large scale production of electronic device covers will be one of the initial focus areas for SABIC's upcoming Digital Composites Manufacturing system for large scale production, which is slated to open in the Netherlands in 2019. Through its collaboration with Airborne International to create a fully automated and digitized production line featuring Siemens technology and offering high speed and efficiency, SABIC aims to lower the system costs and streamline the production of applications made from thermoplastic composites.

To support its efforts in materials and manufacturing innovation, SABIC has expanded its predictive engineering capabilities at its Center of Excellence in Geleen, The Netherlands. The goal is to establish high confidence in the predicted performance of SABIC's materials in new applications using CFRTCs by employing tailored simulation software and proven methodologies.

Customers have told us that they face three hurdles to the introduction of thermoplastic composites in their applications: cost, mass production and design predictability. Through materials innovation, disruptive automated digital manufacturing and sophisticated predictive engineering capabilities, SABIC intends to remove these hurdles and pave the way for broad adoption of advanced thermoplastic composites across industries and geographies.



Q: Who are SABIC's main customers?

SABIC works with leaders in various industries, from electronics to automotive as well as from aerospace to infrastructure.

Q: Are SABIC seeing any growth in its markets and what trends have you seen driving that?

The CFRTC market has not grown at the speed that SABIC and other major players expected. Looking back there has been many challenges in the ability of the value chain to develop materials and provide the right confidence to process and design the right CFRTC solutions. The time has not been wasted though. A lot has been accomplished. There are a healthy number of material suppliers, new technologies to process them and a significant effort has been made to be able to predict performance. The technology is now mature enough to be considered by major players in the automotive, consumer electronics and aerospace sector. Now is the time.

We see several trends from upcoming regulations to carbon emissions, like in automotive. In consumer electronics, for instance, the trend is for mobile devices to prolong the lifespan and energy delivery of the battery without sacrificing portability. In order to enable that, devices need to be lighter and stronger. Hence the covers need to be lighter to allow new battery designs to fit in upcoming models. Another important element in consumer electronics is design freedom so OEMs can innovate new esthetics in surface and texture, and the use of sustainable solutions. When it comes to transportation, we see trends geared toward fuel consumption. OEMs are in continuous pursuit of lightweight, strong and compliant material technologies that can directly benefit the performance of the aircraft in terms of fuel efficiency.

Q: At JEC World we saw you displaying UDMAX™ materials-what do you predict for the future of these materials?

CFRTCs are graduating from incubation. Nevertheless, we are seeing in certain areas that early adopters such as consumer electronics, transportation, automotive and even industrial applica-

tions, like pressure vessels and industrial pipes for Oil & Gas, are considering our tapes for their next generation of products. This means that our customers see the potential value that our material technology can offer. And to help them accelerate the time-to-market of new products made with our thermoplastic composites, we have a dedicated center of excellence in Composites in the Netherlands, where customers can leverage the expertise of our scientists and engineers to predict the performance of our material and model the design in their applications. We also have extensive processing capabilities in the United States at our Plastics Processing Development Center (PPDC).

Q: What are the benefits of large scale of composites manufacturing with UDMAX™ tapes?

There are two reasons why large scale is important. The effect of scale helps bring the production costs down, it is possible to produce products with a high level of consistency and all of this is necessary to be a solution for industries that are by nature dealing with mass produced parts.

The new large-scale manufacturing line, built by Airborne at its facility in The Netherlands using Siemens factory automation and digital control software, can produce multiple thermoplastic composite laminates every minute, achieving over a million parts annually.

For ultimate flexibility, this system can be remotely operated, and can run multiple laminate sizes simultaneously. Machine learning concepts will be used to fine-tune quality and adaptive process control will allow settings to be modified on the fly.

The Digital Composites Manufacturing line will be supported by predictive engineering capabilities at SABIC's Center of Excellence in The Netherlands. Predictive engineering for UDMAX™ tapes is based on computer-aided engineering (CAE) software that uses material data and material modeling (such as elastic properties and damage initiation/rupture behavior) to create simulations of how the composite material will perform in an application during its use, taking into account the influence of manufacturing processes.

The Digital Composites Manufacturing line will premiere its technology to meet immediate needs in the consumer electronics industry.

The Digital Composites Manufacturing line will be able to mass-produce lightweight, high modulus and low warpage, custom-engineered laminates as per thickness, dimensions, lay-up preferences and desired performance. Made with carbon-fiber reinforced polycarbonate composite, these SABIC laminates will be used for laptop covers.

By responding to our customers' needs for increasingly lighter, yet stronger and thinner products in large scale, we will soon be enabling our customers to leverage the advantages of SABIC's laminates to achieve not only weight-out, but also design flexibility and shorter production cycle times for device covers – more effectively than ever before.

Q: In your opinion, what are the other hot topics in reinforced plastics, and indeed other materials, right now?

We believe it's possible to use CFRTCs in mass production, at the right quality and cost. They are the next generation of lightweight-enabling materials, with adoptions and developments growing in industries from electronics to automotive to aerospace.

Also, the trend toward predictive engineering and process modeling is growing in importance.

SABIC has also grown its portfolio of differentiated materials to help expand the application space for Additive Manufacturing last November, including the new filament based on SABIC's LEXAN™ EXL polycarbonate (PC) copolymer technology, which delivers high impact performance and low-temperature ductility.



Marine composites set sail

Liz Nickels

Liz Nickels spoke to marine composites company Nautech Composites about a recent shipyard move and about the current state of shipbuilding in the UK.

UK-based Nautech Composites is a manufacturer of glass fiber reinforced (GRP) tooling and moldings, producing hulls, decks and components for rigid inflatables, superyacht tenders and watercraft, ranging from 4 to 15 m overall length.

The company was set up by Sean Singleton, its current managing director (MD), to meet requirements for new builds, repairs and servicing to a wide variety of craft along the south coast of the UK for many clients, both trade and private. 'Being able to offer cost effective solutions to provide high quality composite moldings for low and medium volume production, I have found a niche in the marketplace,' Sean told *Reinforced Plastics*.

He has over 30 years extensive experience in all areas of composite tooling and moldings, ranging from working with concept designs, design for manufacture, for one offs and full production, as well as repairs, maintenance, servicing and restoration of vessels. According to Sean, the Nautech management team also has a lot of knowledge within the marine industry over many years designing, manufacturing composites and boat building.

Custom builds

Nautech have produced parts for the marine and superyacht industries as well as companies in refrigeration, construction and specialist vehicle conversions. These industries aim for lightweight composite structures and moldings for low and medium volume production, according to the company. Nautech also offers project management including design manufacture, pattern making, tooling, production and assembly. The company works with designers on custom builds and full production builds, producing a range of craft with specific requirements and features. The company can make patterns that are either crafted by hand using traditional methods or by utilizing five-axis CNC machining technology. Manufacturing capabilities include glass fiber moldings with traditional wet lay up in GRP and composite, through to vacuum assisted processes.

Initially the company was approached by various manufacturers to make new patterns for its developing ranges of craft. 'We are flexible within our approach to suit customers' requirements and can work with a combination of modern techniques and traditional skills throughout many areas of the construction process,' says Sean. 'For example, our pattern making can include laser cut frames, to build hull and deck shapes with conventional methods of fitting stringers, building up layers of diagonal planking, shaping, filling, fairing and finishing are carried out, prior to laying up the mold. For low-medium volume production, we can use three axis and five axis milling machines to provide total accuracy, using the design software to sculpt complex hull and deck details with complete accuracy.

'From producing patterns and molds, this enabled us to move quickly into the actual production of the craft as some of our customers were running out of their own resources. Eventually the demand for our manufacturing services grew to full production.

'We now specialize in taking projects from concept through to completion,' Sean added. 'It is of great importance that we meet the specific requirements of each client and develop a long lasting, trusted partnership. We have produced a wide range of plugs, molds and tooling, developing methods to produce high tech tooling systems from splash to full production and infusion molds.'

Craft weight

Nautech has also helped clients to improve the performance of a wide variety of race craft for inshore and offshore races. 'We not only ensure the construction and weight of the craft which are crucial, we ensure the highest efficiency through rigging and drive set up,' says Sean. 'We also improve the performance of production craft to get the maximum efficiency for our clients.'



One project incorporated custom concealed hinges for a beach lander bow option.

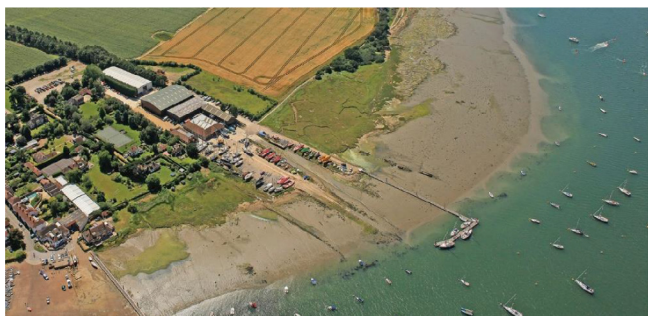
The company also works alongside designers and naval architects on new projects. 'A recent innovative concept, working with Arran McKeon and Cobra Ribs, incorporates opening bow steps and bespoke concealed hinges for their beach lander RIB option,' explains Sean. The design was tooled, molded and assembled by Nautech and is now in full production.

Nautech also works with clients and Lloyds register of Shipping to produce a number of fast rescue tenders that are certified by maritime survey specialists SOLAS. On site it has climate controlled manufacturing facilities where the company can monitor and record all the necessary criteria, to adhere to the quality procedures to Lloyds registered of shipping and DNV.

The company's moldings were recently displayed by PE Marine Designz at the recent Metstrade exhibition in Amsterdam. Working with naval architect, Arran McKeon and Cobra Ribs, the project incorporates custom concealed hinges for the beach lander bow option which includes opening bow steps that can drop crew off to the beach without getting wet. The company tooled, molded and assembled the system, which allows the steps to be easily deployed and retrieved from within the boat.

Restoration work

Nautech was commissioned to supply custom build composite pools for the 52 m long DB9 superyacht which was built in 2010 by Palmer Johnson and refitted in 2012. DB9's interior layout sleeps up to 12 guests in five rooms, including a master suite,



Nautech's new premises in Chichester Harbour.



Nautech produced a number of fast rescue tenders.

two double cabins, two twin cabins and two pullman beds. It features a 16 seat transom jacuzzi, four seater flybridge pool and 9 m x 3 m foredeck pool which were made in-house and transported to the ship in build for installation. 'These were all tooled and manufactured in-house and then transported to the ship in build for installation,' Sean told me.

The company also repaired a tender (a vessel used for providing support to the yacht) which was worn after many years of service and being exposed to the Mediterranean heat. It had been part of a 47 m superyacht based in the South of France. Extensive restoration work was required, including a complete engine rebuild, new upholstery, rewiring with new electronics, various individual GRP repairs, new D section inflatable tubes and a complete re-paint in metallic silver.

Nautech recently moved into waterside premises at Northshore Shipyard in the picturesque Chichester Harbour, straddling the boundary of the counties of West Sussex and Hampshire. The new 20,000 ft² manufacturing factory will provide the company with increased capacity to meet production demands. The new factory has more floor space, dedicated bay areas, up to 30 ton overhead cranes for large components, engines and boat building, outside yard storage and access to the water with an on-site hoist for launching and recovering vessels.

Production capacity

I asked Sean what had prompted the company's move into new premises. 'The move to the new premises was prompted by the



Nautech was commissioned to supply custom build composite pools for a 52 m long superyacht.

need to increase our production capacity, together with improved facilities, to support our high demand for both composites tooling and moldings,' he explained. 'The growing requirements from manufacturers to outsource their GRP/fiber reinforced plastic (FRP) requirements has led to an all-round increase in our services, as well as an increase of the size of the vessels that we are being asked to mold.'

I asked him about what he planned next for Nautech. 'We would like to continue to build on the success that we have already achieved,' he said. 'We now have the additional capacity to grow our business and take on new customers who are looking for partial or full production of their craft.'

'We work with clients and Lloyds register of Shipping to produce a number of SOLAS certificated fast rescue tenders. This is a specialist area that we would like to concentrate on and we hope to expand this type of work. In our new premises, we have climate controlled manufacturing bays where we can monitor and record all necessary criteria to meet the standards of Lloyds and other governing bodies.'

The company already builds many superyacht tenders and is also experiencing a demand for a tailored service to repair and refit jet skis, ribs and tenders.

'As our company expands we will look to take on more skilled technicians as well as new apprentices,' Sean said. 'We are working with a training company and livery company the Worshipful Company of Shipwrights to support our apprentice's education and skills as we recognize that training young adults is essential to our growth and future success.'

Environmental issues

Sean has a positive view of the development of the composite industry over the last few years.

'Composite technology in the last few years has been driven by environmental issues, both on a global scale and for technicians within the work place,' he said. 'Healthier and cleaner methods of production have been adopted, not only to help

the manufacturers to control materials more effectively, but massively improving the environment in which the technicians are working.

'With advancements in material research, the materials themselves have been developed to produce less emissions and volatile organic compounds (VOCs) with the required consumable cost being reduced by the introduction of reusable consumable, and so on. This also has financial benefits, which has made it an easier choice for customers to move to modern production processes. In the past, they may have been deterred by the expense of the required consumables outweighing the material saving.'

This positivity applies to the future of the industry too.

'With environmental calls for low emissions in the automotive industry, this will hopefully extend to the marine industry and I expect to see some exciting new hull designs to increase efficiency and performance in larger craft.'

'Completely eco-friendly materials have already been developed using organic oils and so on,' he added. 'Presently, they are quite expensive as they are only being produced in very small quantities with some still requiring the non-organic hardeners. I hope to see that over the next five years these materials will be more readily available and at a price that will make them viable and appealing to the manufacturers. As natural oil reserves reduce, the cost of traditional resins will only increase.'

And so far, Brexit has had a positive impact on the company. 'So far Brexit hasn't affected any European customer relations and our customers order books are looking very buoyant,' he said. 'The pound being weaker, has made British manufacturing more affordable and appealing to clients in other countries. With the threat of a possible import duty, this will affect both sides, and a few years off, but I can't see them 'rocking the boat' too much.'

Nautech composites

www.nautechcomposites.com



Graphene Flagship yields breakthrough in composites technology for structural applications

Django Mathijsen

Professor Ahmed Elmarakbi recently rocked the reinforced plastics world by unveiling the world's first graphene composite structural, automotive component: a car bumper made of graphene and fiber reinforced plastics. Graphene turns out to be able to enhance the material more than previously expected, but only if you stick to rigorous standards in production and processing. We asked Elmarakbi to give us some details and a glimpse of what nanocomposites have in store for the future.

In 2013, the European Union funded Graphene Flagship was started: a multinational, ten-year mission with a budget of one billion euros, said to be the European Union's biggest research initiative ever. The goal is to take graphene from the laboratory into European society within ten years. That means: to seek, develop and implement worldwide applications of graphene.

The automotive industry is regarded as the industry in which the highest volume of advanced composite materials will be used in the future (Figure 2). So, one of the research projects started within the Graphene Flagship (Task 10.11) is IGCAuto: Innovative Graphene-Based polymer materials for Automotive applications. Its aim is to use graphene to develop lighter and stronger, and thus more energy-efficient, safe vehicles. The material should also provide benefits like better thermal behavior, better flame behavior (flame retardation) and better durability. The project was initiated by Automotive Engineering professor Ahmed Elmarakbi of the Department of Computing, Engineering and Technology of the University of Sunderland, England (Figure 1).

The university is working in a consortium with five research partners from Italy, Spain and Germany: Nanesa, the Centro Ricerche CRF of Fiat Chrysler Automobiles FCA, the Fraunhofer ICT, Interquímica and Delta-Tech S.p.A.

The consortium has managed to develop a very light and strong graphene and fiber composite material with a 40 percent higher specific energy absorption than traditional composite materials. This exceeded all expectations. The material is very stable, absorbs energy in a controlled way, and has already been implemented in a prototype car bumper with the support of CRF.

The outer shape of the bumper is made of carbon fiber and graphene reinforced thermoset polymer, the small inside ribs are made of glass fiber and graphene reinforced thermoplastics (Figure 3).

There are many scientific papers reporting disappointing results if you use graphene in a composite. So how did Elmarakbi's consortium achieve those surprisingly high results? It took a large effort in research and development.

The research

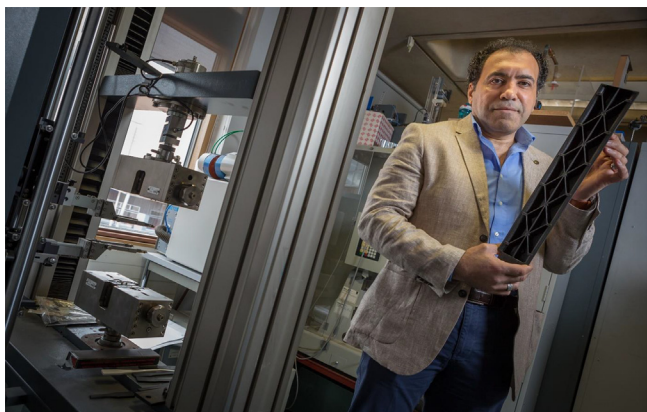
"My role in the Graphene Flagship was to focus on how we can use graphene to build a structural component for automotive applications," Elmarakbi says (Figure 4). "So, we built a small consortium and started out by looking for the graphene itself: the raw material."

They spent a year testing and evaluating many different forms of commercially available graphene with different properties and from different sources (Figure 5). In the end, it turned out they could not use any of the commercially available graphene materials for structural automotive components. Adding it to a composite tended to make it weaker instead of stronger.

"The surface area or weight was not right," Elmarakbi explains. "So, we came up with a graphene that has to be made in a certain way, so it has the right properties. The number of layers for example: if you have ten layers you get higher performance, but if you have twenty layers you get poor performance. So, the number of layers, how we introduce it, what the source is, what the raw material is and so on: that will all affect the performance."

After they found a suitable form of graphene (produced by research partner Nanesa) that could be dispersed in polymers,

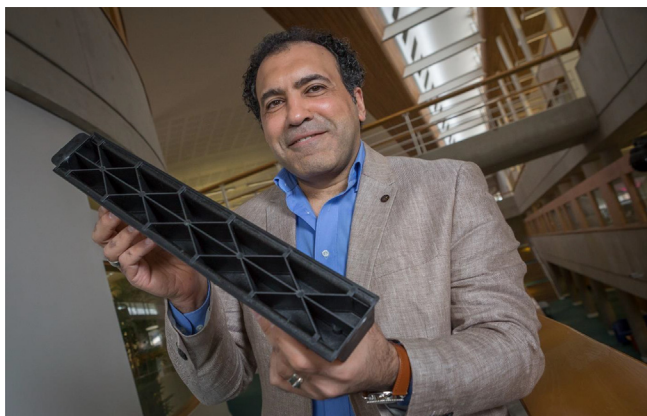
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**FIGURE 1**

Professor Ahmed Elmarakbi in his lab, showing the breakthrough graphene and fiber reinforced polymer car bumper (Photo: University of Sunderland).

**FIGURE 2**

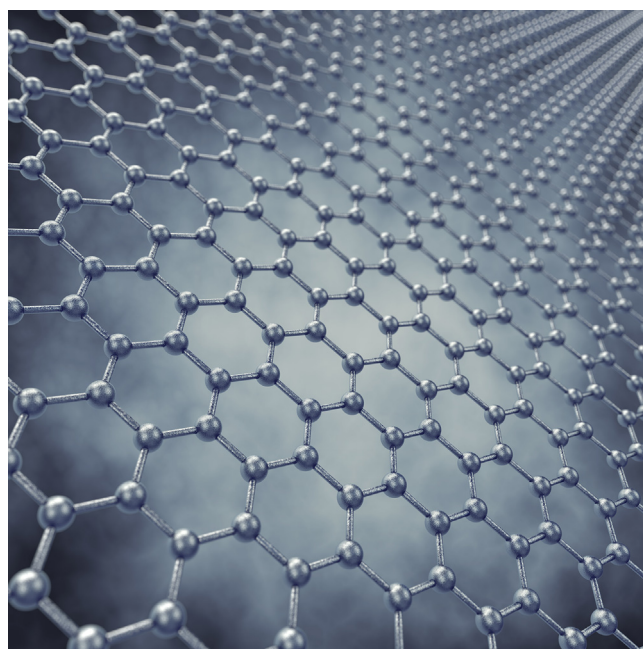
The automotive industry is expected to become the industry with the highest volume of advanced composites, as illustrated by the BMW i3, introduced in 2013: the first mass produced car with most of its structure made of carbon fiber reinforced polymer (Image: Patrick Poendl/Shutterstock).

**FIGURE 3**

The prototype bumper is made of carbon fiber and graphene reinforced thermosets with the ribbing made of glass fiber and graphene reinforced thermoplastics (Photo: University of Sunderland).

**FIGURE 4**

Structural graphene and fiber composites are not only worthwhile for the automotive industry. They can revolutionize aerospace as well, especially now that airplanes with carbon fiber composite fuselages like this Airbus A350 XWB, certified in Europe and America at the end of 2014, are already in service (Image: VanderWolf Images/Shutterstock).

**FIGURE 5**

Graphene is a two-dimensional, hexagonal lattice of carbon atoms that can be seen as a single sheet of graphite (Image: nobeastsofierce/Shutterstock).

different two-phase polymer combinations were made and tested. That is: graphene and epoxy composites, and graphene and thermoplastic composites. Not all epoxies and thermoplastics turned out to be suitable for use with graphene. After again a lot of research and testing, they found a few good combinations. “We used an epoxy, especially created for us within the project by our partner Delta-Tech,” Elmarakbi says. “And for thermoplastics we used PA6, provided by BASF.”

The next step was to add glass fiber or carbon fiber to these two-phase polymer combinations, turning them into three-phase composites. “These three-phase composites are technically



FIGURE 6

When the LaFerrari hypercar came out in 2013, it was state-of-the-art technology in virtually all respects, including extensive use of carbon fiber composites. But now that graphene has shown to be able to improve the properties of those composites, the envelope has been pushed and the race is on: which car manufacturer will be the first one to offer graphene and fiber composites on a road going car? (Image: Krzyzak/Shutterstock.com).

traditional composites, but with the polymer infused with graphene as a first step," Elmarakbi says. "The final product is very strong and light, and has a lot of enhanced mechanical performance."

Between brittle and ductile

Adding graphene to a polymer significantly enhances its properties, especially the mechanical performance: strength, impact strength and so on. And if you then add carbon fiber, you end up with enhanced properties compared to a non-graphene infused carbon fiber composite. "We got 40 percent more energy absorption," Elmarakbi says. "And we managed to reduce the thickness of the carbon fiber component by theoretically (modeling) about 70 percent, but in tests we reduced that to between 30 and 40 percent." With the graphene and fiber composite they managed to get the same (impact) strength with only eight layers as a conventional carbon fiber laminate with twelve layers (Figure 6).

One of the biggest handicaps of traditional carbon fiber composites is of course its brittleness. Using a graphene infused polymer with carbon fiber seems to counteract that problem to a large extent. Although graphene is also brittle, it is elastic as well and it can have a 20% extension. "We tested three different crash tubes," Elmarakbi says. "One crash tube was made of steel, which is ductile. One crash tube was a traditional carbon fiber composite, which is brittle. The third crash tube was made of carbon fiber composite with a small percentage of graphene. When we tested that one, we got a result in between ductile and brittle. The material still behaved brittle, but with more plastic deformation due to the bonding between the graphene and the polymer." So, the high absorbent energy was a result of a combination of brittleness and ductility.

The optimal graphene concentration

Two-phase graphene composites are not suitable for structural components. They can be used for semi-structural applications

but were mainly tested to achieve the enhanced properties for the three-phase composites.

"The performance of both glass fiber and carbon fiber composites was enhanced by graphene, but for sure the carbon fiber was enhanced more," Elmarakbi says.

For glass fiber composites they noticed that by adding just 0.75 percent of graphene, they could reduce the amount of glass fibers by 30% (i.e.: a 30% thinner structure) and obtain the same performance.

Graphene concentrations between 0.5 and 10 percent were tested, but as Elmarakbi says: "The optimum value is around 1 percent, with optimum results obtained for structural applications at around 0.75 percent."

Adding more graphene can render the material too stiff, compromising its toughness and impact strength.

Not too strong, not too weak

A new, patented sonication methodology was developed to ensure a highly uniform dispersion in epoxy. For the thermoplastic polymer, normal extrusion with different rotations was used. Originally, the consortium was worried that achieving uniform dispersion would be a major issue, but with these technologies they have not encountered any big problems.

Functionality however was a major headache, as Elmarakbi explains: "We are looking for structural components. So, we are talking about severe conditions like crashes and so on. For that, the bonding between the graphene and the polymer is crucial. Too strong is not good, too weak is also not good. Trying to achieve good controlled bonding between graphene, polymer and carbon fiber to control the damage during the impact was the tricky issue."

Important parameters controlling the amount of bonding are the surface area of the graphene and the number of layers.

"We did a lot of testing and experimentation, and tried a lot of functionalization techniques until we reached a certain surface area and graphene type that could give us controllable bonding," Elmarakbi says.

Cheaper

Since a graphene concentration in the order of only 1 percent seems to be the sweet spot, the new composite material is quite affordable for automotive mass production. The specially developed graphene for structural automotive applications can be produced at a cost of about 100 euros per kilo.

Suppose a car has 300 kilos of traditional structural carbon fiber composites: Bumpers, bonnets and doors for example. You can replace all that with graphene and carbon fiber composite components with 30–40 percent reduced thickness, saving something in the order of 100 kilos and a lot of associated costs (as for example expensive carbon fibers). This trumps the investment in graphene, which is in the order of 3 kilos, costing about 300 euros for the materials.

So, carbon and graphene composites will be lighter and cheaper, and they will dissipate more deformation energy. "That depends on the thickness of the material," Elmarakbi corrects. If you keep the same thickness, you will get enhanced perfor-

**FIGURE 7**

We have already become accustomed to regularly seeing cars with carbon fiber composites, like this BMW i3, on European roads. By 2023, cars with graphene and carbon fiber composites may be just as common (Image: Intrepid/Shutterstock).

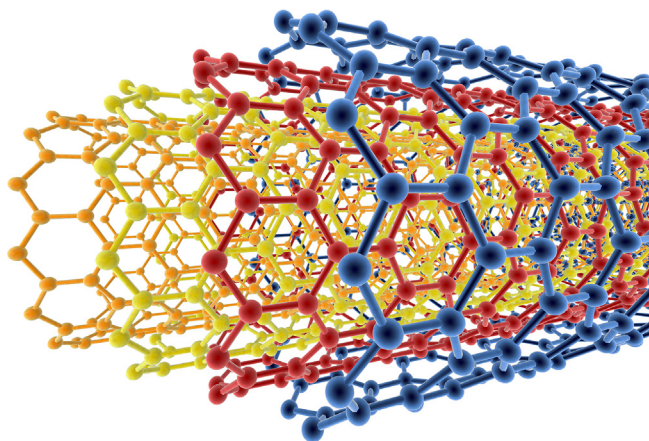
mance. But if you keep the same properties, you end up with a thinner, lighter and cheaper structure.”

The next step: standardization

The prototype bumper is showing the promise graphene and fiber composite parts will have for the automotive and aerospace industries. But before they can be commercialized, regulations must be put in place.

Many companies are producing graphene. Elmarakbi’s consortium is now working on identifying properties and methods required to produce graphene suitable for certain applications, so that these producers will all be able to tweak their production processes to make graphene optimally suited to aerospace and automotive structural applications. Or to painting and coating applications, etcetera.

The traditional manufacturing procedures used for making fiber reinforced composites can then still be used: the same pro-

**FIGURE 8**

Multi-walled carbon nanotubes look like Matryoshka dolls and are relatively cheap to make. But when used as reinforcements in high performance polymers, they offer little advantage (Image: Angel Soler Gollonet/Shutterstock).

duction lines, the same techniques and the same production rates.

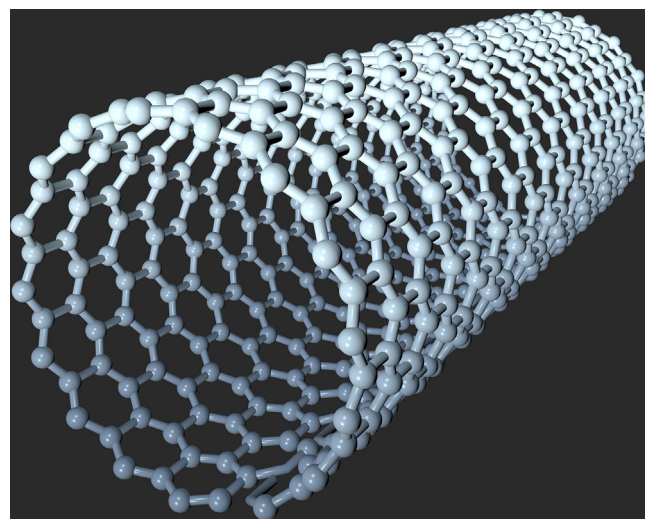
So, the infrastructure to make three-phase composites for the automotive industry already exists to a large extent. The only thing required is standardization of the graphene production process, describing for example the minimum requirements for sonication and dispersion. “We will recommend a few polymers to be used with graphene,” Elmarakbi explains. “And we will come up with standard parameters for the use of graphene.” All the test results must be validated. So, Elmarakbi expects standardization may take another 3–4 years: “But by the time the entire graphene flagship project ends, in 2023, there should already be something on the market on a real car.” (Figure 7).

Other nanomaterials

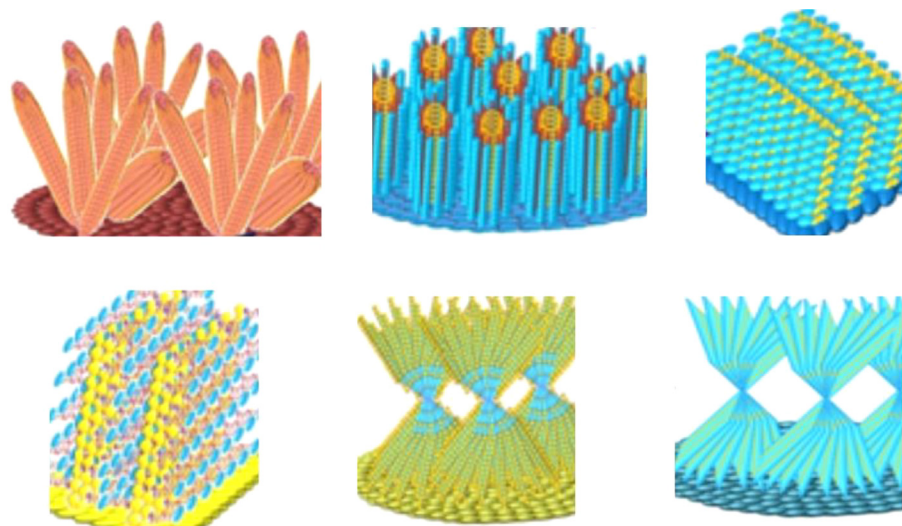
Carbon nanotubes were once very promising as well but are now mainly considered a dead-end street for structural applications: the multi-walled versions (Figure 8) offer virtually no improvements, while the single-walled variants are expensive and difficult to process (Figure 9). Graphene on the other hand is expected to take off in the next few years, dragging many other new nanomaterials along in its wake.

“There are a lot of nanomaterials, useful for different applications,” Elmarakbi explains. “For structural components we tried multi-walled nanotubes, but the 2D materials like graphene have a larger surface area around them, making the material stiffer and tougher.”

Elmarakbi explains that his team is working with different, unique nanomaterials for structural and energy applications, developed in collaboration with professor Sherif El-Safty and his team at the National Institute for Materials Science in Japan: “Different novel nanomaterials based on carbon with different atomic structures and orientations, and combinations with cobalt and metal oxide are being developed. We are building hierarchical structures from the nanoscale and have created

**FIGURE 9**

Single-walled carbon nanotubes do offer improvements in mechanical and thermal behavior when they are used as reinforcements in high performance polymers. But they are expensive and difficult to process (Image: Promotive/Shutterstock).

**FIGURE 10**

Nanomaterials with new shapes that do not exist in nature, like these, can now be constructed and modeled, offering beneficial properties for all sorts of applications¹³ (Image courtesy professor Ahmed Elmarakbi).

unique nano-reinforcements with a controlled shape and structure that you can add to any kind of polymer.

We are using atoms and structures to build shapes that do not exist in nature. For example: longitudinal hierarchy nano/mesocrystals with high-dense exposure facets and anisotropic interfaces. The nanocrystals formed under the controlled engineering of surface morphologies" (Figure 10).

These materials are already implemented in energy storage applications like electrodes for fuel cells. "We converted the material from the nanoscale to the macroscale and used our modeling technique to understand the material's behavior," Elmarakbi says. "We came up with an electrode that is about 90 percent cheaper and offers 200 times higher performance compared to the commercial Pt/C electrode." And he explains that these materials are in development for structural applications as well: "We did a small test on the mechanical properties in a polymer and that was promising. We created the material itself: we do the architecture and can create whatever shape we need. This is very important, because for structural components, you need a certain surface area, strength and surface treatment."

Books, articles and conferences

Professor Elmarakbi is the founding editor in chief of the International Journal of Automotive Composites. And he is also the founder and chairman of the International Conference on Automotive Composites, of which the first edition was held in Lisbon, Portugal in September 2016. "There is a lot of debate and doubt about how graphene would enhance the properties," he says. "So, we try to show the world we have achieved this." The second edition of the conference will be held on 22–25 October 2018, Ponta Delgada, Azores, Portugal.

Elmarakbi is also working on a successor to his "Advanced Composite Materials for Automotive Applications: Structural Integrity and Crashworthiness", a comprehensive, 472-page textbook on general advanced composites for crashworthiness and structural integrity. "I'm developing a similar book, but for

graphene," he explains. "So, graphene composites for automotive applications: two-phase composites, three-phase composites and modeling. Modeling techniques are one of the major challenges, because the material does not exist in nature. Material libraries or material cards did not give us good results. We had to change the algorithms to create new material cards and modeling. We have developed our own codes for two-phase and three-phase composites and hierarchical structures within novel algorithms and constitutive laws."

Commercial software to catalyze new nanomaterials

They are currently in discussion with different companies to make this software commercially available. If you have structural modeling to do on a car that has nanomaterials in every part, you have to calculate the stresses and strains at the nanoscale first, before you can work them out for the macroscale and the full car. That is computationally very costly: it can take up to three months for multi-components and structures.

So, nanoscale modeling software can become an important factor in the next few years, saving a lot of money or experimentation. And it can catalyze the development of more new nanomaterials with shapes and structures tailored to applications and to exactly the required properties, for example, to provide specific stiffness, electrical conductivity or thermal conductivity, and to implement in polymers or metal matrices.

With the modeling software you can predict the properties a certain nanomaterial would have in structural applications. Does the knowledge also exist on how to make these new nanomaterials? "Yes, in our Japanese partners," Elmarakbi answers. "They have been working on that for five years now, and they have an inventory of about twenty patents for twenty different nanomaterials. We model them all, trying to understand their behavior at the nanoscale and how to integrate them in the modeling techniques. The problem is always the link between the nano- and the macroscale. In Japan they are mainly material chemists:

they build the materials. Our role in Sunderland as engineers is to evaluate them as a candidate for real applications.”

Further reading

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The renaissance of flax fibers

Django Mathijsen

Once upon a time all materials were naturally sourced. Now that natural fibers have lost a lot of their traditional market shares to synthetic fibers, they are gearing up to conquer new markets: yarns and fabrics are being tailored to the reinforced plastics industry. Flax is a promising natural fiber. It is relatively stiff and strong. And because it stands out favorably in damping, environmental impact and 3D-capabilities, it is sure to carve out a niche in the composites industry.

"Flax has similar stiffness to glass fiber, but at only half the density," says Sophie de Rijk, manager automotive of Bcomp (<http://www.bcomp.ch/en>), an innovative natural fiber company in Fribourg, Switzerland (See [Figure 1](#)). De Rijk is a mechanical engineer, specialized in composite materials, and structure, fracture and fluid mechanics. "So, it is superior if you want to make something stiff and light. Carbon fiber is stiffer per weight than flax, but flax has much higher damping than glass or carbon fiber."

A vibration in a structure made from carbon or glass fiber reinforced polymers will take much longer to dampen out than in a structure made from flax reinforced polymers. So, an important application of flax fibers is to add damping to a structure made of carbon fiber reinforced plastics.

The strength of flax fibers is a bit lower than S-glass, and its price is higher. But as De Rijk explains, it has a lower environmental impact: "The carbon footprint of flax – the embodied energy to produce the raw material – is much lower than of carbon and glass fiber. Also, it does not interfere with food sourcing, but complements it, because flax is typically used as a shifting crop. If your field has to rest for a year, you plant flax. And you do not need water to extract the fibers."

Flax is harvested by pulling the plants out of the field ([Figure 2](#)). After the seeds are removed, the fibers have to be freed. Common practice is to spread the plants out over the field. Moisture and micro-organisms will then rot away the pectin that binds the fibers together. After a few days, the fibers can be collected from the field, crushed between cog-wheels to remove the stalks, and combed to remove the short fibers. The resulting fluffy bundles of long fibers can then be spun into yarns.

The fact that flax does not tend to shed its fibers makes it especially friendly to parts manufacturers. "You do not need gloves," De Rijk says. "If you are working with glass fiber, you need gloves, otherwise you will get itchy. But flax is a textile and therefore safer and more pleasant to work with."

Started in a garage

Bcomp was started in a garage in 2003 with a few engineers trying to produce a better ski ([Figure 3a,b](#)). "They wanted to make light skies for off-piste freestyle skiers," De Rijk explains. "So, they used carbon fiber composites. But those skis were unpleasant because they vibrated a lot. That is why they turned to flax. Ski cores were our first product, and it is still the one we sell the most. It is a very light laminate of balsawood to take the compressive stresses, and flax fibers inside to take shear stresses." The damping properties of flax make the skis more stable to ride.

As flax fiber fabrics suitable for those ski cores were not on the market, they had to be specially developed, which eventually led to a full range of fabrics, optimized for various composites applications, from 120 g/m² to 350 g/m², now on the market as ampli-[®]Tex. There are non-crimp bi-axial and unidirectional fabrics, low-twist unidirectional and satin weaves, no-twist fabrics and braids.

De Rijk explains that the amount of twist in the yarns is a key issue in developing these materials: "The fibers extracted from a plant have different lengths: typically, 20 to 30 cm. So, if you want to make a continuous yarn, you have to do the same thing the grandmas with their spinning wheels used to do."

If you combine short strands and twist them, you end up with long yarns. In the textile industry they put a lot of twist in those

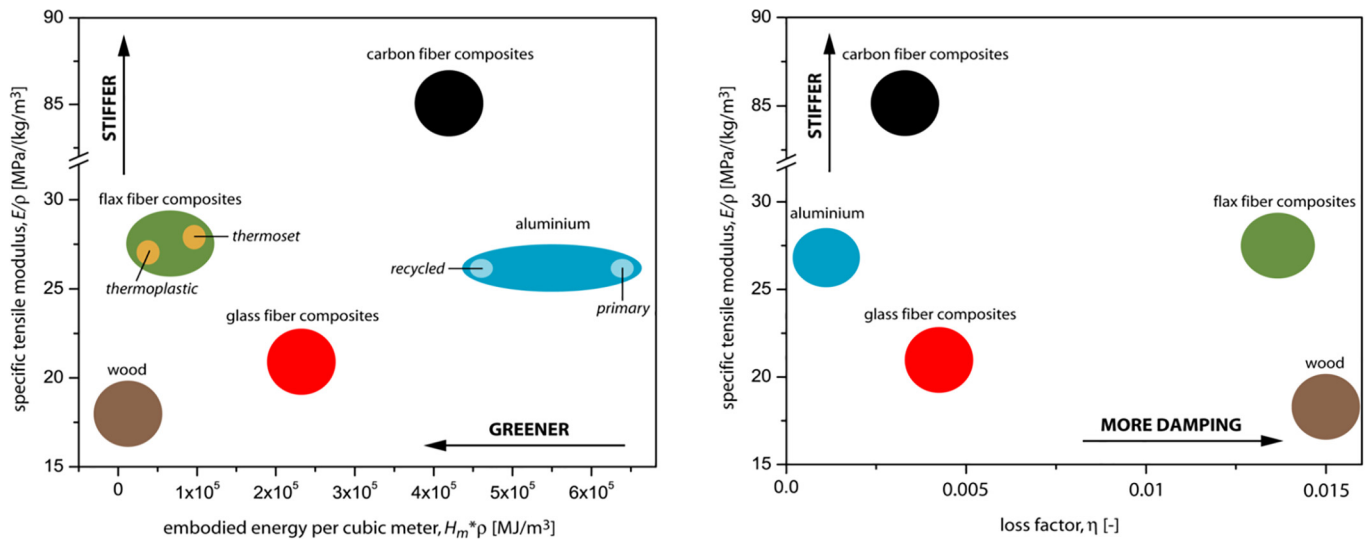


FIGURE 1

Flax fiber composites stand out favorably in damping, stiffness and embodied energy (Image courtesy Bcomp).



FIGURE 2

Flax is harvested by pulling out the plants. The fibers are then freed by spreading the plants out over the field, so the pectin that binds the fibers can rot away (Image courtesy Bcomp).

yarns, because they have to be processed and used in a dry state. It is the amount of twist that keeps the yarns together for their entire life.

But when you use yarns in composites, that twist will cause the fibers to no longer be loaded perfectly longitudinally, the direction in which they are the stiffest. Twist causes sideways loading on the fibers and thus lower stiffness of the composite. "You want to limit the twist in the yarns as much as possible to achieve the highest stiffness," De Rijk says. "But low twist makes the yarns more complicated to handle when they are still in their dry state." So Bcomp spends a lot of time with their suppliers, optimizing the amount of twist in the yarns to get the right compromise between ease of processing and stiffness of the finished composite.

AmpliTex is used in many applications in the sports and leisure industry, surfing for example (Figure 4). But it is also used in musical instruments.

3D reinforcements

An interesting intermediate product Bcomp offers is powerRibs®. This was developed to make full use of the special 3D capabilities of flax.

PowerRibs are a net of flax which can be laminated onto (usually the invisible side of) the surface of a product. It is a convenient way of adding ribs to give a surface a higher bending stiffness (Figures 5 and 6). "Flax is much more effective in creating a 3D rib structure on the back of thin components than glass or carbon fiber," De Rijk says. "We make powerRibs out of very thick flax yarns, which are nice and round. When you manufacture a composite part, you will always apply some kind of pressure: in an autoclave, in the form of a vacuum bag pressing down on the layup, in the form of compression molding. . . With flax yarns, even if you apply pressure, the yarn will stay round, preserving the 3D effect. The whole point of using powerRibs is to create this thick 3D rib structure. If you would try to do the same with glass or carbon fiber, the yarns would just flatten out the moment you start applying pressure, resulting in a 2D reinforcement instead of a 3D one." The amount of twist in the yarns was again crucial in developing this material: it must be high enough so that the yarns stay round when pressure is put on them during processing, and low enough not to lose too much longitudinal stiffness.

The founders of Bcomp came up with the idea for the powerRibs while running in the forest, discussing possibilities of reinforcing poles. "The very first powerRibs were actually plus and minus 45 degrees," De Rijk says. "Now, we have a zero and ninety degrees net. And it is not woven, but stitched together with thin polyester yarn. That way, the yarns slide easily with respect to each other, which is why we can do very complex 3D geometries with compression molding: the raw material just slides into shape."

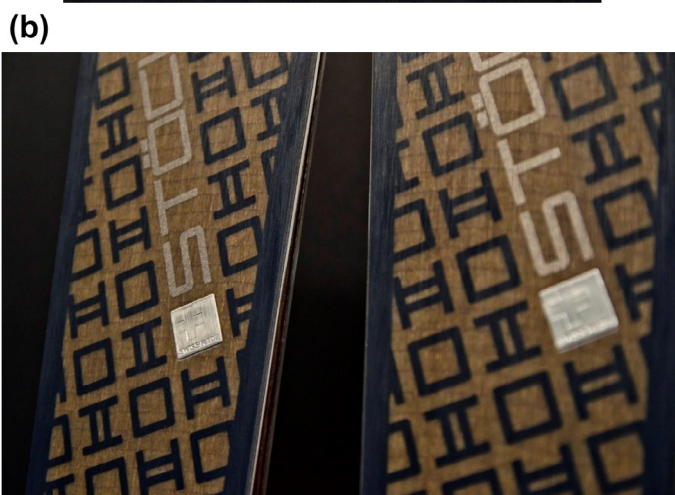


FIGURE 3

(a, b) Flax laminate cores for skis were the first product Bcomp developed. They are used by ski manufacturers like Faction and Stöckli as they provide the skier with a stable ride (Images courtesy Bcomp).

Cars and space ships

One of the applications being developed, is to use powerRibs as reinforcement of a car bonnet, making it lighter and cheaper. “The version with powerRibs will be about 30 percent cheaper compared to a full carbon laminate,” De Rijk says. “And you can do more complex geometries. If you have radii, you start getting into trouble with foams. They are harder to drape: you have to start cutting into it to get it to drape around complex geometries. This is not necessary with powerRibs. The next advantage is crash behavior: carbon fiber shatters into lots of small, sharp splinters. If flax breaks, it becomes a soft fabric again. So, the flax



FIGURE 4

Bcomp's ampliTex is used in many sports and leisure products, like bicycle saddles, skateboards and surfboards (Image courtesy Bcomp).



FIGURE 5

PowerRibs are a net of flax that can be laminated onto a surface to increase bending stiffness (Image courtesy Bcomp).

acts as a catching net: if a carbon and flax composite piece breaks, it stays together. That is for example an advantage for racing cars: for the safety of the drivers, the preservation of the tires of other cars, and the cleaning up of the racetrack after a crash.”

A video of an impact test comparing a carbon fiber panel with a carbon fiber and powerRibs panel can be found on Bcomp's YouTube channel (<https://www.youtube.com/watch?v=D6DFTnK7BaA>).

**FIGURE 6**

If PowerRibs are used on the invisible side of a product, the ribbing cannot be seen on the visible side (Image courtesy Bcomp).

If you add powerRibs to the back, you can use less carbon fibers, cutting the weight by between 20 and 30 percent. “And if you compare a full carbon laminate with a carbon fiber and powerRibs laminate you triple the damping,” De Rijk adds. “This is very important for example for space applications. We have been working on several projects with the European Space Agency, who are very interested in building satellite structures with powerRibs.”

When you launch a rocket into space, everything shakes violently. So, a material that dampens structural vibrations and resonances is a boon at launch. But as De Rijk explains, it is also worthwhile in space itself: “There is no atmosphere there to dampen little vibrations in the structure. So, little electric motors and pumps will cause micro-vibrations in the whole structure.” Those vibrations can wreak havoc with the precision of delicate communication, optics and measurement instruments. Flax fibers will dampen those micro-vibrations.

If powerRibs are used on a glass fiber reinforced structure, the advantages are the same as in a carbon fiber reinforced structure, except for the advantage in price, because glass fiber is cheaper than carbon fiber.

Bcomp is currently in the pre-development and pre-series stage with automotive Tier One and OEM manufacturers to develop interior parts with powerRibs, like door panels, middle consoles, the dashboard and trunk elements (Figure 7). “NFPP (Natural Fiber Poly Propylene) – polypropylene premixed with short natural fibers – is currently being used for this by various brands,” De Rijk says. “Typically, manufacturers like to use it for interior parts and compression molding, because it is much lighter than injected polypropylene. If we replace some of the NFPP with powerRibs, we can make a part 40 percent lighter and much more impact resistant. And we can already pre-bond the powerRibs to NFPP or any other base material. A parts manufacturer receives a sheet of the material and only has to heat it up and compression mold it.”

So, adding powerRibs is not more labor intensive. In thermoset parts, it can even cut labor time. “The powerRibs drape very easily, and since you can do away with a number of layers, you have less layers to place,” De Rijk explains. In vacuum

**FIGURE 7**

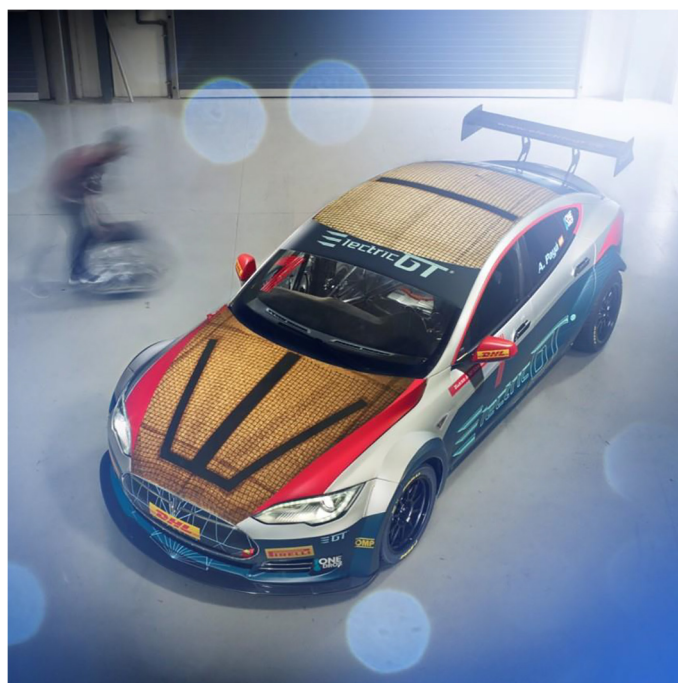
PowerRibs used on the invisible side of a door panel (Image courtesy Bcomp).

infusion, adding a flow medium is not necessary, because the powerRibs already act as channels for the resin. So, no resin gets wasted inside the flow medium.

For pre-preg uses, Bcomp ships the powerRibs in a dry state. “We recommend our clients to use a base material a bit more resin rich,” De Rijk adds. “When the curing cycle is started, the resin becomes less viscous and is pumped into the powerRibs.”

Racing Tesla

An exciting application of powerRibs will be in the automotive racing world: The Electric GT series (<http://www.electricgt.co>) will start in 2018 (Figure 8). “That is a new GT-series with a mod-

**FIGURE 8**

The electric GT series will start in 2018, featuring modified Teslas Model S. The bodies will be fully made of flax composites (Image courtesy Bcomp).

ified Tesla model S,” De Rijk explains. “We are going to make the whole car body out of flax: ampliTex as the base material and powerRibs on the back. They are actually going to use the fact that it is translucent, so you can see the ribs on the back of the part.”

Motor racing has always been a good proving ground as well as an image builder. “That is why we love this project,” De Rijk says. “They dare to go all flax, which technologically makes sense. But the industry is still very attached to carbon and the

carbon look. In most applications, we do not put the powerRib structure on the visible side. We hide it. But in some cases, people want to see it, because it shows the technology.”

If you compare powerRibs to conventional ribbing, what are the advantages? “First of all, tooling,” De Rijk answers. “You need a lot less back injection tooling, which is expensive. PowerRibs are lighter. And unreinforced ribs will shrink more than the material on the front, so it is not always easy to make a visually and dimensionally perfect piece. That is no problem with powerRibs, because flax has a very low thermal expansion coefficient. That is also why it combines well with carbon: they have similar thermal expansion coefficients.”

End of life

When flax fiber reinforced thermoplastic components reach the end of their life, they can be ground up and used as charged injection plastic. For recycling thermoset components, the fibers have to be separated from the matrix and there is no standard solution for that yet. But the material can be burned so at least it does not have to go into a landfill, and you can recuperate some of the energy that went into the material as heat.

Still, would it not make more sense ecologically if the natural fibers were used with natural resins, like PLA (polylactic acid)? “Using natural resins is also a research target we are working on,” De Rijk answers. “Natural resins are harder to source, they tend to age faster, are usually a bit more viscous and their temperature range is a bit less broad. Clients tend to be a bit conservative. Some OEMs refuse to work with PLA because it is made with corn, so it interferes with food sourcing. The development in natural fibers is further ahead than in natural resins. And

(a)



(b)



FIGURE 10

The soundboard of Blackbird's “El Capitan” guitar is made with Flax Tape from Lineo (Image courtesy Bcomp).

FIGURE 9

(a, b) It may look and sound like a wooden ukulele, but this “Clara Concert Ukulele” by Blackbird Guitar is in fact made of durable flax composites (Images courtesy Bcomp).

bio-based resins always have a certain fraction of petroleum based materials in them. But Entropy Resins for instance are launching an in my opinion very nice new bio-based resin where you have the possibility to separate the fibers from the resin.” At the end of its life, a part made with that bio-based epoxy can be dipped into a low temperature bath, where a chemical process dissolves the resin. The fibers can then be taken out and composted, and the diluted epoxy can be recycled into a thermoplastic. “So, there are some nice solutions coming up, but their price is still an issue,” De Rijk adds.

If the use of flax as a reinforcing fiber for plastics really takes off, De Rijk is sure that the industry can provide the volume to meet composites needs: “We are currently sourcing our flax solely in Europe. It is a very old industry in Europe, basically: the textile industry. They have lost a lot of their market. And now they have this enormous capacity and are looking for applications.” The quality of flax depends on the growing conditions and harvesting technique. The highest quality flax is produced in Western Europe and the Ukraine. And although the quality can



FIGURE 11
The rounded backside of the Blackbird guitar is made with Bcomp's ampliTex (image courtesy Bcomp).

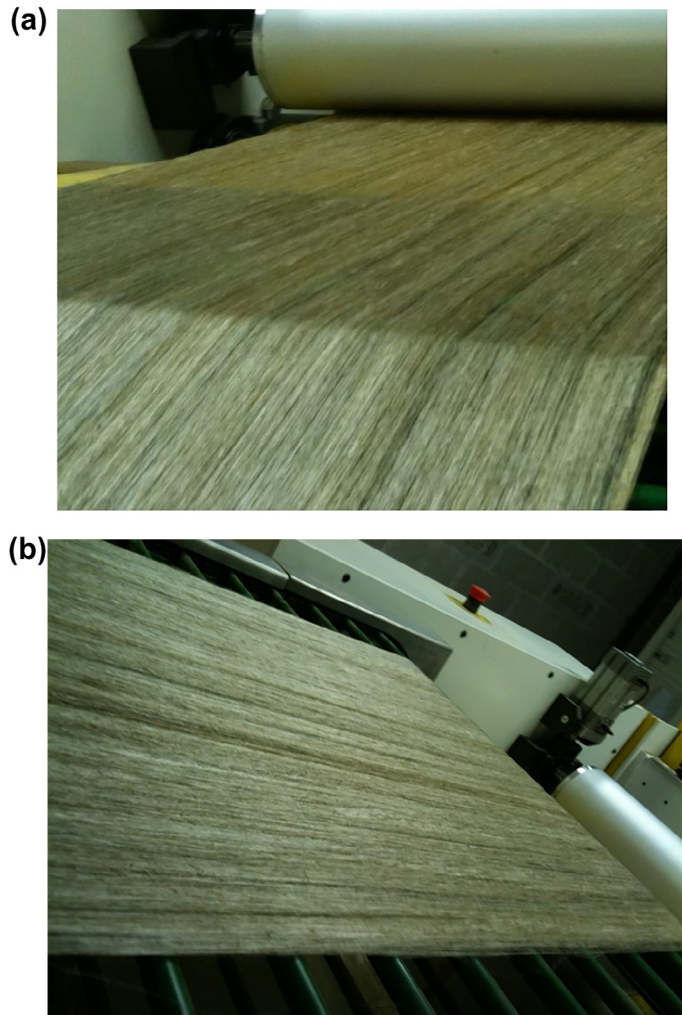
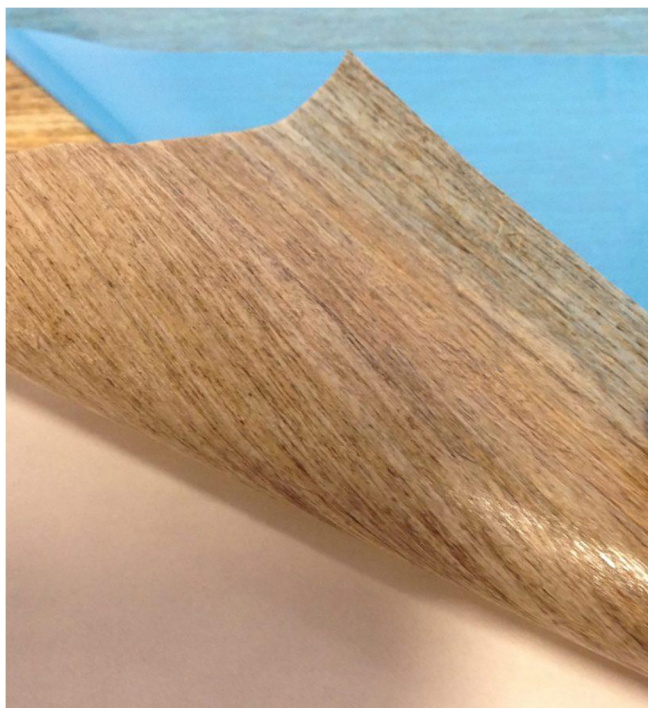


FIGURE 12
(a, b) Lineo's Flax Tape is made on a special, patented prototype production line (Images courtesy Lineo).



FIGURE 13
In this bow by Win&Win Archery, carbon fiber is used to provide stiffness, and Flax Tape to give it damping (Image courtesy Lineo).

**FIGURE 14**

A sheet of Flaxpreg T-UD: impregnated Flax Tape (Image courtesy Lineo).

vary from year to year, the harvest of several years is combined, so that consistent quality can be guaranteed.

Flax – like for example paper and wood fiber – has a large, experienced industry eager and waiting to supply the composites industry with good quality fibers, all with unique properties.

Third generation family business

Another company specialized in supplying flax fibers for composites, is Lineo in France (www.lineo.eu). Where Bcomp got started as a reinforced plastics processing firm that chose to concentrate on flax fibers because it had the right mix of properties for their original application, Lineo originated from the traditional flax processing industry.

The company was founded in 2005 in Belgium, and relocated to France in 2015, but is in fact a third-generation family business, as sales manager Jacqueline Roudot explains: “The father of our founder has been working with flax for 35 years, and his grandfather established the flax processing company in Normandy 67 years ago. So, flax processing knowledge has been in the family for decades. Lineo is the youngest company within the Group, whose activities are still 95 percent for the textile industry. But after the textile crisis, we started to look for new market opportunities and decided to create Lineo to concentrate on composites applications.”

**FIGURE 15**

For his research into new materials for musical instruments, Tim Duerinck made six identical violins, but using five different materials for the soundboard, ranging from tonewood to composites (Image courtesy Tim Duerinck).

Like Bcomp, Lineo has a range of flax fiber materials with unique specifications. There is little overlap between the materials different flax companies offer, as Roudot explains: “You will find several companies who are offering flax composites now. Nevertheless, we are all on the market with different kinds of flax reinforcements.”

So, instead of competing, they tend to complement each other. This is illustrated in the innovative guitars and ukuleles, made by Blackbird Guitars (www.blackbirdguitar.com) (Figure 9a, b). They are completely made of flax fibers with bio-based resins. The soundboard, the top sheet of the guitar body, is made with Flax Tape™ from Lineo (Figure 10). The backside, which is rounded, is made with Bcomp’s ampliTex (Figure 11). The flax fiber composite guitars sound more like traditional wooden guitars than guitars made from carbon fiber reinforced plastics. Carbon fiber composite guitars are usually said to be louder than wooden ones, but lacking its warmth.

“Blackbird Guitars uses Flax Tape,” says Roudot, “which is a laminate made of 100 percent raw, unidirectional flax fibers, available in 50, 70, 110, 200 g/m². We have a special, patented prototype line for it: we put flax fibers onto it, spray water on them and immediately dry them so they stick together” (Figure 12a, b). Compared to ampliTex, Flax Tape is thinner, lighter and cheaper, but cannot be draped into intricate 3D

shapes. So, it is perfect for making thin, flat sheets and sandwich panels.

Flax Tape is also used in furniture, the automotive industry, and sports and leisure. “For example, in tennis rackets and bicycle frames,” Roudot says. “And it is used in a bow, which has multiple layers of flax tape and carbon fiber.” The carbon gives the bow stiffness, the Flax Tape gives it damping (Figure 13).

Constantly expanding the range of available materials

Next to Flax Tape, Lineo also offers Flax Fabric, which is woven and more expensive. It is different from fabrics for the textile industry because it is woven especially for composite applications. Lineo can also impregnate both materials: impregnated Flax Fabric is called “Flaxpreg”. Impregnated Flax Tape is “Flaxpreg T-UD” (Figure 14).

“Customers who are looking for bigger reinforcements to make something stiff, will use Flax Fabric,” Roudot explains. “For something very light, they will use Flax Tape. It is also used for esthetics, because when you impregnate it, it looks like wood. We also offer the Flax Ply range, which is a dry fabric with a 16 percent epoxy sizing on it. That is dedicated to customers who can do their own impregnating. Dry fabric is rather difficult to



FIGURE 16

In the first blind listening test, this violin was deemed to sound the warmest and most like a wooden one: the instrument with the flax reinforced epoxy soundboard (Image courtesy Tim Duerinck).

impregnate since it absorbs a lot of matrix. If you put a sizing onto it, it needs less resin to impregnate and you will get a better result.”

Flax fiber composites are used in sailing yachts because of their good vibration absorption properties. “And some of our customers use the Flax Tape in the interior of the yacht for esthetics,” Roudot adds.

Together with the automotive supplier Faurecia, Lineo is currently developing trunk load floors made of flax tape and polyester matrix. They have also worked on a project with the French army to develop a flax tape pre-preg with a special epoxy matrix that meets aeronautics requirements, especially regarding fire retardment.

Since January 2017, Lineo is offering Flax Tape for thermoplastics. “It is Flax Tape pre-pregged with polypropylene,” Roudot says. Feedback from their customers was an important factor in developing it. “We decided to impregnate with 60 percent matrix and 40 percent fibers,” Roudot adds. “Now we have a lot of companies conducting trials.”

Also since January 2017, Lineo is offering Flax Tape with PLA. They are testing more bio-based resins and are working hard to expand the range of materials they are offering. Fabrics with polyester resin are not being offered yet, but some of Lineo’s customers are conducting trials with flax reinforced polyester.

Expanding the builder’s toolkit

Tim Duerinck used Lineo’s Flax Tape to make the soundboard of a violin. He graduated as a bowed string instrument builder and is now working on his PhD at Ghent University, researching new materials for musical instruments. “I’m looking for materials with certain properties, suitable for musical instruments,” Duerinck says. “I was surprised by the sound of Blackbird Guitars’ flax composite ukulele. So, I included flax in my research.”

Duerinck made six violins (Figure 15). The back and sides of all violins were made of carbon fiber reinforced epoxy, but the

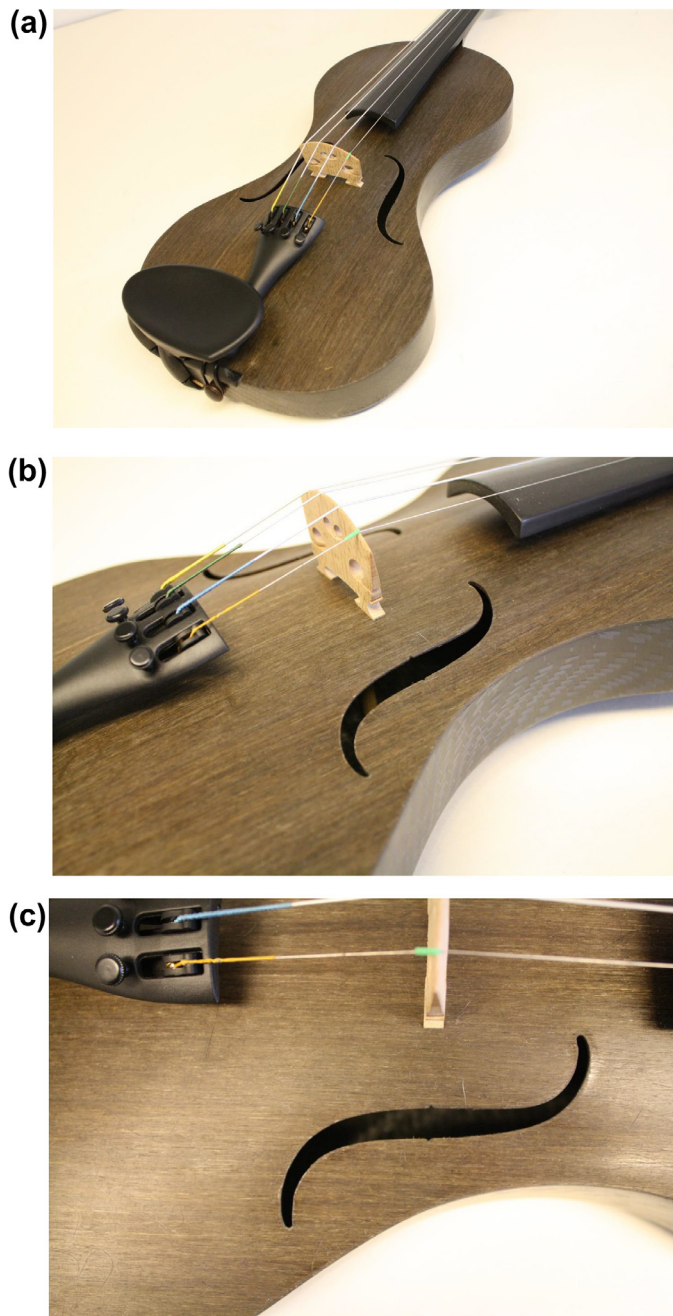


FIGURE 18

(a, b, c) Musicians are attracted to the looks of the flax composite soundboard. Thanks to the fibers, it looks like wood, but not as we know it (Images courtesy Tim Duerinck).



FIGURE 17

(a, b) Tim Duerinck in his workshop on a never-ending quest to develop perfect musical instruments (Images courtesy Tim Duerinck).

soundboard was made of different materials: a Flax Tape composite, a unidirectional carbon fiber composite, tonewood, a carbon fabric and Nomex honeycomb sandwich, and two were made of carbon fabric composite as a reference and to check the repeatability. Epoxy resin was used in all versions, bio-epoxy is subject to further research.

The first blind listening test led to a surprising result: the violin with the flax composite soundboard received the highest score of all for warmth (Figure 16). Duerinck also asked to rate which instrument sounded most like a wooden instrument: again, flax composite was the winner, the carbon fiber version came in second and the wooden version was third.

"The flax composite instrument was also the softest in the test," Duerinck says. "That is because flax is not as stiff as carbon, so I had to make the soundboard a bit thicker and heavier. I had expected that the audience would go for the loudest instrument."

Perfect instruments

These results are all of course very preliminary: Duerinck (Figure 17a, b) has just finished his first year of research. But it does seem to indicate that flax composites are a promising material for musical instruments. It is thought that the reason why flax composites lead to a warmer sound than carbon composites, is because flax damping characteristics attenuate the instrument's higher overtones more than the fundamental and lower overtones. But this is not fully understood yet and very much subject to research. Damping is a non-linear property and difficult to measure.

What is understood, is that a lighter soundboard will lead to a louder instrument. "The soundboard needs to have adequate bending stiffness," Duerinck explains. "If you can achieve that with a lighter material, it will produce more volume. Guitar builders are already sometimes using a sandwich of two layers of veneer and a Nomex honeycomb core. That makes the soundboard 25 percent lighter, causing it to produce more volume. If

you use composites, you can make the soundboard even lighter and thus louder. But it also influences the timbre."

An important advantage of employing composites and sandwiches is that because they sound different than wood, they extend the instrument builder's "tool kit" to shape the timbre of the instrument, without having to deviate from the traditional shape or playing technique of the instrument. Provided of course you know exactly how every material influences the sound. And that is exactly what Duerinck wishes to find out. "There is no such thing as the best instrument," he says. "Personal preference is very important. Some violinists prefer a loud instrument, others want a rich or a warm sound." The trick is to be able to tailor the instrument to make the perfect instrument for the specific preference of each violinist.

Comeback

"I have also found that if I put the instruments on display, musicians are very much attracted to the looks of the flax composite instrument," Duerinck adds (see Figure 18a, b, c). "It is not wood, but looks like it and the fibers are aligned beautifully. You can see that it is a natural material."

An instrument fully made of reinforced plastics is more durable and less susceptible to environmental moisture and temperature changes. Differing climate conditions can cause a wooden instrument to go off-key, warp or even burst.

The process of making the soundboard with flax was much the same as with carbon fiber. "I did notice that with carbon fiber, I can infuse the epoxy an hour or two after pumping the bag vacuum," Duerinck says. "With flax, I got the best result when I let the vacuum in the bag sit for a day or two to get all the bubbles and moisture out. Had I worked with pre-pregs, that would probably not have been necessary. I like working with flax, also from an ecological and a heritage standpoint: sourcing materials close to home. The flax industry used to be very big in Flanders. I love it that this material can now come back inside musical instruments."



Recycled carbon fiber composites become a reality

Mark Holmes

Wider use of carbon fiber in the composites industry is now a possibility through the introduction of recycled materials. *Reinforced Plastics* reports on the development of recycled carbon fibers by ELG Carbon Fibre and how some key industrial partners are using them.

One company developing its own market space in the composites industry at present is ELG Carbon Fibre. Part of the Haniel Group, ELG is one of four corporate divisions with totally different activities, including Bekaert Textiles which was acquired in 2015. The Haniel Group had sales of €4 billion in 2014. ELG specializes in trading and recycling of raw materials, in particular for the stainless steel industry. Split into three business units, one handles stainless steel scrap while a second, ELG Superalloys, recycles high-nickel alloys and has pioneered recycling of titanium for the aerospace industry. The third unit in the group handles other high-performance materials, such as ferrochrome and carbon scrap, and in 2010 made the decision to seek recycling opportunities in the carbon fiber market.

Based at Coseley, near Wolverhampton in the United Kingdom, ELG Carbon Fibre now has 60 employees and a 4,000-square meter warehouse can contain approximately 1,000 tonnes of carbon fiber feedstock (see [Figure 1](#)). “Originally the base business was milled carbon fiber for coatings, primarily for the oil and gas industry,” says Managing Director Frazer Barnes ([Figure 2](#)). “However, we needed to diversify because of the downturn in the oil industry. Replacing virgin carbon fiber with recycled material is not a simple substitution. Recycled carbon fiber is a very different product – lightweight and fluffy – and a difficult material to handle. There have been a lot of challenges and a need to modify equipment. For example, the electrical system in the plant needed attention, because of the very fine fibers. Nevertheless, we are now in a position where we are supplying the composite and compounding industries with recycled carbon fiber.”

ELG Carbon Fibre needed to pass a number of milestones along the way to reach the current position. Since 2012 the plant’s infrastructure and processes have been transformed and

BS: EN 9100 QMS accreditation was achieved in 2015. From mid-2013 the company began developing new recycled carbon fiber products and passed the 1,000 tonnes annual production level at the start of 2016. The first nonwoven recycled carbon fiber materials were produced in the middle of 2016. ELG Carbon Fibre began developing applications for the new nonwoven recycled materials in 2014. Materials for automotive were supplied to Gordon Murray Design for use in iStream platforms for OEMs such as TVR and Yamaha in 2015, and to Alstom for composite bogies in the rail industry at the beginning of 2017. The production of recycled carbon fiber materials for composites began in 2015 and the company secured its first automotive production



FIGURE 1

ELG Carbon Fibre 4,000 square meter warehouse can contain approximately 1,000 tonnes of carbon fiber feedstock.

**FIGURE 2**

Frazer Barnes, Managing Director of ELG Carbon Fibre.

contract in early 2017. In September 2017, ELG Carbon Fibre also extended the certification of its quality management system to BS: EN9100 2016 (AS9100 Revision D) standard. This now covers design and development activities – important for high volume applications, particularly in the automotive sector.

The recycling process

Carbon fiber reclamation initially involves metal removal and cutting of large composite structures to sizes suitable for downstream processing. Shredding of laminates and prepreg enables efficient and consistent processing, with the shredder able to prepare up to four tonnes per hour (see [Figure 3](#)). Fiber recovery is achieved through a modified pyrolysis process, where the resin is burned off (see [Figures 4 and 5](#)). The furnace is capable of providing an output of 1,500 tonnes per year. The carbon fiber is then converted through milling, nonwoven mat production and pellet production. “When we started the project, the design of the line was based on what equipment suppliers believed would work best with carbon fiber,” says Frazer Barnes. “As we started to run the line, we got a better understanding of the interdependencies between different parts of the line to maximize production rates and optimize product performance.”

Carbon fiber recovery has grown from under 200 tonnes in 2012 to nearly 1,100 tonnes in 2015. Feedstock is primarily unused prepreg, however, the process is also suitable for cured production waste and end-of-life materials. The company says that it has established relationships with long term suppliers. This is essential to meet the requirements of OEMs in the

**FIGURE 3**

Carbon fiber reclamation starts with the shredder.

**FIGURE 4**

Fiber recovery is achieved through a modified pyrolysis process.

**FIGURE 5**

Feeding reclaimed carbon fiber to the furnace.

**FIGURE 6**

The ELG Carbon Fibre carding line.

**FIGURE 7**

ELG Carbon Fibre has a carding line capable of providing up to 250 tonnes per year of carbon fiber or carbon fiber/thermoplastic nonwoven mats.

automotive industry, for example, where reliability of a consistent supply of material is crucial. ELG Carbon Fibre has a current supply chain of 1,300 tonnes of carbon fiber from manufacturing waste, much of this coming from long term programs using high quality fibers.

In order to convert the recycled carbon fiber, ELG Carbon Fibre has a carding line capable of providing up to 250 tonnes per year of carbon fiber or carbon fiber/thermoplastic nonwoven mats (see [Figures 6 and 7](#)). A milling center is capable of providing up to 1,000 tonnes per year of milled carbon fiber, while 700 tonnes per year of precision chopped fiber (6–24 mm) and 1200 tonnes per year of chopped fibers (30–150 mm) can also be produced. These fibers are chopped to provide staple carbon fiber, with the length depending on the application.

Possible savings with recycled carbon fiber are significant. “Virgin carbon fiber products are typically between €30–40/kg, while recycled materials are €10–20/kg,” Frazer Barnes adds. “We generally see that using recycled carbon fibre has the potential to reduce the cost of the fiber reinforcement by around 40

percent. A further advantage is that recycled carbon fiber has less than 10 percent of the global warming potential of virgin carbon fiber. Sustainability issues are extremely important for OEMs and recycled carbon fiber can provide a major boost in this area.”

ELG Carbon Fibre says that its fiber recovery process is now industrialized and optimized, providing high quality recovered fibers through efficient recovery technology. Challenges regarding handling short, low bulk density fibers have been identified and overcome, enabling conversion to usable products. The conversion processes are now also industrialized and providing cost effective materials for the composites and compounding industries. The focus is on materials designed for high volume, downstream manufacturing processes. These include compression molded composites for carbon and hybrid nonwovens with longer reclaimed fibers, as well as chopped and pelletized fibers for thermoplastic and thermoset compounds, and milled fibers for coatings and compounds. The recycled fibers can also be used in a hybrid material – 10 percent virgin carbon fiber with 90 percent recycled material – which can reduce costs by 70 percent.

ELG Carbon Fibre has developed a number of recycled carbon fiber products to meet the needs of the market. “The challenge is how to incorporate discontinuous recycled carbon fibers into thermoplastic compounds,” Barnes adds. “We already have production solutions that provide materials that give the same performance as 6 mm virgin carbon fiber. The challenge is providing fiber with lengths of 25 mm or more. There are ways of doing this, but these techniques are still in development and need to be productionized.

“We have recently launched our range of Carbisio CT and Carbisio CT+ products which directly replace virgin carbon fibers up to 12 mm length. Our compounded material, Carbisio MB, is now reaching the final stages of development and will be launched commercially in early 2018. Again, this product is aimed at applications that would traditionally have used 6 mm virgin carbon fiber. Development of products that provide longer fibers (25 mm) is still ongoing.”

Carbisio™ CT+ is a precisely chopped carbon fiber tow and is available in 6 mm and 12 mm lengths. In comparison to the standard chopped tow product, Carbisio™ CT, the plus version is characterized by improved flowability for easy dosing in gravimetric feeding systems for plastics compounding without causing blockages due to fiber ‘fuzz’. The company adds that precisely chopped fibers offer higher structural and electrical conductive properties compared to milled fibers. Carbisio™ CT+ is claimed to be ideal as a reinforcing material for thermoplastic injection molding compounds, coatings, elastomers and rubber compounds. The fibers can be used with most thermoset and thermoplastic matrix systems.

ELG Carbon Fibre adds that Carbisio™ M is a range of nonwoven mats made from recycled carbon fiber that can provide cost and environmental benefits in composite manufacturing processes. The mats are claimed to be ideally suited for closed mold processes and can also be used for the manufacture of intermediate products, such as prepreps and sheet molding compounds. The nonwoven mats can be used with most thermoset and thermoplastic matrix systems.

Carbisio™ TM-PP are nonwoven mats made from recycled carbon fiber and comingled with polypropylene. Nonwovens can

also be made with other thermoplastic fibers, such as PPS. The unsized fibers are compatible with the polypropylene matrix system. Carbisio™ TM-PP is claimed to be ideally suited for press molding and is available in 60/40 or 75/25 weight per cent ratios of polypropylene/recycled carbon fiber.

According to ELG Carbon Fibre, the pyrolysis process provides a recycled material that maintains 90 percent of the carbon fiber’s tensile strength, but there is no change in modulus. The following table shows the typical properties of a recycled carbon fiber reinforced PA66 polymer (base polymer; no coupling agents).

Carbon content		30%	40%
Tensile	Tensile (MPa)	177.9	217.1
	Modulus (GPa)	23.7	26.5
Flexural	Strength (MPa)	288.8	348.0
	Modulus (GPa)	23.1	25.9
Charpy notched impact strength (kJ/m ²)		5.4	5.9

Research & Development is key to demonstrating that recycled carbon fiber can meet the demanding requirements of the composite and compounding industries, and ELG Carbon Fibre has invested in this area. Facilities include two development nonwoven lines and an impregnation line for producing developmental prepreg and sheet molding compounds. There are also manufacturing stations for vacuum infusion, liquid compression molding and prepreg compression molding. ELG Carbon Fibre has also installed a 150tonnes, 600 × 600 mm press for the manufacture of thermoset and thermoplastic laminates. Laboratory facilities include a Zwick testing center for determining laminate mechanical properties, a Favimat single filament test machine for carbon fiber properties, and other test equipment for measuring fiber length and fiber length distribution, moisture content, flow characteristics of milled fiber and fiber contents.

ELG Carbon Fibre has identified a number of target markets that it believes will benefit from increased availability of recycled carbon fiber materials. “The main driver in transportation – in particular automotive, rail and aerospace – is the need for lightweight materials to improve efficiency,” explains Frazer Barnes. “Other considerations include the potential to improve comfort and vehicle durability and reduce damage to infrastructure. There is also an environmental consideration. Major OEMs want to be seen to reduce their waste streams and use more sustainable materials. Other applications where recycled carbon fiber is likely to be of value is in the electronics industry. In addition, we see opportunities in additive manufacturing – 3D printing and selective laser sintering – as well as for composite tooling and marine applications, including in the oil and gas industry.”

The company highlights as an example its iStream Carbon program, where the first production programs started in 2017. A conventional stamped steel chassis typically containing hundreds of stamped metal panels is being replaced by an iStream hybrid structural composite chassis. This structure contains simple low-cost steel tubular members with 14 composite structural panels made from recycled carbon fiber.



FIGURE 8
Rob Elliott, Technical Manager at Sanko Gosei UK Ltd.

Industrial partners

ELG Carbon Fibre is collaborating with a number of companies to find new applications for recycled carbon fiber – one of these is automotive injection molding company Sanko Gosei. “We are always looking for new ways to improve our parts, whether through technology or the production process,” says Rob Elliott, Technical Manager at Sanko Gosei UK Ltd (Figure 8). “This has included the MuCell microcellular foam injection molding process, where the use of eight percent nitrogen can give a 12 percent weight saving in the final product. We have also incorporated the use of recycled carbon fiber within the injection

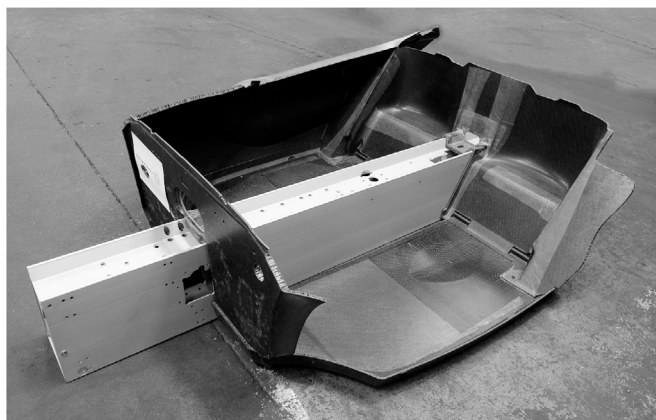


FIGURE 9
Injection molded headlamp support manufactured by Sanko Gosei.

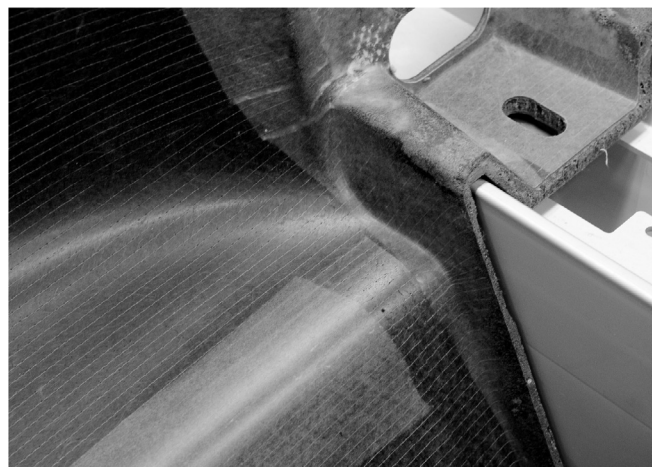
**FIGURE 10**

Co-founder and Chief Technology and Manufacturing Officer of Bright Lite Structures Antony Dodworth.

molding process. For example, in an injection molded headlamp support we replaced a 30 percent glass fiber polypropylene compound with 30 percent recycled carbon fiber (see [Figure 9](#)). We achieved an increase in rigidity and a further weight saving of eight percent. Other advantages include that the carbon fiber compound will process slightly quicker than the glass fiber one and there is a reduction in scrap rates."

**FIGURE 11**

The carbon fiber chassis is fabricated with an aluminum spine to form the rear bulkhead of the Zenos.

**FIGURE 12**

Part of the carbon fiber chassis of the Zenos.

Recycled carbon fiber is also being used in a new composite carbon fiber solution for automotive and aerospace applications developed by Bright Lite Structures, co-founded by Chief Technology and Manufacturing Officer Antony Dodworth ([Figure 10](#)). The company has developed a blended resin that maintains the physical property performance and impact strength of a polyurethane composite resin system, but with a reduced component weight of 25–30 percent. The BLS carbon fiber solution uses a sandwich construction. A top and bottom layer of recycled and virgin carbon fibers are impregnated with the BLS resin, then compression molded to a central core of polycarbonate honeycomb. The forming process is capable of molding complex, deep-draw designs in one step, without pre-forming the reinforcement fiber or honeycomb core. The process simultaneously thermoforms the core and cures the resins. This reduces the manufacturing steps, reducing cure time and lowering costs. Once un-molded, the components are self-jigging and easily bonded to form one unit.

One recent application of the BLS system, for which the company won 'Most Innovative Composite Part' at the 2015 SPE Innovation Awards, are chassis components for the Zenos E10 sports car. Manufacturing involved a spray wet out process, with a skin made of recycled carbon fiber mat combined with multi-layer non-crimp fabric lay-up. It incorporated a recycled polycarbonate core with roll fiber goods only, without pre-forming. The process involved simultaneous thermoforming and resin curing. The extreme deep-draw procedure resulted in complex parts in one step. The carbon fiber chassis is fabricated with an aluminum spine to form the rear bulkhead of the Zenos (see [Figures 11 and 12](#)).

ELG Carbon Fibre is also working with compounder Albis to develop 5–40 percent recycled carbon fiber reinforced polyamide compounds for automotive structural parts. "Trials have been undertaken with 6 mm fibers and we have noticed very little difference in polypropylene injection molding," says Product Manager Sam Anson. "It is at the early stages of development, but it looks like recycled carbon fiber can produce comparable performance. Recycled materials are not a drop-in replacement, so further development work is needed in the compounding to optimize the process."

Future developments

ELG Carbon Fibre has ambitious plans to expand the use of recycled carbon fiber in the composites and plastics industries through expansion in Europe, North America and Asia. "The tar-

get is to have a global production capacity – fiber recovery and conversion – of 6,500 tonnes before 2021," Barnes concludes. "The first expansion plants will be operational in 2019."



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Expanding the market for long fiber technology

Mark Holmes

Significant progress in processing long fiber reinforced plastics and advances in materials technology are providing new opportunities in the composites industry. *Reinforced Plastics* reviews some recent developments.

The potential market for composites based on long fiber technology is increasing as a result of new developments at a number of leading machinery manufacturers. Arburg, in cooperation with SKZ German Plastics Center, for example, has developed a fiber direct compounding (FDC) process for high strength lightweight construction. In FDC, fibers up to 50 mm long are added directly to the liquid melt. Arburg says that this enables lightweight molded parts with thinner wall thicknesses to be produced with the same strength, or metals to be replaced with plastics. The longer the fibers in the component, the better the mechanical properties. Until now, direct processing of longer glass fibers failed due to limitations during material preparation and dosage, as well as the granulate form. The FDC process developed by Arburg and SKZ enables the inline feeding of longer glass fibers, opening up new ways of reinforcing plastics (Figure 1).

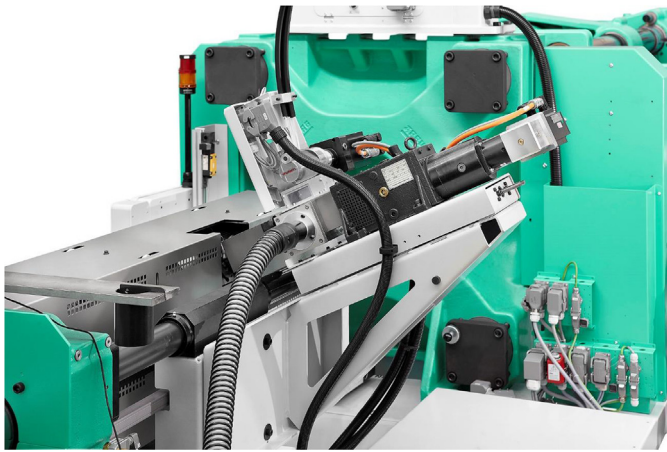
According to Arburg, FDC offers several advantages in comparison with long fiber granulates. These include: targeted influence on component properties due to individual adjustment of fiber length, fiber content and material combinations; reduced destruction of fibers during melt preparation; increased strength through the use of longer fibers in the component; and use of less expensive base materials.

The cutting and inline feeding of fibers into the liquid melt requires specialized technology (Figure 2). A servo-electric side feeder on the injection unit cuts continuous fiber strands into 15–50 mm lengths (with an optimal maximum length of 33.6 mm) and adds them directly to the liquid melt. There is a special cylinder module for the size 2100 injection two-stage screw, which homogenizes the fed-in fibers and prepared melt, and the SELOGICA machine control system makes for simple programming and detailed quality control.

The company adds that cost-effective production at reduced unit costs was the main concern during process development. This includes a large material variety, with individual reinforcement of all common plastics with glass fibers, as well as other fiber types such as carbon. Investment costs are low as the process can be used on standard injection molding machines with clamping forces of 2,500 kN and higher. Fast reconfiguration is possible with universal application on various ALLROUNDERS thanks to the enclosed construction of the side feeder. Arburg adds that it offers maximum flexibility – conventional injection molding via a thermoplastic cylinder module is possible at any time. Highly resilient lightweight parts can be produced with automation through a robotic system for combination with organic sheets (Figure 3).

Continuous pultrusion

KraussMaffei and partners including Thomas Technik, Fraunhofer IGCV, Huntsman, Evonik and Covestro, have collaborated to develop a continuous pultrusion system – iPul – with a production speed of up to 3 m/min (Figure 4). In pultrusion, continuous fibers – usually glass, carbon or aramid – are impregnated with a reactive plastic matrix and formed to the desired profile in a heated mold. Grippers pull the cured profile continuously and feed it to a cutting unit. The new iPul system encompasses the entire sequence. The process encapsulates the impregnation of the fibers, which currently mainly takes place in open vessels, in an injection box that permits the use of fast reacting systems, such as epoxy, polyurethane and polyamide 6. The company says that this increases production speed from the current 0.5–1.5 m/min to approximately 3 m/min. This production efficiency approaches that of PVC extrusion, which opens new markets for this technology.

**FIGURE 1**

During the FDC process, fibers are fed directly into the liquid melt by means of a side feeder on the injection unit.

**FIGURE 2**

The fibers are supplied as rovings and are cut to the correct length during the FDC process.

**FIGURE 3**

FDC ensures that long glass fibers are distributed homogeneously in the part, for example, an automotive housing before and after processing.

The company asserts that the new iPul system sets new standards. "It is the easiest way of producing profiles, there are hardly any turnkey offers, and it is a growth sector. In addition, we are knowledgeable about fibers, metering technology and even about extrusion," says Nicolas Beyl, President of the Reaction Process Machinery business area of the KraussMaffei Group. Already shown at JEC in Paris, the new iPul complete system was demonstrated at a recent Competence Day (Figure 5), where around 220 visitors took the chance of experiencing it live. The event featured presentations by development partners and raw material manufacturers.

The iPul system has been developed over the past 18 months. The 'i' in iPul stands for injected, innovative, integrated and industrialized that are the core features of the system, according to Wolfgang Hinz and Daniel Lachhammer, pultrusion experts at KraussMaffei.

Customized pultrusion

ProTec Polymer Processing has introduced customized pultrusion lines for the production of high quality long fiber reinforced thermoplastics (LFT). The company says that these lines are capable of reliably processing difficult material combinations, such as carbon fibers and polypropylene (Figure 6). ProTec adds that its LFT technology is suitable for producing a wide range of materials comprising variable fiber reinforcement in a defined pellet length and using different polymers as the matrix. The lines are capable of producing LFT pellets with fiber contents of up to 65 weight percent at throughputs of up to 1,000 kg/h. Any conventional thermoplastics or even biopolymers such as polylactic acid (PLA) can be used as the matrix, while glass, steel, carbon or aramid fibers can be used as the reinforcing fibers.

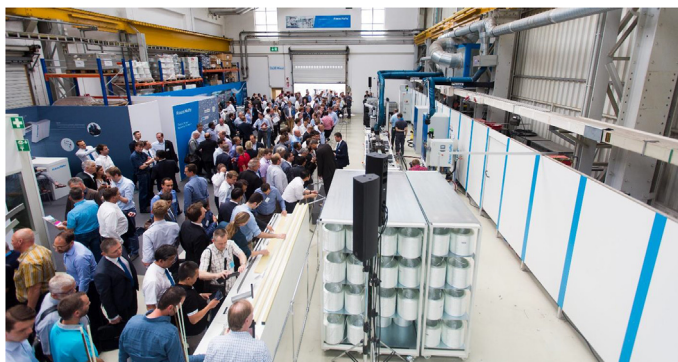
In practice, LFT materials with fiber lengths of 7–25 mm are standard. When injection molded, LFT compounds with fiber reinforcement along the length of the pellets result in components which combine high strength and light weight with good surface quality – a particular requirement of the automotive industry. LFT pellets with a fiber length of approximately 12 mm are ideal for meeting this requirement.

The company adds that a high-performance twin screw compounding extruder is the focal point of the line, permitting highly flexible production of a broad range of individual polymer matrix formulations directly in the process. Recycled material and additional fillers can be included in the material formulation. The LFT line's impregnation die, where the fiber strands are spread apart and coated with polymer melt, is designed in such a way that, even at recycled material contents of up to 10 percent in the melt, consistently high-quality impregnation of the fiber filaments is achieved. Various different creel racks required for unwinding glass and carbon fibers in the pultrusion line are also available. The turntables with the fiber bobbins rotate automatically in accordance with the bobbin diameter, so preventing fiber twisting during unwinding.

A central control system handles the LFT line and all its modules, with line speed, extruder throughput and pellet chopping length all being variably adjustable. Additional functions, located upstream or downstream depending on application, may also be integrated into the controller. These include drying,

**FIGURE 4**

The KraussMaffei iPu continuous pultrusion system.

**FIGURE 5**

Visitors at the Pultrusion Competence Day at KraussMaffei.

conveying, dosing and mixing of the feed components. ProTec says that its LFT pultrusion lines are suitable for producing high quality long fiber reinforced pellets with many different polymer matrices and variable fiber reinforcement (Figure 7).

Industry interface

ENGEL has established a new unit for the project planning of composite systems. The company says that ENGEL Composite Systems will support the launch of production systems for the manufacture of fiber-plastic composite components. The company's Centre for Lightweight Composite Technologies (Figure 8) will now increasingly focus on the interdisciplinary development of new, economical processing procedures.

The development is designed to provide an interface between development, industry and automation experts. ENGEL Composite Systems will be responsible for the project planning of composite systems and project execution. The company says that the new sub-division represents an important interface for

**FIGURE 6**

ProTec Polymer Processing has introduced customized pultrusion lines for the production of high quality long fiber reinforced thermoplastics.

customers between the Centre for Lightweight Composite Technologies, the business units and the automation division. The Centre for Lightweight Composite Technologies focuses on all current composite technologies, as well as advanced technologies ranging from HP-RTM and SMC, the processing of semi-finished thermoplastic products such as thermoplastic fabric and tapes, through to reactive technologies such as in-situ polymerization (T-RTM).

Production processes developed in the Centre for Lightweight Composite Technologies are increasingly finding their way into practice. ENGEL has now established a separate division – ENGEL

**FIGURE 7**

LFT pultrusion lines are suitable for producing high quality long fiber reinforced pellets with many different polymer matrices and variable fiber reinforcement.

**FIGURE 8**

ENGEL's Centre for Lightweight Composite Technologies at Saint Valentin, Austria.

Composite Systems – for the project planning of systems for the production of fiber-plastics composite components.

Long fiber material matters

US-based PlastiComp is a composites technology and solutions firm focused on moving long fiber materials into new applications and markets, and looking to work with partners to improve products using different materials and manufacturing methods that they might traditional use. One current long fiber product development from PlastiComp is a hybrid material that combines long glass fiber and long carbon fiber together in a single pellet, which has been designed to bridge the significant performance and price gap that exists between all-glass fiber and all-carbon fiber material options. The combination of long glass fiber and long carbon fiber creates unique synergies, says the company. Similar performance can be obtained with reduced volume fractions of carbon fiber, with lower levels of carbon fiber having a significant impact on material cost. As a stiffer material, all-carbon fiber products have lower impact resistance – incorpo-

rating long glass fiber with long carbon fiber in hybrid products provides a significant boost in toughness that is valued in many applications.

In addition, PlastiComp is developing polyamide grades with reduced moisture uptake to provide more uniform performance across a wide variety of applications. The company adds that initial evaluation of low moisture polyamides indicates that polyamide 6/6 can be modified to provide mechanical performance similar to polyamide 11 in high humidity or short term water immersion applications at significantly lower cost than existing low moisture polyamides.

Future long fiber development areas at PlastiComp include glass and carbon fiber reinforced unidirectional thermoplastic tapes that are used as inserts during injection molding for selective or strategic reinforcement. PlastiComp has also supplied small diameter continuous fiber reinforced composite strands for 3D printing processes. The company says that it is also further developing multifunctional materials that combine long fiber reinforcement with additional functional performance capabilities such as color for product identification or branding, lubricity for wear and friction resistance, electrical conductivity for ESD and EMI protection, along with FST (flame, smoke, and toxicity) compliance.

One recent project that PlastiComp has been involved with highlights how long carbon fiber composites have been used to particular effect in wheelchair casters to reduce weight, where the company states that they can function like aircraft landing gear to provide a smoother ride. Founded in 1997 by Mark Chelgren, Frogs Legs of Ottumwa, Iowa in the USA has its origins when he encountered a quadriplegic rugby team that needed an alternative to traditional rigid casters for the front wheels on wheelchairs that would allow them to make tight turns. Instead of fixed forks that require the wheel to move up and over obstructions – bouncing the rider in the process – Chelgren designed his forks with a patented pivot point and wedge-shaped shock absorber that allows them to move over impediments in an arc path, functioning much like airplane landing gear, smoothing out the ride.

“An arc is a much more efficient movement,” says Chelgren. “But its compression zones are not linear, so instead of a traditional cylinder-shaped shock absorber, Frog Legs uses a wedge shape to better handle the differential loadings from front to rear.”

The company adds that people with physical disabilities who require wheelchairs for mobility literally feel every bump in the road as their chairs encounter obstacles as seemingly insignificant as cracks and uneven surfaces. A day filled with constant vibration and jolts from these hindrances causes fatigue and can produce spasms in riders that require treatment with medication.

Frog Legs wanted to switch from machined aluminum to a carbon fiber composite for a new generation of wheelchair caster wheels (Figure 9). Testing performed by the Center for Industrial Research and Service at Iowa State University showed that 80 percent of the vibrations wheel chair riders experienced were created by the front caster wheels and that Chelgren's design improvements reduced those vibrations from being transmitted to the wheelchair frame by 76 percent.

**FIGURE 9**

Frog Legs switched from machined aluminum to a carbon fiber composite for a new generation of wheelchair caster wheels, with materials developed by PlastiComp.

“We are always being pushed to lighten our product,” Chelgren adds. “People with disabilities are greatly affected by any additional weight. This time we looked at a different type of manufacturing process than machining aluminum. Injection molding allowed us to have a much more complex shape and carbon fiber composites really gave us advantages in what our design parameters could be. If the idea is to take an aluminum part and make it using carbon fiber, I think people are missing the boat. A carbon fiber part and an aluminum part should not look identical, instead you need to design for the material and process combined. It would be almost impossible to machine or forge the bottom part of our new fork design.”

Frog Legs’ second-generation caster wheels make use of two different long carbon fiber reinforced composite materials from PlastiComp. Machined aluminum has been replaced by a long carbon fiber reinforced polyamide 6/6 composite in the wheel forks and a long carbon fiber reinforced thermoplastic polyurethane in the wheel hub. PlastiComp custom developed the reinforced polyurethane composite to bond with the urethane used for the outer rolling surface of the wheel.

“Using thermoplastic polyurethane for the hub allows us to obtain a chemical bond,” says Chelgren. “With an aluminum hub there are dissimilar materials that never fully bond and can slip.” He adds that changing from aluminum to long carbon fiber reinforced composites reduced the weight of a pair of Frog Legs caster wheels by 33 percent – over 280 grams (0.5 lbs.) lighter – a reduction that is noticeable and appreciated by riders. The new design and materials passed RESNA (Rehabilitation Engineering Society of North America) industry standard testing that put them up against a million-cycle impact and drop forces. Frog Legs went on to test them to failure to have data to compare with traditional metal caster wheels.



The usage of recycled plastics materials (rPM) by plastics converters in Europe

Alexandre Dangis

At the beginning of this year, the European Commission published its long awaited EU Plastics Strategy, which will pave the way to develop more sustainable plastics production and consumption. One of its main objectives is to further stimulate the use of recycled polymers by plastics converting companies. Recycling (collection) targets have been set to a very ambitious level and EU member states will face a huge challenge to reach the new objectives. The industry will have to work harder together throughout the whole value chain to ensure appropriate markets for rPM will be developed. These markets will have to be created simultaneously with quality product standards as well as quality collection and separation guidelines in order to ensure a constant flow of recycled polymers toward the plastics converting industry.

Based on these reasons, the association of European plastics converting companies (EuPC) decided during its General Assembly 2017 to carry out an EU-wide survey to get more extensive knowledge of the current and future use of recycled plastics materials (rPM) by converters. What are the limits of using recycled polymers? Which markets and which technologies can absorb the growing volume of recycled polymers? Which requirements are needed to encourage the use of more recycled polymers? Is there a specific pricing mechanism or financial incentive to consider to stimulate more use? Do converters intend to purchase more recycled polymers in the future? What is driving the use of recycled polymers in Europe?

All these qualitative questions and many more incontestably offer very interesting insights into a new circular economy for the plastics industry. It is not only about what legislators can do to stimulate growth of rPM usage, but also about the current and future technological developments in the plastics converting industry that will ensure a sustainable circular future for the plastics industry in Europe.

"We are embarking on a long circularity journey. Our survey on the use of rPM in the plastics converting industry will enable EuPC to identify the difficulties we are facing as an industry and help to find solutions for the future."

[(EuPC's Managing Director Alexandre Dangis).]

The survey was launched in May 2017 and was open to all European companies active in the plastics converting industry. It was available online in eight languages: English, German, French, Italian, Spanish, Polish, Turkish and Bulgarian. It remained accessible for 5 months and was finished at the end of September 2017. Polymer Comply Europe SCRL (PCE) conducted and evaluated the survey on behalf of EuPC. The survey was distributed through EuPC's network of national as well as European plastics associations and additionally it was disseminated among the members of PCE's Polymers for Europe Alliance.

The survey was conducted at an important time, as the upcoming EU strategy on plastics was expected to set high recycling targets that will have to be met by member states. The support of the industry is indispensable to reach these ambitious goals. The plastics converting industry forms by far the biggest part of the plastics value chain, with more than 50,000 companies that employ 1.6 million people and create a turnover in excess of € 260 billion per year.

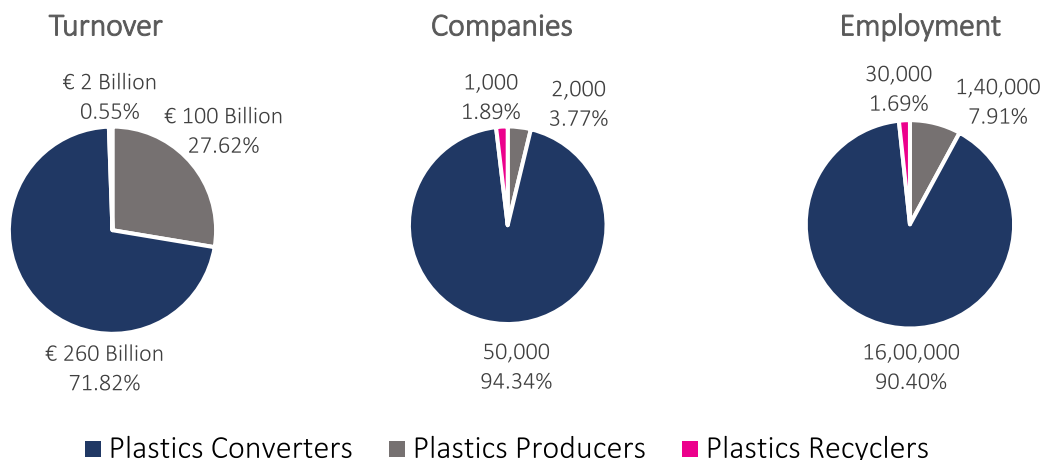
"Plastics Converters are the heart of the plastics industry."

[(Daniel Calleja Crespo, Director-General of DG Environment of the European Commission).]

The plastics converting industry therefore is of decisive importance and converting companies will have to play their part to ensure that recycled plastics materials (rPM) will be used as raw material for the creation of new products. Without a strong market for rPM, the recycling targets are destined to fail and the transition toward a more circular economy would come to a halt.

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The EU Plastics Industry – Key Figures



The participation of 485 respondents from 28 different countries ensures that the results give a representative image of the plastics converting industry as whole. The industry sample as well adequately represents the whole industry in terms of products segments, with companies from all major sectors participating. The packaging sector forms the biggest part, with 51% of the participants active in this field. In the second place lies the building and construction sector (30%), followed by automobile and transport (12%). This corresponds with the importance of the plastics value chain's three markets. The diversity and fragmentation of the plastics converting industry is shown by the fact that 19% of the respondents are serving markets not listed here, like furniture or garments.

The polymer types used by the participating companies also mirror the general state of the industry. Polyethylene (HDPE, LDPE) and polypropylene (PP) are the most widely used polymers, followed by polystyrene (PS) and polyethylene terephthalate (PET) as well as polyvinyl chloride (PVC). The largest majority of the participating companies uses injection molding and/or (co-) extrusion as converting techniques. Other processing techniques include foaming, lamination and calendaring.

The survey was divided in three parts, that aimed at different aspects concerning the usage of rPM. In the first part, participants were asked what the incentives for and the barriers to the use of rPM are for their companies. The second part consisted of the assessment of the current European as well as national regulatory framework and the third and last part gave an outlook on future developments concerning the use of rPM.

The survey results show that quality and steadiness of the supply are equally strong barriers to the use of rPM for plastics converting companies. Nearly 60% of the respondents stated that it is hard or very hard for them to get recycled plastics materials that meet their customers' specifications. Contrary to this, only 16% say that this is easy or very easy for them. The quality is not the sole problem regarding the use of rPM. The participants also have difficulties to find a steady supply in sufficient quantity. Over 58% of the respondents stated that it is difficult or very difficult to get a steady supply of rPM in a sufficient quantity, contrary to only 15% who said it is easy or very easy.

When it comes to incentives for the use of rPM, an overwhelming majority of 78% of the respondents states that price is the main reason for converting companies to use rPM. A better environmental image (52%) and a favorable carbon balance (25%) also play an important role. The results furthermore reveal that the requests of customers can be a decisive factor. The fact that they play this role for just 2% of the participants clearly shows that the customers of converting companies lack behind in the embracement of rPM.

As seen before, quality (74%) as well as stability (39%) of the supply are the most important barriers to the use of rPM. Only 15% of the participants state that the price prevents them from using rPM. This indicates that the quantity of rPM on the market is not a problem, but its inferior quality. Legal issues are hindering the use of rPM as well, especially regarding food contact applications, where the European Commission has failed to establish a working system more than 9 years after the regulatory framework was adopted. The same applies for the legacy additives issues for long-life products, where converting companies are still facing legal uncertainty.

Another impediment is the attitude of the customers of the converting companies toward the use of rPM. Only 27% of the participating companies state that their customers are sufficiently aware of the benefits and the need to use more rPM. Corresponding to this, only 31% of the respondents think that their customers would be willing to switch to a stronger use of rPM. These results are alarming, because without the support of its customers, the plastics converting industry will not be able to boost the use of rPM. The first step to change that attitude would be to increase the awareness, which should in return lead to a better acceptance of rPM. More value chain collaborations with specifiers (e.g. architects) and brand owners are needed to achieve this.

Furthermore, the regulatory framework is as well inhibiting the use of rPM by converting companies. The fact that a majority of almost 60% of the converting companies thinks the current product regulations are not suitable to support a stronger use of rPM in the future clearly shows that the regulatory framework needs to be adjusted. The introduction of quality standards for example would lead to more use of rPM by 41% of the participating companies.

The assessment of quality standards however differs from sector to sector. When comparing the three biggest sectors, it stands out that companies active in the automotive and transport (A&T) sector have the most positive view toward quality standards, followed by companies active in the packaging and building and construction (B&C) sector. In the A&T sector, over 58% of the converting companies think that quality standards would stimulate more use of rPM by their company. In the packaging sector, this number is reduced to 49% and only 35% of the converters active in the B&C sector think that quality standards would boost their usage of rPM.

Despite all these concerns, a vast majority of 76% of the respondents currently is using rPM, and regarding the future use of rPM, 75% of the participants plan to increase their usage of recyclates. Of the companies not currently using rPM, 64% plan to do so in the future, which only leaves 8% of all European plastics converting companies that will not use rPM in the future. This number can be reduced further, when considering that in some applications – like medical products – rPM categorically cannot be used.

When asked for the converting technologies that are the most promising for the incorporation of more rPM, the vast majority of respondents stated injection molding (54%) and/or (co-) extrusion (63%). The fact that the participants mostly consider only two converting processes to be able to incorporate a bigger use of rPM in the future shows that the number of technologies that are able to use large amounts of rPM currently is limited.

More innovation is needed in order to find additional converting technologies to absorb the increasing amount of recycled polymers that is expected to arise in the future.

The EU survey is part of a larger initiative of EuPC to get more knowledge about the state of affairs regarding the current and future use of rPM in the converting industry, in order to support its members and the converting companies in the transition toward a more circular economy.

Based on the results of this first survey, a second set of questions has been drafted and is accessible online until May 2018. The survey is open to all European companies active in the plastics converting industry and the results will be presented during the 2018 EuPC Annual Meeting “A circular Future with Plastics” on the 24th and 25th May in Milan (Italy) with the presence of the EU Commissioner E. Bienkowska and leading CEOs of the plastics industry. To access the survey, please visit the website of EuPC at plasticsconverters.eu.

EuPC will develop further surveys to continue monitoring the development of the use of rPM in plastics converting companies. Comprehensive knowledge and reliable information will be crucial for the future development of the plastics converting industry, as recycling and the use of rPM become more and more important issues for consumers and legislators alike. Additionally, EuPC and the association for plastics recyclers in Europe (PRE) will organize workshops together with national plastics associations to bring together converters and recyclers to support a deeper collaboration throughout the value chain.

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New material: vitrimers promise to impact composites

Denis A. Kissounko, Philip Taynton, Chris Kaffer

Strong and durable like thermosets, yet moldable and recyclable like thermoplastics, vitrimers are ‘malleable thermosets’ which are challenging the status quo in the composites industry. Mallinda, a startup company founded by some of the pioneering inventors of the technology, is developing malleable CFRPs for rapid (30 s) production cycle times.

Background

For over 50 years, synthetic polymers have been divided into two general categories: thermosets which have excellent mechanical properties, but must be irreversibly cured; and thermoplastics, which can be melted down and reprocessed, but have inferior thermal and mechanical properties (Figure 1) [1]. This characteristic allows thermoplastics to be molded relatively quickly for high volume manufacturing, using techniques such as injection molding. Furthermore, these materials can be recycled by melt-processing. On the down side however, the majority of thermoplastics are susceptible to mechanical deformations and creep at elevated temperatures; therefore, they do not have a sufficiently robust dimensional stability at high temperature. In addition, commercial thermoplastics are typically of higher cost in comparison to analogous thermoset resins. Thermosets are the resins of choice for structural composites applications, such as aerospace composite part fabrication where stiffness and durability are critical. While thermoset resins offer significant performance benefits compared to their thermoplastic counterparts, significant cure times for thermoset resins make them unsuitable for high volume applications such as automotive. Furthermore, due to the inability to reprocess thermoset resins after they have been cured, these materials are refractory to repair and remolding. Recently, this paradigm has been challenged by the arrival of malleable thermoset materials, also known as vitrimers.

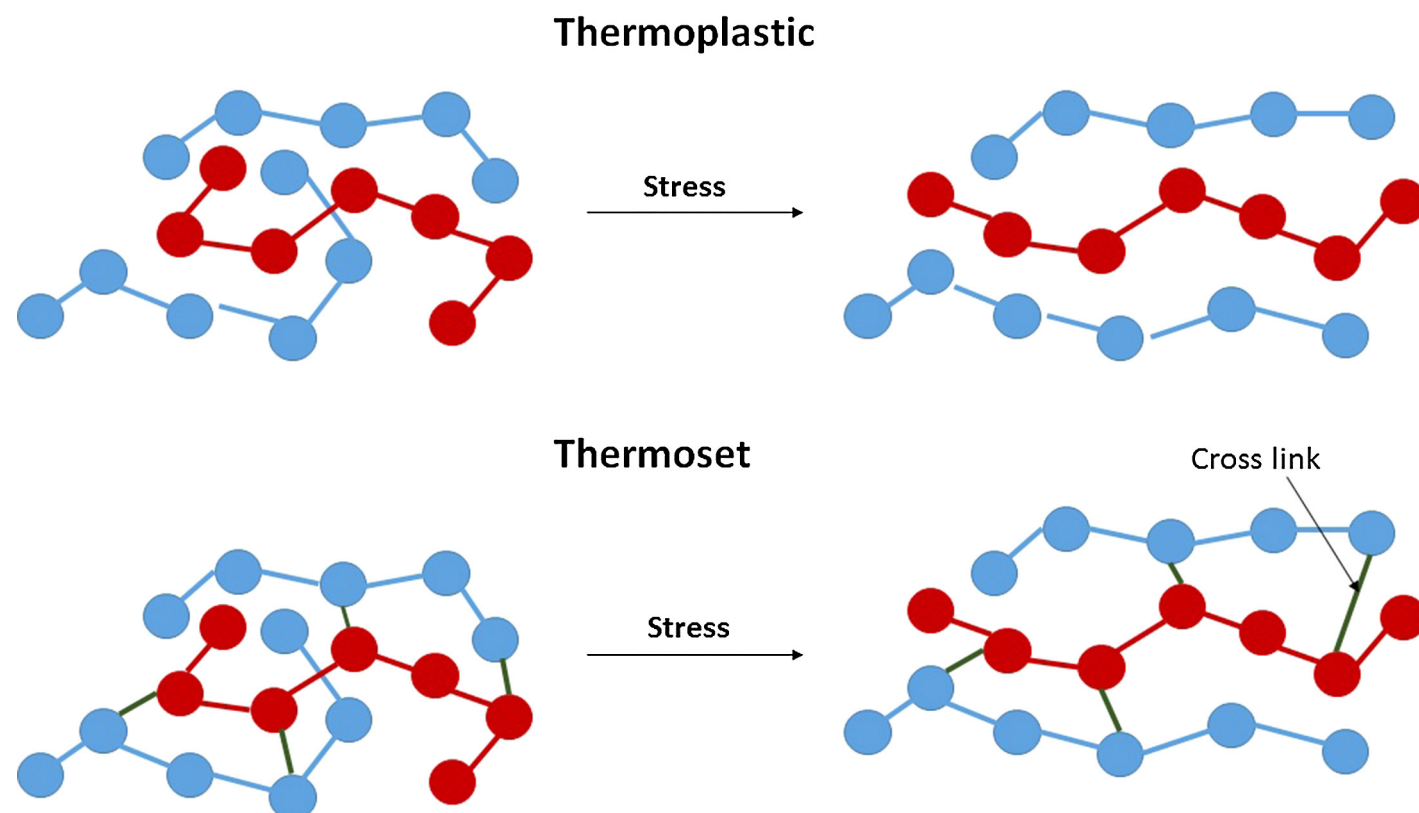
Vitrimers are covalently-bonded crosslinked network polymers, like thermosets, but with the distinguishing feature that the chemical bonds in the network are exchangeable. Typically, a catalyst is included in the resin formulation, which enables bond exchange reactions when the material is heated above the vitrimeric transition temperature [2]. When vitrimers are heated to the malleable state, their total crosslink density

remains constant, but the rate of bond exchange increases with temperature (see Figure 2), since all chemical reactions run faster at higher temperatures. This leads to a gradual decrease in viscosity with temperature, which differs from the relatively abrupt drop in viscosity associated with the melting transition of thermoplastic materials. The reversible nature of vitrimers enables welding, molding, reshaping, and recycling of fully cured materials.

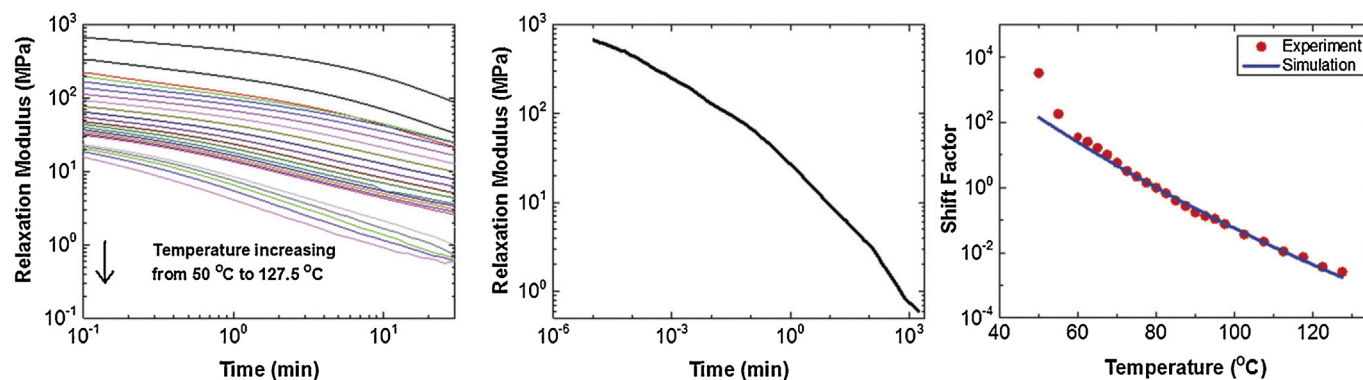
Mallinda co-founders invented the first known vitrimeric materials which do not require a catalyst, and behave like traditional thermosets under ambient conditions. Mallinda's catalyst-free vitrimers exhibit malleable behavior only when heated above the glass transition temperature (T_g) of a given formulation. This means that below the glass transition, the polymer network is frozen, and is thus indistinguishable from a traditional thermoset. Mallinda's vitrimeric polyimine platform is also quite tractable. T_g , for example, can be tuned with formulation from below room temperature to upwards of 200°C.

What does this mean for composites?

The Mallinda team has shown that when structural composite materials, like carbon fiber reinforced plastics (CFRPs), are made using vitrimeric resins, several distinct advantages arise. First, unlike traditional thermosets, vitrimeric composite materials can be reprocessed after being cured. Fully cured materials can be heated, remolded, and reshaped without losing their original strength. Second, these composite materials can be heat-welded together to form monolithic cured multilayer laminates. Finally, CFRPs made with vitrimeric resins can be easily recycled in a solution-based process in which the fiber and resin can be separated, recovered and reused to their original strength [3].

**FIGURE 1**

Thermoplastics vs. thermosets.

**FIGURE 2**

Temperature-dependent stress relaxation behavior of vitrimers shows that malleable flow of vitrimers correlates with reaction-rate of bond exchange.

Mallinda is using vitrimer technology to develop a new class of 'pre-cured pre-impregnated laminates (prepreg)' which will impact current prepreg users as well as high throughput producers who currently rely on Resin Transfer Molding (RTM) processes with quick-cure resins. The envisioned pre-cured prepreg malleable composite materials can be cured upstream in the manufacturing process as individual laminates in a roll-to-roll process, and stored indefinitely at room temperature. To manufacture composite parts, any number of plies can be heated to the material's specifically-formulated T_g , laid up in a mold to the desired thickness, and both consolidated and formed into a final part through compression forming [3] (in a video demon-

stration, a 20 s compression forming step is used: <https://youtu.be/o97q-2oDPfQ>). Within 1-min the formed part can be demolded and handled immediately, with full rigidity occurring upon cooling. Scrap material can be further repurposed to form other parts, or can be recycled in the solution-based process wherein the fiber and resin materials are recovered and reused (see demonstration video at <https://youtu.be/FNd2bBt8CMU>) (Figure 3).

At present, prepreg materials offer several advantages over other CFRP manufacturing approaches such as Resin Transfer Molding (RTM) processes. Prepreg materials offer guaranteed (rather than estimated) fiber/resin ratios, and consistent mechan-

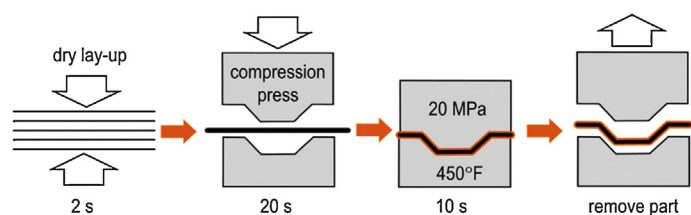


FIGURE 3

High speed consolidation and molding for Mallinda's malleable materials.

ical properties. They are more reliable than RTM materials, as void space, and trapped bubbles are common problems for RTM materials. They offer a simpler, cleaner, and safer lay-up process, since there is no need to handle wet chemicals on site, as opposed to RTM. The drawbacks of traditional thermoset prepreg materials are related to shelf-life, refrigeration logistics, cost, and a higher scrap rate.

Due to the irreversible nature of traditional thermoset curing, prepreg materials, are partially cured in the roll-to-roll fiber impregnation process (called B-staging), and immediately frozen to prevent completion of the curing process until the material is used to manufacture a composite part. The manufacturing step typically involves vacuum bagging the lay-up over a mold, followed by autoclave treatment for up to several hours to cure the resin. Compared with current prepreg materials, pre-cured prepreps offer the advantages of extended shelf-life stability, ambient shipping and storage (no refrigeration), faster cycle time (no waiting for cure during layup/consolidation), and recyclability of cured scrap and end of life material. If the pre-cured prepreg materials are made at sufficient scales, these materials will become available at a fraction of the price of present prepreg materials.

How is it made?

While there are many features which are unique to malleable thermosets, one feature which is shared with traditional thermoset materials is the initial curing step. Similar to traditional thermoset materials, malleable thermosets must be formed in a polymerization reaction in which a liquid precursor solution is cured into a polymeric solid. As with traditional materials, this initial curing step is the optimal step for combining the polymer with reinforcing fibers, since the low viscosity of the uncured resin enables consistent and even flow into, and impregnation of, the fine reinforcing fibers. This means that vitrimeric resins can be infused into reinforcing fibers using existing prepregging equipment. A key differentiation in processing vitrimeric prepreg materials is that the resins are cured in-line immediately after resin infusion. Mallinda has partnered with an existing prepreg supplier to pilot the infusion process with initial success, and the company is moving to scale-up its industrial processing for its introductory product offering.

Why are vitrimer composites easier to recycle?

Due to the same dynamic covalent bond exchange phenomenon described above, polyimine resins are intrinsically recyclable in a solution of some of the resin's precursors. The precursors in solu-

tion undergo bond exchange reactions with the vitrimeric resin at room temperature, leading to gradual dissolution of the polymer.

At this point, the solubilized resin solution can be separated from the fabric. Upon the addition of complementary precursor, the resin can polymerize again and can be reused in a new cycle (Figure 4). Mallinda has incorporated up to 30% recycled resin onto new materials with no loss in mechanical performance.

As the recycling process does not stress the fiber in any way, virgin-like fiber materials are recovered, with no loss in mechanical performance.

What is the expected cost of vitrimer resins?

Mallinda's resins are prepared from high-volume commercially-available precursors, which makes scaling, and supply chain manageable. It is expected that malleable resins will be cost competitive with epoxy resins when developed to similar scales. Due to other efficiencies, Mallinda expects its prepreps to be less expensive than competitive materials at launch.

What are Mallinda's near-term and long-term plans?

Currently, Mallinda is exploring the following markets as the entry points for precured prepreps: sporting goods, aerospace, automotive, wind energy, and gas storage pressure vessels.

Due to the relatively low barriers to entry, Mallinda's first market is within the sporting goods segment. As such, Mallinda has been developing its first product line of moldable protective sports gear with an OEM serving a branded sporting goods company. The company's initial product offering enables an end-user to heat Mallinda's protective materials to 'activate' malleability to fit the fit the specific contours of the end-user's body and extremities. Mallinda's enabling technology is both fully malleable passes the impact test qualification required by National Operating Committee on Standards for Athletic Equipment (NOCSAE). Mallinda's partners will undergo an initial product rollout in 2018.

While the sporting goods vertical market represents the company's beach head market, Mallinda's vitrimeric composite materials are poised to make a significant impact within the transportation segment.

CFRPs offer the most efficient means of reducing the mass of traditionally manufactured legacy metal parts/products without

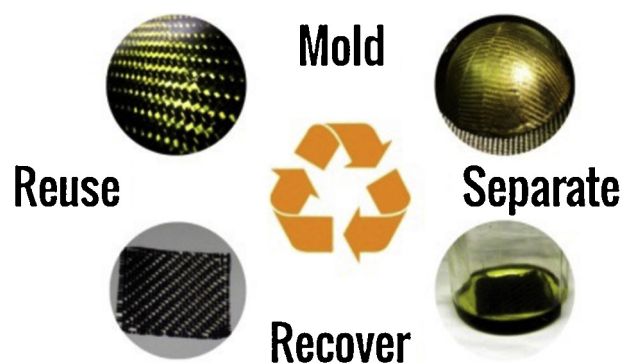


FIGURE 4

New recycling paradigm of the polyimine-based composites.

TABLE 1

Lightweighting potential of materials.

Material	Density (g/cm ³)	Comparison to steel			
		Strength/density	Modulus/density	Cost	Mass reduction potential
Mild steel	7.87	1	1	1	0%
High-strength steel	7.87	1.86	1	0.9–1.2	10%
Adv high-strength steel	7.87	3	1	0.8–1.5	10%–28%
Gen 3 high-strength steel	7.87	7	1	1.0–2.0	15%–30%
Ceramics	3.9	0.7	3.05	1.5–3.0	10%–30%
Sheet molding compound	1.1–1.9	4.39	1.16	0.5–1.5	20%–30%
Glass fiber composites	1.4–2.4	4.74	5.75	0.9–1.5	25%–35%
Plastics	0.9–1.5	0.82	0.08	0.7–3.0	20%–50%
Aluminum	2.7	3.95	1.02	1.3–2.0	30%–60%
Titanium	4.51	4.73	0.98	1.5–10	40%–55%
Metal matrix composites	1.9–2.7	5.41	35.28	1.5–3.0	50%–65%
Magnesium	1.74	3.66	1.02	1.5–2.5	30%–70%
Carbon fiber composites	1.0–1.6	20.9	5.41	1.5–5.0	50%–70%

sacrificing mechanical performance (Table 1). The Table 1 clearly shows the superior combination for carbon fiber composites (highlighted in red box) in terms of strength, density, modulus, cost and mass reduction potential in comparison to other commercial materials. However, despite the promise of CFRCs in vehicle lightweighting, their adoption has remained limited due to manufacturing challenges resulting in high costs, and challenging end-of-life material management. These challenges must be overcome, as lightweighting targets – and thus vehicle efficiency targets – cannot be met without carbon fiber composites [4]. Vitrimer composites address both of these challenges and improves the economics of CFRP part production by improving manufacturing cycle times by enabling consolidation and compression forming of prepreg materials in a single step for sub 1-min cycles times.

While the benefits of vitrimer technology will benefit the thermoset composite industry in general, the automotive segment will be significantly impacted should Mallinda's technology be adopted. Decreasing vehicle weight is one of the primary methods for improving vehicle fuel efficiency, and the integration of carbon fiber composites represents the most promising pathway to vehicle lightweighting. By improving the cost effectiveness of CFRPs through improved cycle times, etc., vitrimers will be catalytic in the lightweighting of light, medium, and heavy duty vehicles. By enabling the recycling of

carbon fiber composites, this technology will not only divert waste from landfill, but will also reduce the embodied energy in carbon fiber carbon fiber from end-of-life products.

In addition, based on the cost of Vitrimer materials, and the scale of the process, the company estimates that it can produce prepreg CFRP materials in the range of \$11–16 per pound, which is only a fraction higher than the cost of bare fiber. As a result, Mallinda will enable greater adoption of lightweight composites in adjacent industries such as wind power [5].

Figure 5 [6] provides a window into the cost savings potential of vitrimer technology. By eliminating the need for a pre-forming step, all non-materials costs are removed from the 'pre-form' step (Step 1 in Figure 5). Furthermore, by eliminating the need for resin transfer molds and autoclaves, Mallinda's customers can eliminate most of the capital, utility, and labor costs of the 'molding' step (Step 2 in Figure 5). Mallinda expects an all-in production process cost reduction of roughly 25–30%.

Finally, it is well known that the overall process for making carbon fiber is an energy intensive process contributing to the high cost of carbon fiber. Thus the key energy benefit of Mallinda's pre-cured malleable thermoset prepreg materials is in the manufacturing energy savings related to part production and ambient solution-based recycling of scrap and end-of-life products for the recovery of full length and woven fibers.

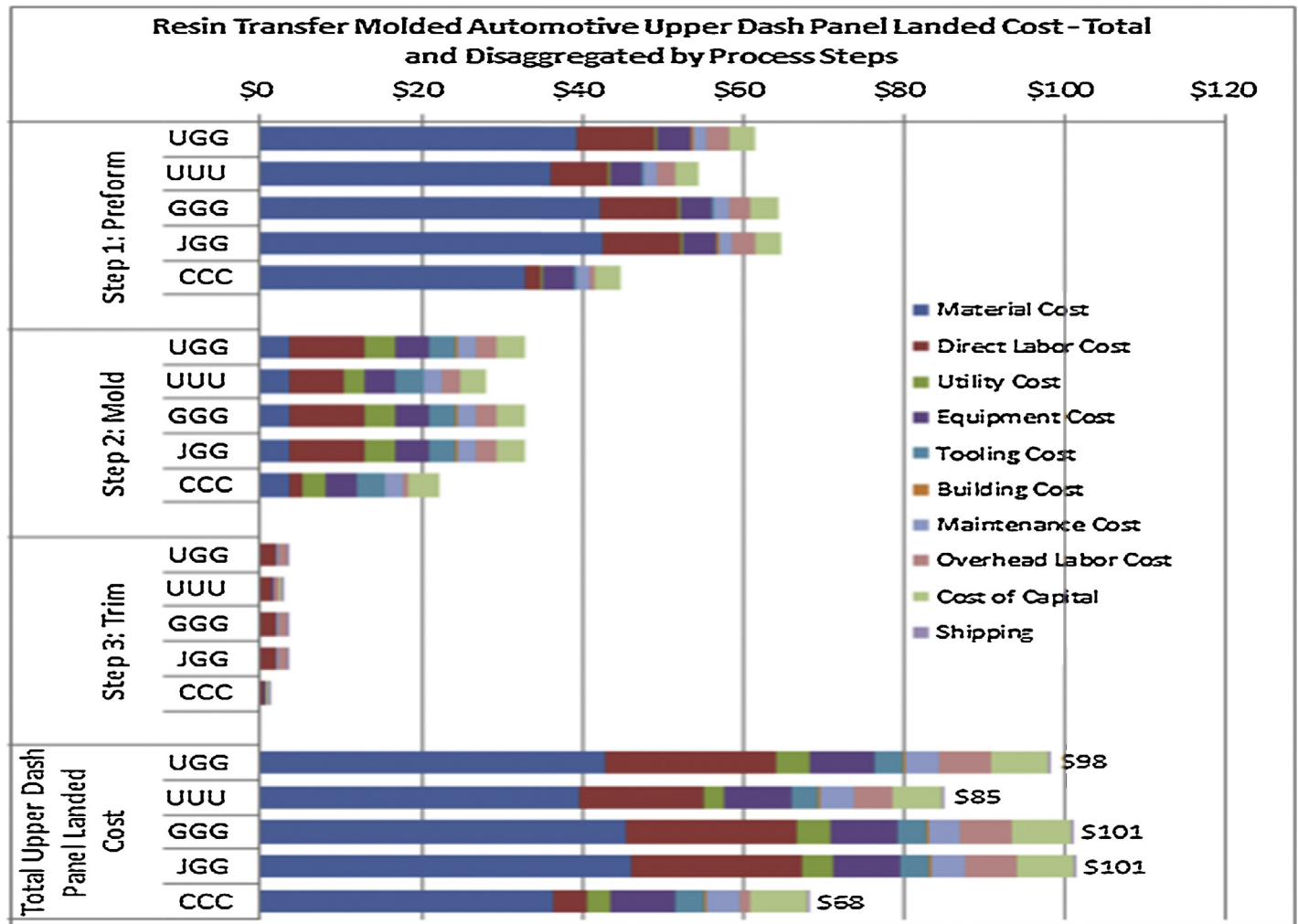


FIGURE 5

CFRP Mfg costs.

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ELSEVIER

Events Diary

5-7 June 2018

Birmingham, UK
The Engineer Expo
Contact: Darren Arcanjo, commercial manager
Tel: +44 (0)207 970 4691
E-mail: darren.arcanjo@centaurmedia.com
www.theengineer-expo.co.uk

5-7 June 2018

Birmingham, UK
Utomechanika Birmingham
Contact: Forest Exhibitions
E-mail: caroline.carr@uk.messefrankfurt.com
www.automechanika-birmingham.com

6-8 June 2018

Shanghai, China
ANEX/SINCE 2018
Contact: UBM Asia Ltd
Tel: +852 2827 6211
Fax: +852 3749 7342
E-mail: damian.goh@ubm.com
www.asianonwovens.org

19-20 June 2018

Lyon, France
Plastics Meetings France 2018
Contact: ABE (Advanced Business Events)
Tel: +33 (0)1 41 86 41 70
Fax: +33 (0)1 46 04 57 61
E-mail: info@advbe.com
www.plastics-meetings.com

20-21 June 2018

Nottingham, UK
Composites Innovation 2018
Contact: NetComposites Ltd
Tel: +44 (0)1246 266 244
E-mail: info@netcomposites.com
compositesinnovation.com

26-28 June 2018

Amsterdam, Netherlands
Additive Manufacturing Europe 2018
Contact: Tarsus Group Plc

Tel: +44 (0)20 8846 2700
Fax: +44 (0)20 8846 2801
E-mail: info@3dprintshow.com
www.amshow-europe.com

26-28 June 2018

Toulouse, France
Toulouse Space Show 2018
Contact: ABE (Advanced Business Events)
Tel: +33 (0)1 41 86 41 70
Fax: +33 (0)1 46 04 57 61
E-mail: contact@toulousespaceshow.eu
www.toulousespaceshow.eu

27-28 June 2018

Las Vegas, USA
Global Composites
Contact: American Composites Manufacturers Association
Tel: +1 703 525 0511
E-mail: info@acmanet.org
www.globalcompositesconference.com

28-30 June 2018

Berlin, Germany
Biopolymer Congress 2018
Contact: Conference Series LLC
Tel: +1 800 216 6499
E-mail: biopolymercongress@chem-series.com
biopolymers.conferenceseries.com

3-5 July 2018

Southampton, UK
Seawork International
Contact: Mercator Media Ltd
Tel: +44 1329 825335
Fax: +44 1329 550192
E-mail: info@seawork.com
www.seawork.com

10-12 July 2018

Nottingham, UK
International Conference on Manufacturing of Advanced Composites
Contact: IOM Communications Ltd
Tel: +44 (0)20 7451 7302
E-mail: chia.brooks@iom3.org
www.icmac2018.org

16-22 July 2018

Farnborough, UK
Farnborough International Airshow 2018
Contact: Helen Watt
Tel: +44 1252 532842
helen.watt@farnborough.com
www.farnboroughairshow.com/trade

29 July-1 August 2018

Cairns, Australia
11th Asian-Australasian Conference on Composite Materials
Contact: Cairns Convention Centre
E-mail: accm11conference@gmail.com
www.accm11.org

5-7 September 2018

Las Vegas, NV, USA
Interdrone 2018
Contact: BZ Media LLC
Tel: +1 (631) 421 4158
E-mail: info@bzmedia.com
www.interdrone.com

11-13 September 2018

Charlotte, NC, USA

UTECH North America 2018
Contact: Debbie Hershfield
Tel: +1 330 608 0231
E-mail: dhershfield@crain.com
www.utech-north-america.com

25-27 September 2018

Boston, MA (USA)
Aircraft Interiors Americas 2018
Contact: Reed Exhibitions Companies
Tel: +44 20 8271 2134
Fax: +44 20 8910 7823
E-mail: rxinfo@reedexpo.co.uk
www.aircraftinteriorexpo-us.com

2-4 October 2018

Tampa, FL, USA
IBEX 2018
Contact: IBEX show director
Tel: +1 716 662 4708
E-mail: anne@ibexshow.com
www.ibexshow.com

3 October 2018

Loughborough, UK
Composites in Sport 2018
Contact: NetComposites Ltd
Tel: +44 (0) 1246 266 246
E-mail: info@netcomposites.com
www.compositesinsport.com

4 October 2018

London, UK
Thermoplastic Composites 2018
Contact: Composites UK
Tel: +44 (0)1442 817502
E-mail: info@compositesuk.co.uk
compositesuk.co.uk

9-11 October 2018

Berlin, Germany
Gocarbon Fibre 2018
Contact: Smithers Rapra
Tel: 01372 802000
E-mail: info@smithersrapra.com
www.gocarbonfibre.com

15-18 October 2018

Dallas, TX, USA
CAMX 2018
Contact: ACMA
Tel: +1 703 525 0511
E-mail: rosemay@sampe.org
thecamx.org

16-18 October 2018

Hanover, Germany
Foam Expo Europe
Contact: Smarter Shows
Tel: +44 1273 916 301
E-mail: jamie.reid@smartershows.com
www.foam-expo.eu

16-18 October 2018

Hanover, Germany
Sustainable Materials for Transportation Expo
Contact: Deutsche Messe AG
E-mail: +44 1273 916 300.
E-mail: info@smt-expo.eu
www.smt-expo.eu

30-31 October 2018

Dallas, TX, USA
Bremen, Germany
ITHEC 2018

Contact: Messe Bremen
Tel: +49 (0) 421 35 05 347
E-mail: borgmann@messe-bremen.de
www.ithec.de

29 October-1 November 2018

Moscow, Russia
Plastics Industry Show 2018
Contact: ZAO Expocentr
Tel: +7 (495) 255 37 23/33
Fax: +7 (495) 205 80 55
E-mail: centr@expocentr.ru
chemistry-expo.ru/en

31 October 2018

Birmingham, UK
Composites Industry Awards Dinner 2018
Contact: Composites UK
Tel: +44 (0)1442 817502
E-mail: info@compositesuk.co.uk
compositesuk.co.uk

31 October-1 November 2018

Birmingham, UK
Advanced Engineering 2018
Contact: Easyfairs
Tel: 44 (0)20 3196 4350
E-mail: paul.love@easyfairs.com
www.easyfairs.com/advanced-engineering-2017/advanced-engineering-2017/

6-8 November 2018

Stuttgart, Germany
COMPOSITES EUROPE 2018
Contact: Reed Exhibitions Deutschland GmbH
Tel: +49 211 901 91-0
Fax: +49 211 901-91-123
E-mail: info@composites-europe.de
www.composites-europe.com

14-16 November 2018

Seoul, Republic of Korea
JEC Asia 2018
Contact: Anne-Manuele Hebert, JEC
Tel: +33 1 58 36 43 93
www.jeccomposites.com

21-22 November 2018

Marknesse, The Netherlands
International Symposium on Composites Manufacturing ISCM 2018
Contact: NLR-Netherlands Aerospace Centre
Tel: +31 88 5113113
E-mail: info@nlr.nl
www.nlr.org

4-6 December 2018

San Diego, CA, USA
Carbon Fiber 2018
Contact: CompositesWorld
Tel: +1 858 552 1234
www.compositesworld.com

20-31 January 2019

Amsterdam, Netherlands
Composites in Construction
NetComposites Ltd
Tel: +44 (0)1246 266 246
E-mail: info@netcomposites.com
compositesin.constructionhttp://www.microscopy.org/events/events.cfm