EVONIK FOR COMPOSITES

Products for efficiency
and performance

EVONIK
POWER TO CREATE

Evonik products for composites

Composites consist mainly of a combination of polymers that have endless fibers imbedded in them. The polymer serves to protect the load-bearing fibers against all environmental influences and to transfer loads evenly over the fibers. For this reason, the polymer for this matrix plays a pivotal role in composites.

Examples of composites include laminates that consist of fiber-matrix combinations, or sandwich constructions that feature a combination of two very thin composite laminates with a lightweight core material between them.

Evonik itself does not offer composites, but unidirectional tapes, specialty foams for sandwich construction cores, and the components that go into composites. Evonik's broad product portfolio includes different types of matrices or matrix-related products, such as hardeners and additives.This brochure aims to provide manufacturers of composite prepregs or parts a comprehensive overview of the products available to them.

You are more than welcome to ask our experts for further information about specific products.

Content

A growing number of challenges presented by renewable energy, efficient resource management and ecological aspects can only be mastered now and in the future by using lightweight construction. Fiber-reinforced composites will play a major role in this regard as one of the key technologies for the 21st century.

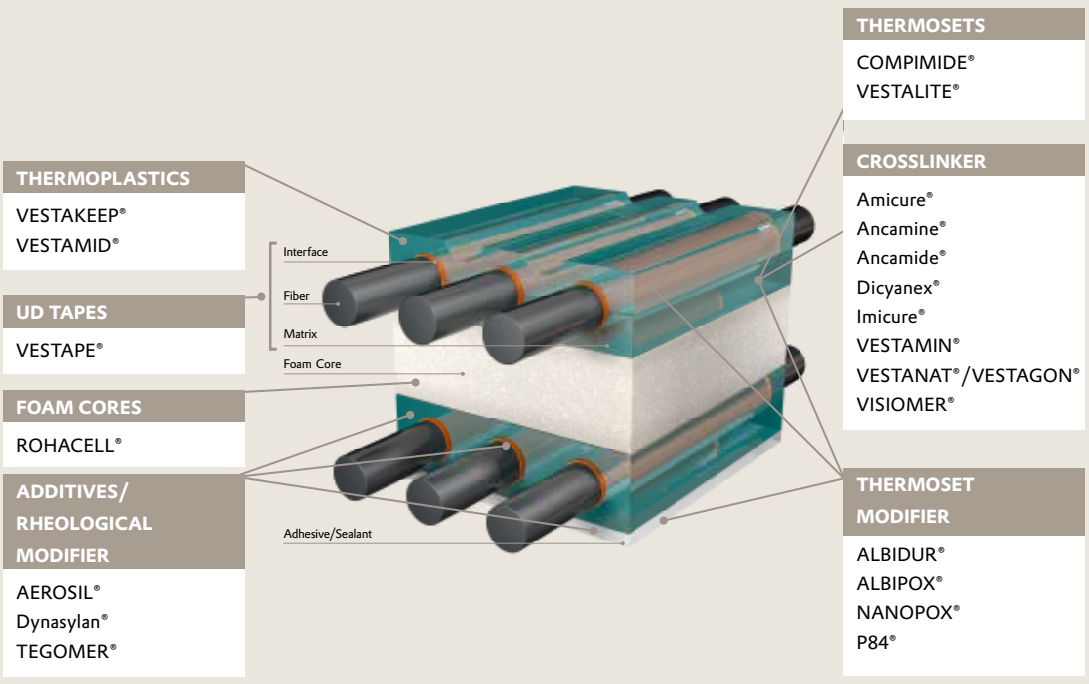
Evonik manufactures a range of products that can be found in almost all components of fiber-reinforced composites. We supply unidirectional tapes, core materials for sandwich construction, thermoplastic and thermosetting resin matrices, as well as the essential components for matrices such as crosslinkers, catalysts, impact strength modifiers or processing and process additives. Some of these products are used in sizings for glass or carbon fibers, and in adhesives for joining fiber-reinforced composites.

EVONIK'S STRENGTH IS DIVERSITY

Our experts in fiber-reinforced composites think "systems," not "products". Even in cases of applications where products from their own department are not the material of choice, our experts involve the specialists from other departments to identify the optimal solution for the customer. According to the philosophy: when you work with us, you have the support of the entire team of specialists at Evonik. In short, you talk to one, you talk to all.

The fact that composite specialists within Evonik are closely connected to each other across the respective business divisions is an enormous advantage for our customers. A result of this cooperation is the platform that serves to exchange technical information between experts and the group-wide Composites Industry Team. This ensures that specialist knowledge is available to our customers at all locations.

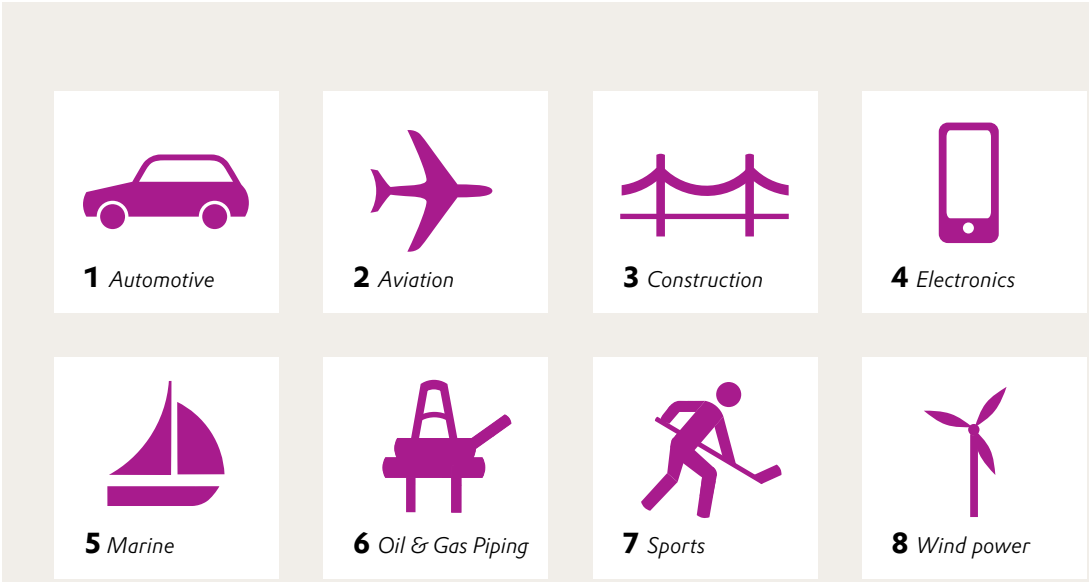
CROSS SECTIONAL VIEW



Composites market overview

WORKING IN MANY DIFFERENT MARKETS

With its wide range of products, Evonik Industries provides product solutions for a variety of different applications to the end markets for fiber-reinforced composites. The group's composite activities are focused on the automotive, aviation, wind power, construction and oil & gas markets. In addition composites with Evonik materials are used in medical applications and sports equipment.



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Matrix systems

The matrix in a fiber-reinforced composite serves to:

- Keep the fibers in place
- Transfer stresses evenly over the fibers
- Provide a barrier under adverse conditions such as chemicals and moisture
- Protect the surface of the fibers from mechanical degradation, for example,as a result of abrasion

The matrix you select has a major impact on the compressive, interlaminar shear, and in-plane shear properties of the composite material.

Polymer matrix systems fall into two broad categories: thermosets and thermoplastics. A thermoset matrix has a three-dimensional network structure, where the molecular chains are permanently crosslinked. The transformation is irreversible, and the original properties of the material cannot be restored. The advantage of thermoset resins is that they are easy to formulate and use.

A thermoplastic matrix has a linear structure that must be heated to be formed, and cooled to be set. That is, the chains lock into place. You can reverse the operation, thereby regenerating the material, and repeat it. The advantage of thermoplastic matrix systems is that they allow faster production rates, are storable at ambient temperatures without any special protection, and are reprocessable.

When selecting a matrix, a manufacturer considers primarily its basic mechanical properties. For high-performance composites, the most desirable mechanical properties of a matrix are:

- High tensile modulus, which influences the compressive strength of the composite
- High tensile strength, which controls the intraply cracking in a composite laminate
- High fracture toughness, which controls ply delamination and crack growth
- Good dimensional stability at elevated temperatures (glass transition temperature higher than maximum use temperature)
- Resistance to moisture and solvents, for example, fuels and gasoline, motor oil, deicing fluids and anti-freeze, and paint strippers (polymer should not swell, crack or degrade)

Evonik is one of the leading suppliers of high-performance resins and crosslinkers to the composite industry: resin modifiers and curing agents for epoxy systems, PBO crosslinked phenolic resins, bismaleimide resins (BMI) for high temperature composites, polyimides as BMI modifiers, polyetheretherketones (PEEK) and polyamides for thermoplastic matrices, and special acrylics.

THERMOSETS

The following are the most important thermoset resins:

Epoxies: principally used in high-performance composite applications, for example, aerospace and aeronautics, automotive, wind energy (rotor blades), composite pipes, and high-performance boats.

Polyesters, vinyl esters: used mostly in commodity composite applications, for example, automotive, marine, and electrical applications.

Polyimides: used for high-temperature aerospace applications.
Phenolics: used almost exclusively because of their flame-retardant properties, for example, in the aircraft industry.

Polyurethanes: used for their in-situ moldability, high weathering stability (aliphatics).

Bismaleimides: provide outstanding performance in composites such as high temperature performance, high glass transition temperature (Tg), excellent retention of mechanical properties up to 250 °C and performance in hot or wet conditions.

EPOXY COMPOSITES

Common epoxy matrix resins are based on diglycidyl ether of bisphenol A (DGEBA), which contains two epoxy groups, one at each end of the molecule. They are low-molecular-weight liquids. Typically, amines are used to cure the epoxy resins, after which a three-dimensional network is achieved.

DIAMINES

Evonik is one of the leading suppliers of high-performance crosslinkers to the composite industry. Evonik crosslinkers play an important role in a majority of advanced composite applications.

VESTAMIN® IPD, a cycloaliphatic diamine, is regarded as the industry standard for crosslinkers and is formulated for epoxy composite systems. The cycloaliphatic structure and medium reactive amino groups offer the following advantages:

- Good processability of the liquid matrix system
- High-performance composites with high glass transition temperatures
- High mechanical strength
- Improved mechanical properties
- Good temperature performance
- Resistance to impact stress
- Moisture and hot-water resistance
- Good chemical resistance

Typical applications are fiber-reinforced composites for rotor blades, pipes, leaf springs, pump cases, high-performance boats, light airplanes, sporting goods, printed circuit boards, automotive parts, construction profils, and housings for office machines.

VESTAMIN® PACM, also a cycloaliphatic diamine, shows a similar behavior as VESTAMIN® IPD in epoxy composites regarding the mechanical properties. An additional advantage is it's lower exothermic behavior during curing as well as the lower water uptake of PACM based epoxy matrix systems when exposed to water.

VESTAMIN® TMD, an aliphatic diamine, provides higher impact resistance to composites due to it's linear structure. It's high reactivity makes it suitable for ultra fast cured epoxy composites.

The VESTAMIN® product group comprises the following amines

PRODUCT	DELIVERY FORM	CHARACTERISTICS	APPLICATION
VESTAMIN® IPD	Liquid, 100%	Isophorone diamine, cycloaliphatic diamine	Hardener component for epoxy resins for rotor blades, pipes, leaf springs, pump cases, high-performance boats, sporting goods
VESTAMIN® PACM	Liquid, 100%	4,4'-Diaminodicyclohexylmethane, cycloaliphatic diamine	Hardener component for epoxy resins for composites
VESTAMIN® TMD	Liquid, 100%	Trimethyl hexamethylene diamine, aliphatic diamine	Fast curing hardener component for epoxy resins for composites

REACTIVE RESIN MODIFIERS

NANOPOX®

Evonik is the leading manufacturer of surface modified silica nanoparticles in epoxy resins. Using nanosilica several important properties of fiber reinforced composites can be improved:

- Significantly improved modulus and flexural strength
- Drastically improved fatigue performance
- Increased toughness
- Improved surface quality (reduced print through)
- Reduced microcrack formation

The nanoparticles are chemically synthesized from aqueous sodium silicate solution. In this unique process the epoxy matrix resin is not altered, in contrast to processes in which powdered fillers are dispersed with dissolvers or other equipment using high shear energy.

These products are concentrates and, for most composite applications, are diluted with standard epoxy resins. Typical nanosilica levels in, e.g., VARTM resin systems are 10 percent.

The NANOPOX® products are suitable for all hardeners and all manufacturing processes. As the silica nanoparticles do not sediment, even solvent-based prepregging does not pose a problem.

Due to their small size and the absence of any larger aggregates, the nanoparticles can easily penetrate all fiber structures without compromising the impregnation by excessive viscosity, thereby enabling all the state-of-the-art process technologies like resin infusion, RTM, or resin injection. In addition to significantly improved mechanical properties (modulus, fracture toughness), the thermal expansion, shrinkage and electrical properties can also be improved.

15 % nanosilica

4 % nanosilica – TEM-Pictures of GFRCs with different levels of SiO_2-nano-particles (based on NANOPOX® F 400)

The standard grades of the NANOPOX® product group

PRODUCT	BASE RESIN	EEW [G/EQUIV]	DYN. VISCOSITY, 25 °C [MPA·S]	CHARACTERIZATION
NANOPOX® F 400	DGEBA	295	60,000	Special for glass, aramide and carbon fibers; 40% SiO_2-nanoparticles
NANOPOX® F 520	DGEBF	275	20,000	Low viscous; 40% SiO_2-nanoparticles
NANOPOX® F 631	EEC	220	5,500	Cycloaliphatic formulations; 40% SiO_2-nanoparticles
NANOPOX® F 700	epoxidized novolac	310	20,000 (at 50 °C)	High performance novolac, high Tg

ALBIPOX®

Epoxy resins have a substantial disadvantage: their brittleness. This disadvantage can be more than compensated by an elastomer modification (so-called "toughening" or impact resistance modification). In contrast to an elastification, the elongation at break of the cured modified resin normally remains under 10 percent.

The toughening of epoxy resins proves to be difficult, however. Thus, for example, the use of flexible hardeners or the addition of non-reactive flexibilizers significantly impairs a number of important properties such as tensile strength and modulus, thermal and chemical resistance as well as thermodimensional stability.

These negative effects can be avoided by toughening with copolymers based on reactive elastomers. However, the pure liquid elastomers are only slightly miscible with epoxy resins, if at all.

The different ALBIPOX® grades are reaction products between epoxy resins and an elastomeric copolymer. Hereby, an epoxy resin is reacted with an excess amount of the reactive liquid elastomer. After the reaction, the elastomer molecules are epoxy functional and will be chemically bonded to the resin matrix during curing.

ALBIPOX® products can be used by epoxy resin formulators like a modular system. There are no limitations in respect to the resins and hardeners that can be used. Typical addition levels are 25–40 percent.

As a synergy exists between the modification with NBR and nanosilica, several products contain both modifications.

An additional advantage is the improved processability of the modified laminates, thereby avoiding splintering on mechanical finishing. The shrinkage is also reduced, as the rubber domains formed upon cure can absorb the internal stresses arising during curing.

The standard grades of the ALBIPOX® product group

PRODUCT	BASE RESIN	EEW [G/EQUIV]	DYN. VISCOSITY, 25 °C [MPA·S]	CHARACTERIZATION
ALBIPOX® 1000	DGEBA	330	200,000	Standard type, 40% NBR
ALBIPOX® 3001	DGEBA/DGEBF	215	22,000	Application-ready resin
ALBIPOX® 8001	DGEBA	210	400,000; 4,000 (at 80 °C)	Extremely efficient tackifier (addition level 3–5 %)
ALBIPOX® F 080	DGEBA/DGEBF	330	70,000	Contains NBR*) and nanoparticles
ALBIPOX® F 081	DGEBA/DGEBF	260	35,000	Contains NBR*) and nanoparticles
ALBIPOX® F 091	DGEBA/DGEBF	220	15,000	Contains NBR*) and nanoparticles

ALBIDUR®

One of the drawbacks of rubber toughening is the increase in viscosity, which cannot be tolerated in some injection methods. By using core shell elastomers as tougheners, the viscosity increase becomes minimal.

ALBIDUR® products consist of a reactive resin in which silicone elastomer particles of a defined size (0.1–3 µm) are finely distributed. The silicone elastomer particles have an organic shell structure comprising reactive groups. The toughening mechanism is the same as for reactive liquid rubbers; however, the rubber domains are already preformed and not built during the curing process.

The typical addition levels are 10 percent and result in a substantially improved toughness over a very broad temperature range, reduced shrink and no or minimal loss of modulus and Tg.

In contrast to the ALBIPOX® products, unsaturated polyester resins and vinyl ester resins can also be modified with ALBIDUR® based on such resins. Please refer to the separate ALBIDUR® brochure.

ALBIDUR® for epoxy resins

PRODUCT	BASE RESIN	EEW [G/EQUIV]	DYN. VISCOSITY, 25 °C [MPA·S]
ALBIDUR® EP 2240 A	DGEBA	300	35,000

PROCESS ADDITIVES FOR EPOXY RESINS, VINYL ESTER RESINS AND UNSATURATED POLYESTER RESINS

TEGOPREN®, TEGOMER®, TEGO® ANTIFOAM

PROPERTY AND PROCESSING IMPROVEMENTS

By using small amounts of these additives in thermosetting resin formulations (typically 0.1 – 0.8 %) the manufacturing process of fiber-reinforced composites can be made easier. If such an additive is used as internal release agent, demolding even without using an external mold release agent is no problem anymore. Surface properties like scratch resistance can be increased significantly. The use of defoamers reduces the amount of bubbles or pores in a fiber-reinforced composite, which consequently exhibits better mechanical performance.

Technical data[1]

PRODUCT NAME	CHEMICAL COMPOSITION	CHARACTERIZATION
TEGOMER® DA 626	Polymeric structure	dispersing agent, defoamer
TEGO® Antifoam D 2340, TEGO® Antifoam D 2345	Polymer solution	defoamer
TEGOPREN® 6875	Alkyl-modified siloxane	dispersing agent, improved scratch resistance
TEGOMER® M-SI 2650	Organo-modified siloxane containing non-reactive aromatic groups	internal release agent, dispersing agent

[1] no specification

INTERNAL RELEASE AGENT

Especially in fast manufacturing processes like VARTM efficient demolding is necessary. Time and cost-intensive external mold release agents cannot be used. Therefore internal release agents are part of the epoxy resin formulation. They offer several advantages:

- fast demolding of the composite part
- superior surface appearance of the composite part
- no negative effects on paintability of the composite part
- no negative effects on processability of the epoxy resin

Internal release agent

RESIN	FIRST RECOMMENDATION	SECOND RECOMMENDATION
Standard epoxy resins	0.1 – 0.2 % TEGOMER® M-Si 2650	
Standard UP resins	0.1 – 0.2 % TEGOMER® M-Si 2650	0.1 – 0.2 % TEGOPREN® 6875

DEFOAMERS

Air trapping and bubble formation can be a nasty problem in several composite manufacturing processes like pultrusion or RTM processes.

Defoamers

RESIN/HARDENER	FIRST RECOMMENDATION	SECOND RECOMMENDATION
Epoxy, anhydride cure	0.2 – 0.8 % TEGOMER® DA 626	0.5 – 1 % TEGO® Antifoam D 2340
Epoxy, amine cure	0.4 – 1 % TEGOMER® DA 626	0.5 – 1 % TEGO® Antifoam D 2340
UP resin, BPO or MEKP cured	0.3 – 0.8 % TEGO® Antifoam D 2345	0.1 – 0.2 % TEGOPREN® 6875

SCRATCH RESISTANCE

Just think about public transportation – and the scratch resistance of panels made from SMC becomes an imminent issue. The figure shows the possible improvements. Low addition levels of 0.3 – 0.6 % can already yield significant improvements. For the modification of unsaturated polyester resins based on orthophthalic acid we recommend these products:

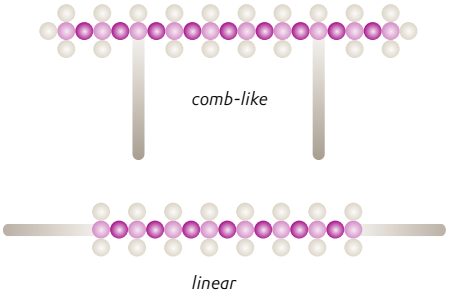
Scratch resistance

CURING AGENT	RECOMMENDATION
Methylethylketone peroxide (MEKP)	TEGOMER® M-Si 2650 TEGOPREN® 6875
Dibenzoyl peroxide (BPO)	TEGOPREN® 6875

[1] no specification

Scratch resistance of cured unsaturated polyester with 0.4 % TEGOMER® M-Si 2650 / without additive

Schematic illustration of the structure of an OMS and its interaction with a polymer

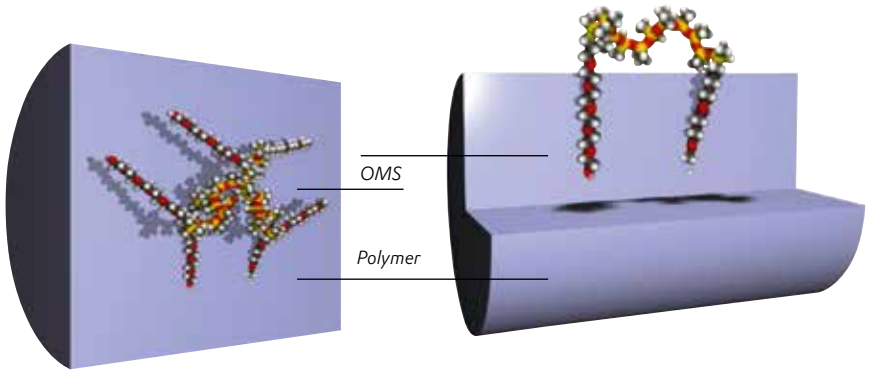


Methylgroup
Silicon
Oxygen

Organic Substituents

- *Alkyl*
- *Epoxide*
- *Hydroxy*
- *Amino*
- *Carboxyl*
- *Acrylate*

HOW IT WORKS Organo-modified siloxanes (OMS) consist of a siloxane backbone with attached organic groups. The organic groups ensure a permanent functionalization of the polymer without bleeding of the OMS. Different molecular architectures of OMS derivatives are available. The figure at the left shows the comb-like as well as the linear structure of the OMS together with the possible functional groups. By varying the density and nature of the attached organic groups the OMS called TEGOMER® or TEGOPREN® are tailor-made products to the final application. The figure below shows the functionalization of a polymer matrix with OMS. These derivatives can either work for bulk modification (case A) or for surface modification (case B).



EPOXY CURING AGENTS

Evonik is the leading supplier of high-performance epoxy curing agents to advance composite manufacturing and adhesive bonding of composites.

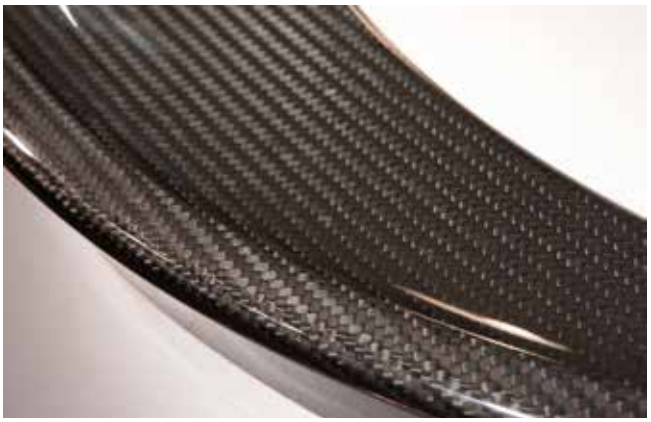
The portfolio contains a full range of high quality amine hardeners, catalysts and accelerators for a wide range of applications, including infusion technologies, filament winding and prepreg applications.

Ancamine® curing agents are mostly cycloaliphatic amines used across many different composite applications, including filament winding and pipe rehabilitation applications. Modified amines are also employed as anhydride and epoxy accelerators in heat curing.

Ancamide® curing agents can be divided into two major classes: amidoamines and polyamides. Amidoamines are known for low viscosity, excellent fiber wet-out and long pot life. They are recommended for wet lay-up laminating and filament winding applications. Polyamides are known for low toxicity, very good adhesion to multiple substrates and good flexibility. Evonik offers a range of polyamides and adducts that include standard grades as well as grades that do not require an induction time, improved chemical resistance, lower viscosity and faster cure speed.

Amicure® and Dicyanex® products are Dicyandiamide (DICY) catalysts and substituted ureas for one component heat cure high-performance composites and adhesives.

Imicure® products are imidazoles which are tailor-made to accelerate anhydride and amine curing epoxy resins. They offer a broad range of latency, rapid cure beyond activation temperatures as well as high thermal and chemical resistance in prepreg applications and bonding of composites.



Top Recommendations

TECHNOLOGY	Curing Agent	BENEFITS: Low mix viscosity	Long pot life/ Latency @ 25 °C	Low exotherm	Low temp through-cure	Temperature resistance High Tg	Chemical resistance	Mechanical performance ILSS retention	Lap Shear & T-peer	Toughness / Flexibility/ Thermoshock	COMPOSITES PROCESSING ROUTES/ APPLICATIONS: Filament Winding	RTM / Infusion	Casting	Prepreg	Pultrusion	Wet/Hand Lay-up	Pipe Rehabilitation / CIPP	Adhesive Bonding of Composites
Cycloaliphatic	Ancamine® 2450*	●	○			●●	●●	●			●	○	○					●
	Ancamine® 2913*	●	●●	●●	●●		●	○		●			●	●			●	
Amidoamine	Ancamide® 506	●●	●●	●●	●●	●		●	●	●	●					○		
	Ancamide® 502	●●	●	●●	●●			●		●	●					○		
	Ancamide® 2798	●●	●●	●●	●●					●			●				●	
Polyamide	Ancamide® 351A			●●	●●				●	●								●
	Ancamide® 3030	●	●●						●	●		○		●				●●
	Ancamide® 910			●●	●●				●●	●●								●
Anhydride Acc	Ancamine® 2908A*		●●	●●							●		●		●			
Dicyandiamide	Amicure® 1200G**													●				●
	Dicyanex® 1400B**													●				●
	Amicure® UR2T		●●							●				●				●
Imidazoles	Imicure® EMI24					●●								●				●
	Imicure® AMI1					●●								●				●
Accelerators for heat cure	Ancamine® 2014 AS/FG		●●						●●					●				●●
	Ancamine® K 54		●●		●●	●								●				

* not commercially available in EMEA

** Benefits depending on formulations

●● excellent

● highly recommended

○ recommended

VISIOMER® METHACRYLATE ENVIRONMENTALLY FRIENDLY SOLUTIONS FOR FULL OR PARTIAL SUBSTITUTION OF STYRENE IN COMPOSITE RESINS

There has recently been growing concern in the composites industry about the use of styrene in unsaturated polyester resins (UPR) and vinyl ester (VE) formulations. Reduction of styrene in applications like open mold and hand lay-up processing, where workers are exposed to styrene vapors, is an area of interest for many companies.

Evonik offers a wide range of low-volatile and low-odor methacrylate monomers for full or partial substitution of styrene in composite resins. Our methacrylate-based crosslinkers, such as VISIOMER® 1,4-BDDMA, are well known for creating low-odor and styrene-free resins with improved mechanical properties. They can be used alone or in combination with other monofunctional methacrylate monomers such as VISIOMER® Terra IBOMA and c-HMA. The combination of different VISIOMER Methacrylates allows creation of various styrene-free solutions with different mechanical properties, such as flexural strength and UV resistance. Evonik's specialists can support you in optimizing your resin systems to attain the required mechanical properties.

The recently developed VISIOMER® GLYFOMA offers the possibility of creating low-odor and styrene-free vinyl ester based resins. VISIOMER® GLYFOMA is partially bio-based and has practically no odor; it is therefore highly recommended for applications in which reactive resins are handled in an open atmosphere.

The VISIOMER® product group comprises the following methacrylates

MONOMER GROUP	VISIOMER®	APPLICATION AND PROPERTIES
Crosslinkers	1,3-BDDMA 1,4-BDDMA 1,6-HDDMA EGDMA TRGDMA PEG200DMA TMPTMA	Enhance mechancial properties of composite resins
Alkyl/aryl methacrylates	IBOA, Terra IBOMA, BNMA, c-HMA	Provide good solubility for UP and VE resins
Special methacrylates	GLYFOMA	Low odor and potentially label free

BISMALEIMIDES COMPIMIDE®

High performance materials helping you to meet your future requirements for advanced composites today

The COMPIMIDE® bismaleimide resin family represents a full range of proprietary thermosetting resins and specialties that have been developed for the production of high-performance composites, adhesives, and moldings.

Evonik offers more than 40 years of experience in bismaleimide resins. Our products are certified and referenced throughout the industry. COMPIMIDE® bismaleimide matrix resins are characterized by their high glass transition temperature (Tg). They offer improved high temperature performance over epoxies and cyanate esters. Other outstanding features are:

- Easy processing by autoclave, platen press, and compression molding techniques
- Retention of excellent mechanical properties up to 250 °C
- Good solvent resistance
- Excellent performance in hot and wet conditions
- Superior flame and radiation resistance, low smoke and toxicant emissions

The COMPIMIDE® BMI product group offers the most complete portfolio of bismaleimide products in the market:

- Monomers
- Co-monomers
- Pre-formulated resin blends
- Resin solutions
- RTM resins

Applications

COMPIMIDE® thermosetting BMI resins and formulations have been developed for the use in all relevant processing techniques

- Prepregging
- Resin Transfer Molding (RTM)
- Vacuum Assisted Resin Infusion (VARI)
- Filament Winding (FW)
- Compression Molding
- And many more

MONOMERS	CO-MONOMERS	PREFORMULATED RESINS	RESIN SOLUTIONS	RTM RESINS*
COMPIMIDE® MDAB 4,4'-bismaleimido-diphenyl- methane; CAS 13676-54-5	**COMPIMIDE® TM124** o,o'-diallylbisphenol-A; CAS 1745-89-7	**COMPIMIDE® 353 A** Eutectic mixture of bismaleimide monomers	**COMPIMIDE® 1206R55** Formulated resin solution	**COMPIMIDE® 353RTM-ST** Formulated resin blend
COMPIMIDE® TDAB 2,4-bismaleimido-toluene; CAS 6422-83-9	**COMPIMIDE® TM124-Ether** 2,2'-bis[4-allyloxyphenyl] propane; CAS 3739-67-1	**COMPIMIDE® 796** Eutectic mixture of bismaleimide monomers	**COMPIMIDE® 1224 L60** Formulated resin solution	**COMPIMIDE® 353RTM-HT** Formulated resin blend
COMPIMIDE® MXBI m-xylylenebismaleimide; CAS 13676-53-4	**COMPIMIDE® TM123** 4,4'-bis[o-propenylphenoxy]benzophenone; CAS 109423-33-8	**COMPIMIDE® 50LM** Low melting eutectic mixture of bismaleimide monomers		**COMPIMIDE® 50L-RTM** Formulated resin blend
COMPIMIDE® MAHD 1,6-bismaleimidohexane; CAS 4856-87-5				

* One-pot melt blends for liquid resin processing including RTM, VARTM, resin infusion, etc.

EPOXY AND PU RESIN FORMULATIONS FOR AUTOMOTIVE LIGHTWEIGHT SOLUTIONS

VESTALITE®

VESTALITE® products are tailor-made solutions for high performance composite parts based on epoxies and polyurethanes.

VESTALITE® products allow for cost-efficient and fast processing for high performance composite parts which makes them particularly suitable for next generation automotive composite applications.

VESTALITE® products are supported by VESTARO to bring next generation composites onto the road with you. VESTARO combines Evonik's chemistry with automotive engineering.

VESTALITE® P

VESTALITE® P resin formulations yield non-toxic, reversibly shapeable prepregs for fast and automated prepreg compression molding with low investment costs.

VESTALITE® P is a matrix system for prepregs based on aliphatic diisocyanates VESTANAT® IPDI. Its unique properties make VESTALITE® P suitable for large scale automated manufacturing. Due to Evonik's blocking-agent free uretdione chemistry the prepreg resins exhibit long shelf life at ambient conditions, manufacturing of form stable pre-forms and easy handling with robots.

VESTALITE® P 312 POLYURETHANE RESIN FORMULATION WITH EXCELLENT SURFACE QUALITIES

The resin allows for excellent surface qualities including high UV stability and ductility. Due to low reaction heat upon curing even thick parts can be cured within 5 – 10 min at 140 – 150°C.

Applications
- Exterior panels
- Exposed interior parts
- Leaf springs

Benefits
- Potential reduction of painting costs
- Outstanding toughness and flexibility
- Low exothermic curing reaction

VESTALITE® P 342 POLYURETHANE RESIN FORMULATION FOR METAL COMPOSITE HYBRID PARTS

The combination of conventional steel and aluminum grades with composite materials allows for a material- and cost-efficient light-weight approach. Since the resin exhibits excellent metal adhesion no additional primer or adhesive is needed.

Applications
- Body components
- Structural parts
- Part derivatization

Benefits
- Metal reinforcement without adhesive application
- Fast cycle times by controlled pre-curing
- High energy absorption

VESTALITE® S

VESTALITE® S curing agent offers a styrene free, high performance SMC material when combined with a liquid epoxy resin.

VESTALITE® S is a curing agent for sheet molding compounds based on Evonik's diamine chemistry. Its unique properties make VESTALITE® S suitable for large scale automated manufacturing. Due to Evonik's diamine chemistry the resulting epoxy system exhibits a low initial viscosity, storage stability, fast curing and best in class mechanical performance. Due to the EP chemistry VESTALITE® S based SMC have lowest VOCs and no styrene emissions.

Applications
- Semi-structural parts
- Supporting structures
- Exterior / Interior parts

Benefits
- Low initial viscosity for high fiber volumes and excellent fiber wetting
- High storage stability (> 30 days) of intermediate SMC
- Excellent mold flow combined with fast curing (3 min at 150°C)
- Best in class mechanical performance
- Low VOCs and no styrene emissions

POLYURETHANE COMPOSITES

Evonik is one of the leading suppliers of high-performance crosslinkers to the composite industry. Evonik provides colorless and UV stable isocyanates as hardeners for polyurethane systems.

Polyurethanes are based on polydiols and diisocyanates. Common polyols are polyethers and polyesters which differ in their chemical backbone, functionality, molecular weight and viscosity.

Evoniks portfolio contains monomeric diisocyanates as well as polyisocyanates (isocyanurates) based on isophorone diisocyanate or hexamethylene diisocyanate.

These products are used for applications such as composites, gel coats, coatings, adhesives and elastomers. VESTANAT® T 1890/100 is the isocyanurate of isophorone diisocyanate. It is solid at room temperature. It is typically blended with liquid isocyanurates for easy processing.

The cycloaliphatic structure of VESTANAT® T 1890/100 provides

- easy processing of liquid matrix systems
- high glass transition temperatures
- excellent mechanical properties
- extremely short cycle times
- light and weathering stability
- good chemical resistance

The combination with HDI based polyisocyanates provides both high mechanical strength and excellent toughness.

VESTANAT® HT 2500/100 is an isocyanurate based on hexamethylene diisocyanate. In comparison to VESTANAT® T1890/100 the product is a liquid. Due to its aliphatic character it provides high weathering resistance, light stability and flexibility. VESTANAT® HT 2500/LV is the low viscosity version of VESTANAT® HT 2500/100.

VESTANAT® HT 2500/LV and HT 2500/100 are optimal to be blended with T 1890/100 for easy processing.

Furthermore, Evonik offers VESTANAT® EP-T 2354, a modified grade combining easy processing with high Tg and excellent mechanical properties.

VESTANAT® Crosslinkers for composites, coatings, adhesives and elastomers

PRODUCT	PHYSICAL FORM	VISCOSITY	CHARACTERISTICS	BENEFITS
VESTANAT® T 1890/100	pellets, 100%	–	Polyisocyanate based on isophorone diisocyanate	Crosslinker for high Tg (>100°C)
VESTANAT® HT 2500/100	liquid, 100%	3000 mPa s (at 23 °C)	Polyisocyanate based on hexamethylene diisocyanate	Liquid crosslinker for high flexibility
VESTANAT® HT 2500/LV	liquid, 100%	1200 mPa s (at 23 °C)	Polyisocyanate based on hexamethylene diisocyanate	Crosslinker with improved viscosity for high flexibility
VESTANAT® EP-T 2354	highly viscous, 100%	1200 mPa s (at 60 °C)	Modified polyisocyanate	Crosslinker for high Tg and easy processing

THERMOPLASTICS

COMPOSITES WITH THERMOPLASTIC MATRIX

Matrices for composites have so far been mainly thermoset matrices used in established processes that draw on many years of experience. Used with the same reinforcing fibers, thermoplastic matrices allow significantly shorter cycle times in component production, can be stored indefinitely at room temperature, absorb less water (depending on the matrix), and are particularly suitable for medium- and large-scale production. Also particularly noteworthy are the simpler bonding technique (fusion) and the significantly higher continuous working temperatures (up to 200 °C, depending on the polymer) and impact tolerance of components with a thermoplastic matrix.

In VESTAKEEP® (PEEK) and VESTAMID® L (PA12), Evonik offers thermoplastic polymers that have proven their worth as matrices and can be selected for different requirements in regard to continuous working temperature and mechanical properties. Prepregs (preimpregnated reinforcing materials) in the form of coated woven fabrics and unidirectional tapes are sheet products produced using Evonik matrices. These polymers are available as granules, powders of various particle size distribution, and films for further processing by melt impregnation, powder coating, or suspension impregnation, and even for the film stacking process.

In addition, Evonik offers unidirectional (UD) tapes branded VESTAPE®.

THERMOPLASTIC MATRICES
POLYETHERETHERKETONE
VESTAKEEP®

VESTAKEEP®, the PEEK from Evonik as a matrix for thermoplastic composites

Evonik, which has been producing high performance polymers for more than 50 years, is known for its powder technology expertise in development, production, application, and customer service. VESTAKEEP® molding compounds and powders are particularly suitable for applications where extreme mechanical, thermal, and chemical requirements must be satisfied.

VESTAKEEP® is suitable as a matrix for unidirectional fiber layouts or woven fabrics of glass, carbon or aramid fibers, and thus makes it possible to produce fiber composite materials with a thermoplastic matrix. The thermoplastic fiber composite materials are produced by a powder-coating or dispersion-coating process. Evonik has developed optimized powders suited specifically to these processes, thus confirming its eligibility for production of composites. Its VESTAKEEP® 2000 powder line with different particle sizes is established as the ideal polymer for this application.

The semi-crystalline polymer features superior, thermal and chemical resistance.

- High Tg
- Self-extinguishing parts
- Very high heat deflection temperature
- High stiffness
- Low water absorption and therefore high dimensional stability
- Excellent chemical resistance
- Excellent hydrolytic stability
- Good processability
- No tendency to stress cracks

Our powder grades

VESTAKEEP®	POLYETHERETHERKETONE
2000 P 2000 FP 2000 UFP	Unreinforced, medium viscosity

P	Powder, 500 µm
FP	Fine powder, 55 µm
UFP	Ultra fine powder, 20 µm

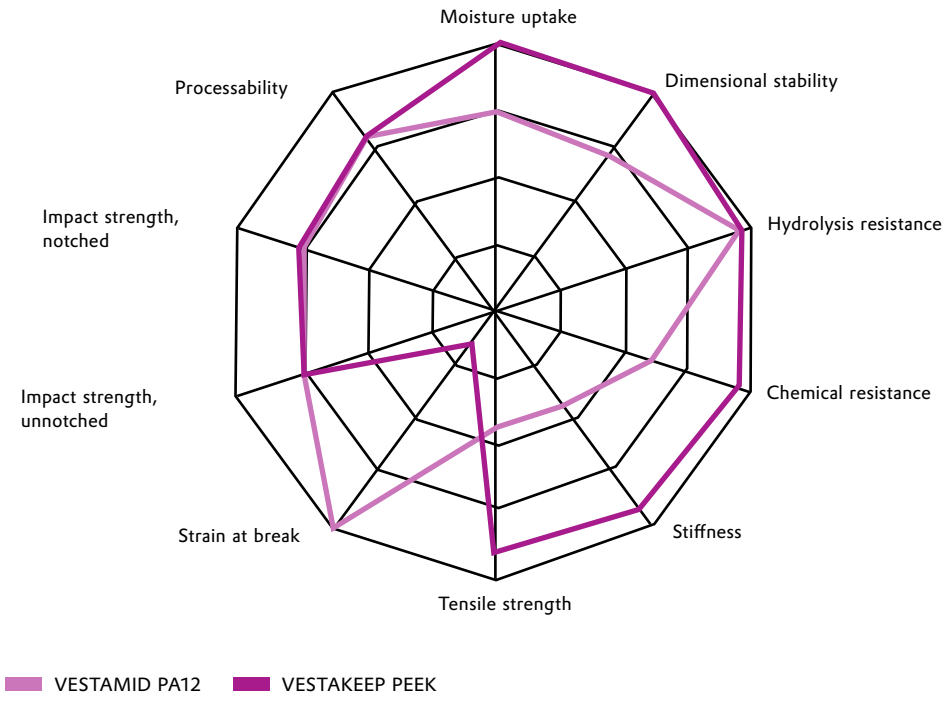
POLYAMIDE VESTAMID® L

VESTAMID® L (PA12) has been used as a matrix for many years in composites. So far, it has been used in automotive, sports, and orthopedic applications as well as in the oil and gas industry. Composites with VESTAMID® L as the matrix are processable at a lower temperature. Compared to high temperature-resistant matrices such as PEEK, PPA, and PPS, this presents an advantage, thus significantly shortening cycle times for mass-production.

Further general properties:

- Low weight
- High impact resistance
- High elongation and high abrasion resistance, even at low temperatures
- Low water absorption
- Good electrical isolation and dielectric strength

Relative comparison of PA12 and PEEK recommended for composites



Properties of PA12 and PEEK matrix materials for UD tapes

PROPERTIES		UNIT	VESTAMID® PA12	VESTAKEEP® PEEK	TEST METHOD
Polymer		–	Polyamide 12	Polyetherether-ketone	–
Density	23°C	g/cm³	1.01	1.30	ISO 1183
Melting temperature DSC	2nd heating	°C	178	340	ISO 11357
Tensile test					ISO 527-1
Stress at yield		MPa	46	100	ISO 527-2
Strain at yield		%	5	5	ISO 527-2
Strain at break		%	>200	30	ISO 527-2
Tensile Modulus		MPa	1400	3700	ISO 527-1
CHARPY notched impact strength	23 °C	kJ/m²	5C[1]	6C[1]	ISO 179/1eA
CHARPY notched impact strength	-30°C	kJ/m²	4C[1]	6C[1]	ISO 179/1eA

C[1]: complete break

SPECIALTIES

THE DEGAPLAST® REACTIVE SYSTEM

Thanks to modern prosthetics, disabled people can scale mountains and break records at the Paralympic Games. In everyday life, too, prostheses provide high mobility and freedom of movement to the people who wear them, thanks to the perfect interaction of technology, electronics, and innovative materials.

Besides metals, plastics play an important role here, too, with DEGAPLAST® based lamination systems occupying a prominent position, particularly in the handcrafting industry. Despite mechanization, certain components such as shafts, which have to be adapted individually, still have to be customized by hand.

Like aircraft and automotive designers, prosthetists value the high strength of these resins, not to mention their low weight and dimensional stability, even at slight thicknesses. Another important fact fueling the popularity of these materials is the ease of care and maintenance of the end products, which perfectly fits in with today's increased demands on hygiene.

DEGAPLAST® is based on methyl methacrylate (MMA), solved polymethyl methacrylate (PMMA) and special modifiers. The cured parts are thermoplastic and will not become brittle.

DEGAPLAST® GH is a reactive resin for casting purposes. In the orthopedic technology, it is used for manufacturing softly adjusted shanks, protective sleeves, soft sockets, and a soft adjustment of other DEGAPLAST® resins.

DEGAPLAST® LH 80:20 works satisfactorily as the "number one laminating product for the orthopedic manufacturing industry". It is suitable with almost all common materials such as wood, leather and different kinds of canvas as well as DEGAPLAST® Resins. Producing inlays by casting, it can be adjusted with 20 percent (m/m) DEGAPLAST® GH for a higher flexibility. Special features are a short curing time, fast and safe impregnating of the filling fabric and a tack-free hardening. DEGAPLAST® LHC is a specially developed reactive resin for laminating carbon-fibers.

DEGAPLAST® SH is a reactive resin for sealing purposes. It is used for sealing virtually all porous materials.

High-grade materials enhance the functionality of the C-Leg from Otto Bock.

Thermoplastic UD tapes

Endless fiber-reinforced plastics offer a promising and innovative solution with high potential for lightweight construction.

Our composites of endless fiber reinforced plastics consist of carbon fibers and a matrix made of high performance polymers. In a UD tape, the properties of both materials combine ideally to create innovative construction materials for new paths in component design.

Several layers of UD tapes in a laminate form "organosheets," which significantly outperform the mechanical properties of metal sheets of the same thickness. Organosheets can be thermoformed and, therefore, adopt a variety of component geometries. They also offer the opportunity of integrating additional functions or components, as the parts can be overmolded with a fiber-reinforced compound. Naturally, using the same polymer class as for the matrix in the UD tape ensures a good connection between the two components, which is essential for dynamic load conditions.

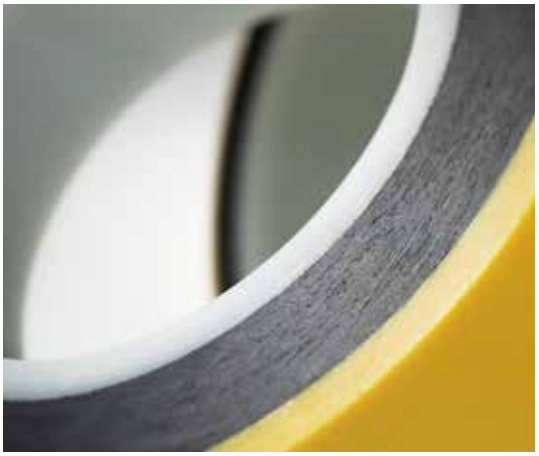
VESTAPE®

The matrix of VESTAPE® UD tapes is made from specially developed high-performance polymers with, e.g., a high glass transition temperature and therefore features good heat resistance. It is customized to high-strength endless fibers and allows production of parts that can be used even in areas exposed to extreme temperatures. Evonik is one of the leading suppliers of high performance thermoplastic resins such as specialty polyamides for use under adverse environmental conditions and polyetheretherketones (PEEK).

APPLICATIONS

Oil and gas industry

VESTAPE® is the material of choice for the production of hybrid liners for the oil recovery from deep sea oilfields. Hybrid liners or full TCPs (Thermoplastic Composite Pipes) replace heavy steel solutions and allow for reaching deeper oilfields than before. The lightweight construction of the extruded polymer in combination with winded UD tapes offers weight savings up to 60% compared to conventional solutions.



AIRCRAFT

Large aircraft manufacturers are using more and more thermoplastic composites to reach the lightweight design targets which are substantial to keep competitive. VESTAPE® composites with a PEEK matrix are best suited for applications where extreme mechanical, thermal and chemical requirements must be satisfied. Their mechanical properties stay unchanged over a wide range of service temperature.

VESTAPE® production line

Properties of UD tapes with PA12 and PEEK matrices

	UNIT	VESTAPE® PA12-CF45 10141	VESTAPE® PEEK-CF45 24241	TEST METHOD
TAPE PROPERTIES				
Polymer	–	polyamide 12	PEEK	–
Fiber	–	HT carbon fiber	HT carbon fiber	–
Fiber volume fraction	% by vol.	45	45	EN 2559
Fiber weight fraction	% by weight	59	53	EN 2559
Tape areal weight	g/m^2	343	381	
Tape density	g/cm^3	1.36	1.51	ISO 1183
Tape thickness	mm	0.25	0.25	–
Tape width	mm	150	150	–
LAMINATE PROPERTIES				
Tensile modulus (0°)	GPa	100	106	ISO 527
Tensile strength (0°)	MPa	1850	1850	ISO 527
In plane shear modulus G12	GPa	1.4	approx. 345	ISO 14129
In plane shear strength τ12M	MPa	30	approx. 145	ISO 14129
PROCESSING PROPERTIES				
Melt temperature	°C	approx. 176	370–410	ISO 11357
Glass transition temperature	°C	approx. 45		ISO 11357
Typical processing temperature	°C	210–240		

Structural foams

ROHACELL®, a polymethacrylimide-based structural foam, has been used in the composites industry for almost 50 years.

Unique performance:

- Low weight
- Excellent mechanical properties and stability over a wide temperature range, even at low densities
- High temperature resistance up to 210 °C in pressure-free post-cure processes
- Unique compressive creep behavior for processing up to 190 °C and 0.7 MPa
- Excellent dynamic strength
- Cell sizes customizable to a variety of processing methods
- Featuring closed cells, ROHACELL® is manufactured without CFC or heavy metals

ROHACELL® is used as a structural core in component designs. Its natural stiffness can also be useful for braiding, winding, and preforming processing. To construct a complex integral sandwich design, producers can use ROHACELL® as a means of ensuring an efficient and stable process.

ROHACELL® can be shaped easily on common CNC-machines or thermoformed within minutes without special outgassing or surface preparation.

It can also be foamed directly inside a mold to create complex geometric parts for high volume serial production. Because of its high thermal and creep resistance, it can be cured at elevated temperatures in almost no time at all. No other core material offers such easy and fast curing for autoclave, resin infusion, or press molding processes.

The right product for your success

PRODUCT GRADE	APPLICATION INDUSTRY	CELL SIZE	CURING TEMPERATURE	SPECIAL PROPERTIES
A	Aircraft	Coarse	≤130 °C	Low temperature curing/ standard aircraft grade
HERO	Aircraft	Medium	≤180 °C	Highest elongation at break/ damage tolerance
RIST-HT	Aircraft	Medium	≤180 °C	Designed for resin infusion/ small cells
RIMA*	Aircraft Sport	Fine	*≤180 °C	Designed for resin infusion/ smallest cells
XT*	Aircraft	Coarse	*≤190 °C	Highest temperature resistance/ usable with BMI resins
WF*	Aircraft Radomes	Coarse	*≤180 °C	Most frequently qualified aircraft grade
S	Aircraft Railway Shipbuilding	Coarse	≤130 °C	Good fire behavior for railcars/ ships/small aircraft (no OSU)
EC*	Aircraft Electronics	Medium	*≤180 °C	Electrically conductive/designed for UAVs and other stealth applications
HF	Radomes Medical	Fine	≤130 °C	High frequency transparency/ designed for radome and medical x-ray table applications
SL*	Sport Automotive	Medium	*≤180 °C	Increased elongation at break
IG-F	Automotive Medical Sport Electronics	Medium	≤130 °C	Standard grade for non-qualified applications
WIND-F	Wind	Medium	≤130 °C	High volume/low weight performance foam

* 180 °C only with HT version

The ROHACELL® product range offers process temperatures up to 190 °C across a full line of grades. Customers can choose from products with various cell sizes and densities – from 32 to 200 kg/m^2 – making it possible for their specific mechanical and weight targets to be met.

BUILD SANDWICH COMPONENTS THAT ARE LIGHTWEIGHT, YET HIGHLY DURABLE.

EXPLORING SANDWICH CONSTRUCTION

A lightweight core of polymeric foam can be sandwiched between two skins of fiber composite, sheet metal, or film to create structural components that deliver superior mechanical performance at a very low weight.

The core lends the skins their shape, spacing them apart from each other evenly. Because of the space between the skins, the core significantly increases the rigidity of the composite: the greater the space, the better the rigidity. The weight of the core material is, however, significantly lower than that of the additional skins that would be necessary to achieve comparable rigidity in the absence of a core.

The core material must nevertheless be able to withstand high stresses. All impact must be transmitted from one skin to the other and the compressive forces fully absorbed.

Foams based on polymethacrylimide (PMI) have proven their worth, particularly at high processing temperatures and pressures. They are easily processed and offer considerable cost savings in the manufacture of the complete component.

Sandwich design

CONSTRUCTION CONCEPT	SKETCH	RIGIDITY	WEIGHT	LAYUP COST	ASSEMBLY COST
Full sandwich design		++	+	++	++
Skin sandwich		+	++	+	0
Profile reinforcement		+	+	0	+

ROHACELL®
Cover layer, e.g. CFRP

++ Very good
+ Good
0 Satisfactory

We are always ready to support our customers in their challenges to design optimal solutions for their applications. We work together with them to evaluate a number of options for incorporating ROHACELL® more efficiently in their sandwich designs.

FROM PROJECT DESIGNS TO PROTOTYPES AND MORE

At our Sandwich Technology Center (STC), we arrange prototype construction, small production runs and conduct sandwich core testing. Our experienced team is able to demonstrate the use of ROHACELL® in common curing techniques such as liquid composite molding and autoclaving. In addition, we provide samples to customers and offer hands-on training in handling and thermoforming ROHACELL®.

ENJOY THE ADVANTAGES OF READY-TO-USE FOAM CORES

Evonik offers a full range of ROHACELL® foam shaping services to provide convenient delivery of foam cores that are pre-shaped and ready for use in sandwich components.

Our professional shaping capabilities and experience with ROHACELL® enable customers to remove internal risks, lower overall lead time by eliminating dependence on shaping subcontractors, and reduce in-house shaping waste and inventory costs.

Design freedom is unlimited at Evonik's shaping facilities with a choice of shaping your foam cores using either CNC machining, thermoforming or thermoshaping.

FOAMS

LESS WEIGHT.
ADDED VALUE.

ROHACELL® for aeronautics:

- stable and reliable process
- short curing times
- co-curing
- no water damage
- more net load

ROHACELL® for automotive:

- high temperature resistance for short curing cycles
- lowest weight
- cataphoretic painting
- temperature stable
- fuel consumption savings
- stabilized crash elements

ROHACELL® for antennas and radomes:

- dielectric properties close to that of air
- high specific properties, but almost transparent
- tightest dimension tolerances for best antenna performance

ROHACELL® for medical technology:

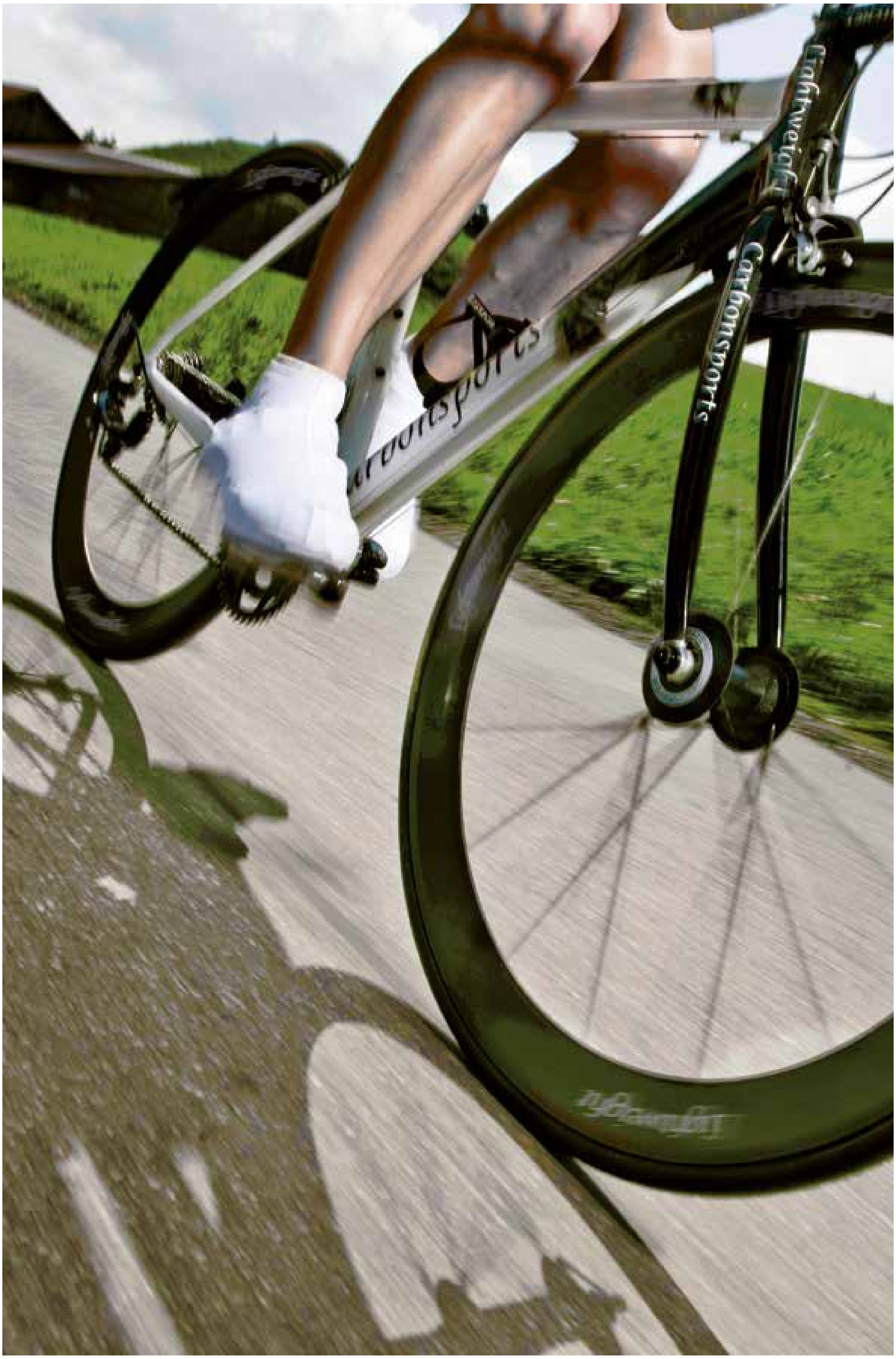
- stable and reliable process
- lightweight beds for easy handling
- low dielectric properties ensure high-quality X-rays and CT patient beds with minimal radiation exposure

ROHACELL® for sports and leisure:

- lightweight professional equipment with extreme durability
- highest specific properties
- design freedom

ROHACELL® for wind power:

- reduced blade mass and lower turbine loads
- shorter cycle times (pre-curing and post-curing)
- enables extended blade lifetime


Carbonsports

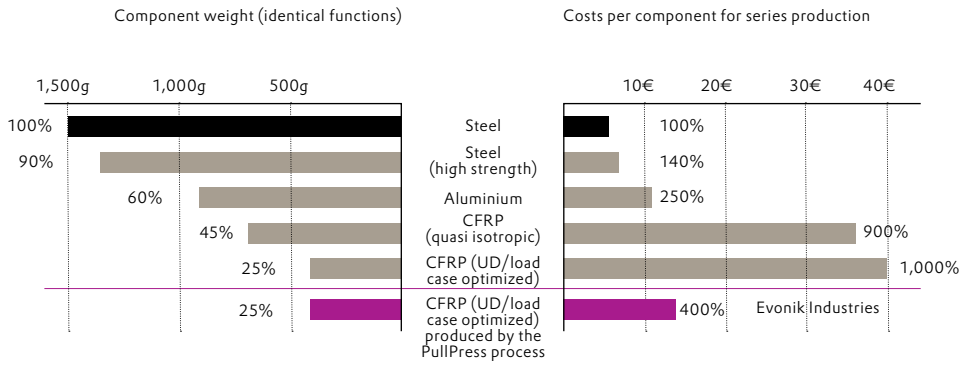
PULPRESS™ TECHNOLOGY WITH ROHACELL®

While interest in using composites to reduce vehicle weight and CO_2 emissions increases, established production methods are often too costly or too complex for mass production of components. PulPress™ technology provides manufacturers with a new tool in the replacement of heavy metal with lightweight composites – without paying a high price tag.

TECHNICAL AND ECONOMIC ADVANTAGES

PulPress™ uniquely combines both pultrusion and press processes. The resulting complex profiles produced can be used as structural components in the car body or as add-on parts that can even include integrated inserts. ROHACELL® foam core is the recommended core material for use in PulPress™ due to its glass transition temperature (Tg) of 180 °C, compatibility with quick resin curing processes and ability to be easily thermoformed.

This efficient process guarantees high production speed, tight tolerances and excellent mechanical properties of finished parts. Quick and continuous processing with almost no waste during part production means there is a significant reduction in the cost of manufacturing, up to 60% compared to a classic fiber-reinforced plastic (FRP) processes. Additionally, the finished weight of these fiber-reinforced parts are up to 75% less than typical structural steel parts of like performance.



IN-SITU FOAMED CORES FOR COMPLEX STRUCTURAL PARTS

Using innovative ROHACELL® Triple F, geometries that are complex to produce can now be foamed "in-situ" – directly inside a mold. Even geometries previously impossible with NC machining.

ROHACELL® Triple F foam core:

- In-situ foamed
- Complex geometries
- Integrated inserts
- High compression strength and temperature resistance at low density
- Compatible with fast curing processes
- Densities between 70 kg/m^3 and 200 kg/m^3 (4.4 lb/ft^3 and 12.5 lb/ft^3) can be customized to your needs.

The process conditions for final parts made with ROHACELL® Triple F are optimized for high volume serial production rates between 1,000 and 40,000 or more parts/year.

Coatings & gel coats

IN A VARIETY OF APPLICATIONS, SUCH AS YACHTS, PIPES, OR ROTOR BLADES FOR WIND TURBINES, THE COMPOSITE HAS TO BE PROTECTED AGAINST, FOR EXAMPLE, SUNLIGHT, HUMIDITY, AND ABRASION. IN SUCH CASES, OR FOR SURFACE REFINEMENT, COATINGS OR GEL COATS ARE USED.

POLYISOCYANATES VESTANAT®

Composite materials exhibit a limited weathering durability, which is attributable to the inherent properties of matrix systems used nowadays, such as epoxy or unsaturated polyesters. It is thus essential to use aliphatic, non-yellowing polyurethanes (PUR), either as a gel coat as coating or as inmold coating, for exterior applications like rotor blades, automotive composite parts, or yachts. With its

VESTANAT® polyisocyanates, Evonik offers a full range of crosslinkers for light-stable PUR coatings: HDI based polyisocyanates (VESTANAT® HT) as standard crosslinkers, whereas IPDI polyisocyanates (VESTANAT® T 1890) are used to optimize drying and chemical resistance. Special solutions for high-solids formulations are available.

VESTANAT® EP-M FAMILY

The properties of gel coats can further be improved by addition of Evoniks new VESTANAT® EPM family portfolio. These silane based crosslinkers enhance the scratch resistance of coatings significantly.

VESTAGON®

Next to its liquid polyisocyanates Evonik offers a full range of solid crosslinkers for thermosetting powder inmold coatings, which allows you to apply the coating on the mold in the process fully automated. The crosslinkers are also aliphatic and therefore show no yellowing.

DIAMINES VESTAMIN®

For applications where light stability is not required, epoxy resin systems are often used as gel coats. Furthermore they can be used as inmold coatings for automotive composite applications. Our products play an important role as crosslinkers in this regard (see product description on page 9).

VESTANAT® and VESTAGON® products for composite coatings

PRODUCT	DELIVERY FORM	CHARACTERISTICS	APPLICATIONS
VESTANAT® HT 2500	Solvent-free, various solution grades	Aliphatic polyisocyanate based on HDI-isocyanurate	Branched crosslinker, with low viscosity and low monomer content
VESTANAT® T 1890	Various solution grades	Cycloaliphatic polyisocyanate	Branched, high TG crosslinker to impart drying properties and chemical resistance
VESTANAT® EP-M 95	Solvent-free	Silane functional crosslinker for curing at elevated temperatures (requires a catalyst such as VESTANAT® EP-CAT 11 B)	Scratch resistance “booster” for stoving enamels
VESTANAT® EP-MF 201	Solvent-free	Silane functional crosslinker for curing at ambient temperature	Ready-to-use, self-crosslinking hybrid binder
VESTAGON® BF 1540	Granules	Standard linear grade Blocked NCO content: 16.1 %	Deblocking at ≥ 180°C, by applying a dedicated catalyst the deblocking temperature can be reduced to 130°C A stoichiometrical ratio of 1:1 (NCO : OH) is recommended Internal blocked (No release of blocking agents)
VESTAGON® BF 1320	Coarsely ground	Linear grade but higher functional compared to BF 1540 Blocked NCO content: 14.3 %	
VESTAGON® BF 1321	Coarsely ground	Tin-free version of BF 1320 Blocked NCO content: 14.8 %	

Additives

GLASS FIBER REINFORCED COMPOSITES

Glass fiber products, such as endless glass fibers, chopped strands, mats, rovings, yarns and milled glass fiber are used as reinforcing materials in plastics. Natural glass fiber shows poor adhesion to polymers, especially in the presence of moisture. For this reason, the glass surface is made organophilic by a size or finish treatment. Our Dynasylan® products are essential components in sizing or finishing, which positively effect the following:

- Transmission of glass fiber strength to the polymer
- Improvement of adhesion
- Minimization of moisture sensitivity, and mechanical protection of glass fibers

Selecting the right organofunctional group of Dynasylan® silane is decisive for the bond to the polymer. The best results are obtained with methacryl-functionalized Dynasylan® MEMO sized products in polyester and vinyl ester resins. The epoxysilane Dynasylan® GLYMO and the aminosilanes Dynasylan® AMEO and water-based Dynasylan® HYDROSIL 1151 sized products show superior performance in epoxy resins.

Dynasylan® for glass fiber

PRODUCT	DELIVERY FORM	CHARACTERISTICS	APPLICATIONS
Dynasylan® AMEO	Liquid	Aminosilane	*, ** PA, PU, EP, Phenolic, Melamine
Dynasylan® GLYMO	Liquid	Epoxysilane	*, ** EP, PU, Phenolic, Melamine
Dynasylan® MEMO	Liquid	Methacrylsilane	*, ** UP, Acrylic,
Dynasylan® VTMOEO	Liquid	Vinylsilane	*, ** UP
Dynasylan® 2201 EQ	Liquid	Ureidosilane	PA, Phenolic
Dynasylan® 1189	Liquid	Sec. Aminosilane	PP, PA
Dynasylan® SIVO 214	Liquid	Proprietary aminosilane composition	PP, PA, Phenolic
Dynasylan® 1175	Liquid	Cationic aminosilane	PA, EP, Phenolic
Dynasylan® HYDROSIL 1151	Liquid	VOC free water borne silane system	PA, PU, EP, Phenolic

* Important component in glass fiber sizes
** adhesion promoter for (selection): PA = polyamide, PU = polyurethane, EP = epoxy resin, UP = unsaturated polyester, PP = polypropylene

ADDITIVES FOR BONDING PASTES

Large quantities of bonding pastes are used in the manufacturing of wind turbine rotor blades. The normal production procedure is to manufacture the upper and lower shell of the rotor blade shell in separate molds and glue them together by the bonding pastes. These bonding pastes must have good thixotropic and specific slump properties. That is why AEROSIL® fumed silica are used as standard thixotropes in bonding pastes based on epoxy, polyurethane, vinylester resins, etc.

The hydrophobic fumed silicas AEROSIL® R 208 and AEROSIL® R 202 are high-performance thixotropes used in bonding pastes for the manufacturing of rotor blades. Furthermore, bonding pastes must also possess excellent fatigue properties. Structure-modified fumed silica grades like AEROSIL® R 7200, AEROSIL® R 8200, and AEROSIL® R 9200 can adjust bonding pastes with excellent reinforcing properties. Organofunctional silanes like Dynasylan® GLYMO, Dynasylan®AMMO, Dynasylan® 1124, and Dynasylan® 1146 act as adhesion promoters in bonding pastes, and they can further improve the crosslinking density of suitable bonding pastes.

Product range for bonding pastes

PRODUCT	DELIVERY FORM	CHARACTERISTICS	APPLICATIONS
AEROSIL® R 208	White powder	Hydrophobic fumed silica	The most efficient thixotrope for bonding pastes. Highly hydrophobic behavior.
AEROSIL® R 202	White powder	Hydrophobic fumed silica	The thixotrope of choice for bonding pastes based on EP, PU, as well as VE resins for the bonding of rotor blades. Excellent storage stability.
AEROSIL® 200	White powder	Hydrophilic fumed silica	Thixotrope for bonding pastes based on polyester and MMA resins, and for relatively non-polar amine hardeners for epoxy systems.
AEROSIL® R 7200 AEROSIL® R 8200 AEROSIL® R 9200	White powder	Structure-modified hydrophobic fumed silica	Reinforcing agent with low thickening properties and excellent mechanical properties.
Dynasylan® AMMO	Liquid	Primary aminosilane	Conventional adhesion promoter – especially suitable for amine hardeners.
Dynasylan® 1124	Liquid	Secondary aminosilane	Adhesion promoter – especially suitable for amine hardeners for bonding pastes. High crosslinking potential.
Dynasylan® 1146	Liquid	Oligomeric aminosilane	Adhesion promoter – especially dedicated to 2K-PU and 2K-EP chemistries. Can also improve the crosslinking densities of bonding pastes and impart outstanding hydrophobicity. Innovative silane due to reduced VOC.
Dynasylan® GLYMO	Liquid	Epoxy silane	Adhesion promoter, can be formulated into the resin part of 2K-EP, and can be used in 2K-PU as well.

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