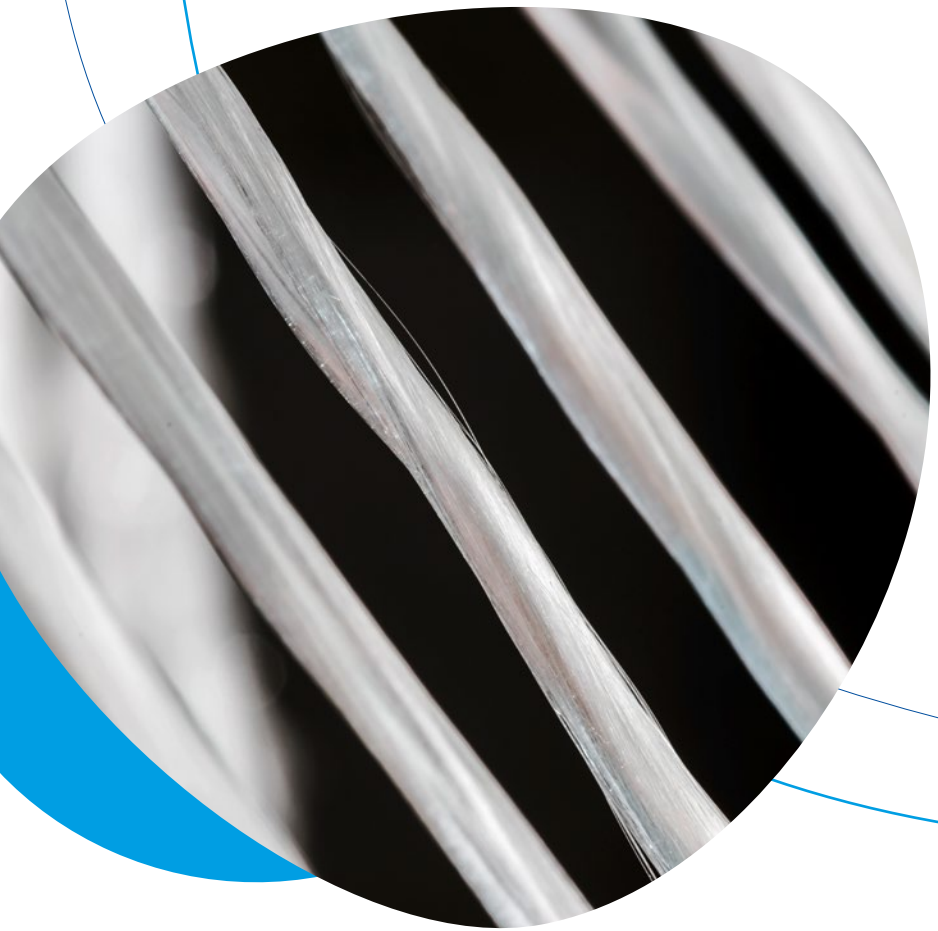


APPLICATION INFORMATION

ADDITIVES FOR PULTRUSION

Contents

Introduction

Fiber-reinforced composites have shown remarkable growth in the automotive, electrical, and construction industries since their introduction in the 1960s. They offer advantages over conventional materials such as metal. They can achieve very high strengths and stiffnesses with a very low weight. Furthermore, they are corrosion-resistant, have easily adjustable electrical properties, high energy absorption, and low thermal conductivity. Most important, however, is the individuality of each composite material. This means that a fiber-reinforced composite can be optimally designed for the requirements of the respective application by selecting suitable components and sensible alignment of the reinforcing fibers.

Pultrusion is an automated process to produce fiber-reinforced plastic profiles. In the continuous manufacturing process, a profile is created through the targeted connection of fiber reinforcements and resin systems. In pultrusion, additives are usually added to the resin matrix to optimize the processing and properties of the product. Additives improve process control and thus ensure lower process forces, higher production speeds, and better product quality.

For additional information on additives and technical topics, please contact us:
Thermosets.BYK@altana.com

Note

To ensure the best appearance and full functionality, please open in Adobe Acrobat.

Examples for pultruded parts:

- Transportation:
  railway, train, tram, bus
- Electrical industry
- Construction, bridges
- Wind energy

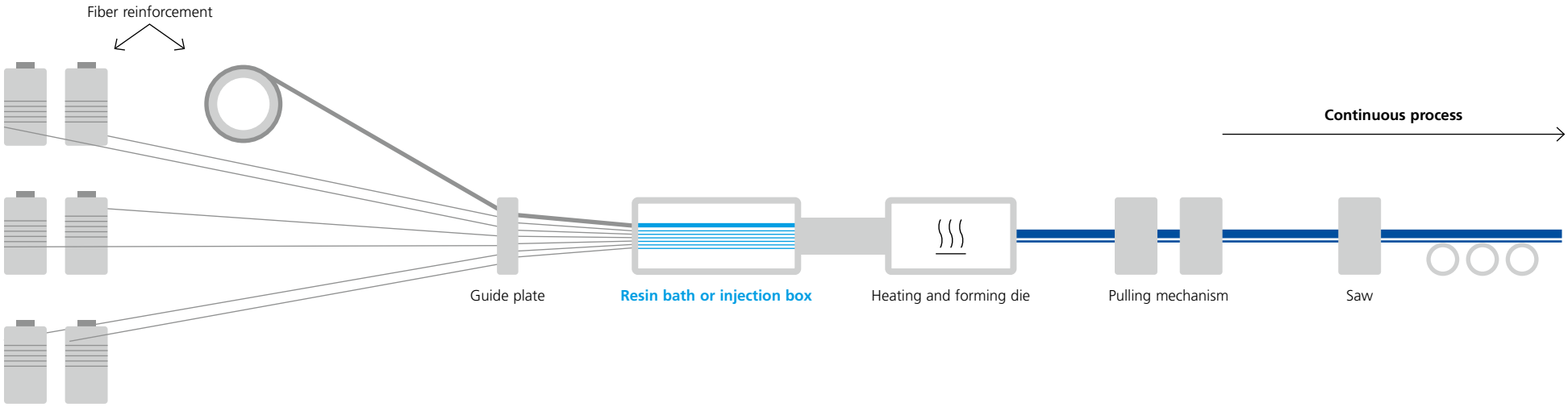
Process

Pultrusion is a continuous process for the production of composites with constant cross sections and material properties tailored to specific purposes with a consistent quality.

The reinforcement is pulled through a guide and placed precisely. The fibers are then processed through an impregnation area (resin bath or injection box), where the fibers are impregnated with the matrix material.

The fiber reinforcement impregnated with the resin system is heated in a die and brought into the desired profile shape. The profile is continuously pulled out of the die at different speeds depending on the resin type and profile cross-section, and cut to the required length.

Pultrusion line



Raw materials

Resin systems

The resin system has the task of distributing the external forces evenly to the embedded fibers. It also protects the fibers from environmental influences and corrosion, and keeps the composite in its shape.

In pultrusion, both thermosets and thermoplastics can be used as a matrix. The difference between these lies mainly in the form of curing. Thermosets are cured through a chemical crosslinking reaction. The most common resins for pultrusion are unsaturated polyester resins because they offer good properties at a comparatively low cost. Depending on the application, vinyl ester, epoxy, acrylic, polyurethane, or phenolic resins are also possible.

Additives

Additives, despite their low dosage level, have a significant impact on the properties of a composite and make the products economical. The following additives are particularly interesting for pultrusion:

- Wetting and dispersing additives ensure a homogeneous composition in resin systems with fillers.
- Air release additives prevent and destroy air bubbles.
- Processing additives generally improve the handling of the composite during processing.
- Coupling agents improve the fiber-matrix-adhesion and therefore can increase mechanical properties.

Most of the additives can have a positive effect on fiber wet-out.

Fibers

Fibers in composites absorb the highest possible forces. Flexural and tensile strength as well as other important mechanical properties of fiber-reinforced plastics (FRP) are largely adjusted by the embedded fibers. The simplest form of reinforcement are unidirectional fiber bundles, so-called rovings. Further possibilities are multiaxial nonwovens, fabrics, or fleeces, in which the anisotropy is largely compensated by means of multidirectional fibers. For the highest mechanical properties, a combination of rovings and fabrics can be used.

The most commonly used reinforcement are glass fibers because they provide a good cost-performance ratio with a moderate density.

Fillers

Various fillers are generally used to make production as efficient as possible. Fillers are inexpensive materials that are added to fill the volume and thus reduce material costs. In addition, suitable fillers can also improve the properties of the FRP. For example, shrinkage is reduced, abrasion resistance or flame retardancy is increased.

Wetting and dispersing additives

General use of wetting and dispersing additives

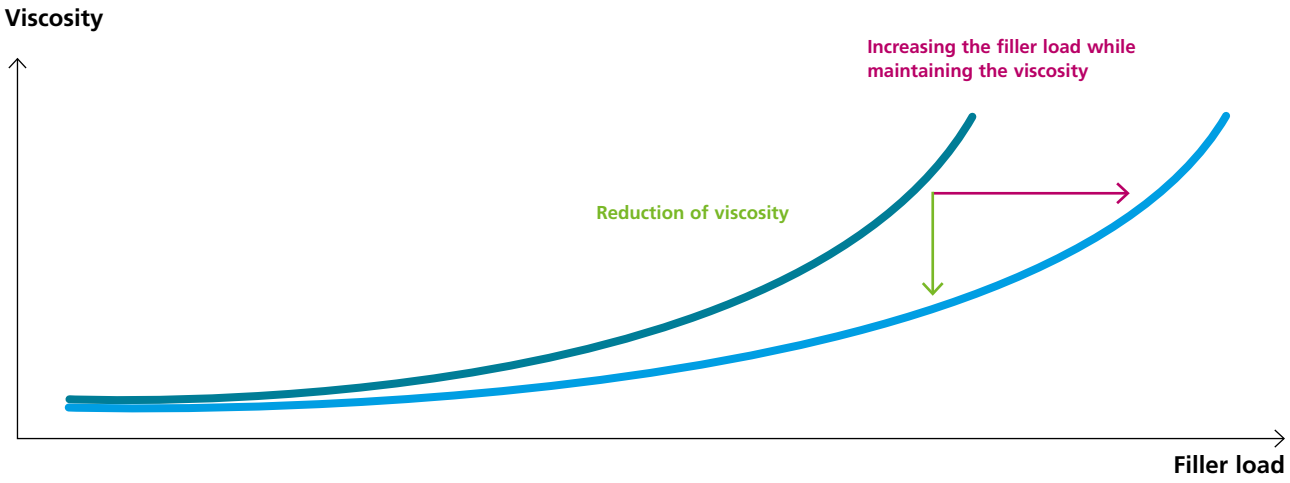
The use of wetting and dispersing additives can result in a lower viscosity of the formulation. In addition, it is possible to adjust the filler load while still maintaining the same viscosity (G.02).

Anti-separation and anti-sedimentation additives

Anti-separation additives improve the homogeneity of the resin system and keep the system stable in the filled state. BYK's anti-separation additives compatibilize the difference in the molecular weight of the components and improve color homogeneity and color depth of the compound.

To avoid sedimentation of fillers, special W&D additives can be used to stabilize the solid particles.

Application example for wetting and dispersing additives



● Without additive ● Formulation including wetting and dispersing additive

G.02

Air release additives

Air bubbles can develop into pinholes, which increases porosity and dramatically reduces the overall performance of the final part. BYK's air release additives or defoamers prevent and destroy these air bubbles and enable improved processing, a perfect surface, and optimum product properties.Air release additives work in three steps (G.03).

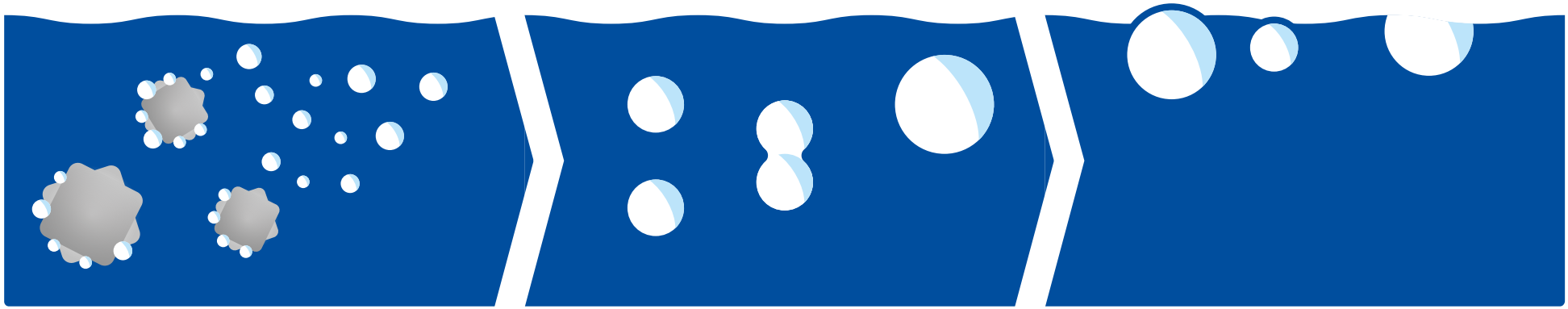
Step 1: By reducing the interfacial tension between the resin and the solid particles (filler, pigments), the air from the particles is displaced into the resin solution.

Step 2: Substances which stabilize the air bubbles are displaced by the air release additive. As a result, smaller bubbles coalesce to form larger bubbles, and the larger bubbles rise to the surface faster because of their higher buoyancy (Stoke's law).

Step 3: Air bubbles break when they reach the surface.

Air release additives work in three steps

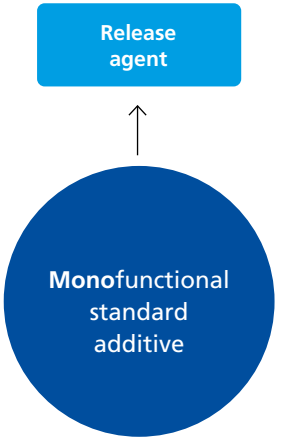
Step 1 **Step 2** **Step 3**

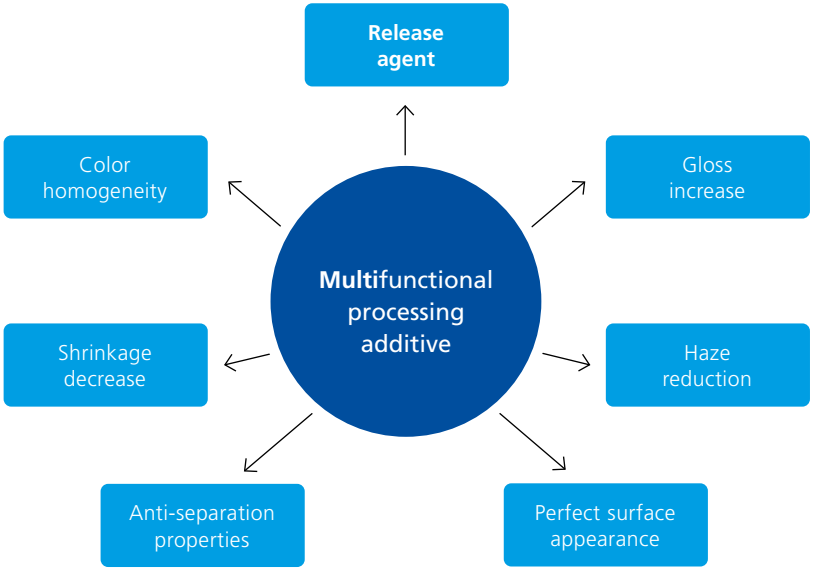


Processing additives

Internal mold release agents or lubricants are used to reduce friction in the die and to guarantee a continuous process. BYK processing additives have generally positive influences on a wide range of processing parameters and the properties of the final product compared to standard internal release agents. Due to the liquid delivery form of the additives, they are easier to incorporate into the resin system (G.04).

Benefits of BYK processing additives



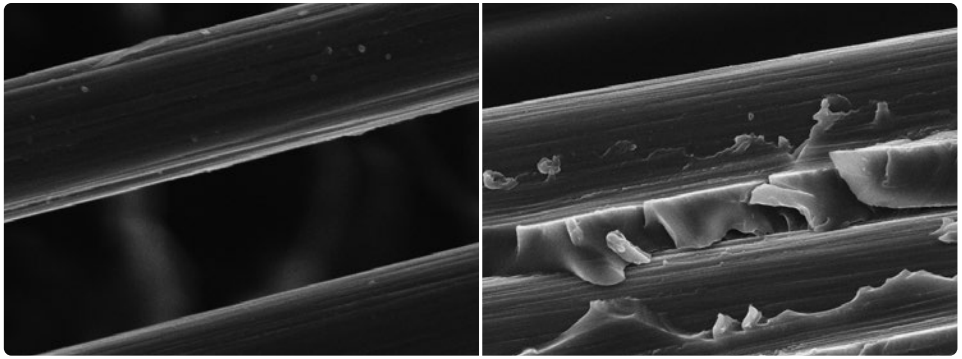


Coupling agents

In pultrusion systems, the condition of interfaces is a significant influencing variable for the efficiency in the final application. Interfaces are developed where solids and liquids or different solid structures meet. A multitude of molecular and physical forces determine how strong the bond is between these phases. The objective of coupling agents is to create as many stable additional bonds between the liquid and the solid components to improve the mechanical properties. Coupling agents can improve both the static and the dynamic resilience of the component through improved filler/fiber-matrix bonding (G.05).

The coupling effect

No coupling effect | **Coupling effect**



Adhesive failure | Cohesive failure in the matrix

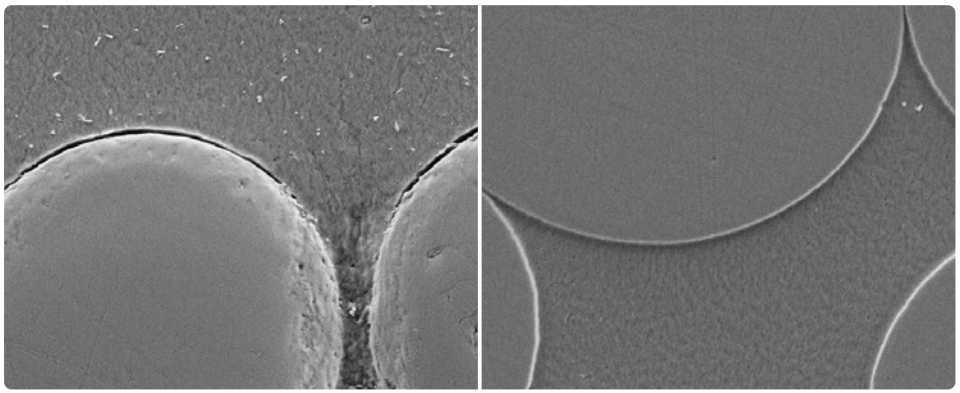
G.05

Additives with fiber wetting properties

Additives with fiber wetting properties are used to optimize the wetting process of resin systems on different fibers. An enhanced wet-out of the fibers leads to a better quality of the final part. By using these additives, an improved fiber impregnation with no dry spots and no air entrapment can be achieved (G.06).

Improved fiber impregnation

Without additive | **With additive**



G.06

Overview

The following overview provides the products needed in your formulation to produce improved pultruded parts:

Application	Unsaturated polyester and vinylester	Acrylate	Epoxy	Polyurethane
Viscosity reduction and/or increased filler load	BYK-W 908 BYK-W 985 BYK-W 996 BYK-W 9010 BYK-W 9011 BYK-W 9012	BYK-W 996 BYK-W 9010 BYK-W 9011 BYK-W 9012	BYK-W 985 BYK-W 996 BYK-W 9010 BYK-W 9011 BYK-W 9012 DISPERBYK-2152	BYK-W 903 BYK-W 969 BYK-W 996 BYK-W 9010
Pigmentation	BYK-9076 DISPERBYK-2152 DISPERBYK-2157	BYK-9076	BYK-9076	BYK-9076
Anti-separation	BYK-9076 BYK-W 972 BYK-W 974	RHEOBYK-D 410	RHEOBYK-7410 ET RHEOBYK-D 410	BYK-P 9904 RHEOBYK-D 410
Anti-sedimentation	ANTI-TERRA-204 BYK-W 940 BYK-W 980 RHEOBYK-7410 ET RHEOBYK-D 410	ANTI-TERRA-204 BYK-W 940 BYK-W 980 RHEOBYK-7410 ET RHEOBYK-D 410	ANTI-TERRA-204 BYK-W 980 RHEOBYK-7410 ET RHEOBYK-D 410	BYK-W 961 RHEOBYK-D 410
Air-release	BYK-A 515 BYK-A 555 BYK-A 560	BYK-070 BYK-A 515 BYK-A 555 BYK-A 560	BYK-1788 BYK-A 530 BYK-A 560 BYK-P 9920 BYK-S 732	BYK-054 BYK-088 BYK-A 535
Fiber wetting	Glass fiber: BYK-A 515 BYK-A 560 BYK-W 972 Carbon fiber: BYK-9076	Glass fiber: BYK-A 515 BYK-A 560 BYK-W 972 Carbon fiber: BYK-9076	Glass fiber: BYK-A 525 BYK-P 9920 BYK-S 732 Carbon fiber: BYK-9076 BYK-P 9920	Glass fiber: BYK-A 560 BYK-S 732 Carbon fiber: BYK-9076
Processing	BYK-P 9051 BYK-P 9065 BYK-P 9080	BYK-P 9051 BYK-P 9065 BYK-P 9080	BYK-P 9065 BYK-P 9912	BYK-P 9912
Mechanical properties	Glass fiber: BYK-C 8000 BYK-C 8003 Carbon fiber: BYK-C 8013 BYK-C 8014	Glass fiber: BYK-C 8000 BYK-C 8002	Glass fiber: BYK-C 8001	Carbon fiber: BYK-C 8014

For additional information on additives from bio-based materials, please refer to brochure B-G 5:
Additives from bio-based materials

TS-A 11 03/2022

BYK-Chemie GmbH
Abelstraße 45
46483 Wesel
Germany
Tel +49 281 670-0
Fax +49 281 65735

info@byk.com
www.byk.com