APPLICATION INFORMATION

ADDITIVES FOR SHEET MOLDING COMPOUNDS (SMC)

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Introduction

Fiber reinforced composites such as SMC (Sheet Molding Compound) have shown remarkable growth in the automotive, electrical, and construction industries since their introduction in 1960s. SMC parts are based on a matrix system, fillers, and fibers. By adding BYK additives, these parts are able to meet the latest requirements of the industry and a broader variety of manufactured components (e.g. several parts for cars, trucks, and trains) can be produced.

Through the continuous development of raw materials, fibers, and processes, a wide range of applications for sheet molding compounds has been established. Using a glass-fiber-reinforced SMC results in signficant weight savings compared to steel parts. In addition, resistance to corrosion and chemicals is increased. The use of carbon fibers can further increase the focus on "lightweight applications" and high mechanical strength. Reducing the weight of components is of particular interest in, for example, aerospace and automotive industries, where environmental aspects like emission reduction and lower fuel consumption is of high interest.

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

Note

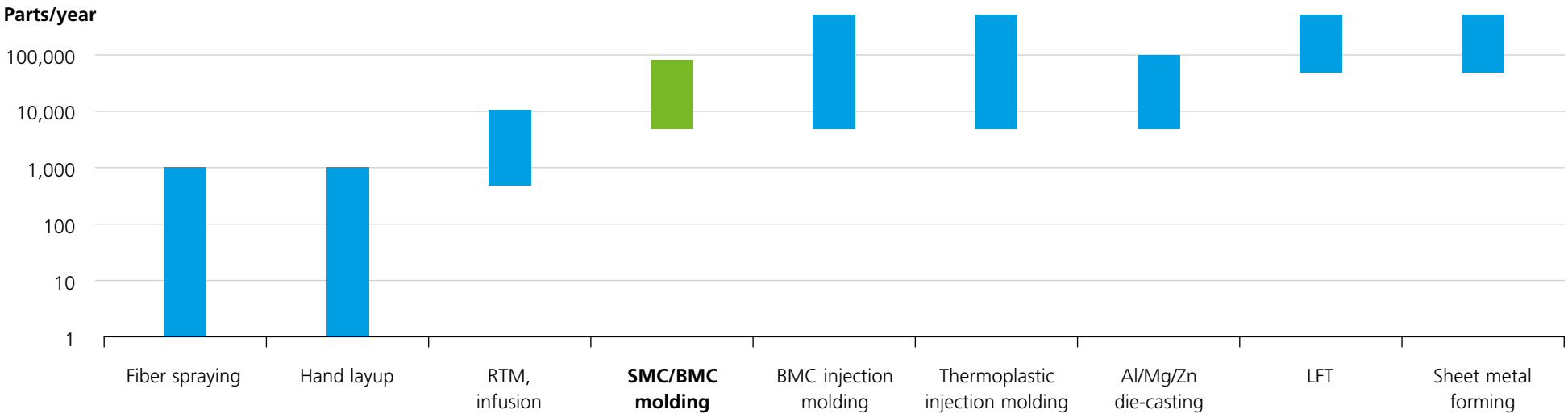
To ensure the best appearance and full functionality, please open in Adobe Acrobat.

Advantages and examples of SMC

The advantages of SMC parts lie in a more robust, faster, and cost-efficient process. Sheet molding compounds allow more design freedom, and a higher number of manufactured parts can be produced using a wear-free production process.

Compared to steel, fiber-reinforced composites have a lower density and therefore the weight of the final part can be decreased. In addition to the weight advantage, composites have a better resistance to corrosion and chemicals, and a higher stiffness.

Amount of parts



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Examples of SMC applications:

- Automotive: trucks, cars, and other commercial and agricultural vehicles
- Mass transit: trams, trains, light railways, and monorails
- Electrical & electronic: housings, fuses, and switchgears
- Building & construction: civil engineering and household fixtures
- Sanitary: washrooms, bathtubs and hygienic surfaces

SMC systems and production process

To identify the different types of SMC systems, a distinction is made between standard, low shrink (LS), and low profile (LP) formulations. The differences between these three types can be created by variations in the composition of the compound, resulting in different shrinkage and surface appearances.

Standard systems with high waviness are mainly used for low-cost applications. Low shrink (LS) systems are often used in industrial, transportation, or sanitary applications. For an excellent surface with almost no waviness in automotive class A applications, low profile (LP) systems show the best performance in regard to visual appearance.

The differences between the systems and their advantages

Formulation	Surface	Shrinkage	Pigmentation	Application
Standard 	Waviness	> 0.15 %	Pigmentable	Low cost
LS (Low shrink) 	Improved waviness and surface appearance	0.05 – 0.15 %	Pigmentable	• Electrical • Sanitary • Transportation • High flame retardancy
LP (Low profile)	Excellent surface appearance, nearly no waviness	< 0.05 – (– 0.20) %	Not pigmentable	• Automotive • Class A

T.01

SMC production process – the four steps

1. Preparation of the SMC paste

The raw materials, including all liquid components and fillers, are mixed homogeneously to prepare the paste.

2. SMC production

The SMC paste is applied to the SMC line in doctor boxes that determine the thickness of the formulation. Fibers are added automatically on the line during this process step. The fiber weight content is adjusted via the speed of the SMC line.

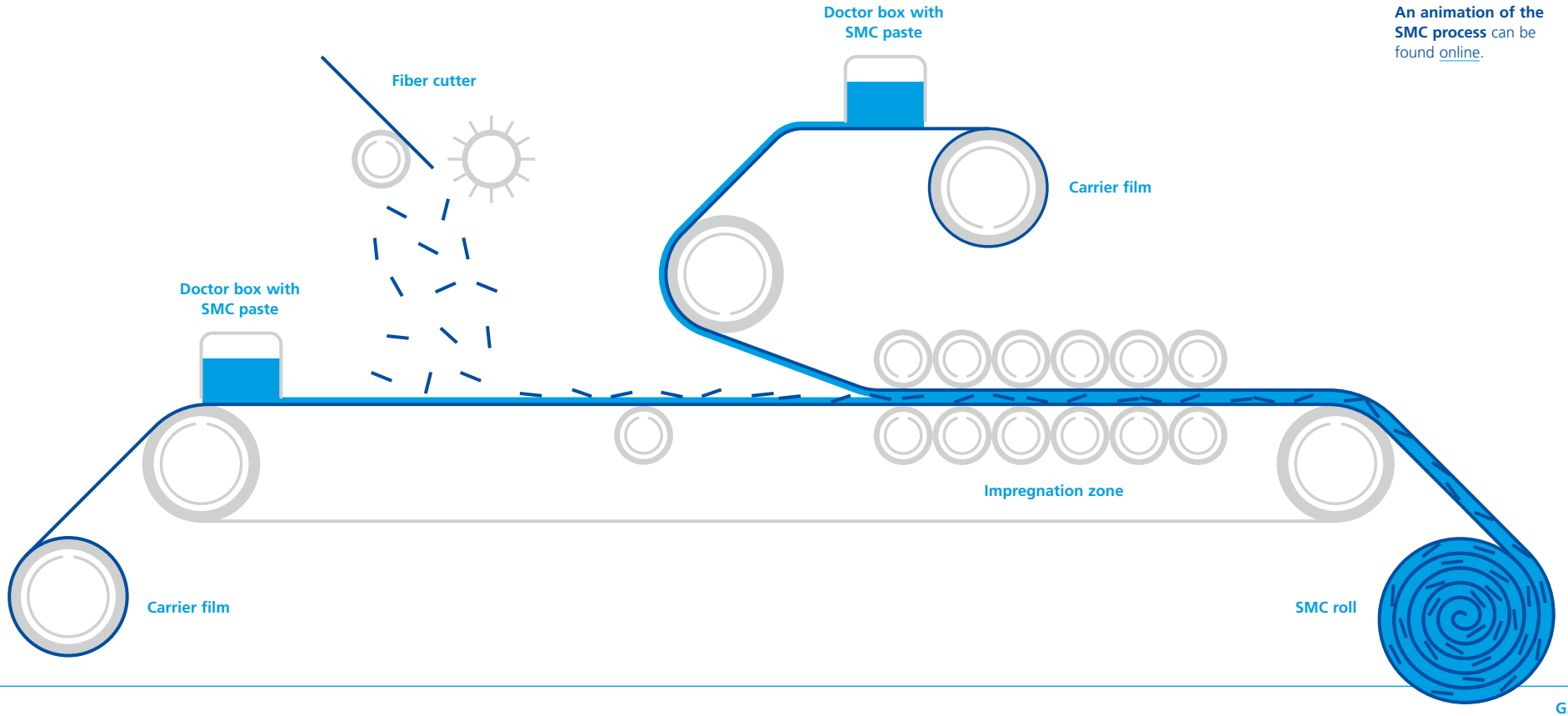
3. Maturation

Due to the addition of a thickening agent, SMC maturates over time; this can be done at elevated temperatures. Usually SMC has a shelf life of several weeks to several months from the date of production.

4. Cutting and molding

After maturation, the SMC can be cut to the desired size and molded under pressure and temperature.

An animation of the SMC process can be found online.



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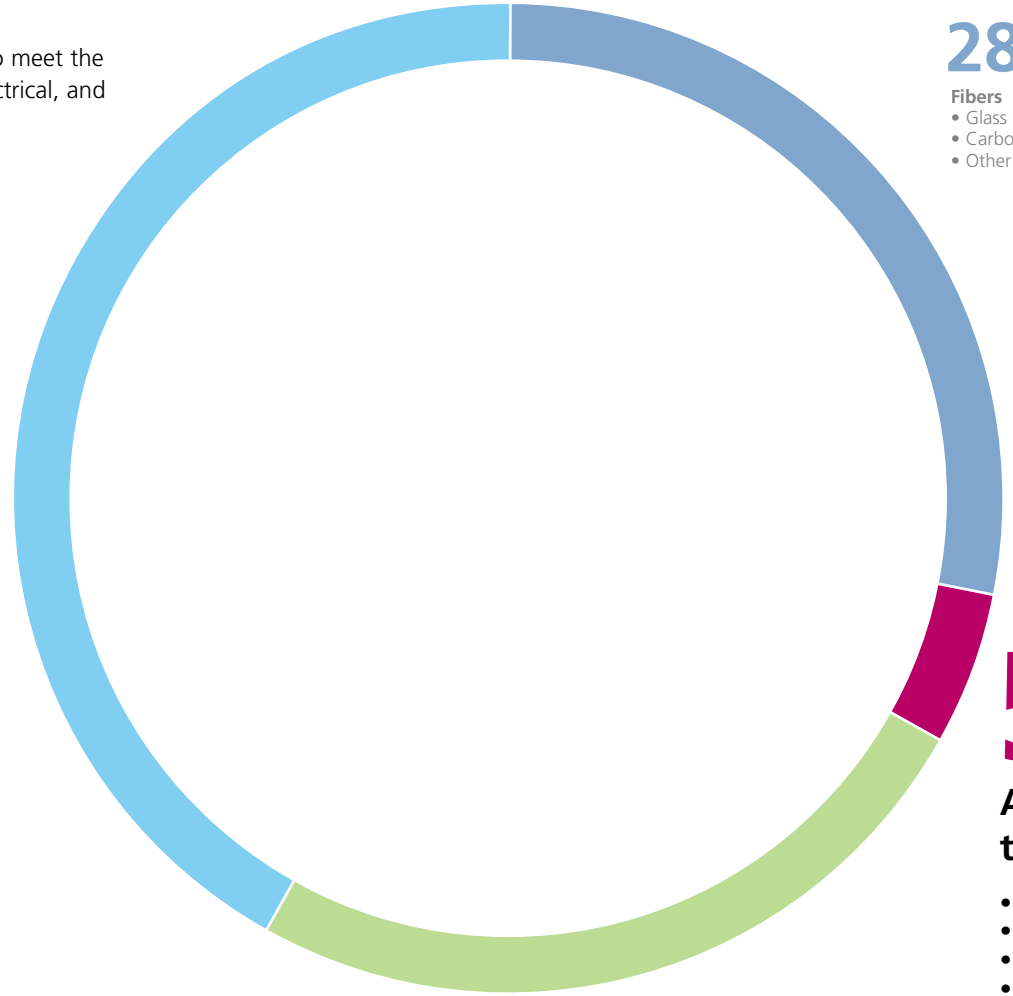
A wide variety of different raw materials – an extract

The fiber-reinforced matrix can be formulated to meet the most demanding chemical, flame-retardant, electrical, and environmental conditions.



28 %

Fibers
- Glass fibers
- Carbon fibers
- Other fibers

42 %

Fillers and pigment pastes:
- Calcium carbonate
- Aluminium trihydrate (ATH)
- Pigment pastes
- Hollow glass spheres

5 %

Additives and thickening agents:
- Wetting and dispersing additives
- Anti-separation additives
- Processing additives
- Coupling additives
- Additives with fiber wetting properties
- Air release additives

25 %

Resins and cure system:
- Unsaturated polyesters
- Epoxy resins
- Vinyl esters
- Hybrid resins

Typical SMC formulation

G.03

Resins and cure systems

Unsaturated polyesters have a universal use and are low cost matrix systems. By comparison, vinyl ester systems are often used for improved mechanical properties and chemical resistance. The newest matrix systems are epoxies, which are often used in combination with carbon fibers. Epoxy systems provide very good mechanical properties and good chemical resistance. The cure system depends on the resin that is used in the SMC formulation. Curing agents can be e.g. peroxides with inhibitors for unsaturated polyesters and vinyl ester resin systems.

Additives and thickening agents

Widely used additive groups are:
- Wetting and dispersing additives
- Anti-separation additives
- Processing additives
- Coupling additives
- Additives with fiber wetting properties
- Air release additives

Thickening agents are added for maturation and to improve the processability of the SMC formulation.

Fillers and pigment pastes

Fillers have a significant impact on the properties of the SMC parts. Calcium carbonate is a low-cost filler that ensures a good surface appearance in the final part. Formulations can also be highly filled with ATH (aluminium trihydrate) to improve the flame retardancy in applications such as transportation. Hollow glass spheres can reduce the density of the SMC but are difficult to process. They can cause surface defects after sanding of the molded part. Common pigment pastes with carbon black, titanium dioxide or other pigments are widely used in SMC. A good filler particle distribution is very important as it has a huge impact on such aspects as the surface, color, and mechanical properties of the molded part.

Fibers

A variety of fibers can be used in SMC applications. The most commonly used are glass fibers as they provide a good cost-performance ratio with a moderate density. Carbon fibers have a lower density and very good mechanical properties but are cost intensive compared to glass fibers and can have a poorer impregnation. Other fiber materials such as natural or aramid fibers are less common. Natural fibers also have a low density and good mechanical properties but can have a high moisture content.

In special applications, orientated fibers in the form of fabrics, such as unidirectional or biaxial materials, can have a positive impact on the mechanical properties.

Selection of additives and how they work
You will find more information in our multimedia brochures, which provide interactive graphics, fascinating animations, and videos.

Wetting and dispersing additives

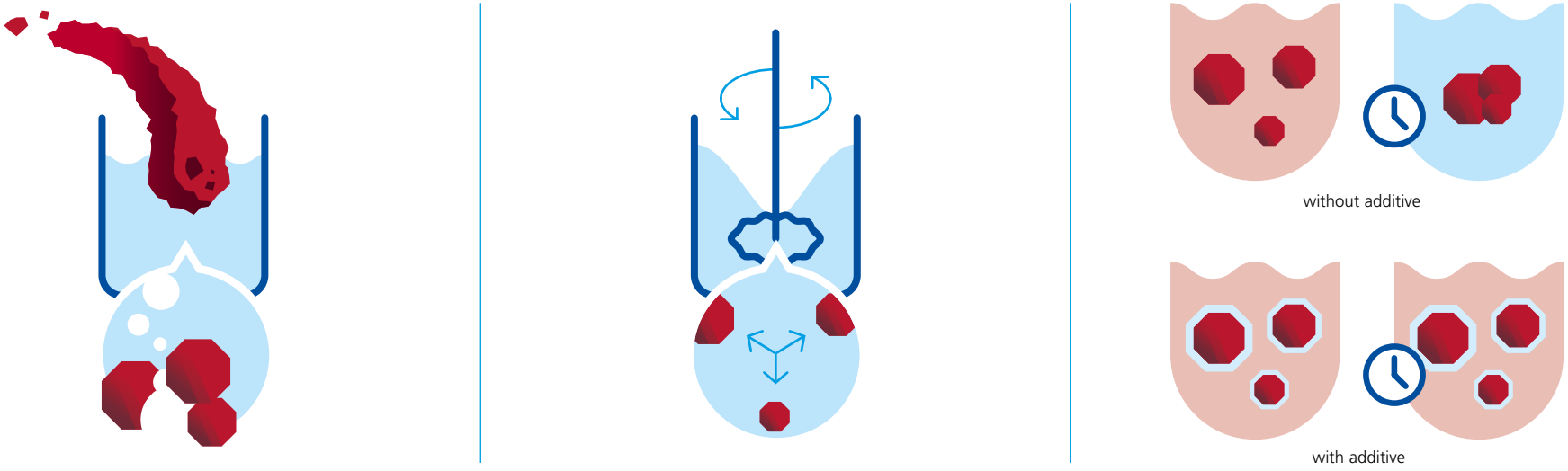
The use of BYK's wetting and dispersing additives results in a fine and homogeneous distribution of solid particles in liquid media and ensures the long-term stability of such systems. The additives stabilize fillers and pigments.

Wetting and dispersing additives improve the wetting of solids and stabilize them in the system.

The wetting and dispersing additives provide the freedom to create formulations with great variety in the quantity of fillers and pigments, coarser or finer filler particle sizes, constant impregnation viscosity, and a good flow behavior of the paste on the SMC line. In order to ensure optimum performance, the additive should be added before the solids.

The wetting and dispersing process

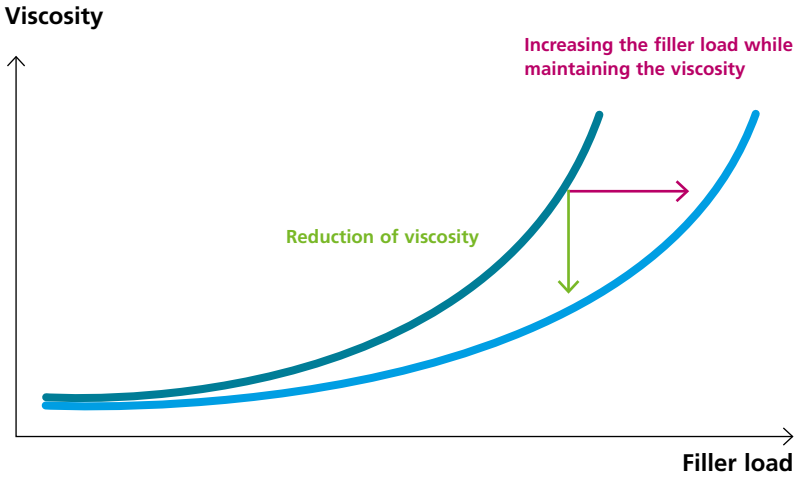
Wetting 〉 **Dispersing** 〉 **Stabilizing**



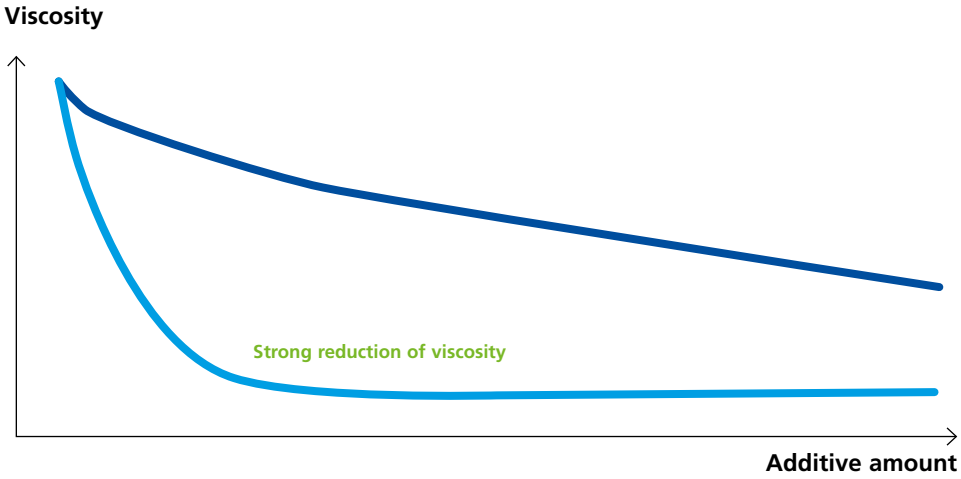
The use of wetting and dispersing additives can result in a lower viscosity of the paste. In addition, it is possible to adjust the filler load while still maintaining the same viscosity (G.05).

Extra styrene can be added to the resin system to decrease the viscosity of the SMC formulation (G.06). Using more solvent for the viscosity reduction decreases the performance of the final part. The shrinkage is increased, the quality of the surface is reduced, or it leads to poor mechanical properties. A lower viscosity of the compound therefore becomes a key factor when it comes to the possibility of using higher filler loads. No extra styrene is needed when using wetting and dispersing additives.

Application example for wetting and dispering additives



● Without additive ● Formulation including wetting and dispersing additive **G.05**



● Formulation including additional styrene ● Formulation including wetting and dispersing additive **G.06**

Additives overview

Product	Resin system			Dosage
	UP	VE	EP	
BYK-W 903			●	1.0–2.0 % b.o.f.
BYK-W 995	●	●		1.0–2.0 % b.o.f.
BYK-W 996	●	●		1.0–2.0 % b.o.f.
BYK-W 9010	●	●	●	0.5–1.0 % b.o.f.
BYK-W 9011	●	●	●	0.5–1.0 % b.o.f.
BYK-W 9012	●	●		0.5–1.0 % b.o.f.

b.o.f. = based on filler

T.02

Anti-separation 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.

Without using such anti-separation additives, the well-dispersed shrink control particles can reagglomerate and separate again.

A non-homogeneous SMC will also result in non-homogeneous molded parts. Defects such as product warpage or non homogenous surfaces can be expected, which may result in paint or bonding problems.

Additives overview

Product	Resin system		Dosage	Remarks
	UP	VE		
BYK-9076	●	●	1.0–2.0 phr	Solvent-free
BYK-W 972	●	●	1.0–2.0 phr	
BYK-W 974	●	●	1.0–2.0 phr	
DISPERBYK-170	●		1.0 phr	Only for UP with polystyrene
DISPERBYK-185	●		1.0 phr	Only for UP with polystyrene

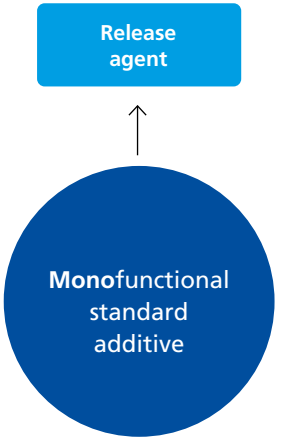
phr = per hundred resin

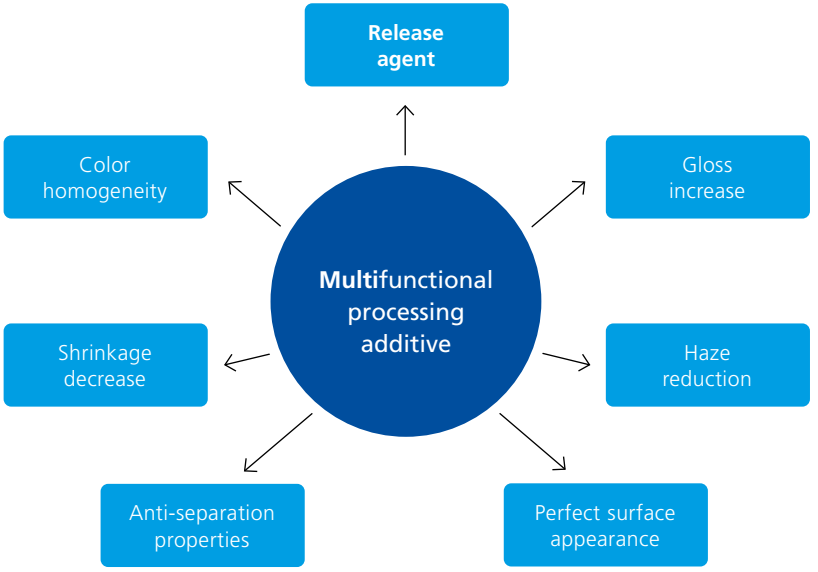
T.03

Processing additives

Processing additives from BYK are used in several plastics applications. 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 SMC formulation.

Benefits of BYK processing additives





Perfect surface appearance

Using BYK processing additives results in an improved flow behavior, which in turn leads to smoother surfaces. This can clearly be seen on larger molded parts.

Without processing additive

With processing additive

Color homogeneity

The processing additives replace the classic stearates that are the main cause for many of the defects in pigmented compounds.

With zinc stearate

With processing additive

Additives overview

Product	Effect									Resin system			Fiber		Dosage	Remarks
	Mold release	Paintability	Surface appearance	Bonding properties	Mechanical properties	Water resistance	Color homogenity	Decreased shrinkage	Flow behavior	UP	VE	EP	GF	CF		
BYK-P 9060	●	●	●				●		●	●	●		●		3.0–4.0 phr	Low shrink formulations
BYK-P 9065	●	●	●	●	●	●	●	●	●	●	●	●	●	●	2.5–3.0 phr	Low shrink formulations
BYK-P 9080	●	●	●	●				●	●	●	●		●		4.0–5.0 phr	Low profile formulations
BYK-P 9085	●	●	●		●				●	●	●		●	●	4.0–6.0 phr	Low profile formulations, only for chrome plated molds
BYK-P 9912	●											●	●	●	1.0–3.0 phr	

phr = per hundred resin

T.04

Coupling agents

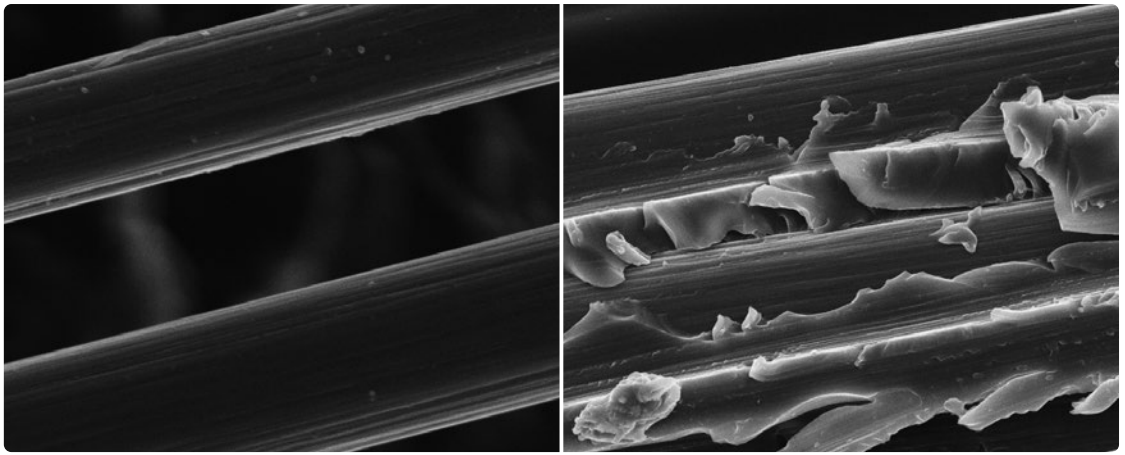
In SMC systems, the condition of interfaces is a significant influencing variable for the efficiency in the final application. Interfaces are developed where solids and liquids or different solid structures meet. A multitude of molecular and physical forces determine how strong the bond is between these 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.

The coupling effect

No coupling effect | **Coupling effect**



Adhesive failure | Cohesive failure in the matrix

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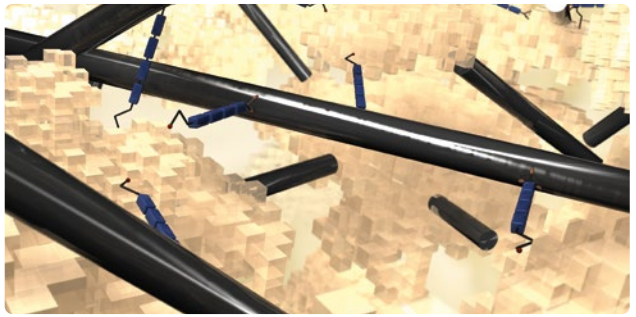
Mode of action



G.09

Additives overview

Product	Resin system			Fiber		Dosage	Remarks
	UP	VE	EP	GF	CF		
BYK-C 8001			●	●		1.0–5.0 % b.o.l.	
BYK-C 8013	●	●			●	3.0–5.0 phr	
BYK-C 8014	●	●			●	3.0–5.0 phr	Also suitable for MDI/ isocyanate thickening

phr = per hundred resin b.o.l. = based on liquid

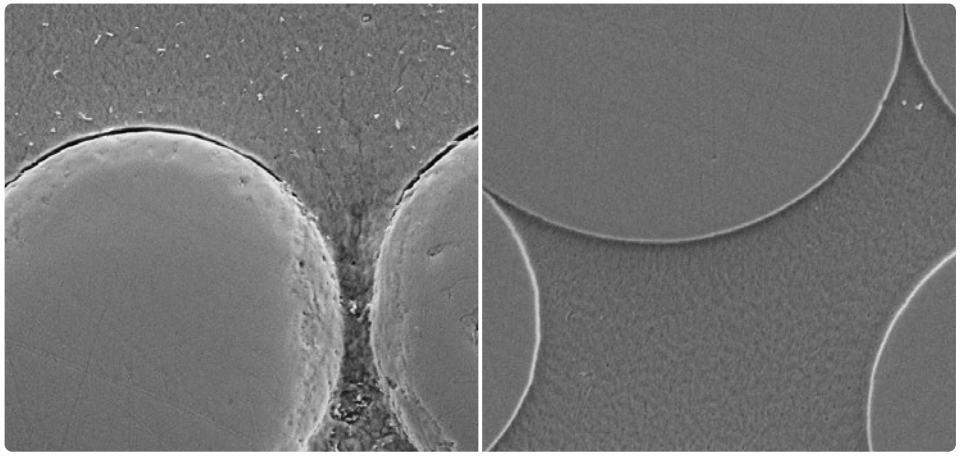
T.05

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 compound. By using these additives, an improved fiber impregnation with no dry spots and no air entrapment can be achieved.

Improved fiber impregnation

Without additive **With additive**



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Additives overview

Product	Product group	Effect		Resin system			Fiber		Dosage	Remarks
		Air release	Wetting of fiber	UP	VE	EP	GF	CF		
BYK-9076	Wetting and dispersing additives		●	●	●	●		●	1.0–3.0 phr in UP/VE 1.0–3.0 % b.o.l. in EP	
BYK-A 560	Air release additives	●	●	●	●		●		1.0 phr	
BYK-P 9920	Processing additives	●	●			●	●	●	1.0–3.0 % b.o.l.	Crosslinking with EP matrix possible
BYK-S 732	Surface additives		●			●	●	●	0.25–1.0 phr	

phr = per hundred resin b.o.l. = based on liquid

T.06

Air release

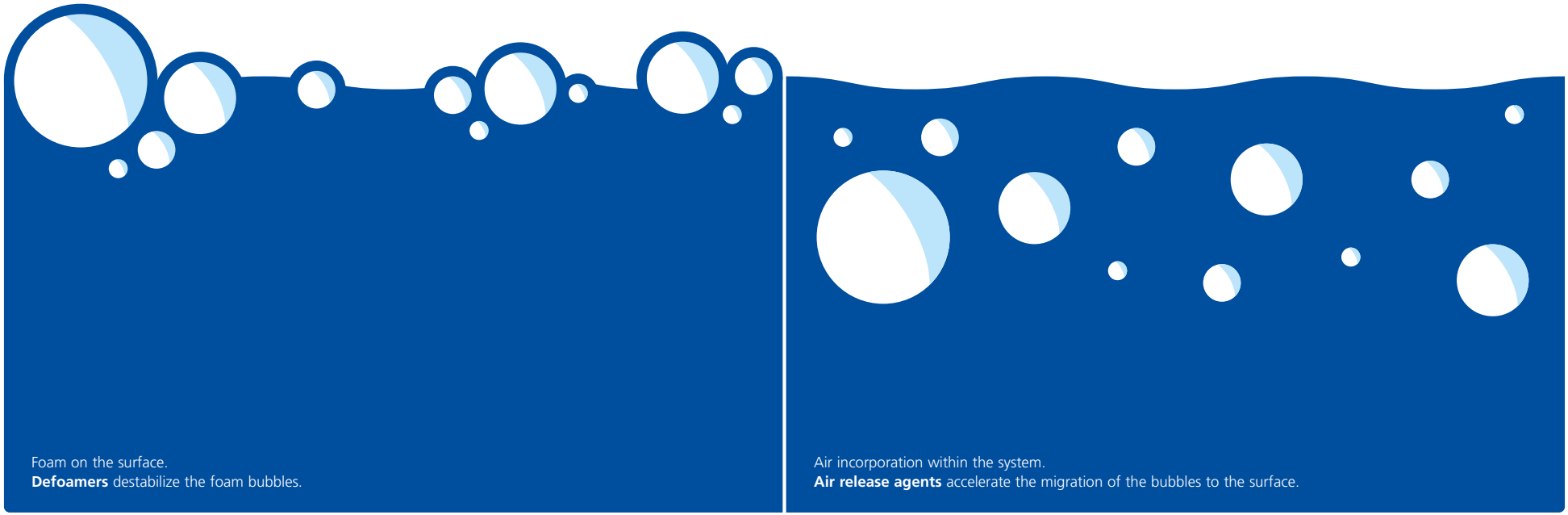
Air bubbles can develop into pinholes, which increases porosity and dramatically reduces the overall performance of the final part. BYK's air release agents or defoamers prevent and destroy these air bubbles and enable improved processing, a perfect surface, and optimum product properties.

Additives overview

Product	Resin system			Dosage	Remarks
	UP	VE	EP		
BYK-A 525			●	0.5–1.0 phr	
BYK-A 530			●	0.5–1.0 phr	
BYK-A 555	●	●		0.5–1.0 phr	
BYK-A 560	●	●		0.5–1.0 phr	
BYK-P 9920			●	1.0–3.0 % b.o.l.	Crosslinking with EP matrix possible

phr = per hundred resin b.o.l. = based on liquid T.07

Defoaming and air release



Foam on the surface.
Defoamers destabilize the foam bubbles.

Air incorporation within the system.
Air release agents accelerate the migration of the bubbles to the surface.

Additives overview (1/3)

Product	Product group	Effect													Resin system			Fiber		Dosage	Remarks
		Air release	Anti-separation	Coupling	Wetting of fiber	Wetting of filler	Mold release	Paintability	Surface appearance	Bonding properties	Mechanical properties	Water resistance	Color homogenity	Decreased shrinkage	Flow behavior	UP	VE	EP	GF	CF		
BYK-A 525	Air release additives	●																●	●	●	0.5 – 1.0 phr	
BYK-A 530	Air release additives	●																●	●	●	0.5 – 1.0 phr	
BYK-A 555	Air release additives	●														●	●		●	●	0.5 – 1.0 phr	
BYK-A 560	Air release additives	●			●											●	●		●	●	Air release: 0.5 – 1.0 phr Fiber wetting: 1.0 phr	
BYK-C 8001	Coupling agents			●							●							●	●		1.0 – 5.0 % b.o.l.	
BYK-C 8013	Coupling agents			●							●					●	●			●	3.0 – 5.0 phr	
BYK-C 8014	Coupling agents			●							●					●	●			●	3.0 – 5.0 phr	Also suitable for MDI/ isocyanate thickening

phr = per hundred resin b.o.l. = based on liquid b.o.f. = based on filler

Additives overview (2/3)

Product	Product group	Effect													Resin system			Fiber		Dosage	Remarks
		Air release	Anti-separation	Coupling	Wetting of fiber	Wetting of filler	Mold release	Paintability	Surface appearance	Bonding properties	Mechanical properties	Water resistance	Color homogenity	Decreased shrinkage	Flow behavior	UP	VE	EP	GF	CF		
BYK-P 9060	Processing additives						●	●	●				●		●	●	●		●		3.0–4.0 phr	Low shrink formulations
BYK-P 9065	Processing additives						●	●	●	●	●	●	●	●	●	●	●	●	●	●	2.5–3.0 phr	Low shrink formulations
BYK-P 9080	Processing additives						●	●	●	●				●	●	●	●		●		4.0–5.0 phr	Low profile formulations
BYK-P 9085	Processing additives						●	●	●		●				●	●	●		●	●	4.0–6.0 phr	Low profile formulations, only for chrome plated molds
BYK-P 9912	Processing additives						●											●	●	●	1.0–3.0 phr	
BYK-P 9920	Processing additives	●			●												●	●	●	●	1.0–3.0 % b.o.l.	Crosslinking with EP matrix possible
BYK-S 732	Surface additives				●													●	●	●	0.25–1.0 phr	

phr = per hundred resin b.o.l. = based on liquid b.o.f. = based on filler

Additives overview (3/3)

Product	Product group	Effect														Resin system			Fiber		Dosage	Remarks
		Air release	Anti-separation	Coupling	Wetting of fiber	Wetting of filler	Mold release	Paintability	Surface appearance	Bonding properties	Mechanical properties	Water resistance	Color homogenity	Decreased shrinkage	Flow behavior	UP	VE	EP	GF	CF		
BYK-9076	Wetting and dispersing additives		●		●								●			●	●	●	●	●	Anti-separation: 1.0–2.0 phr Fiber wetting: 1.0–3.0 phr in UP/VE 1.0–3.0 % b.o.l. in EP	
BYK-W 903	Wetting and dispersing additives					●									●			●	●		1.0–2.0 % b.o.f.	
BYK-W 972	Wetting and dispersing additives		●			●					●		●		●	●	●		●		1.0–2.0 phr	
BYK-W 974	Wetting and dispersing additives		●										●			●	●		●		1.0–2.0 phr	
BYK-W 995	Wetting and dispersing additives					●									●	●	●		●	●	1.0–2.0 % b.o.f.	
BYK-W 996	Wetting and dispersing additives					●									●	●	●		●	●	1.0–2.0 % b.o.f.	
BYK-W 9010	Wetting and dispersing additives					●									●	●	●	●	●	●	0.5–1.0 % b.o.f.	
BYK-W 9011	Wetting and dispersing additives					●									●	●	●	●	●	●	0.5–1.0 % b.o.f.	
BYK-W 9012	Wetting and dispersing additives					●									●	●	●		●	●	0.5–1.0 % b.o.f.	
DISPERBYK-170	Wetting and dispersing additives		●													●			●		1.0 phr	Only for UP with polystyrene
DISPERBYK-185	Wetting and dispersing additives		●													●			●		1.0 phr	Only for UP with polystyrene

phr = per hundred resin b.o.l. = based on liquid b.o.f. = based on filler

TS-A 10 02/2022

BYK-Chemie GmbH
P.O. Box 10 02 45
46462 Wesel
Germany
Tel +49 281 670-0
Fax +49 281 65735

info@byk.com
www.byk.com