BYK

Application Information TS-A 6

Additives for Insulating Materials for Use in the Electrical and Electronics Industry

A member of ALTANA

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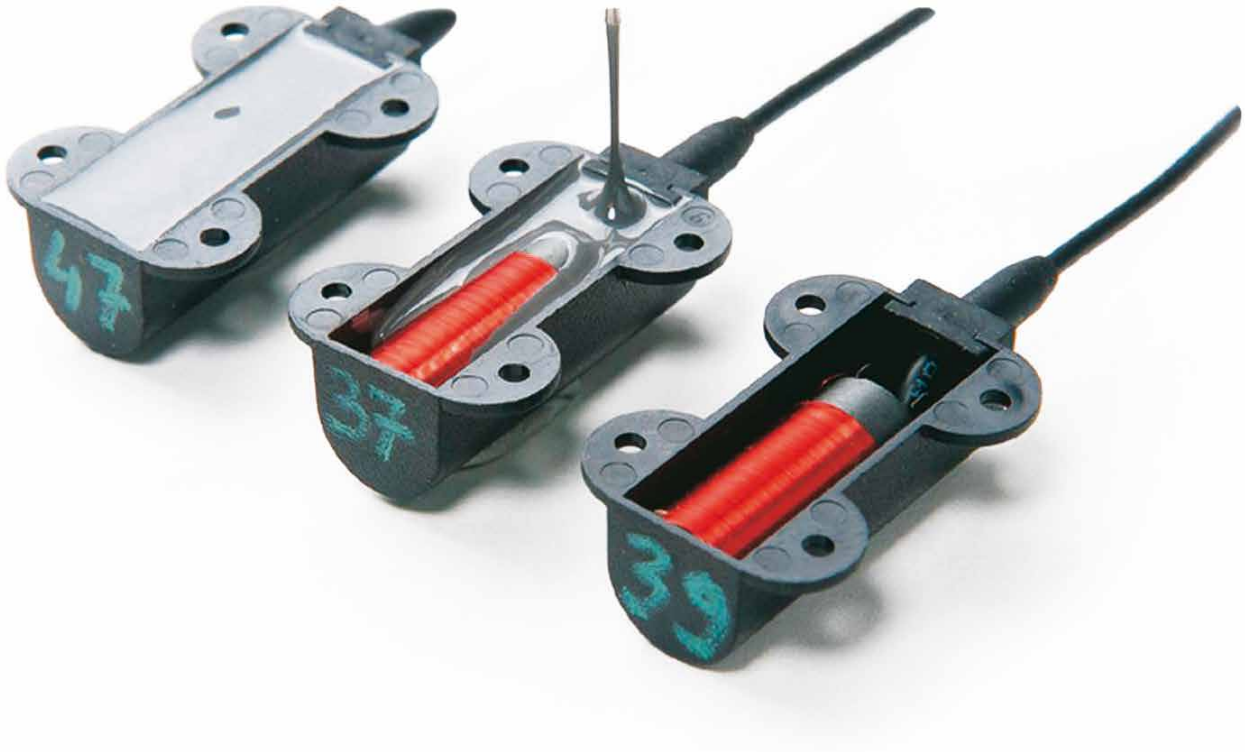
Content



Insulating Materials for the Electrical and Electronics Industry

Insulating materials based on organic resin systems are used in electric motors, cars, television sets, computers and many other devices. As a result of the large number of different applications, the requirements on the insulating systems also differ considerably.

In addition to a series of electrical characteristic values such as resistance, dielectric strength and dielectric dissipation factor, other physical properties such as thermal conductivity, combustibility, and chemical resistance may also be of key importance.

Not least, factors such as processability, quality and price also influence the selection of the correct system. By using suitable additives, it is possible to markedly improve all of these properties and the quality of the insulating materials.

This brochure summarizes our additive recommendation for this application.

Electrical Insulating Systems

Electrical insulating systems can be subdivided into three main groups (figure 1):

Primary Insulation: Primary insulation is the first insulating layer that is applied directly on the electrical conductor. Primary insulating materials are wire enamels.

Secondary Insulation: Secondary insulation, also called impregnation, describes the next stage of insulation. It improves the entire electrical insulation and protects it against external influences. It is used in motors, generators and stationary electrical machines such as transformers and sensors.

Electronic & Engineering Materials (E & E): These systems refer to insulating and construction materials that are used to embed, completely encapsulate or coat electrical and electronic components.

The following recommendations predominantly apply to secondary insulation and E&E, although they may also be used in the field of primary insulation.

Classification of Electrical Insulating Systems and Frequently Used Resin Systems

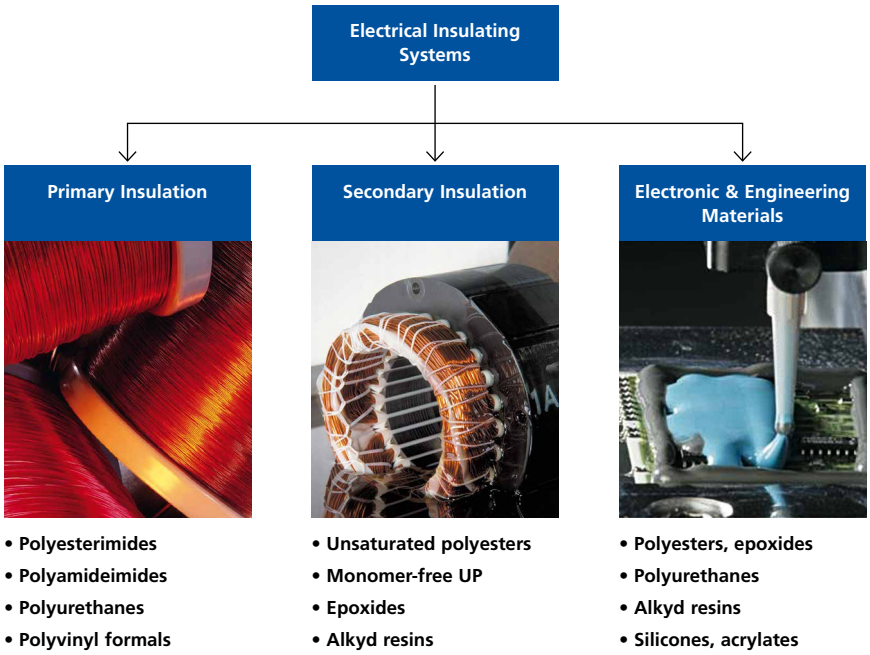


figure 1

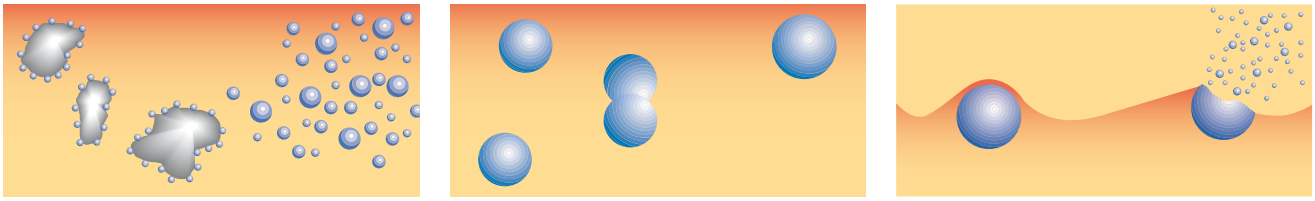
Air Release Agents/Defoamers

In electrical insulation systems, the electrical and mechanical properties of the respective resin system are of particular importance. So that these properties are utilized to the greatest possible effect, it is important to prevent air bubbles remaining in the system after curing. Air inclusions have an adverse effect on the electrical and mechanical properties and, at worst, may lead to a premature breakdown of the component.

Air can get into the insulating material via fillers and pigments or air can be trapped as a result of dispersion and agitation processes during manufacture or when using the material.

Air release agents work in three stages (figure 2): Firstly, the air attached to the surface of the pigments/fillers is detached from the solid particles; small air bubbles coalesce to form larger bubbles, which can then rise faster to the surface due to their greater buoyancy. Finally, the bubbles burst at the surface.

Air Release Agents Work in Three Stages



Stage 1 **Stage 2** **Stage 3**

figure 2

To achieve optimum air release, resin-specific additives are used that enable spontaneous air release and significantly accelerate degassing under vacuum. In all cases, the aim is to drastically reduce the air inclusions in cured systems (figure 3).

Significant Reduction in Air Inclusions by Using 0.3 % BYK-A 555 in an Unsaturated Polyester Resin

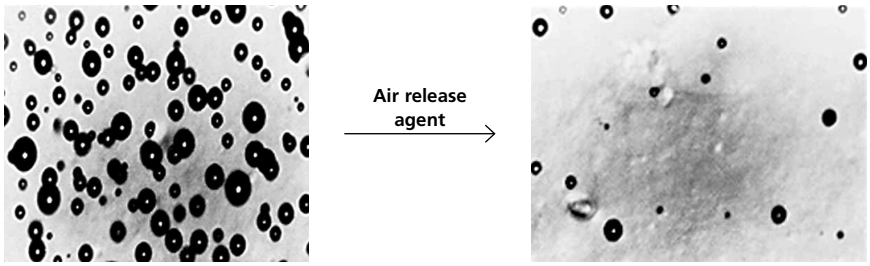


figure 3

Air Release Agent Recommendations

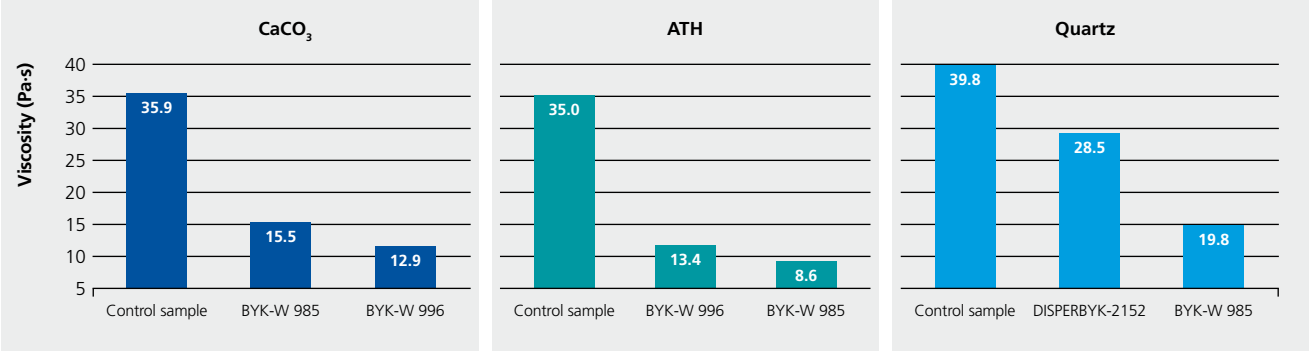
System	General applications	VOC-free systems	Transparent systems
Epoxy	BYK-066 N BYK-A 501* BYK-A 530	BYK-067 A BYK-1794* BYK-P 9920	BYK-141* BYK-A 500*
Polyurethane	BYK-067 A BYK-088	BYK-A 535*	BYK-141*
Unsaturated polyester (also monomer-free)	BYK-A 515 N* BYK-A 555*		BYK-A 500*

* silicone-free

figure 4

Wetting and Dispersing Additives

Viscosity Reduction of a Filled Electrical Insulating System Using Wetting and Dispersing Additives



System: 60 % filler and 40 % standard Bisphenol A resin

figure 5

Wetting and dispersing additives are needed if the insulating system contains pigments and/or fillers. Pigments are used to color the system; fillers are used to reduce costs, but are also able to improve certain physical properties, such as thermal conductivity or flame retardancy.

When incorporating fillers or pigments in the resin system, the viscosity of the formulation increases. The flow behavior that is modified in this way can make the system more difficult to process. Viscosity can be significantly reduced by the use of suitable additives that improve the wetting of solid particles and prevent flocculation of the particles (figure 5). Or you can increase the filler content at the same viscosity.

In some systems, the fillers and pigments settle during storage and sediment forms. This also makes the system difficult to process. In these cases, suitable wetting and dispersing additives are also able to stabilize the dispersion of the solid particles against sedimentation (figure 6).

Stabilization of a Filler Dispersion Against Settling

figure 6

Wetting and Dispersing Additives

System	Viscosity reduction	Anti-settling
Epoxy	BYK-W 980 BYK-W 985 BYK-W 996 DIPSERBYK-2152	ANTI-TERRA-204 BYK-W 940
Polyurethane	BYK-9076 BYK-W 903 BYK-W 969 BYK-W 996	BYK-W 961
Unsaturated polyester (also monomer-free)	BYK-W 908 BYK-W 966 BYK-W 985 DISPERBYK-2152	BYK-W 940

figure 7

Rheology Additives

Flow behavior is one of the most important properties of an electrical insulating system with regard to material processing. For easy processing, the material needs to be fluid, though it must be ensured that the layer thickness does not fall short of that required for the insulating effect.

The viscosity, its dependence on the arising shear forces and also its time dependence (thixotropy) play a major role here.

Rheology additives are able to adjust the flow behavior in such a way that the insulating materials can be easily processed and simultaneously exhibit a high stability (no sagging).

This also enables the settling behavior to be controlled so that there is no sedimentation of the solids (fillers, pigments) in the resin during storage.

RHEOBYK-410 is a liquid rheology additive used to generate and enhance thixotropy. It is stirred into the system as a liquid and forms a three-dimensional network structure to create highly thixotropic behavior. It acts as an anti-settling additive and increases the sag resistance of the system.

RHEOBYK-R 605, the thixotropy booster. Often, GARAMITE or hydrophilic fumed silica is used to control rheology, which also create thixotropy by forming network structures. RHEOBYK-R 605 enhances thixotropy in such systems by producing an even closer-meshed network via the hydroxyl groups of the silica (figure 8). The additive does not work with hydrophobic fumed silica.

RHEOBYK-607 works in a similar way and is specifically recommended for epoxy resins. If GARAMITE or hydrophilic fumed silica is used in an epoxy resin, there is hardly any thixotropy due to the high polarity of the resin; the resin therefore remains highly fluid. If this resin is mixed with a hardener that contains RHEOBYK-R 607, the additive activates the solid thixotrope in the overall mixture and a highly thixotropic system with considerably high sag resistance is produced. RHEOBYK-R 607 makes a very viscous mixture out of two low viscous components (figure 9).

Particularly high thixotropy is achieved in epoxy systems using a combination of RHEOBYK-R 607 and GARAMITE-7305.

Major Sagging in a Material with Fumed Silica (Left) and Excellent Stability (Right) if RHEOBYK-R 605 is Used in Addition

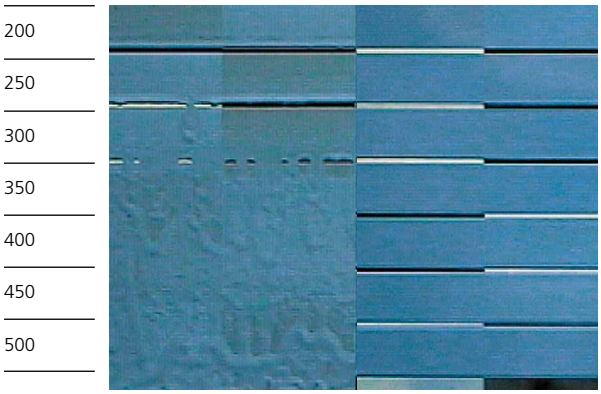
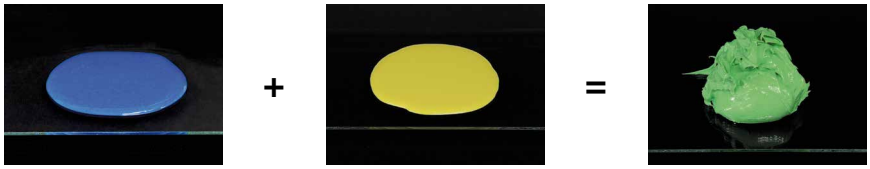


figure 8

Thixotropy Enhancement in a Fumed Silica-based Epoxy Resin Using RHEOBYK-R 607



Epoxy resin with hydrophilic fumed silica

Amine hardener with RHEOBYK-R 607

Thixotropic mixture

figure 9

Rheology Additives

System	Thixotropy booster	Liquid thixotropic additive	Solid thixotrope	Viscosity control technology
Epoxy	RHEOBYK-R 605 RHEOBYK-R 607*	RHEOBYK-410	GARAMITE-7305	BYK-P 2710 BYK-P 2720
Polyurethane	RHEOBYK-R 605	RHEOBYK-410	-	
Unsaturated polyester (also monomer-free)	RHEOBYK-R 605		GARAMITE-1210 GARAMITE-1958	

* for the hardener

figure 10

Viscosity Control Technology (VCT) – Processing Additives for Epoxy Systems

BYK-P 2710 and BYK-P 2720 are recommended for solvent-free and solvent-borne epoxy resins containing hydrophilic fumed silica for anti-sagging properties in medium/high viscous systems.

BYK-P 2710 – Thixbreaker

- Add to epoxy resin
- Effective with hydrophilic, fumed silica
- Resin viscosity can be adjusted and controlled
- A high amount of additive blocks the structural build-up of the hydrophilic fumed silica and avoids an increase in viscosity

BYK-P 2720 – Thixbooster

- Add to amine hardener
- Effective with hydrophilic, fumed silica
- ardener viscosity can be adjusted and controlled
- Dosage must be calculated always on the amount of hydrophilic fumed silica in the entire system

VCT adjusted viscosities lead to a better and easier mixing …

… and instantly maintain a high application viscosity

figure 11

BYK-P 2710 – Thixbreaker

BYK-P 2720 –Thixbooster

figure 12

Surface-active Additives

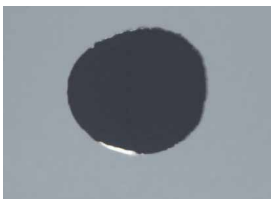
Surface-active additives are used to prevent surface defects or improve the resin's penetration in a component. Typical surface defects are, for example, poor substrate wetting and cratering. A fundamental parameter in all effects of this kind is the surface tension of the materials involved. If the surface tension of the coating is reduced, this improves the substrate wetting and prevents craters forming. Modified polysiloxanes ("silicones") are widely used to reduce surface tension.

These products also improve the penetration of the resin in a component, as the adhesion to the component is stronger than the cohesion of the liquid particles to each other. This makes it easier for the resin to penetrate the component.

Besides modified polysiloxanes, surface-active additives that are based on polyacrylates are also used. These products can also prevent cratering and leveling defects, however they do not reduce surface tension or do so only to a very minor extent.

Improved Substrate Wetting Using a Silicone-based Additive that Reduces Surface Tension

Poor substrate wetting



Reduction of the surface tension using a silicone-based additive: better substrate wetting

figure 13

Surface-active Additives

System	Silicone-based	Acrylate-based (silicone-free)
Epoxy	BYK-307 BYK-310 BYK-320	BYK-358 N BYK-S 706
Polyurethane	BYK-307	BYK-S 706
Unsaturated polyester (also monomer-free)	BYK-307 BYK-330 BYK-370	BYK-361 N

figure 14

For more information about our additives and instruments, as well as our additive sample orders please visit:

www.byk.com

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Additive Guide

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