WACKER

CREATING TOMORROW'S SOLUTIONS

VINNAPAS®

COMPOSITES I ADDITIVES

VINNAPAS® SOLID RESINS

Low-Profile Additives for Composites

VINNAPAS® POLYVINYL ACETATE AS A LOW-PROFILE ADDITIVE

APPLICATIONS IN FIBER-REINFORCED PLASTICS (FRP)

1. General Information

VINNAPAS® is a solid, homogeneous, odorless and nontoxic thermoplastic synthetic polyvinyl acetate resin.

WACKER produces VINNAPAS® homopolymer B and UW grades with varying degrees of polymerization, varying molecular weights and varying viscosities in solution.

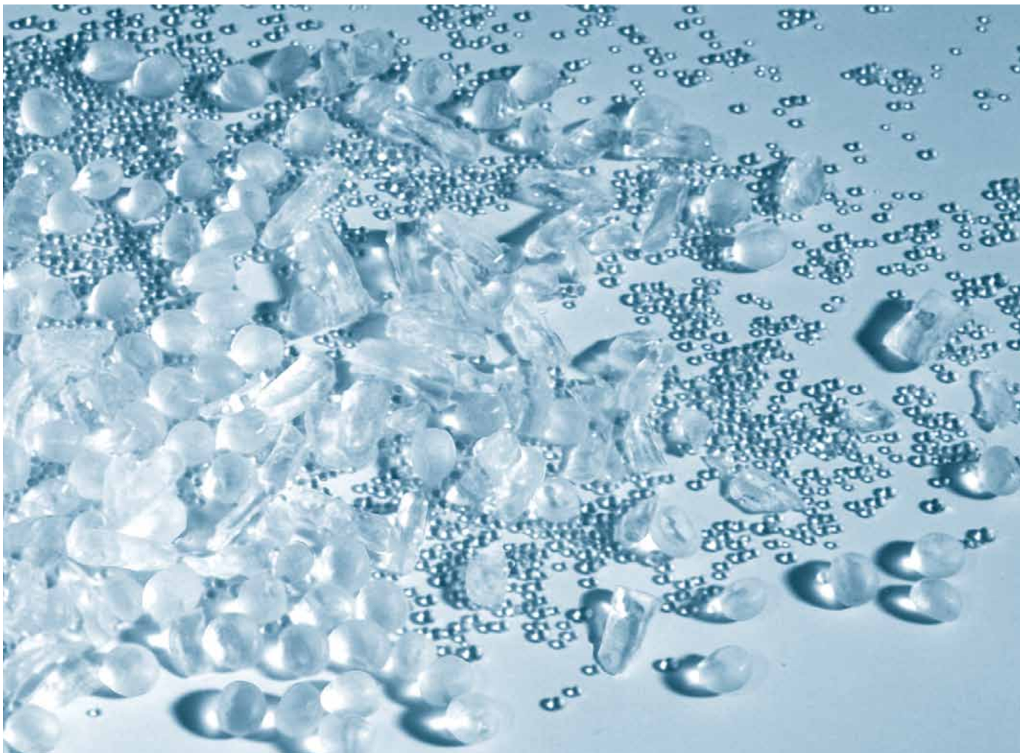
In addition to VINNAPAS® B and UW homopolymer grades, WACKER also manufactures carboxylated VINNAPAS® copolymer C grades based on vinyl acetate and crotonic acid.

VINNAPAS® (polyvinyl acetate) resins are used as low-profile additives in FRP composites. The great versatility of VINNAPAS® low-profile additive resins has led to many FRP applications, successfully combining zero shrink, Class A surface quality, full viscosity control and design flexibility.

On the following pages, we introduce our VINNAPAS® (polyvinyl acetate) resins for use as low-profile additives in FRP composites.

2. Low Profile Technology

Unsaturated polyester composites for fiber-reinforced plastics comprise unsaturated polyester resins compounded with styrene, various fillers, peroxide catalysts, thickening agents, mold release agents, **low-profile additives** and reinforcing glass fibers. Low-profile technology includes various compounding techniques and various molding techniques depending on the desired quality and shape of the molded parts.



GOOD COMPATIBILITY WITH ALL MAJOR COMPOUNDING TECHNIQUES

2.1 Description of the Compounding Techniques

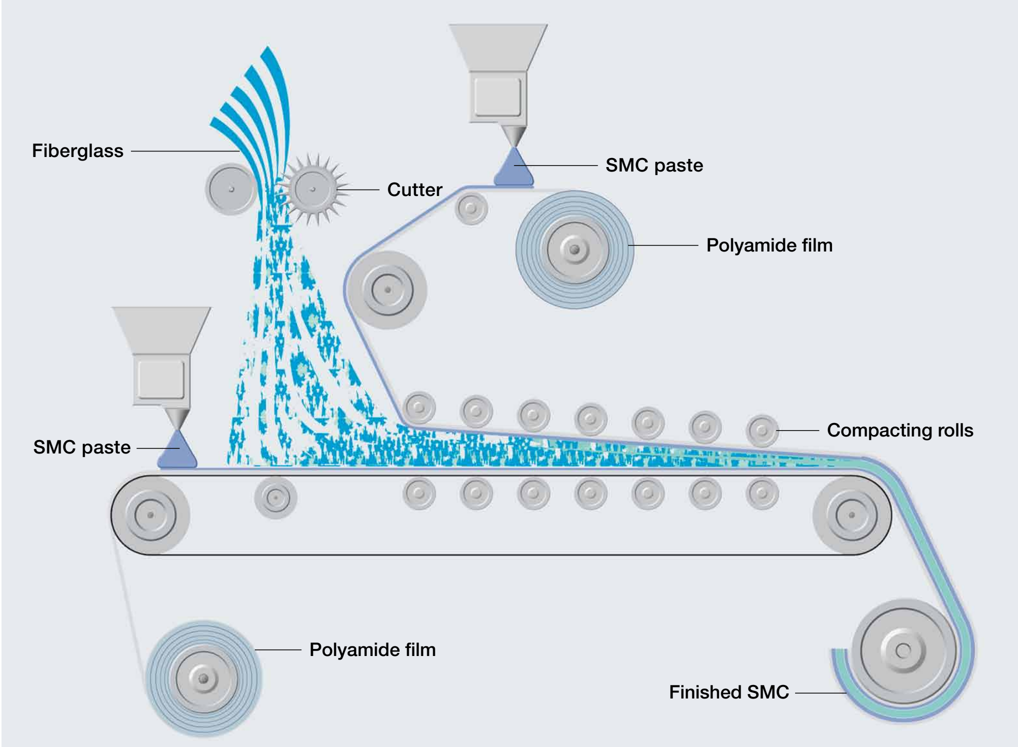
SMC: Sheet Molding Compound
SMC is prepared by applying a paste containing unsaturated polyester resin, styrene, filler, peroxide catalyst and a low-profile additive (LPA) solution in styrene onto a polyamide film. Chopped glass strand (glass-fiber) is dropped onto the UP resin paste sheet, and a second layer of the SMC paste is applied to sandwich the glass-fiber layer. This multilayer sheet runs through compaction rolls and is rolled up for maturation. After maturation, the compound has a very high viscosity, which allows good glass-fiber distribution during mold flow and easy handling of the material. Once maturation is complete and the required viscosity has been reached, SMC can be cut into shapes and compression-molded at high pressure and elevated temperature.

Other compounding techniques used to harden and transform unsaturated polyester resin composites into functional parts include:

BMC: Bulk Molding Compound
BMC is manufactured in a sigma-blade mixer and the resulting compound is either injection-molded or compression-molded under high pressure and at elevated temperature.
Pultrusion: In the pultrusion process for thermoset resins, fiber reinforcement is pulled through a resin impregnation area to coat the reinforcement. Then it is processed through preform plates to begin to shape the fiber/resin bundle. Afterwards, it is pulled through a heated die to cure the resin. This process produces little waste material. The cured part pultruded from the die requires no further processing. The quality of pultruded composites is affected by process variables such as pull speed, die temperature or quality of fibers/resins. VINNAPAS® homopolymer grades provide superior stability and excellent shrinkage-control properties.

RTM: Resin Transfer Molding
In the RTM process, a combination of continuous mat is laid in the mold cavity. A matching mold half is fixed to the first half tightly. Afterwards, a pressurized resin system mixed with a free-radical initiator is pumped into the closed mold containing the reinforcement. The resin and fiber remain in the mold until cross-linking takes place. Then the composite can be removed. The material may be cured at room temperature or in a heated mold by proper choice of initiator. The RTM process is affected by such parameters as: resin characteristics, resin injection pressure, mold temperature or vacuum conditions of the system. VINNAPAS® homopolymer grades provide superior stability and excellent shrinkage-control properties.





SMC Production

2.2 Polyester Resin Applications: Molding techniques

Unsaturated polyester resin molding compounds are transformed into functional articles by a wide variety of molding techniques.
They include:

- Hand lay-up and spray-up
- Filament winding and continuous lamination
- Pultrusion
- Injection molding
- Compression molding

The UP composite is typically modified with LPA for the following molding techniques:

- Compression molding of SMC or BMC at high pressure and elevated temperature
- Injection molding of BMC at high pressure and elevated temperature
- Pultrusion: for special applications
- Resin transfer molding (RTM): for special applications, the UP resin batch is modified with LPA

3. Low-Profile Additives

Both SMC and BMC technology used to be subject to severe limitations because of the following problems:

- Warpage of molded parts prevented the molding of close tolerances
- Depressions ("sink marks") on the surface
- Rough, wavy surfaces resulted in a poor appearance

These problems were the consequence of the high polymerization shrinkage of unsaturated polyester resin with the crosslinking styrene monomer. They are remedied by adding certain thermoplastics to the molding compound. The most effective shrinkage-control additive was found to be polyvinyl acetate. With polyvinyl acetate compounds with zero shrinkage and zero expansion can be formulated. This results in moldings with excellent surface smoothness and dimensional stability without warpage.

3.1 VINNAPAS® as Low-Profile Additive

VINNAPAS® is a most effective thermoplastic anti-shrink (low-profile) additive in UP resin composites processed at high molding temperatures.

In addition to the zero shrink effect, certain high-temperature unsaturated polyester applications, such as SMC and BMC, require effective thickening for easy handling of the composite and for good glass-fiber distribution during mold flow: Carboxylated VINNAPAS® C grades, in combination with magnesium oxide or calcium oxide, are the perfect thickening systems for unsaturated resin composites. Carboxylated VINNAPAS® C grades, in combination with a thickening paste, result in a high and constant viscosity level. After maturation, this combination is ideal to prevent exudation of the thermoplastic resins. Carboxyl-free homopolymer VINNAPAS® B and UW grades are used when only moderate or no thickening of the UP resin composite is required.

Benefits of VINNAPAS® Solid Resins:

- Zero shrinkage/expansion in FRP composites
- Excellent gloss and surface smoothness
- Effective thickening of SMC
- Easy to process and to formulate
- Consistent high quality
- Good mechanical properties
- Fast and complete solubility in styrene

VINNAPAS® C Grades
Very effective thickening in combination with MgO or CaO
VINNAPAS® UW Grades
Moderate thickening effect without MgO or CaO
VINNAPAS® B Grades
No thickening effect

Typical SMC Formulation	
Components	**Parts by wt**
Unsaturated Polyester Resin	
Orthophthalic polyester resin (65% in styrene)	65.0
Additives	
VINNAPAS® PVAC (40% in styrene)	35.0
t-Butylperbenzonate	1.0
Peroxy ester	0.2
Pigment dispersion	10.0
Zinc stearate	2.0
Filler	
Calcium carbonate 3 micron	180.0
Glass-fiber	
50 mm chopped glass-fiber, wt %	27 – 29

VINNAPAS® LOW-PROFILE ADDITIVES: OVERVIEW

VINNAPAS® LP Additives							
Grade	**Type**	**Solids content**	**Appearance**	**Acid[1] mg KOH/g**	**Viscosity[2] mPas**	**Molecular weight[3] Mw**	**Viscosity in styrene[4] 40 % in mPas**
VINNAPAS® LL 8251	carboxylated PVAc	100%	Flakes	6–9	2.0–2.3	~ 30 000	~ 300
VINNAPAS® C 341	carboxylated PVAc	100%	Flakes	6–8	3.5–3.8	~ 60 000	~ 1 000
VINNAPAS® C 501	carboxylated PVAc	100%	Flakes	6–9	7.5–9.5	~ 130 000	~ 6 500
VINNAPAS® B 60 sp	PVAc	100%	Pellets	< 0.5	3.5–5.0	~ 65 000	~ 1 000
VINNAPAS® B 100 sp	PVAc	100%	Pellets	< 0.5	5.0–6.5	~ 90 000	~ 2 000
VINNAPAS® UW 1 FS	PVAc	100%	Beads	< 0.5	8.0–11.0	~ 130 000	~ 5 000
VINNAPAS® UW 4 FS	PVAc	100%	Beads	< 0.5	23–30	~ 280 000	~ 66 000
VINNAPAS® UW 10 FS	PVAc	100%	Beads	< 0.5	35–55	~ 360 000	~ 160 000

[1] Acid number: number of milligrams of potassium hydroxide required to neutralize the alkalireactive groups in 1 gram of VINNAPAS® LP Additive
[2] Viscosity-conditions: 10% solution of VINNAPAS® LP Additive in ethylacetate, ASTMD 445–06; 20 °C
[3] SEC conditions: PS standard; THF; 60 °C; weight average
[4] Brookfield PHL 002 /23 °C

	Application			
	SMC	**BMC**	**Pultrusion**	**RTM**
VINNAPAS® LL 8251	●	●	●	○
VINNAPAS® C 341	●	●	●	○
VINNAPAS® C 501	●	●	●	○
VINNAPAS® B 60 sp	○	○	●	●
VINNAPAS® B 100 sp	○	●	●	●
VINNAPAS® UW 1 FS	○	●	●	○
VINNAPAS® UW 4 FS	○	●	○	○
VINNAPAS® UW 10 FS	○	●	○	○

● = Recommended ○ = Suitable

The table at the top lists VINNAPAS® grades used as low-profile additives in UP resin composites and also demonstrates the broad range of molecular weights/viscosities covered by both the homopolymer and the carboxylated VINNAPAS® grades.

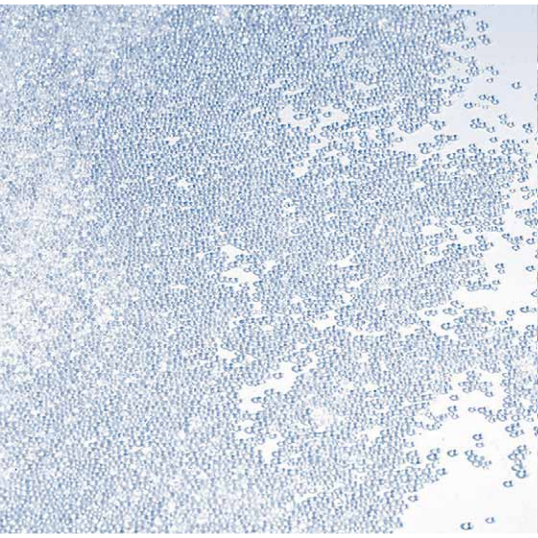
3.2 VINNAPAS® Solution in Styrene

VINNAPAS® low-profile additives (LPA) are almost exclusively used as solutions in styrene. The solid VINNAPAS® polyvinyl acetate resins are readily soluble in styrene and thus enable you to prepare VINNAPAS® solutions in styrene according to your needs.

Preparing a VINNAPAS® Solution in Styrene:
Add the VINNAPAS® resin to the styrene while stirring well to prevent the formation of lumps during dissolution. This should usually be done at room temperature; some temperature increase during the dissolving process is normal due to shear friction. Protect the resulting solution from direct light during storage. Additional temperature will increase the dissolving speed. However, a control of solution stability is necessary due to the monomeric styrene's tendency to polymerize. VINNAPAS® LPA solution typically contains 40 % solids, but this may vary depending on the molecular weight of the VINNAPAS® grade and the compound formulation. Average figures for VINNAPAS® LPA solutions in styrene are:

VINNAPAS® C grades	40 %
VINNAPAS® B grades	40– 45 %
VINNAPAS® UW grade	30– 40 %

GENERAL INFORMATION



VINNAPAS® beads

VINNAPAS® pellets

VINNAPAS® flakes

Dangerous Chemical Regulations

All VINNAPAS® resins (B, UW and C grades) are not classified as dangerous chemicals under the German hazardous substances legislation – Gefahrstoffverordnung (GefStoffV, 11th issue 1997) – and therefore do not have to be labeled as such. A certificate of origin, details on labeling and safety data sheets are available upon request.

Storage of VINNAPAS® Polyvinyl Acetate

VINNAPAS® resins exhibit excellent stability when stored under cool and dry conditions. However, because they are thermoplastic materials, it is strongly suggested that the lower-molecular-weight VINNAPAS® B grades in particular be stored below 20 °C to prevent caking. All VINNAPAS® resins will retain their free-flowing characteristics when stored in a cool (less than 20 °C) and dry place. Even if the material is blocked, the chemical nature of the polymer remains unchanged.

Packaging

Standard packaging for VINNAPAS® B, UW and C grades:
Paper bags, 25 kg net weight.
Other types of packaging are available upon request.

Shelf Life

Please refer to the technical data sheet.

Further information regarding individual products (technical data sheets, material safety data sheets) is available at:

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