

A circular inset image showing a rheology test. A wooden disc is mounted on a metal base, and a metal plate is positioned above it, ready to be lowered. The setup is part of a larger machine, likely a rheometer, used for testing the flow properties of coatings.

TECHNICAL INFORMATION
**RHEOLOGY ADDITIVES FOR AQUEOUS
WOOD & FURNITURE COATINGS**



Contents

- 03** Introduction
- 04** Rheology of coatings
- 06** Shear rate
- 09** Rheology additives in wood coatings
- 10** RHEOBYK associative thickeners – products and applications
- 11** Structure of RHEOBYK associative thickeners
- 13** RHEOBYK associative thickeners for tinting paste systems
- 14** RHEOBYK associative thickeners – product overview
- 15** RHEOBYK associative thickeners – product differentiation
- 16** Influence of cosolvents on rheological properties
- 17** Selection guide for associative thickeners
- 18** RHEOBYK liquid thixotropes
- 20** Natural and synthetic clays
- 23** LAPONITE and OPTIGEL – advantages
- 24** Producing perfect hydroclay gels

Introduction

Flow behavior is one of the most important characteristics of a liquid coating. To a great extent, flow behavior determines the handling and application properties of the coating.

A key factor in describing flow behavior is viscosity (η). However, for most coating systems, viscosity is not a constant; it is dependent on a variety of parameters. In addition to its dependence on temperature, another primary parameter is the coating's response to mechanical stress, as this can influence application properties.

Note

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

Rheology of coatings

Rheology is the complex interrelationship between viscosity and shear forces. The rheology of a coating system is determined primarily by the:

- binder (chemistry, molecular weight)
- solvent content and resin solubility
- pigmentation level

It can also be influenced by wetting and dispersing additives. Deflocculating additives (e.g. DISPERBYK-2015, DISPERBYK-190) reduce the viscosity, while controlled flocculating additives (such as ANTI-TERRA-250) increase the viscosity and thixotropy. These wetting and dispersing additives are primarily used for pigment stabilization, while their rheological impact is a desirable side effect (see ebook, Wetting and Dispersing Additives).

Rheology additives

Consequently, special rheology additives are required for optimum adjustment of rheological properties. In most cases, these additives are used to improve anti-settling properties during storage and sag resistance during application. In addition, improved flow behavior controls the uniform orientation of matting agents as well as effect pigments (aluminium and pearlescent pigments) and factors such as image sharpness in printing inks. Numerous products designed to control the rheology of coating systems are already on the market and their mechanisms are essentially the same: In the liquid phase, these additives form three-dimensional networks (typically by hydrogen bonding). These lattice structures are temporarily destroyed by shear, and recover after shear is discontinued to give the coating its pseudoplastic or thixotropic flow properties.



Sedimentation, sagging

During storage, pigments and fillers in a coating can settle and form sediments that are difficult to reincorporate (G.01). During application on inclined and vertical surfaces, runs and sags frequently occur at higher film thicknesses (G.02). Higher viscosity at low shear in combination with a yield point can substantially reduce both sedimentation and sagging. This results in longer shelf life with less settling and better sag resistance during application.

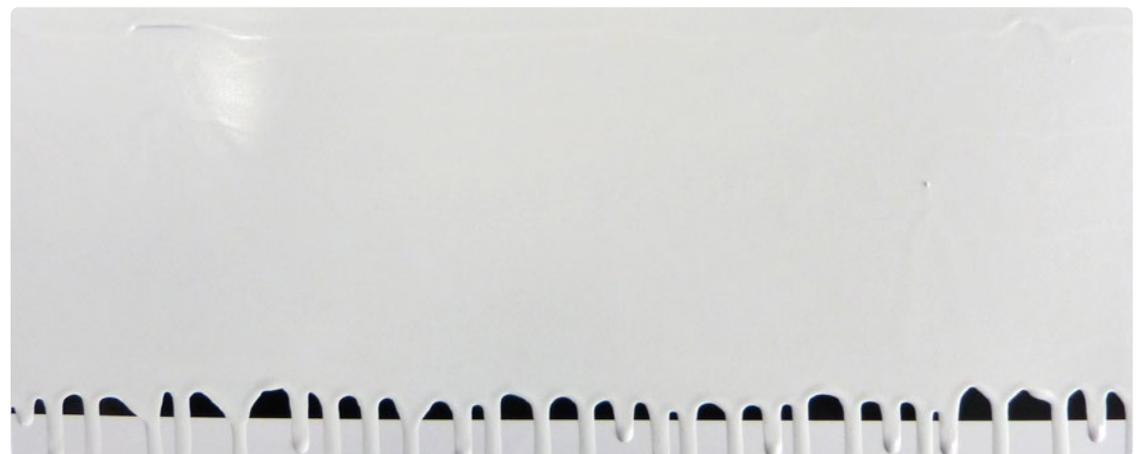
However, the rheological properties described above may also have undesirable effects on the deaeration/defoaming and leveling properties of the coating: air bubbles rise to the coating surface more slowly and surface leveling is impaired. Clearly the "right" flow behavior is always a compromise partly governed by the application parameters for each particular application.

Sedimentation and settling



G.01

Sagging



G.02

Shear rate

The dependence of viscosity on shear rate is of practical importance. In practice, a relatively large shear range must be considered (G.03). During production (dispersing, blending, and filling) and application (rolling, brushing or spraying), coatings are exposed to high shear rates ($> 1000 \text{ s}^{-1}$); during storage and in the interval between application and hardening, shear rates are relatively low ($< 1 \text{ s}^{-1}$). Rheological characterization over the entire shear range is best obtained with rotational viscometers. In all instruments of this type, the liquid to be tested is sheared between a stationary surface and a moving surface.

A known rotational force is applied and the resulting rotation speed, dependent on the liquid's resistance to flow (viscosity), is measured. From the measured shear rate $\dot{\gamma}$ (proportional to the rotation speed) and shear stress τ (proportional to the force applied), the viscosity η may be calculated and charted in a viscosity curve diagram (G.03).

Important rheology parameters

Parameter	Definition	Unit
Shear stress τ	$\frac{\text{Force}}{\text{Area}}$	$\text{N/m}^2 = \text{Pa}$ (Pascal) Formerly: dyne/cm^2 $1 \text{ dyne/cm}^2 = 0.1 \text{ Pa}$
Shear rate $\dot{\gamma}$	$\frac{\text{Velocity}}{\text{Distance}}$	$(\text{m/s})/\text{m} = 1/\text{s} = \text{s}^{-1}$
Viscosity η	$\frac{\text{Shear stress}}{\text{Shear rate}}$	$\text{Pa}\cdot\text{s}$ Formerly: P (Poise) $1 \text{ cP} = 1 \text{ mPa}\cdot\text{s}$

T.01

Formula for calculating
shear stress

$$\tau = \frac{F}{A}$$

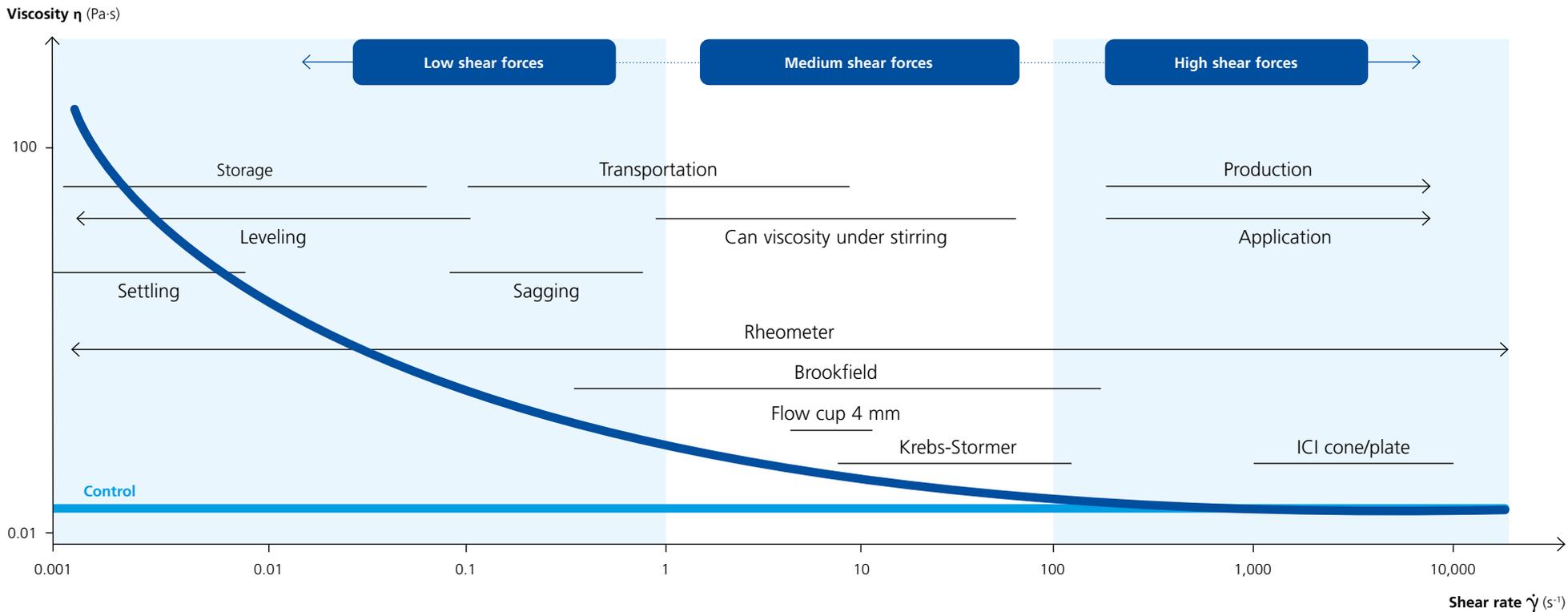
Formula for calculating
shear rate

$$\dot{\gamma} = \frac{v}{d}$$

Formula for calculating
viscosity

$$\eta = \frac{\tau}{\dot{\gamma}}$$

Typical shear ranges



G.03

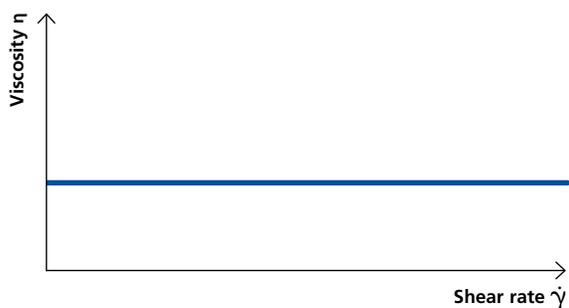
Low-shear conditions are typically experienced by the coating while it is stored in the can and immediately after it has been applied to the substrate. During these phases, low shear viscosity is needed to resist pigment settling and film sag while providing the required leveling of the applied coating film. Low shear viscosity is often measured using a Brookfield viscometer.

Medium-shear conditions are created during coating stirring, pouring, and some types of pumping. During these phases, medium shear viscosity helps to facilitate good in-can appearance and handling properties and may also affect spattering. Medium shear viscosity is often measured using a Krebs-Stormer viscometer and a Brookfield viscometer at high rpm. Krebs-Stormer viscosity is expressed in Krebs Units (KU), and rheology additives are often referred to in "KU builders" or "medium-shear builders."

High-shear processes include brushing, certain aspects of rolling, and spraying. High shear viscosity influences brush and roller drag, as well as film building and hiding power.

High shear viscosity is often measured using a cone-plate viscometer including the standard ICI viscometer. Therefore, rheology additives that offer a good high shear viscosity are often referred to as "ICI builders" or "high-shear builders."

Newtonian flow behavior



G.04

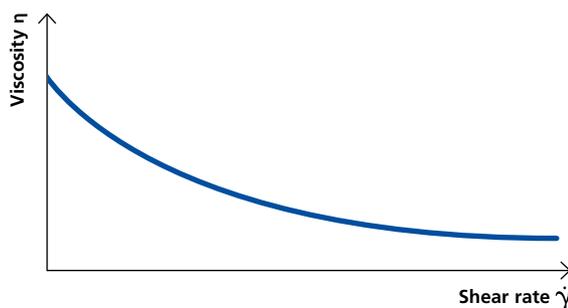
Newtonian flow behavior

The simplest form of flow behavior occurs if viscosity is independent of shear rate. This behavior, also known as Newtonian flow, only occurs in ideal liquids and can be observed in water, pure solvents, and mineral oils, for example. Since viscosity does not depend on shear rate, it can be measured at any shear rate (single-point measurement) to obtain a complete rheological description of the system. In coating systems, however, Newtonian flow behavior is not typical and actually undesirable (other than in some stain formulations): the slightest shear stress (gravity) induces flow, resulting in sagging after application. Such formulations also exhibit rapid settling.

Pseudoplasticity and thixotropy

With regard to sedimentation behavior, pseudoplastic and thixotropic materials demonstrate very similar performance: high viscosity at low shear rates reduces settling. The differences between pseudoplastic and thixotropic liquids become more obvious when focusing on sagging and sag resistance: Pseudoplastic materials allow application of fairly thick films without sagging because viscosity recovery occurs very quickly following application. Thixotropic materials also display increased sag resistance, however, the effect is less pronounced because the process of viscosity recovery is slower. On the other hand, this can be beneficial regarding deaeration and leveling.

Pseudoplastic flow behavior

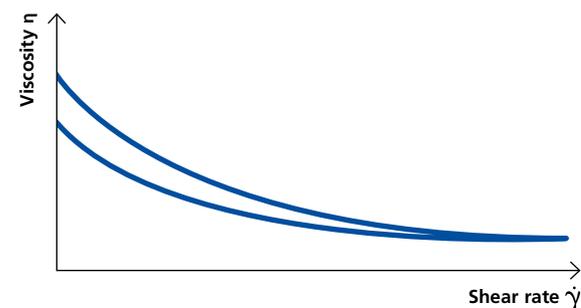


G.05

Pseudoplastic flow behavior

More typical flow behavior seen in coating systems is pseudoplasticity, also known as "shear thinning." Here, viscosity is inversely proportional to shear rate: Viscosity decreases as shear increases, i.e. the coating material becomes thinner. Frequently, such liquids also exhibit a yield point: it does not flow at low shear; flow only begins after the yield point has been reached or exceeded. In terms of application properties, this type of flow behavior has some advantages: The coating has a low viscosity when subjected to high shear, simplifying handling during production and application. At lower shear rates, for example during storage, the coating's viscosity is higher, thus effectively eliminating pigment sedimentation. At the same time, sag resistance following application on vertical surfaces is substantially improved. However, higher viscosity at lower shear rates may be undesirable for surface flow and deaeration of the freshly applied wet paint film. A stated viscosity for any pseudoplastic material is only meaningful if the corresponding shear rate is also indicated. Hence, a single-point measurement for such materials is of little value; the rheological behavior of the material can only be represented by the entire viscosity curve.

Thixotropic flow behavior



G.06

Thixotropic flow behavior

Thixotropy describes viscosity behaviors that are both time-dependent and shear-dependent. A pseudoplastic substance exhibits different viscosities as a function of changing shear rates, but these viscosities are independent of time. When a thixotropic substance is sheared at a constant rate, viscosity decreases as shear (time) duration increases. Once the shear is discontinued ($= 0$), viscosity returns to the original value. The viscosity curve of thixotropic liquids typically shows a "hysteresis loop," i.e. viscosity recovery after shear does not replicate the initial shear thinning from the equilibrium curve. Recovery viscosity is lower than the shear down viscosity at every shear rate. This clearly shows that it is not possible to attribute a unique viscosity value at a given shear rate for a thixotropic material; the viscosity measured depends on the sample's prior shear history.

Rheology additives in wood coatings

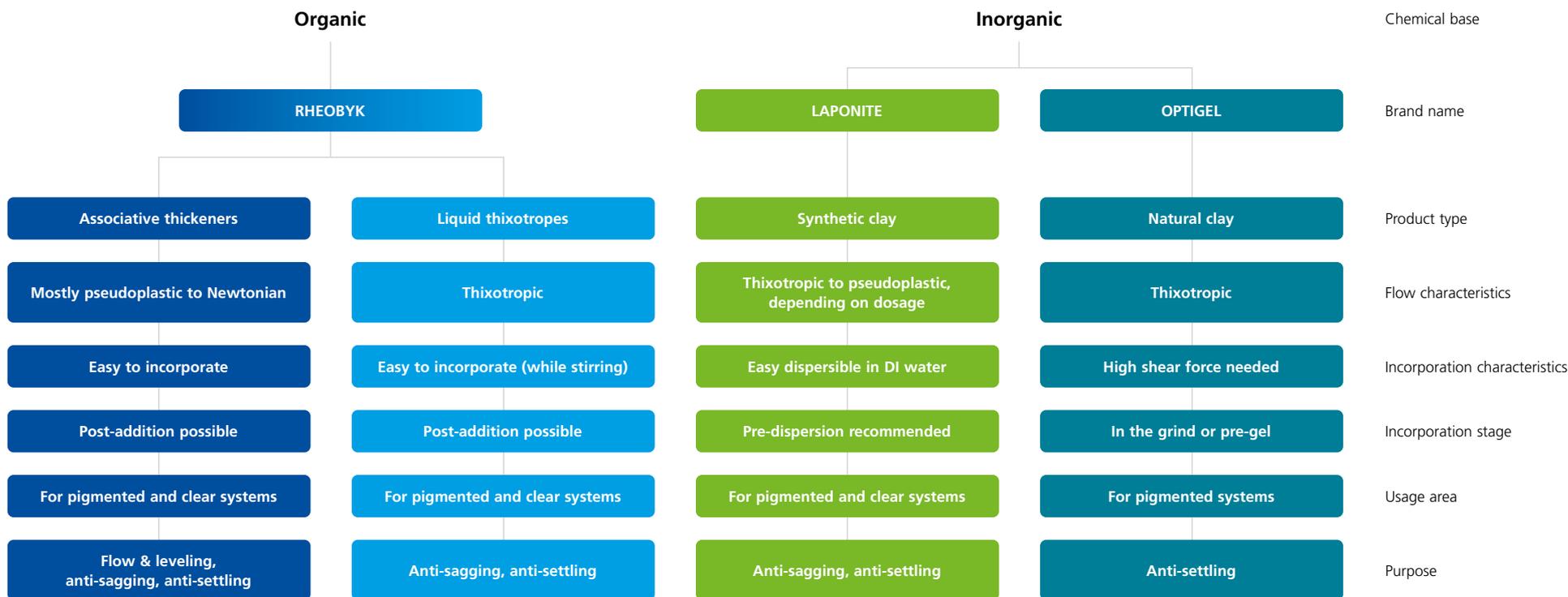
Wood coatings are applied in different ways and each application method requires a different viscosity profile. Therefore the choice of additive also changes depending on whether the film is applied by roller, curtain coater or if it is sprayed by HVLP or airless/airmix. In addition to the application method, both the geometry and position (vertical or horizontal) of the coated object are also important when choosing flow properties.

Coatings applied by spraying require some pseudoplasticity so that their viscosity is low enough to pass through the nozzle, yet high enough not to sag once they hit the substrate.

In addition to the application method, the formulation itself also plays a key role: Matted and pigmented systems require a certain elastic flow to prevent settling.

BYK offers a full product range to cover and fulfill all of these different requirements.

BYK rheology additives for wood coatings



RHEOBYK associative thickeners – products and applications

RHEOBYK associative thickeners have been designed to offer formulators broad formulating latitude in paints, coatings, inks, sealants, caulks, and adhesives while alleviating many of the problems often encountered with conventional urethane-based thickeners. RHEOBYK associative thickeners impart excellent flow and leveling, high film build, excellent stability, and unsurpassed resistance to blister, spatter, and syneresis when used with a broad variety of latex binders, including large and small particle size acrylics, vinyl acrylics, styrene acrylics, and ethylene vinyl acetates (EVAs). While the use of RHEOBYK associative thickeners can eliminate or reduce the need for cellulosics, these products are more compatible with cellulosics than urethane-based thickeners, leading to reduced paint syneresis and curtain sagging.

RHEOBYK associative thickeners technology in paints and coatings:

- Increased resistance (to water, alcohol, liquid cleansers, etc.)
- Improved barrier effect
- Improved viscosity stability with tinting pastes
- Increased stability with respect to pH fluctuations
- No syneresis and improved storage stability
- No reduction in gloss
- Haze-free
- VOC-free
- Tin-free

Rheological effects

Different associative thickeners can be used to adjust various effects in the three different shear ranges: low, medium, and high shear. Low-shear thickeners lead to an improved storage stability and sag resistance. Medium-shear thickeners are used to improve in-can viscosity and high shear thickeners increase brush drag and improve the spatter resistance.

HEUR – Hydrophobic ethoxylated urethane

- Non-ionic and emulsifier-free
- Typical HEUR odor and clarity
- Designed for high shear viscosity range for PU and acrylic dispersions, as well as vinyl, EVA, and low-responsive systems
- Suitable for exterior coatings

Structure of HEUR

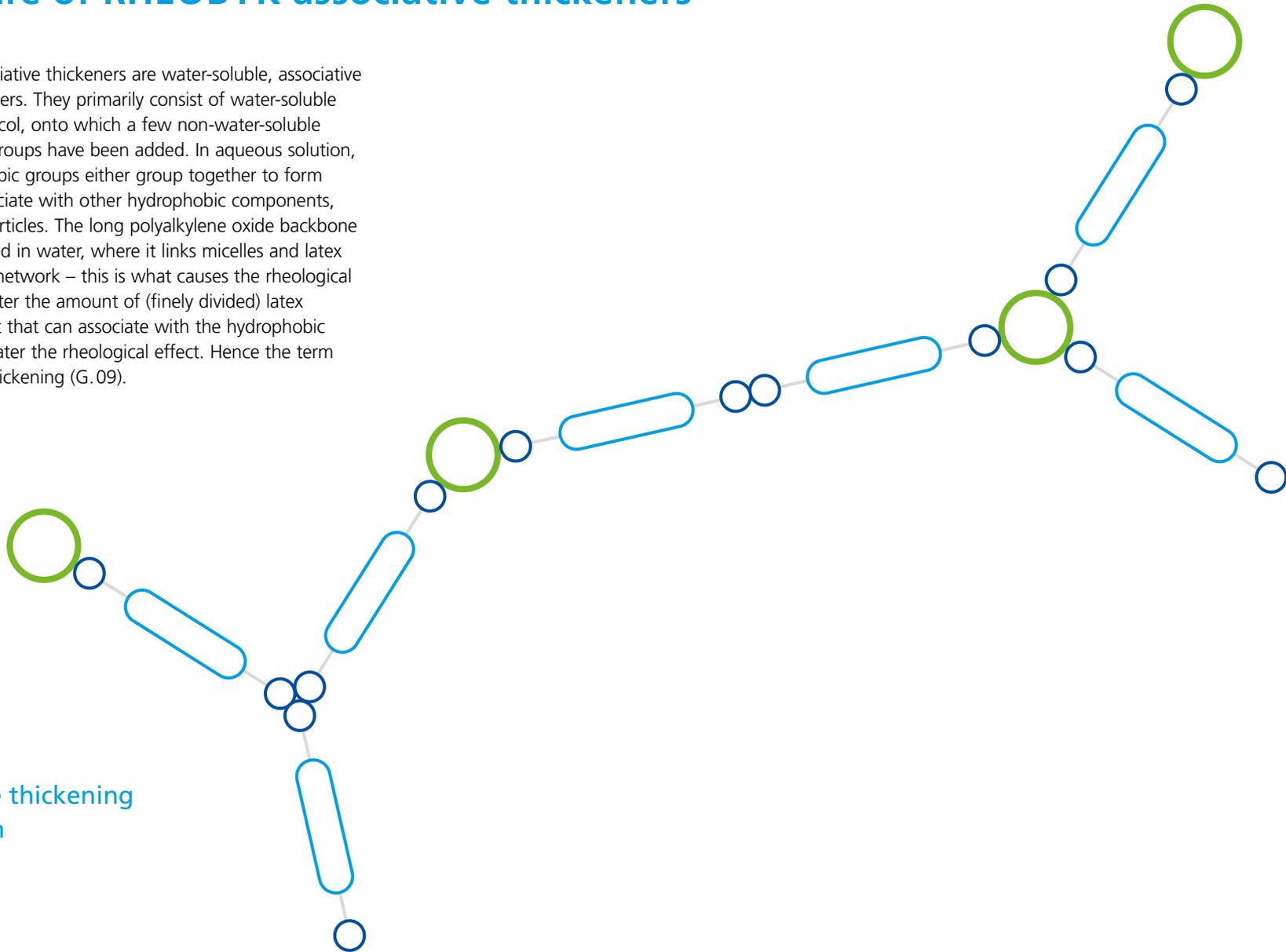
HEUR
Hydrophobic ethoxylated urethane



● Hydrophobic groups ● Connecting groups ● Compatibility providing units

Structure of RHEOBYK associative thickeners

RHEOBYK associative thickeners are water-soluble, associative polymer thickeners. They primarily consist of water-soluble polyalkylene glycol, onto which a few non-water-soluble (hydrophobic) groups have been added. In aqueous solution, these hydrophobic groups either group together to form micelles or associate with other hydrophobic components, such as latex particles. The long polyalkylene oxide backbone remains dissolved in water, where it links micelles and latex particles into a network – this is what causes the rheological effect. The greater the amount of (finely divided) latex particles present that can associate with the hydrophobic groups, the greater the rheological effect. Hence the term “associative” thickening (G.09).



Associative thickening mechanism

How it works

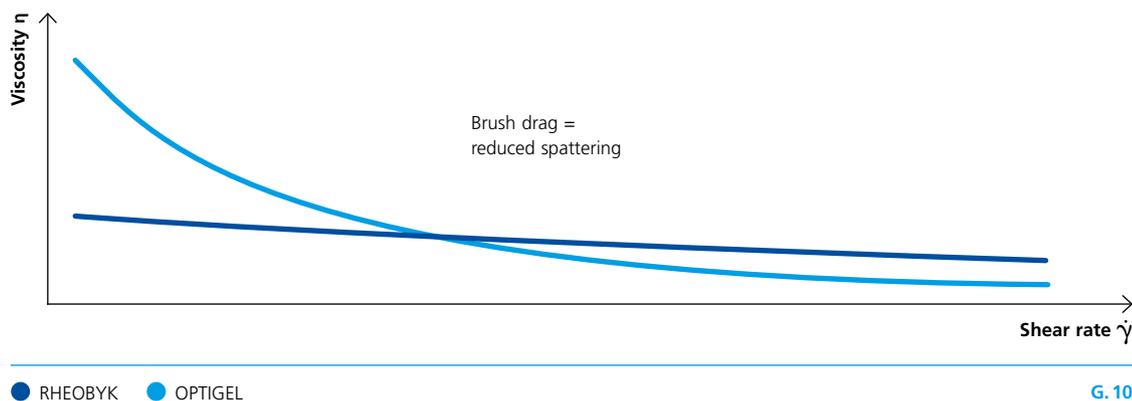
When the interactions described above form a three-dimensional network, associative thickeners greatly increase viscosity, especially under high-shear conditions. This strengthens the internal structure and thickens the material to a honey-like consistency, a process also described as brush drag. The number and chemical nature of the hydrophobic groups in the thickener molecule determine whether the increase in viscosity that can be achieved will produce a Newtonian or thixotropic/pseudoplastic behavior. Unlike systems utilizing laminar silicates (OPTIGEL) to produce a thixotropic behavior, systems thickened with RHEOBYK associative thickeners have no yield point, which ensures superior paint flow and leveling (G. 10).

Impact of structure on performance

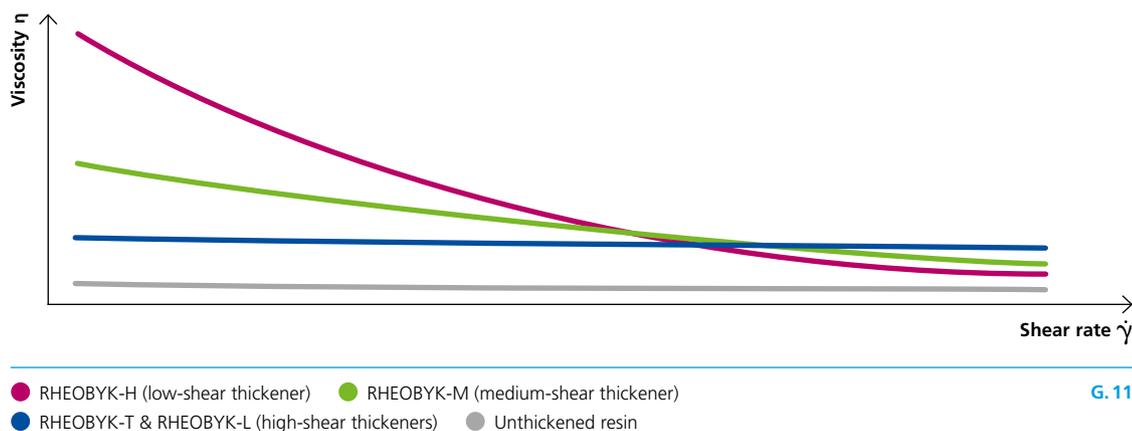
The size of the hydrophobic groups influences the additive's performance. These hydrophobic groups are mostly aliphatic hydrocarbon chains with a chain length of 6–16 C atoms. With longer chains the flow behavior will be more pseudoplastic and the viscosity at low shear will be high. These additives are called low-shear thickeners.

Shorter hydrophobic chains will result in a more Newtonian flow: instead of providing high viscosity at low shear, they provide higher viscosity at higher shear rates. These products are called high-shear thickeners (G. 11).

Associative thickener vs. a laminar silicate



Impact of hydrophobic chain length



RHEOBYK associative thickeners for tinting paste systems

Associative thickeners are often sensitive to the addition of surfactants, dispersing agents, wetting agents, and solvents. These additives reduce the associative interactions between the latex particles and the hydrophobic groups of the thickener, thereby reducing viscosity. This problem primarily arises when adding pigment concentrates that contain large amounts of interfering agents, such as dispersants and surfactants. (G. 12)

RHEOBYK-7600 leads to a considerable increase in viscosity in the low shear range, stabilizes viscosity when colorant is added, and improves color paste acceptance.

The rheological properties are comparable with those of HEAT technology. The new additive also offers significantly better leveling properties. In addition to being VOC-, APEO-, and tin-free, RHEOBYK-7600 is also liquid, which facilitates incorporation and handling. Due to its composition, it is highly compatible in many aqueous systems. Both sagging tendency and storage stability are improved. It is not necessary to adjust the pH value or control the temperature during incorporation.

Processability is optimized by combining with rheology additives that are effective in the high shear range.

Benefits

- Very good viscosity stability after tinting
- Balanced ratio of anti-sagging and leveling – improved leveling properties
- Improved colorant acceptance
- Improved anti-settling and anti-sagging properties
- Good compatibility with different systems
- Easy handling and incorporation due to the viscosity of the additive
- VOC-, APEO-, and tin-free

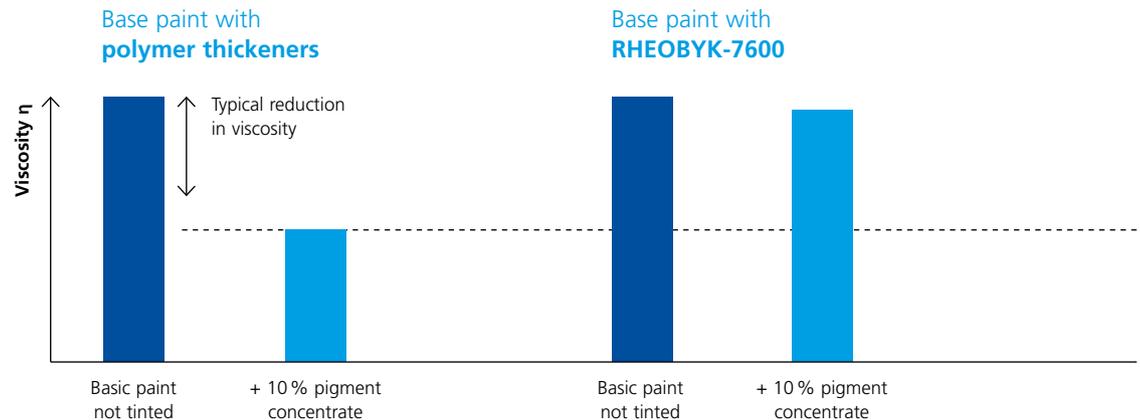
Conclusions

Over the years, the paint and coatings industry has adopted environmental regulations to lower VOC emissions in architectural coatings. As a result, paint manufacturers are moving from traditional oil-based paint systems to aqueous paint systems. The challenge for the paint manufacturer is to maintain performance properties such as brushability, stain removal, and durability.

The RHEOBYK associative thickeners system introduced in 1997 was designed for the paint manufacturer for use in

latex or aqueous paints to provide a smooth and creamy paint consistency with butter-like brush feel while preventing roller spatter (splashing that can occur from the paint roller). In addition, a patented technology allows all RHEOBYK associative thickeners to be supplied VOC-free. This technology, known as RHEOBYK associative thickeners VF technology, will also further enhance paint quality in areas such as color uniformity and paint consistency (less separation).

RHEOBYK-7600 – theoretical consideration of viscosity stability after tinting



RHEOBYK associative thickeners – product overview

Product	Chemistry								Remarks	
	Actives (%)	Ratio P:N*1	VOC-free	SVOC (g/l)	Formaldehyde-free	APEO-free	Organotin-free	Typical usage (%)		
High- & medium-shear thickeners										
RHEOBYK-L 1400 VF	HEUR	20.0	2.0 : 4.5	●	1.5-5.0	●	●	●	0.8-2.0	Highly efficient ICI builder suited for acrylic and styrene-acrylic systems
RHEOBYK-M 2600 VF	HEUR	20.0	3.0 : 3.0	●	5.0-10.0	●	●	●	0.8-2.0	Designed for lower response resin systems and offers “balanced rheology” in these systems
RHEOBYK-T 1000 VF	HEUR	22.5	1.0 : 5.0	●	< 1.5	●	●	●	0.8-2.0	ICI Driver with minimal impact on KU response
RHEOBYK-T 1010 VF	HEUR	22.5	1.5 : 4.5	●	< 1.5	●	●	●	0.8-2.0	Improved Newtonian/ICI Driver and resistance to syneresis
Low-shear thickeners										
RHEOBYK-425*2	HEUR	50.0	4.0 : 1.0	●	1.5-5.0	●			0.1-2.0	
RHEOBYK-7610	HEUR	20.0	5.0 : 0.0	●	< 1.5	●	●	●	0.2-2.0	Excellent leveling properties while providing good sag-resistance, for airless application
RHEOBYK-H 3300 VF	HEUR	17.5	4.0 : 2.0	●	< 1.5	●	●	●	0.5-2.5	Most universal associative thickener with balanced properties. Good starting point for evaluations
RHEOBYK-H 6500 VF	HEUR	20.0	5.0 : 2.0	●	5.0-10.0	●	●	●	0.5-2.5	
RHEOBYK-H 7500 VF	HEUR	17.5	5.0 : 1.0	●	5.0-10.0	●	●	●	0.5-2.5	Developed for a variety of hard-to-thicken latexes
RHEOBYK-H 7625 VF	HEUR	20.0	4.0 : 0.0	●	< 1.5	●	●	●	0.1-1.5	cPs/KU Driver for low binder systems, ideal for spray applied contractor brands
Specialty rheology modifiers										
RHEOBYK-7600	HEUR	15.0	5.0 : 0.0	●		●	●	●	0.1-1.5	Excellent viscosity stability during tinting
RHEOBYK-HV 80	HASE	30.0	7.0 : 1.0	●		●	●	●	0.5-2.5	

● Yes *1 P = pseudoplastic, N = Newtonian, 1 = weak, 7 = strong *2 Contains organotin

RHEOBYK associative thickeners – product differentiation

The typical rheology profile of associative thickeners is caused by the differently pronounced interactions between the acrylic copolymer dispersion and the associative thickener.

All associative thickeners demonstrate pseudoplasticity. After shear stress is stopped the viscosity will recover immediately.

The greater the pseudoplasticity, the greater the increase in viscosity in the low shear area. Conversely, the lower the pseudoplasticity, the lower the shear thinning effect, and the more Newtonian the viscosity profile, respectively (G. 13).

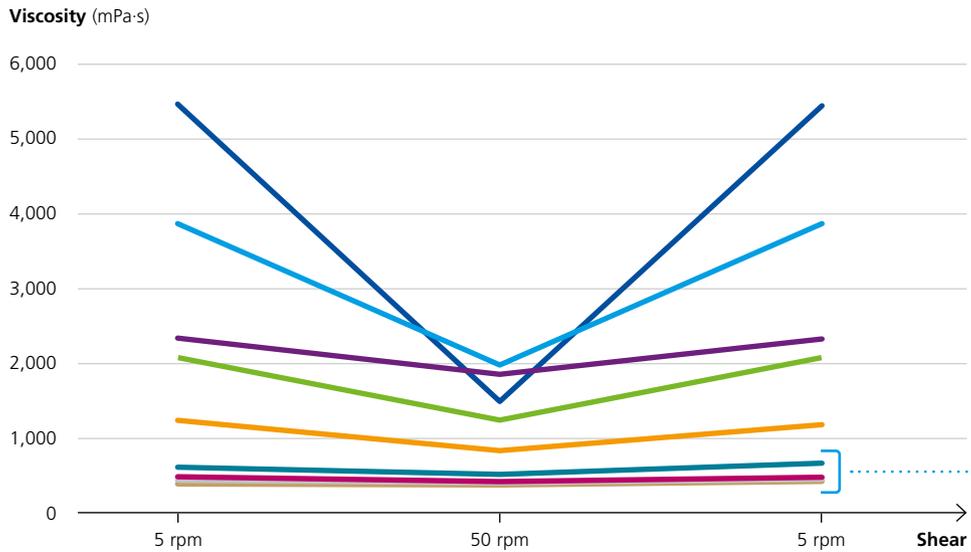
The highly pseudoplastic RHEOBYK-H additives are used in airless and airmix spray applications, especially in vertical spray. Here it is also useful to combine a pseudoplastic associative thickener such as RHEOBYK-H 7500 VF with LAPONITE products to prevent the sagging effect.

Medium pseudoplastic additives RHEOBYK-M 2600 VF or RHEOBYK-H 3300 VF will build in-can viscosity and are generally a good starting point for evaluation of RHEOBYK associative thickeners.

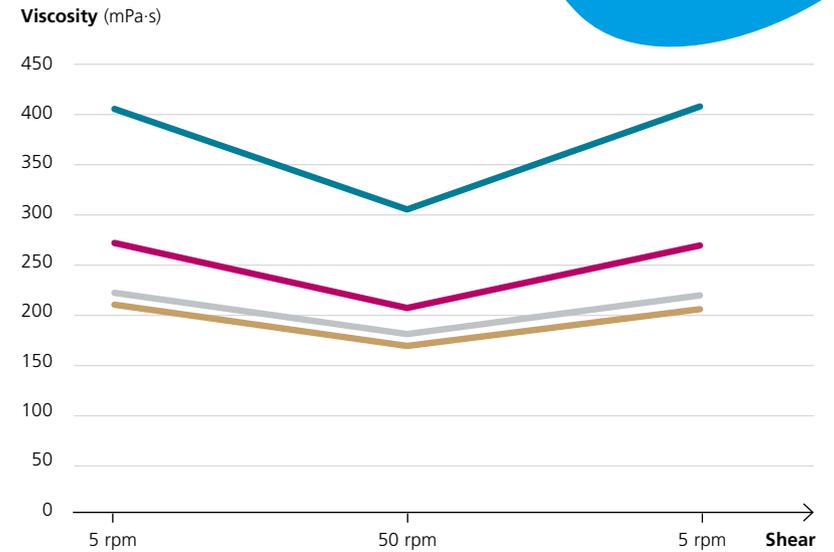
The more Newtonian additives are used for roller or curtain coater applications. They will also improve the brushability and prevent spattering due to their strong performance in the high shear area. In combination with LAPONITE, they will also provide the typical alkyd feeling during brush application.

Test system: Aqueous acrylic systems
Dosage: 0.1 % active substance
Measurement: byko-visc Advanced EX, Spindle R3, Shear rate 5/50/5 rpm
Measurement time: 1 min. for each step

All products

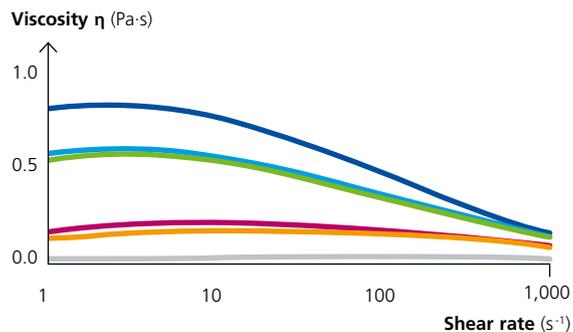


High- & medium-shear thickeners



Influence of cosolvents on rheological properties

Impact of cosolvents on associative thickener performance



- Without additional cosolvent and RHEOBYK-H 3300 VF **G. 14**
- Butyl glycol (BG) ● Butyl diglycol
- Dipropylene glycol methyl ether (DPIM)
- Dipropylene glycol n-butyl ether (DPnB)
- Ethyl diglycol (EDG)

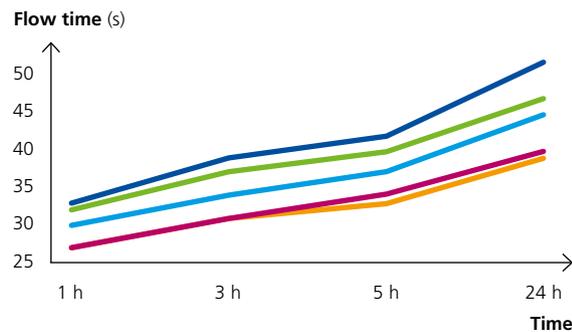
Test system: aqueous floor coating based on urethane hybrid dispersion; viscosity measurement: 1 day after incorporation, Anton-Paar Rheometer; RHEOPLUS/32 V3.62, CP25-1/1 – 1,000 s⁻¹

The efficiency of the associative thickeners strongly depends on the cosolvents used. As the water solubility of the solvent increases, the performance of the rheology additive decreases, particularly in the low shear range.

In parallel to the cosolvent, the emulsifier, the particle size of the binder emulsion and the solid content also have a strong impact on the performance of the rheology additive.

Water insoluble cosolvent have a positive effect on the viscosity build up in the low shear range because they cause the emulsion particle to swell and might also participate in the hydrophobic interactions.

Time dependency caused by water soluble cosolvents

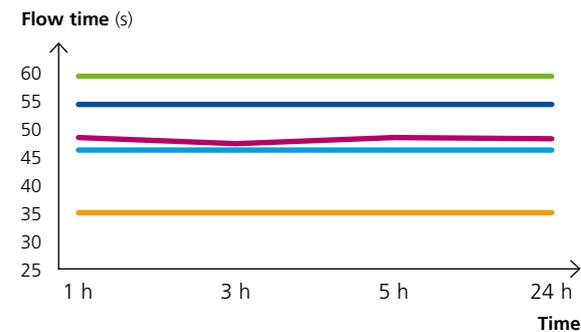


- 2.0% RHEOBYK-T 1000 VF **G. 15**
- 1.5% RHEOBYK-L 1400 VF
- 0.6% RHEOBYK-M 2600 VF
- 0.4% RHEOBYK-H 3300 VF
- 0.4% RHEOBYK-H 6500 VF

Test system: aqueous acrylic system, cosolvent BG, viscosity measurement with DIN 4 cup

When using highly water-soluble cosolvents, a significant time dependency can be observed in the performance of the associative thickeners. Therefore, special attention must be paid to viscosity development during storage so that it can be adapted to the final application conditions.

Immediate viscosity build by usage of water insoluble cosolvents



- 1.0% RHEOBYK-T 1000 VF **G. 16**
- 0.75% RHEOBYK-L 1400 VF
- 0.3% RHEOBYK-M 2600 VF
- 0.2% RHEOBYK-H 3300 VF
- 0.15% RHEOBYK-H 6500 VF

Test system: aqueous acrylic system, cosolvent DPnB, viscosity measurement with DIN 4 cup

Cosolvents with a limited solubility in water lead to a faster or instantaneous viscosity build.

However, this typical behavior might not be observed in all cases. Interactions of individual components will remain unpredictable and will need to be verified through laboratory testing.

Selection guide for associative thickeners

RHEOBYK-H 3300 VF is the starting point for all aqueous wood and furniture coatings. It generally performs well for all kind of application methods, but in some cases, depending on the emulsifier or cosolvent, for example, it might be necessary to switch to a different product. The testing order is shown in the following chart.

For spray applications, the flow should be adjusted to be more pseudoplastic, while roller applications require a more Newtonian viscosity profile.

Sometimes it is also useful to try combinations of two or more rheology additives, especially a combination of high and low-shear thickeners.

Selection guide

Low-shear thickeners ("H grades")

Pseudoplastic

Spray application

In combination or as stand-alone rheology modifier

RHEOBYK-H 6500 VF

RHEOBYK-H 7500 VF

RHEOBYK-H 7625 VF

Improvement of **anti-settling** and **anti-sagging** properties
Prevention of **picture framing**
Elimination of **insufficient edge coverage**

Starting point

RHEOBYK-H 3300 VF

RHEOBYK-M 2600 VF

Adjustment of "in-can" viscosity ("body") at low additive dosage

A combination might be helpful

High-shear thickeners ("L/T grades")

Newtonian

Roller application

A combination might be helpful

RHEOBYK-L 1400 VF

RHEOBYK-T 1000 VF

RHEOBYK-T 1010 VF

Improvement of **leveling**
Adjustment of **"brushability"**

RHEOBYK liquid thixotropes

RHEOBYK-420 is a liquid rheology additive that creates strong thixotropic flow behavior in coatings and printing inks. This product is a solution of a modified urea in N-methyl pyrrolidone (N-methyl pyrrolidone-free versions are also available). Their functional mechanism is based on the fact that the active substances in these additives are insoluble in common coating solvents and/or blends: properly incorporated into coating systems, the additive separates in a controlled manner, forming very fine, needle-like microcrystals, which in turn, form a three-dimensional lattice structure via hydrogen bonds. The initial formation of this structure may take up to several hours. Hydrogen bonding between the urea groups of the individual molecules leads to the formation of the network structure. During application of such a modified coating system, very low shear forces are sufficient to destroy these lattice structures, giving the coating the desired low application viscosity. Following application, the structure reforms in a delayed manner that is characteristic of thixotropic materials and the viscosity of the applied wet coating layer increases again.

RHEOBYK-420 (and its derivatives) is also rheologically active in pure water and does not require the presence of resins. Nevertheless, the presence of cosolvents can improve compatibility and lead to easier incorporation.

Chemical structures

RHEOBYK-420



● Urea groups Modifying groups: ● high polar ● medium polar

G. 18

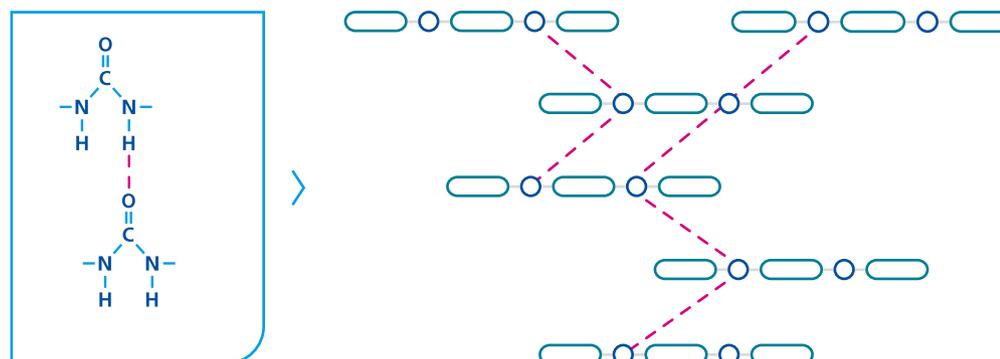
Modified urea products

Product	Active content	Carrier	Label	Remark
RHEOBYK-420	52 %	NMP		
RHEOBYK-D 420	52 %	DMSO		Crystallizes below 5 °C
RHEOBYK-7420 CA	52 %	Cyclic amide		
RHEOBYK-7420 ET	42 %	Amide ether		

NMP = N-methyl pyrrolidone, DMSO = Dimethyl sulfoxide

T. 03

Network formation via hydrogen bonding



G. 19

Compatibility check and improvement

1. Incorporation

The first step to check compatibility is to add the liquid thixotrope to the non-pigmented formulation. It should be incorporated homogeneously while vigorously stirring.

2. Compatibility test

Next, compatibility must be assessed following incorporation. This can be done visually. It might be helpful to draw the system down onto a glass plate. It might take a few minutes for the rheological effect to build up.

Homogeneous

- Excellent thickening
- No particles



No particles/no seeds and a good rheological effect: Compatibility is good and no formulation changes are necessary.

Inhomogeneous

- No or only weak rheological effect
- Particles visible in the coating or application



If seeding is observed, a compatibility improvement is required, which can be achieved by using different cosolvents and wetting & dispersing additives.

2 % RHEOBYK-420
in water/BG/
DISPERBYK-192
94/5/1



Recommended cosolvents

- Polypropylene glycol (PPG 600)
- Butyl glycol (BG)
- Dipropylene glycol dimethyl ether

2 % RHEOBYK-420
in pure water



Natural and synthetic clays

Mode of action

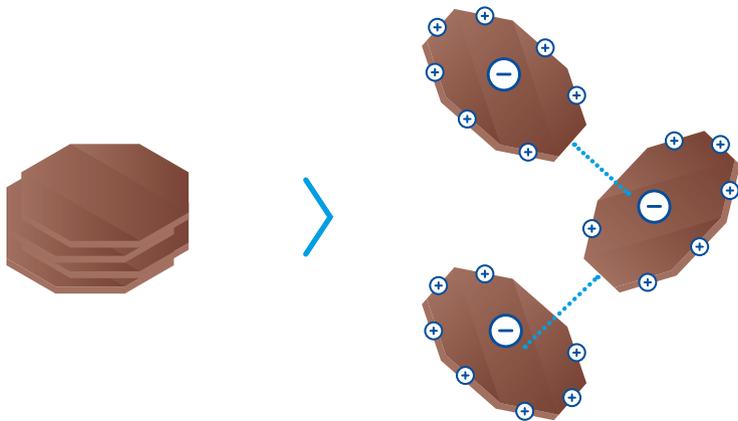
LAPONITE and OPTIGEL products from BYK are smectite-based rheology additives for aqueous systems. Smectites are a group of layered silicate minerals that occur naturally, but which can also be produced synthetically. Smectites have a platelet structure; the platelets are very thin, about 1 nm. The platelet diameter is about 500-1000 nm (1 μm) for natural smectites (OPTIGEL products) and 25-50 nm for synthetic smectites (LAPONITE products). These platelet stacks then separate into their individual platelets when added to water and dispersed under high shear conditions.

House-of-cards structure

The surfaces of individual LAPONITE/OPTIGEL platelets are negatively charged, but their edges are either neutral or positively charged. Because their overall charge is predominantly negative, the platelets repel each other in the suspension, a process that distributes them evenly throughout the solution.

The difference in charge between their edges and their surfaces then generates a slight edge-to-face attraction between the platelets. Small amounts of divalent cations, such as Ca^{2+} or Mg^{2+} , can further contribute to this interaction. These produce a house-of-cards structure, which results in a gel formation.

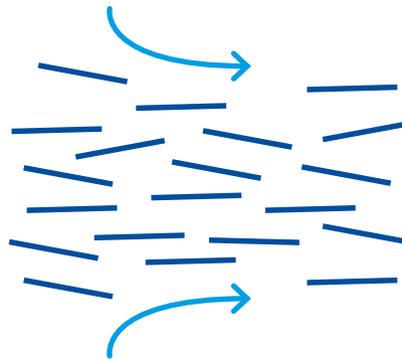
Mode of action – house-of-cards structure



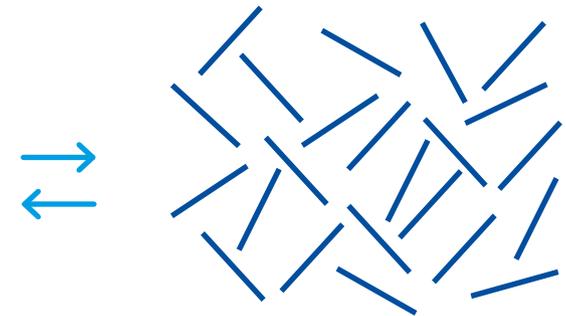
G.21

Mode of action in motion and at rest

In motion



At rest



G.22

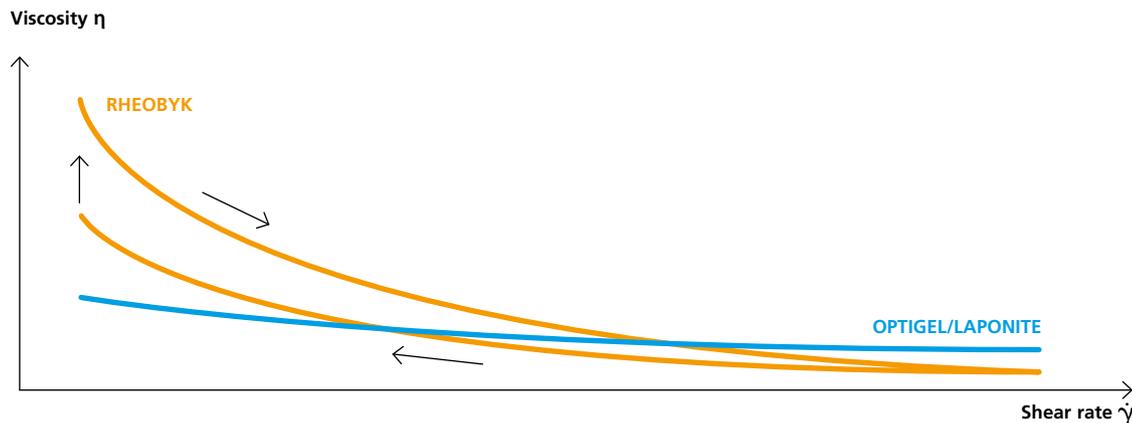
Yield point and thixotropy

The stability of the gel reflects the bonding strength between platelets. When external forces (such as a stirrer, paint brush or roller) act on the gel, the house-of-cards structure collapses and the gel returns to its fluid state. Once the external force is reduced, the structure reforms and the liquid again behaves like a gel. LAPONITE and OPTIGEL produce what is known as a yield point. This means, a minimum force is required before a substance starts to flow.

Additionally, the gel exhibits a thixotropic behavior. The greater the stirring force acting on the gel, the more completely the house-of-cards structure will collapse, i.e. the thinner the liquid will become. After stirring, the house-of-cards structure will reform within a short period of time and the viscosity will return to its original level.

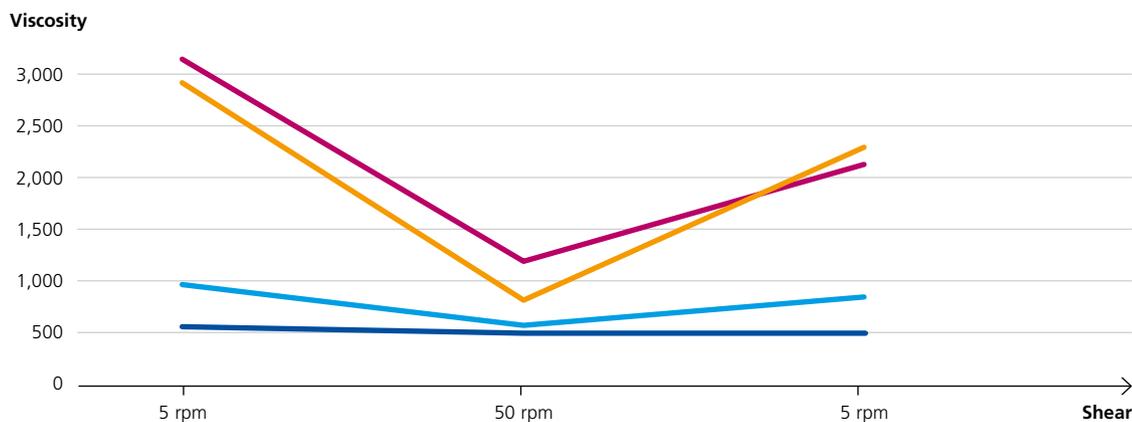
On the other hand, the associative/Newtonian thickeners in the RHEOBYK associative thickeners product line behave differently, exhibiting virtually no yield point and remaining highly viscous, even when vigorously stirred.

Yield point and thixotropy



G.23

Thixotropic and pseudoplastic



● 0.5 % RHEOBYK-T 1010 VF/RHEOBYK-H 7500 VF ● 0.5 % OPTIGEL-WX ● 0.5 % LAPONITE-RDS
● 0.5 % LAPONITE-SL 25

G.24

OPTIGEL/LAPONITE – major applications

Product	Features
LAPONITE-EP	Modified; for adjustment of in-can viscosity
LAPONITE-RD	General purpose grade; highest gel strength; pseudoplastic flow; high elasticity performance
LAPONITE-RDS	Easier to disperse; longer processing period; higher Ca ²⁺ /Mg ²⁺ tolerance
LAPONITE-S 482	Powder grade for intermediate sole grade preparation; for higher dosage levels; for post-addition and post-correction
LAPONITE-SL 25	Ready-to-use version; for post-addition and post-correction
OPTIGEL-CK	Universal, thixotropic thickener for water-soluble systems; stabilizer for latex paints, ceramics
OPTIGEL-CL	Thixotropic anti-settling agent/stabilizer for paints, ceramics
OPTIGEL-CG	Economical, thixotropic thickener for paints and building chemicals
OPTIGEL-CMO	Thixotropic thickener and stabilizer for paints and technical applications; compatible with large amounts of electrolytes
OPTIGEL-LX	Highly effective thickener for flat and semi-gloss latex paints, silicon resin paints, and adhesives
OPTIGEL-WA	Effective thickener for flat and semi-gloss latex paints, water-soluble paints, additive for the building industry and cleansers
OPTIGEL-WM	Highly effective, universal thickener for semi-gloss latex paints, water-soluble paints, adhesives, and textile auxiliaries
OPTIGEL-WX	Effective thickener for flat and semi-gloss latex paints, water-soluble paints, silicate paints, and printing inks
OPTIGEL-W 724	Highly effective thickener for semi-gloss and high PVC latex paints, water-soluble coatings, and anti-corrosion primers (i.e. 2-pack PUR, 2-pack epoxy)

LAPONITE-RDS and LAPONITE-S 482 pre-mixes can be added at any stage of the manufacturing process.

LAPONITE-SL 25 is ready to use at any stage of the manufacturing process

LAPONITE and OPTIGEL – advantages

Benefits of the yield point

The formation of a yield point reduces sagging. This makes it possible to apply thick coats of paint in a single application without negative side effects such as beading, dripping or sagging. This is achieved thanks to the stabilizing effect of the OPTIGEL house-of-cards structure, which rebuilds completely shortly after the paint is applied. The yield point significantly improves storage stability, keeping pigments and fillers in suspension and preventing heavier pigments from settling and lighter pigments from floating up to the surface. Thixotropic behavior alone would not have this effect; it may slow down the settling process, but does not prevent it. The system must also have a yield point, which also reduces liquid separation (syneresis).

Advantages

For your product:

- Easy handling
- No sagging
- No dripping
- Excellent storage stability
- No settling

For your production processes:

- Easy to meter
- Easy to disperse
- Universally applicable

LAPONITE products

LAPONITE-RD is a fully synthetic, inorganic product with a precisely controlled chemical composition. It has a powerful stabilizing effect. Other outstanding features are its superior whiteness and its ability to form transparent gels. LAPONITE-RDS and LAPONITE-S 482 have been modified in a way that makes these powdered products particularly easy to disperse. LAPONITE-SL 25 is a ready-for-use aqueous dispersion at 25 % solid content.

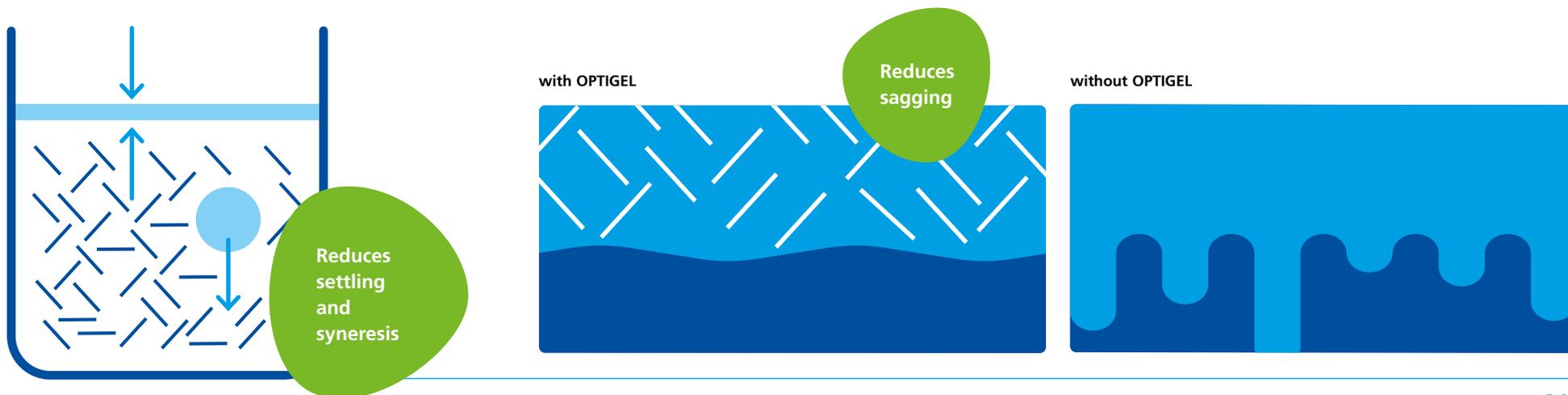
OPTIGEL-C products

OPTIGEL-C products are natural smectites and can be stored as a powder or as a pre-gel. They produce a high yield point in aqueous and water-soluble systems. This is why OPTIGEL-C products significantly improve the stabilization of systems and help to prevent settling and sagging without raising the apparent viscosity.

Modified OPTIGEL products

OPTIGEL-LX, OPTIGEL-WA, OPTIGEL-WM, OPTIGEL-WX, and OPTIGEL-W 724 are organically modified. They increase the viscosity and give aqueous and water-soluble systems a thixotropic behavior. All OPTIGEL products are easy to disperse and are excellent stabilizers and anti-sagging agents.

LAPONITE and OPTIGEL



Producing perfect hydroclay gels

Organoclays (bentonites, hectorites) are widely used as thickeners in coating formulations to create or enhance pseudoplastic flow behavior and thixotropy in order to counteract settling and sagging. These materials come in powder form and must be properly dispersed in the coating system to achieve the desired results. Preparing organoclay pastes in solvents (organoclay gels) as a masterbatch is often found to be very convenient because these pastes can then be easily introduced into various coating systems.

Theory...

Dry organoclay powder consists of particles where many clay platelets are stacked together (G.26). Solvents penetrate the space between the platelets and the stacks swell up. High shear forces are necessary to completely separate the platelets from each other. Water is used as chemical activator to create the organoclay gel: small amounts of water are sufficient to form links between several platelets via hydrogen bonds resulting in a three-

dimensional network (G.26). This network, which is destroyed under shear and rebuilds when shear forces are removed, is the reason for the pseudoplastic and thixotropic flow behavior.

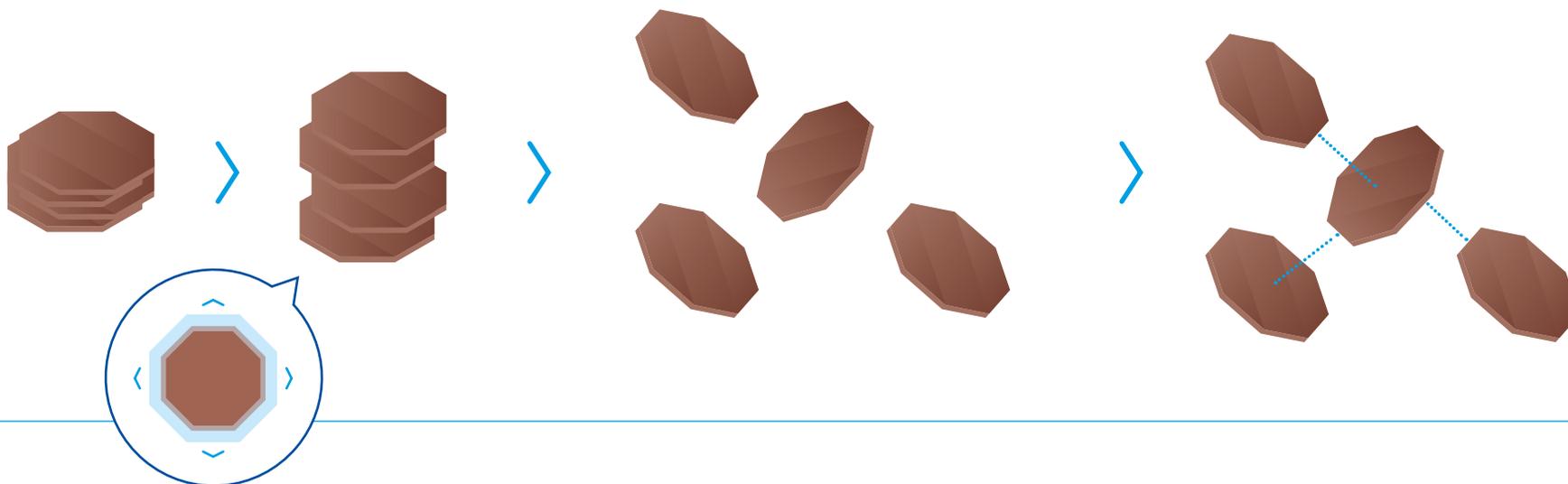
Well-dispersed organoclay

Dry stack of organoclay platelets

Solvent swells organoclay

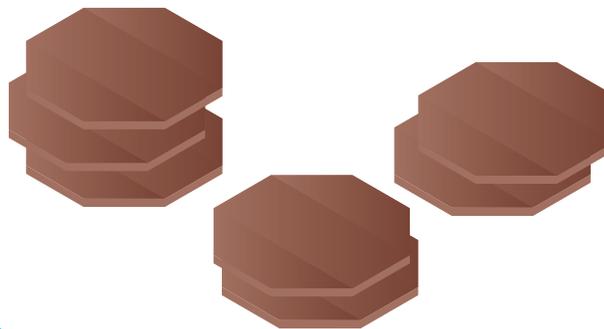
Well-dispersed organoclay platelets

Formation of three-dimensional network:
pseudoplastic and thixotropic flow behavior;
excellent anti-sagging and anti-settling properties



...and practice

In practice, it has been found that it is not possible to achieve good dispersion of the clay platelets with high shear forces alone (G. 27). Incomplete dispersion yields a highly viscous paste and a significantly reduced rheological effect: insufficient anti-settling and anti-sagging properties. It is common practice to use suitable wetting and dispersing additives to guarantee complete dispersion of the clay platelets. The resulting paste has a lower viscosity, but demonstrates excellent anti-settling and anti-sagging performance when incorporated into a coating system.

Poorly dispersed organoclay**Incomplete dispersion of organoclay platelets****Important**

High viscous paste,
reduced rheological
effectivity, reduced
transparency

LAPONITE**Handling instructions – incorporation into water pre-mix preparation**

- Preparation of water pre-mixtures (preferably DI water)
- Rapid and homogenous incorporation under agitation
- Stirring period of approx. 30 min. for full activation
- Pre-mix processing period depends on water hardness and dosage (high water hardness cause pre-mix processing reduction)
- Pre-mixes should be processed as long as they are liquid (no visible structure)

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