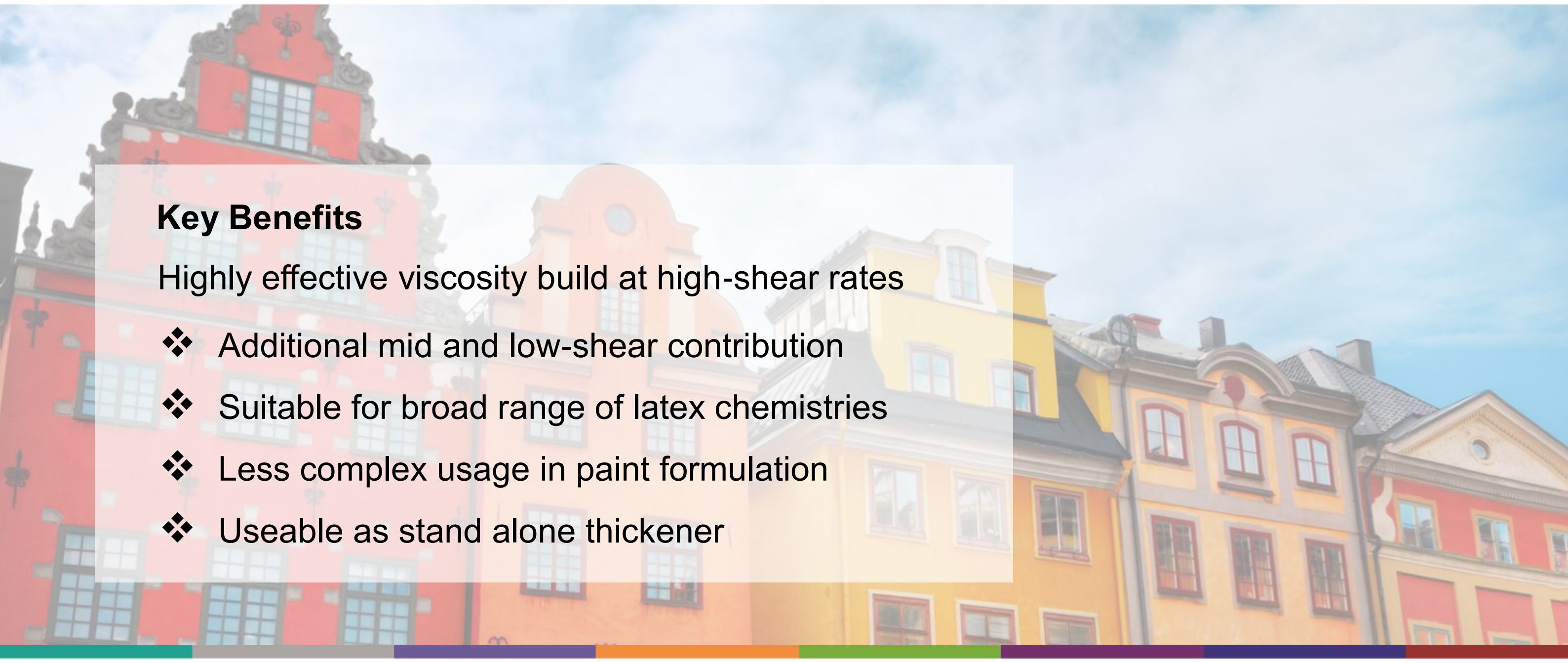
ELEMENTIS

A global specialty chemicals company

Application Leaflet

RHEOLATE® HX technology

Highly efficient nonionic synthetic associative thickener (NiSAT) for excellent high-shear viscosity with low and mid-shear viscosity contribution



Key Benefits

Highly effective viscosity build at high-shear rates

- Additional mid and low-shear contribution
- Suitable for broad range of latex chemistries
- Less complex usage in paint formulation
- Useable as stand alone thickener

Background

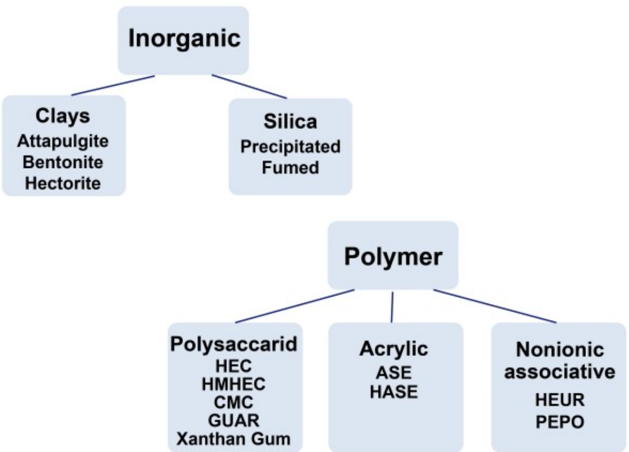
Continuously lower VOC targets for paints and coatings have forced manufacturers of latex based paints and coatings to develop low - and zero VOC systems. The chemistry and stabilization of this latest generation of systems has resulted in different requirements for the relevant thickeners. Efforts to advance conventional nonionic synthetic associative thickeners (NiSAT), based on structure/property relationships have led to continuously developing NiSAT thickeners which are unique in chemistry and performance to provide the formulator flexible solutions.

In this leaflet, the performance of the latest NiSAT thickener technology is illustrated. It is displayed that the RHEOLATE® HX grades allow a significant decrease of the concentration required to achieve the targeted viscosity specification of the relevant system without adversely affecting the application properties.

Introduction

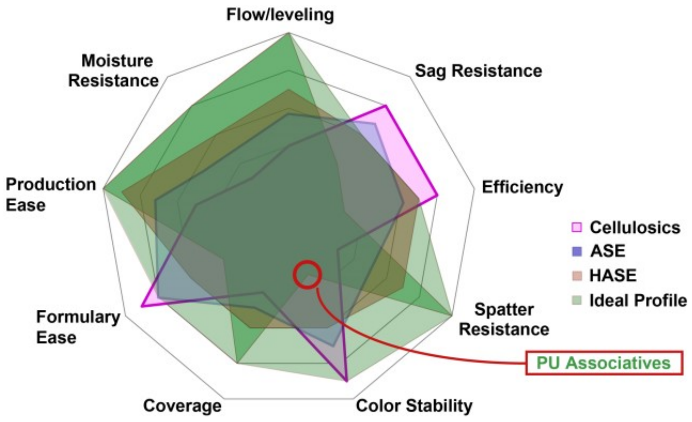
The choice and the composition of rheology modifiers is typically having a major influence on the application properties and the final appearance of the resulting film of the relevant paint or coating. Typically used thickener grades for latex paints can be divided in certain classes such as cellulose-based water soluble polymers, polyacrylate based (H)ASE and non-ionic synthetic associative thickeners (NiSAT). Further product classes dedicated to aqueous systems are silica and clay based inorganic grades.

The NiSAT based rheology modifiers are the most modern thickeners and nowadays commonly used in the formulation of latex based paints and coatings.



Polymeric rheology modifiers derive their thickening properties typically either from volume exclusion due to its molecular weight (hydrodynamic volume) and/or from from an associative mechanism in which interactions with the latex particles and, to a lesser extend with pigment and extenders, build a transient network structure.

In the below chart, the positive and negative attributes of certain thickener classes is being compared. No type of rheology modifiers is dominant in all properties so that the choice is mainly depending on the cost and performance requirements of the final system.



It is obvious, that the group of NiSAT thickeners performs typically superior in the fields of flow and levelling, coverage (film build), moisture resistance as well as reduction of roller spattering. The effectivity of these thickeners is typically not equal to other classes. Further, associative thickeners are often sensitive to viscosity loss on tinting with colorants. This is especially relevant for richly colored paints that are popular for DIY applications.

The efficiency differences of the NiSAT thickeners in comparison to the mentioned other classes has been exacerbated by the new environmental regulations requiring decreasing amounts of VOC. In addition, changes in the resin technology, meant to reduce the need for coalescents, have resulted in an increase of the amount of surfactant which might also have an adverse affect of the NiSAT`s efficiency. Also the use of open time extenders meant to counteract the also have an effect on the effectivity of rheology modifiers.

Within the class of NiSAT`s, the additives designed to provide predominately Newtonian characteristics (high-shear thickeners) are commonly the dominating part. These products are designed to provide good film build, without extensive build-up of the “in-can-feel” and superior levelling of the paint. These are the thickeners that would mostly benefit by an improvement in efficiency. Higher efficiencies can than result in both, reduced cost along with improved film properties such as hardness, water resistance, scrub, etc.

The herein described new high-shear thickeners, promoted as RHEOLATE® HX grades, are the culmination of an extensive effort to improve the efficiency without sacrificing any positive attributes of the final paint system. These grades have shown a significant improvement in thickening efficiency in comparison to the currently used technology. The relative impact on the rheological characteristcs, performance and efficiency is illustrated in the following in a number of various paint and coating systems.

Both grades which are being described, RHEOLATE® HX 6008 and RHEOLATE® HX 6050, are novel nonionic synthetic associative thickener, (NiSAT) providing outstanding rheological properties for aqueous applications. They develop high shear viscosity very efficiently, and additionally display some mid-shear viscosity contribution. RHEOLATE® HX 6008 is specifically dedicated in aqueous acrylic and alkyd systems. RHEOLATE® HX 6050 shows its strength especially in vinyl acetate-ethylene (VAE) as well as Vina-Veova based systems. In the field of styrene-acrylic binder systems, both grades are performing equally well.

Properties	RHEOLATE® HX 6008	RHEOLATE® HX 6050
Type	Efficient high-shear viscosity builder with low and mid-shear contribution	
Appearance	Opaque liquid	
Active solids, [%]	25	
Specific gravity, [g/ml]	1.05	
Viscosity, [cps]	<3000	
VOC, [%] (ASTM D 6886-03)	<0.2	
Odour	Very low	
pH	4 - 6	6.5 - 8
Dedicated latex technology	Acrylic Styrene Acrylic Aqueous alkyd	VAE Vina-Veova Styrene-acrylic

Key benefits

- Extremly highly effective thickener providing both, high-shear (ICI) and mid to low-shear properties
- Compatible in various resin systems
- Excellent balance of sag, flow and levelling
- Minimal effect on final paint properties

Incorporation and levels of use

RHEOLATE® HX 6008 and RHEOLATE® HX 6050 can be used in the delivery form or, if necessary, furtherly diluted with water. The addition can take place at any time during the manufacturing process, however, incorporation into the mill base before the letdown is recommended. Both grades can be combined with other associative rheological additives, clay based thickeners or cellulosic thickeners for to achieve the required rheological characteristics in accordance with the individual requirements.

It is furtherly important to assess the effectiveness of RHEOLATE® HX 6008 in the entire system, as performance might be affected by other raw material ingredients. Further detailed background information on the technology of nonionic synthetic associative thickeners can be found in the Elementis rheology handbook.

Typical use levels of RHEOLATE® HX 6008 and RHEOLATE® HX 6050 are in a range 0.1% to 1.5% (product weight) related to the total system weight.

Products tested

Part 1: Performance evaluation in a pure acrylic based paint

- Pure acrylic based paint (PVC 30%)
  For exterior coatings, plasters and external wall insulations systems and primers
- Paint (PVC 30%)
  For interior paints, textured finishes, gloss/satin latex paints, primers and silicate emulsion paints
  This paint will be equipped with various binder systems:
  - Styrene-acrylic
  - Vina-Veova
  - Vinylacetate-ethylene

Part 2: Reduction of complexity

- RHEOLATE® HX 6008 in pure acrylic based paint (PVC 30%)
  For exterior coatings, plasters and external wall insulations systems and primers
- RHEOLATE® HX 6050 in VAE based paint (PVC 50%)
  For interior paints, textured finishes, gloss/satin latex paints, primers and silicate emulsion paints

Part 3: Evaluation of the influence on final coating properties

- 1C acrylic high gloss clear wood coating
  For parquet varnishes, wood stains sealers, MDF, and furniture coatings

Part 1: Performance evaluation in a pure acrylic based paint

Pure acrylic based paint (PVC 30%) formulation

Table 1: Test formulation

	PVC 30%	PVC 30%		
Raw material	**Concentration [%]**		**Function**	**Supplier**
Millbase stage				
Deionized water	7.55	14.90	Diluent	
Add under stirring in the denoted order				
NUOSPERSE® FX 504	0.10	0.10	Dispersing agent	Elementis
Defoamer	0.20	0.30	—	Elementis
Sodium polyphosphate	0.50	0.10	Softener	BK Giulini ICL
Titanium dioxide	4.10	5.80	Pigment	Kronos International
Calcium carbonate, various particle size	21.7	30.90	Extender	Omya
Micro Talc IT Extra	2.40	3.40	Extender	Elementis Talc
Aluminium silicate	1.10	1.50	Extender	Evonik Industries
Grind for 15 min. at 10 m/s.				
Add and stir for further 10 minutes at low speed				
Defoamer	0.05	0.10	—	Elementis
Deionized water	10.00-X	9.70-X	Diluent	
Add under stirring				
Pure acrylic emulsion	51.55	—	Binder	
Styrene-acrylic, Vina-Veova or VAE emulsion	—	32.10	Binder	
DAPRO® FX 511	—	0.80	Coalescing agent	Elementis
DOWANOL™ DPnB	0.55	—	Coalescing agent	DOW
Add and stir slightly for 10 min.				
Rheological additive(s)	X	X	Rheological additive	
Ammonia solution w=25%	0.15	0.20	pH adjustment	Elementis
Parmetol® A 26	0.05	0.10	In can preservative	Schülke & Mayr
	100.00	100.00		

X is variable in accordance with individual concentration.

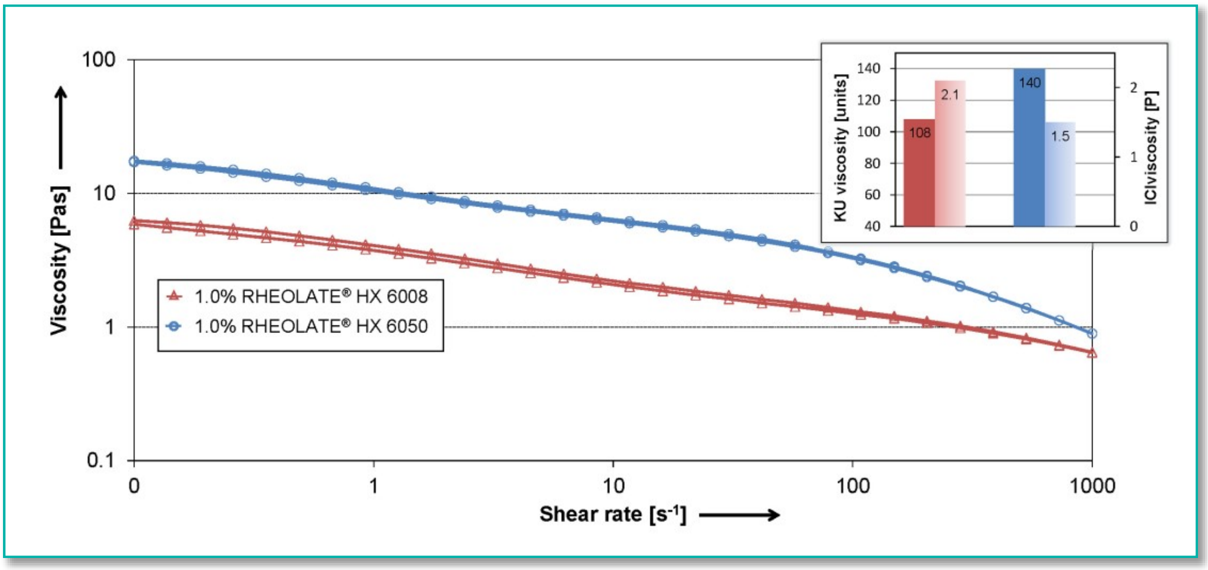
The PVC 30% test formulation was based on an aqueous copolymer emulsion of acrylic/methacrylic acid esters. These APEO free APEO-free binder has a solid content of 46%, Tg of 23 °C and a particle size of 120 μm. It is commonly used in exterior coatings e.g. for masonry paints containing coalescing agents, deep shade paints, plasters and textured coatings, external wall insulations systems and primers.

The PVC 50% paints will be equipped with various binder system. In the first case, a styrene acrylic, in the second a Vina-Veova and in the third case a vinyl acetate-ethylene (VAE) based system will be used.

Note, only the PVC 30% paint are formulated with the acrylic binder. The styrene-acrylic, Vina-Veova and VEA binder emulsion are formulated in the PVC 50% paints.

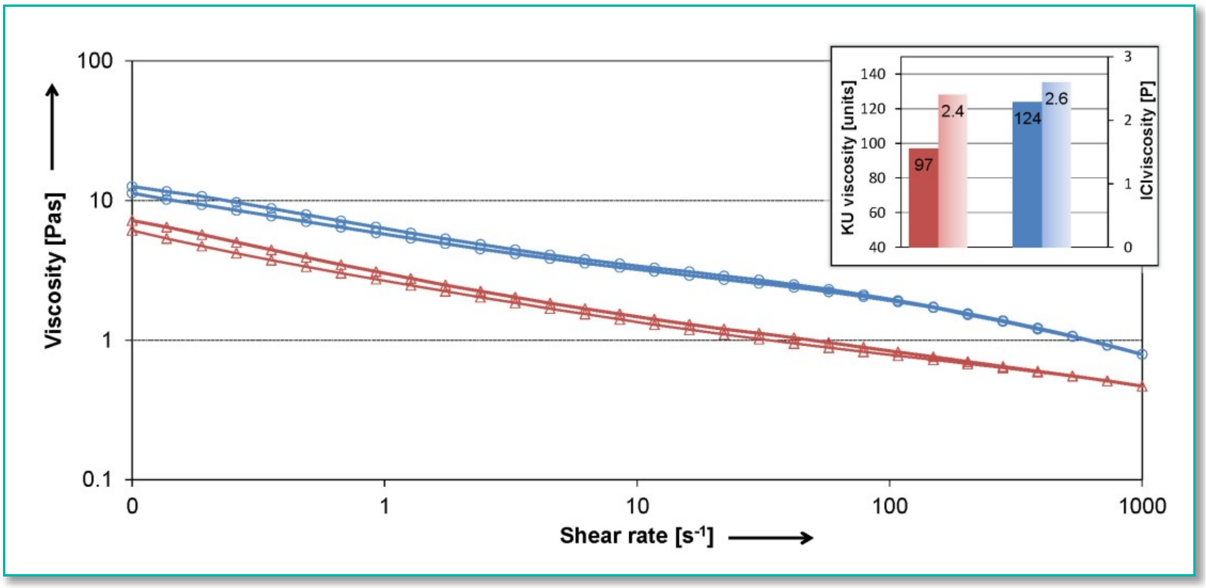
In this part of the study, both additives, RHEOLATE® HX 6008 and RHEOLATE® HX 6050 were formulated at equal concentration. In the acrylic and the styrene acrylic system, a concentration was chosen, that with RHEOLATE® HX 6008 a mid-shear/KU viscosity of 100 units was obtained. In the Vina-Veova and the VAE based paint, the standard KU viscosity was adjusted by RHEOLATE® HX 6050.

Figure 1: Pure acrylic PVC 30% paint



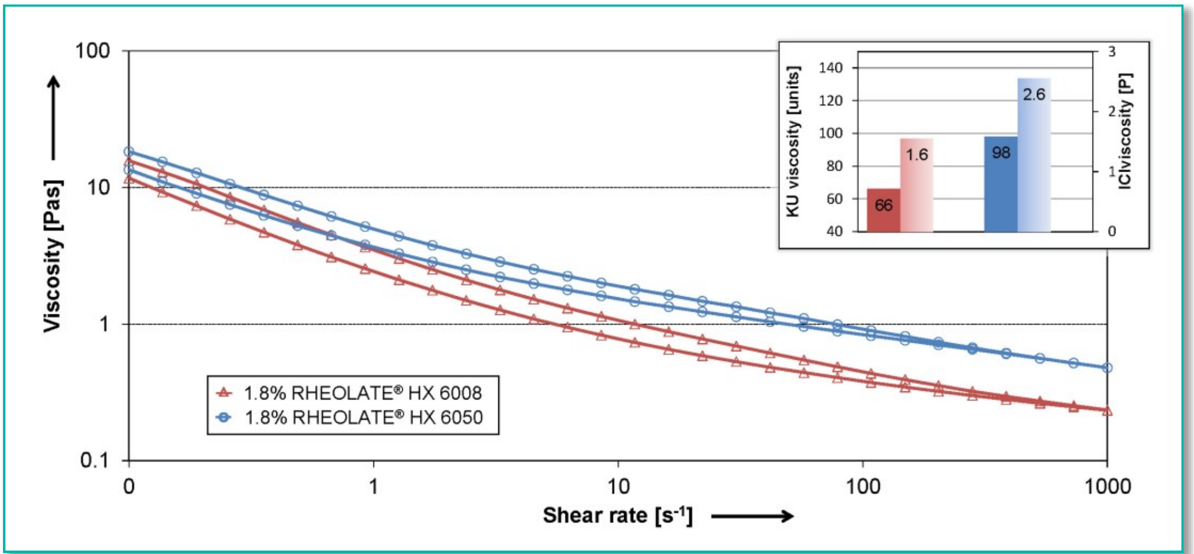
In the pure acrylic PVC 30 paint, RHEOLATE® HX 6008 provides the strongest Newtonian flow characteristics. The flow behavior caused by RHEOLATE® HX 6050 was markedly more shear thinning than with RHEOLATE® HX 6008 when formulated at equal concentration of 1%. This was also displayed by a significantly higher KU viscosity and noticeably lower high-shear viscosity values with RHEOLATE® HX 6050.

Figure 2: Styrene-acrylic PVC 50% paint



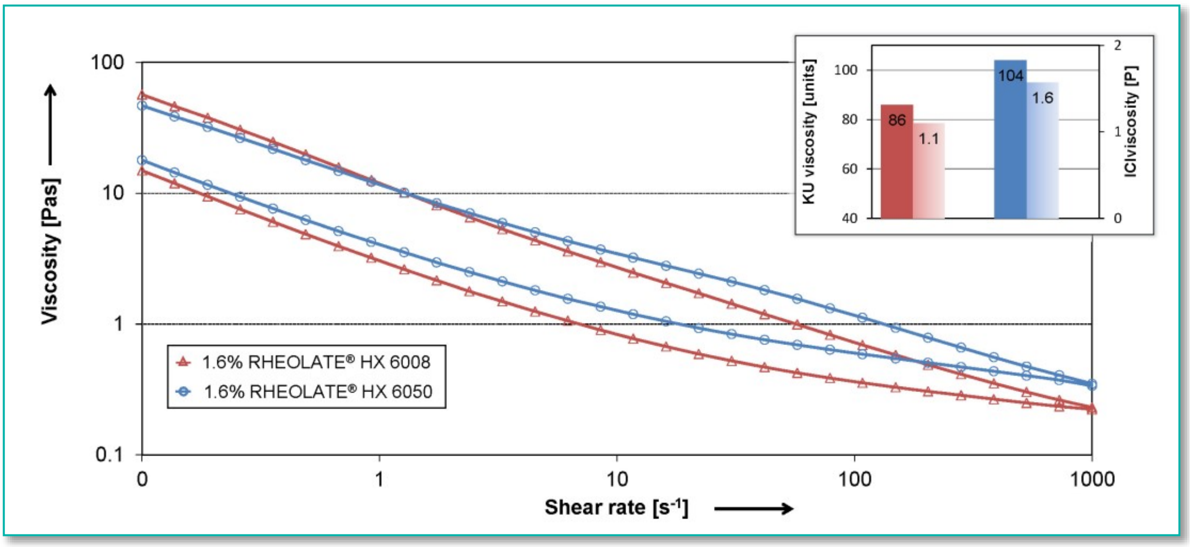
Both rheology modifiers provided similar flow character. Only a marginally stronger Newtonian flow was noticed with RHEOLATE® HX 6008. However, the entire viscosity level with RHEOLATE® HX 6050 was shifted slightly upwards in comparison to the sample with RHEOLATE® HX 6008. Also high and mid-shear/KU viscosity was higher with RHEOLATE® HX 6050.

Figure 3: Vina-Veova based PVC 50% paint



In the Vina-Veova based paint, RHEOLATE® HX 6050 provides the strongest mid and high-shear contribution. This was also detected as noticeably higher high-shear viscosity at 10000 s^{-1} and mid-shear/KU viscosity values in comparison to RHEOLATE® HX 6008.

Figure 4: Vinyl-acetate-ethylene based PVC 50% paint



In the VAE based paint, the use of RHEOLATE® HX 6050 resulted in the strongest Newtonian flow behavior. High-shear viscosity at 10000 s^{-1} and mid-shear/KU viscosity values were also higher than with RHEOLATE® HX 6008.

Part 1: Summary

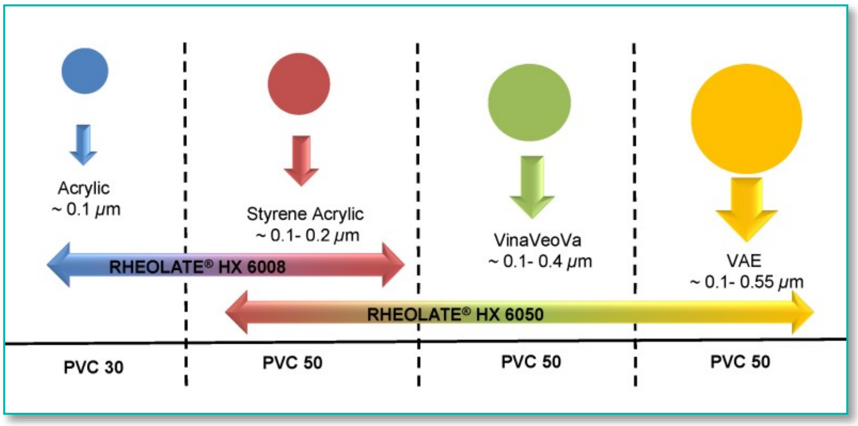
In this part of the study, it was shown that RHEOLATE® HX 6008 provided the strongest Newtonian flow character together with the highest viscosities at high shear rates in the pure acrylic system. In Vina-Veova and VAE based paints, RHEOLATE® HX 6050 was dominant, in providing Newtonian flow characteristics.

In styrene-acrylic paints and coatings, both RHEOLATE® HX 6008 and RHEOLATE® HX 6050 performed very similar.

Nevertheless, it was noticed that in all systems, higher mid-shear viscosity build was provided by RHEOLATE® HX 6050. This was particularly the case in acrylic, and to a somewhat lesser extend, with styrene-acrylic systems. This, on the first view, appears as advantage. However, it also means that with very low dosage of RHEOLATE® HX 6050 an extraordinary increase of the mid-shear viscosity might be the result.

On the other hand, the rheological character with RHEOLATE® HX 6050 in a pure acrylic systems is markedly less Newtonian than with RHEOLATE® HX 6008.

The shown results also demonstrate, that RHEOLATE® HX 6008 provides much more Newtonian flow character in acrylic binders of small emulsion particle size. The use of RHEOLATE® HX 6050, specifically gives the most Newtonian flow in Vina-Veova and VAE based systems. In styrene-acrylic systems, an overlapping performance with both RHEOLATE® HX 6008 and RHEOLATE® HX 6050 was observed.



Part 2: Reduction of complexity

One way to control costs in paint production is to reduce the number of thickeners and therefore the number of raw materials. This results in a reduction of the complexity of a formulation and a simplification of formulators practice.

Many formulating practices require a combination of a high-shear and a low/mid-shear thickener in order to meet a targeted rheological profile. RHEOLATE® HX 6008 and RHEOLATE® HX 6050 have the ability to take over the functions of both high-shear and a low-shear thickener.

To illustrate this properties of RHEOLATE® HX 6008 and RHEOLATE® HX 6050 were evaluated in the irelevant paint system were its performance was seen to be dominant in part 1 of this study. A market references, typical combinations of commercially available low/mid-shear thickener and a high-shear viscosity builder were taken.

In case of RHEOLATE® HX 6008 the pure acrylic based PVC 30% paint was chosen. RHEOLATE® HX 6050 was formulated at in the VAE based PVC 50% paint systems. To have reference viscosity values, all paints were adjusted to identical mid-shear/ KU and high-shear (10000 s^{-1}) viscosities. The following values adjusted as shown below.

	RHEOLATE® HX 6008	RHEOLATE® HX 6050
System	Acrylic, PVC 30%	VAE, PVC 50%
Mid-shear/KU viscosity, units	118 ± 1	105 ± 1
High-shear viscosity, poise [10000 s^{-1}]	3 ± 0.2	1.5 ± 0.2

Concentration - RHEOLATE® HX versus additive combinations

Figure 5: RHEOLATE® HX 6008 - acrylic PVC 30% paint

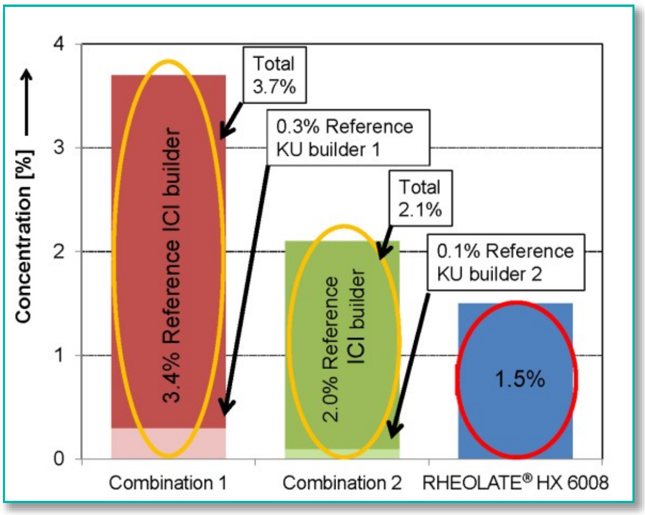
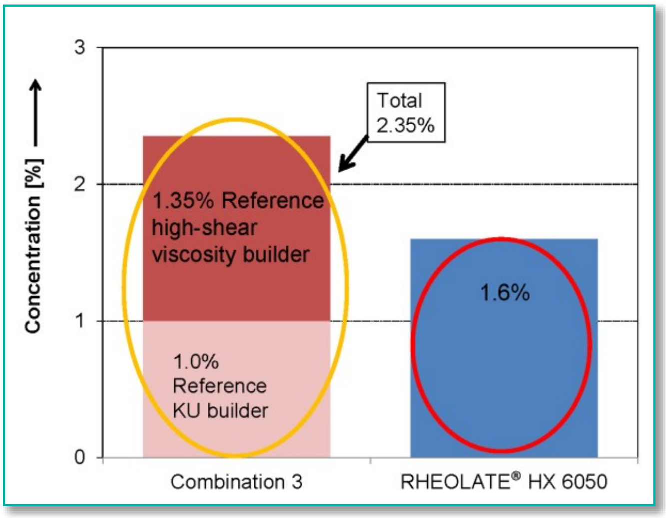


Figure 6: RHEOLATE® HX 6050 - VAE based PVC 50% paint



Both, RHEOLATE® HX 6008 and RHEOLATE® HX 6050, show the ability to replace a combination of a mid/low-shear and a high-shear thickener. Further, both grades demonstrate markedly higher effectivity so that it was possible to achieve the required mid and high shear viscosities at significantly lower quantities.

Rheograms - RHEOLATE® HX versus additive combinations

Figure 7: RHEOLATE® HX 6008 - acrylic PVC 30% paint

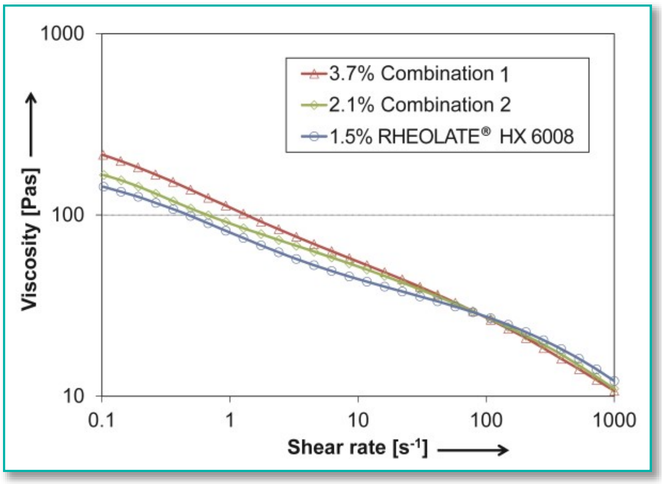
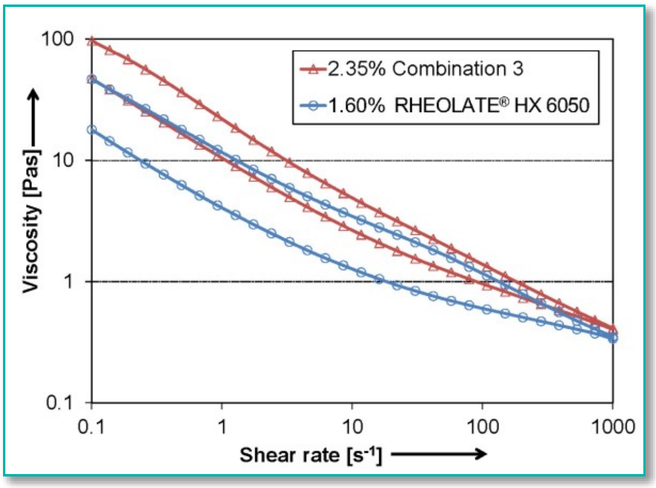


Figure 8: RHEOLATE® HX 6050 - VAE based PVC 50% paint



RHEOLATE® HX 6008 provides slightly more Newtonian flow characteristics in the acrylic PVC 30% paint than both tested competitive combinations. At a shear rate of approximately 100 s^{-1}, a crossover point of all samples is appearing, this represents the mid-shear/KU viscosities were the system was initially adjusted to.

RHEOLATE® HX 6050 displays marginally less shear thinning flow than the tested combination out of commercially available competitive grades. At a shear rate of about 100 s^{-1} both curves are very close. This again indicates the mid-shear/KU viscosity.

Sag stability - RHEOLATE® HX versus additive combinations

Figure 9: RHEOLATE® HX 6008 - acrylic PVC 30% paint

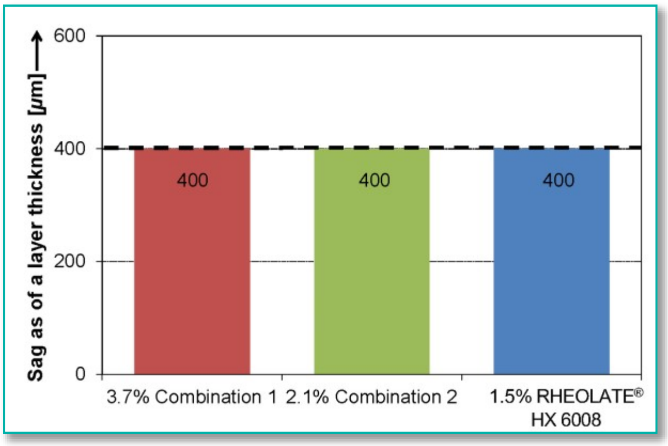
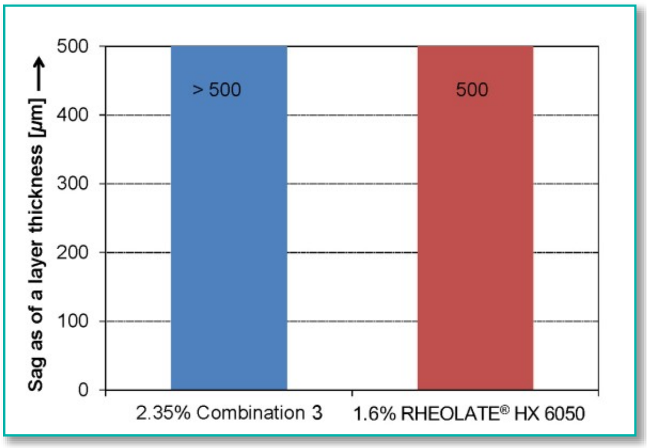


Figure 10: RHEOLATE® HX 6050 - VAE based PVC 50% paint



Both, RHEOLATE® HX 6008 and RHEOLATE® HX 6050, provide equal or comparable sag stability up on blade application in comparison to the relevant additive combination in their individual test paint.

Brush-out leveling - RHEOLATE® HX versus additive combinations

Figure 11: RHEOLATE® HX 6008 - acrylic PVC 30% paint

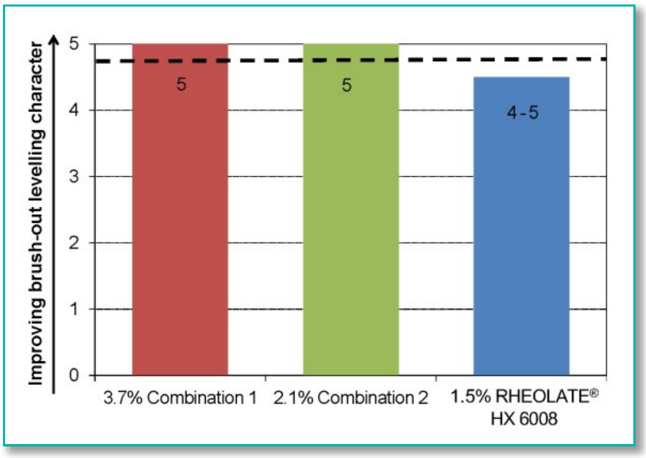
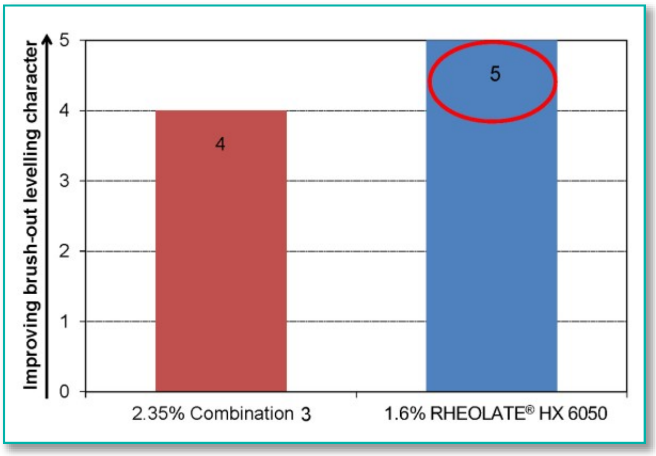


Figure 12: RHEOLATE® HX 6050 - VAE based PVC 50% paint



The use of RHEOLATE® HX 6008 and RHEOLATE® HX 6050 results in almost equal leveling up on brush application in comparison to the relevant additive combination in their individual test paint.

Leveling blade 419 - RHEOLATE® HX versus additive combinations

Figure 13: RHEOLATE® HX 6008 - acrylic PVC 30% paint

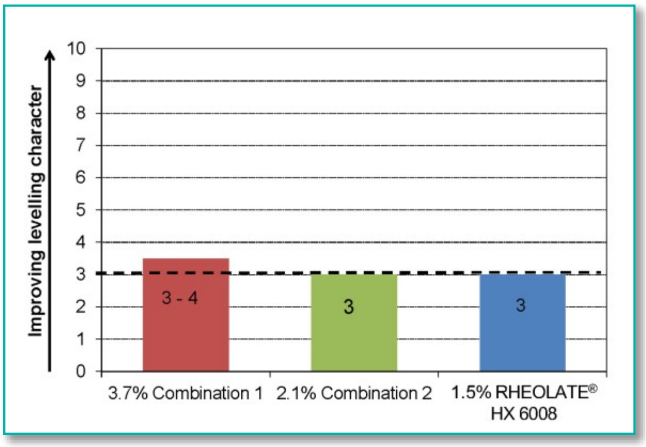
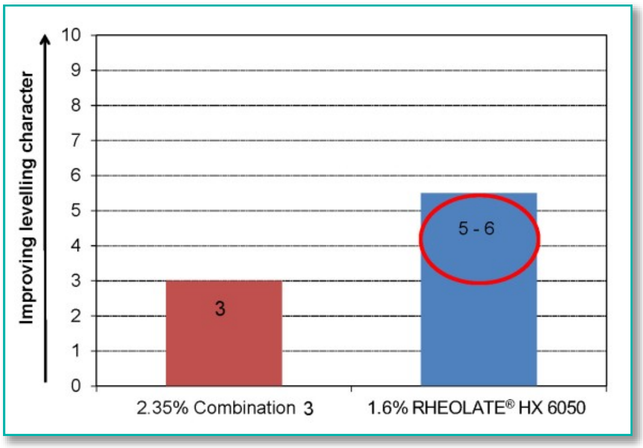


Figure14: RHEOLATE® HX 6050 - VAE based PVC 50% paint



In comparison to leveling after brush application, all leveling results after blade application perform on a lower level. Using these test method, RHEOLATE® HX 6008 shows equally good performance compared to both test combinations in the acrylic test paint. RHEOLATE® HX 6050 gives slightly beneficial properties to the tested competitive combination in the VAE based system.

Roller spattering - RHEOLATE® HX versus additive combinations

Figure 15: RHEOLATE® HX 6008 - acrylic PVC 30% paint

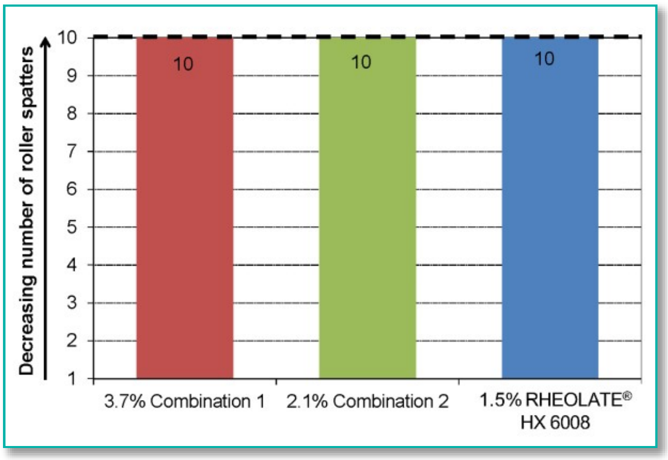
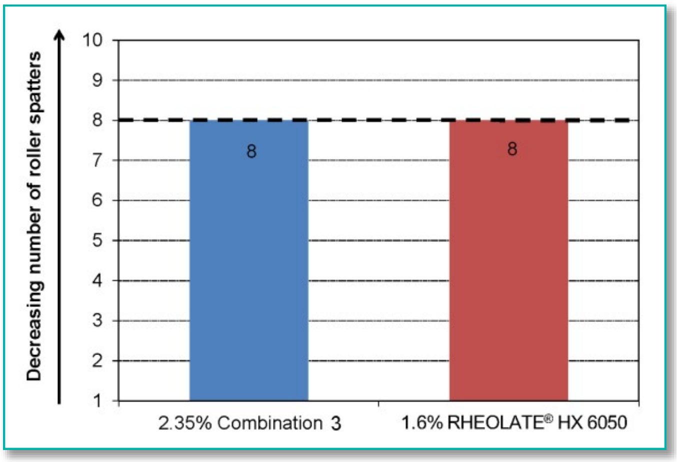


Figure 16: RHEOLATE® HX 6050 - VAE based PVC 50% paint



Both, RHEOLATE® HX 6008 and RHEOLATE® HX 6050 performs equally excellent to the relevant additive combination in the individual test paint.

Part 2: Summary

In this part of the study, it was shown that RHEOLATE® HX 6008 and RHEOLATE® HX 6050 have the ability to replace both, a mid and a high-shear thickener, which are in accordance to todays formulatory practice being used in combination, by one in their individually recommend binder systems.

The resulting performance and application behavior of the paint with RHEOLATE® HX remains very similar and shows only minor variations.

Part 3: Evaluation of the influence on final coating properties

Performance parameters of the finally cured coating, such as gloss, hardness etc, are very critical. Sometimes these performance is adversly affected with even smaller changes in the formulation.

In the following, the influence of RHEOLATE® HX 6008 on the rheological properties and certain secondary paint parameters after application and curing of an acrylic parquet laquer system is illustrated in comparison to a commercially available and leading market reference product.

1C Acrylic high gloss clear wood coating formulation

Table 2: Test formulation

1 C High performance wood coating (Glossy)			
Raw material	**Weight in %**	**Function**	**Supplier**
Alberdingk® AC 2714	83.00	Binder	Alberdingk Boley
Add under stirring in the denoted order			
Defoamer	1.60	—	Elementis
DAPRO® W-77	0.50	Substrate wetting	Elementis
DOWANOL™ DPM	4.00	Coalescing agent	DOW
DOWANOL™ DPnB	5.00	Coalescing agent	DOW
Rheological additive(s)	X	Rheological additive	
Deionized water	5.90-X	Diluent	
Disperse for 10 min. 6 m/s			
	100.00		

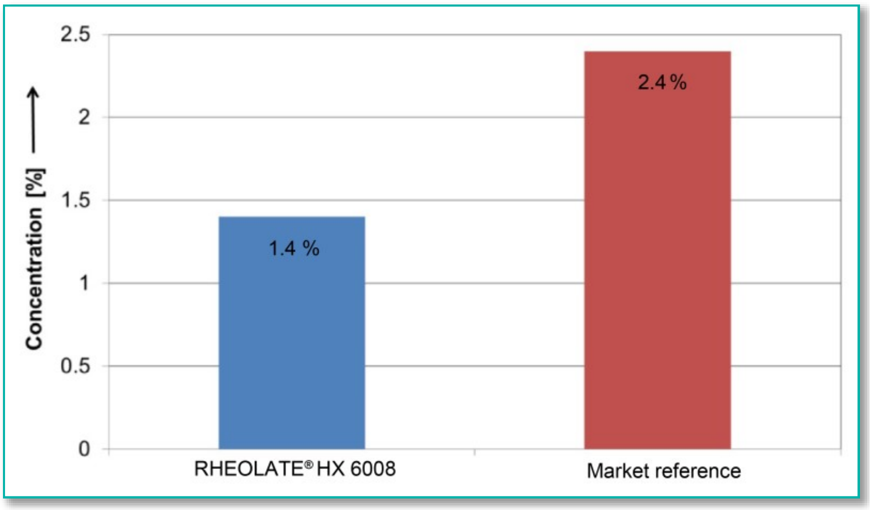
X is variable in accordance with individual concentration.

The acrylic binder emulsion is a universal self-crosslinking multiphase acrylic dispersion. The binder has a solid content of 44%, an MFT of 50 °C and a König pendulum hardness of 105.

The coating is commonly used for parquet varnishes, wood stains sealers, concrete floorings, MDF, furniture and general plastics like ABS, PC, etc.

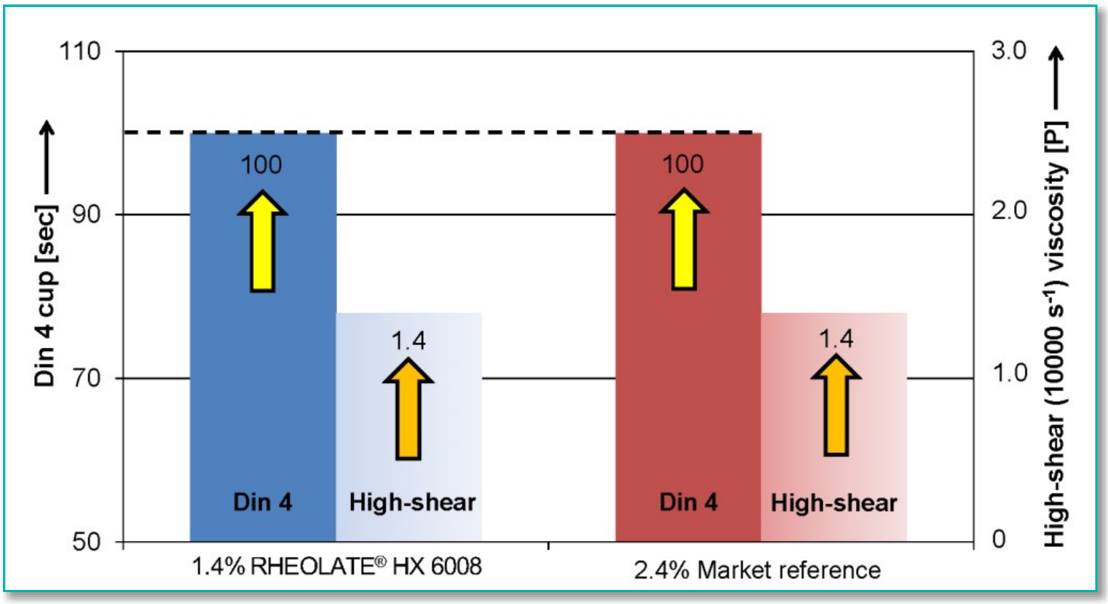
In the following test series, the system was adjusted to a DIN 4 cup viscosity of 100 seconds. The DIN 4 cup viscosiy of blank was 14 seconds.

Figure 17: Efficiency - acrylic parquet lacquer



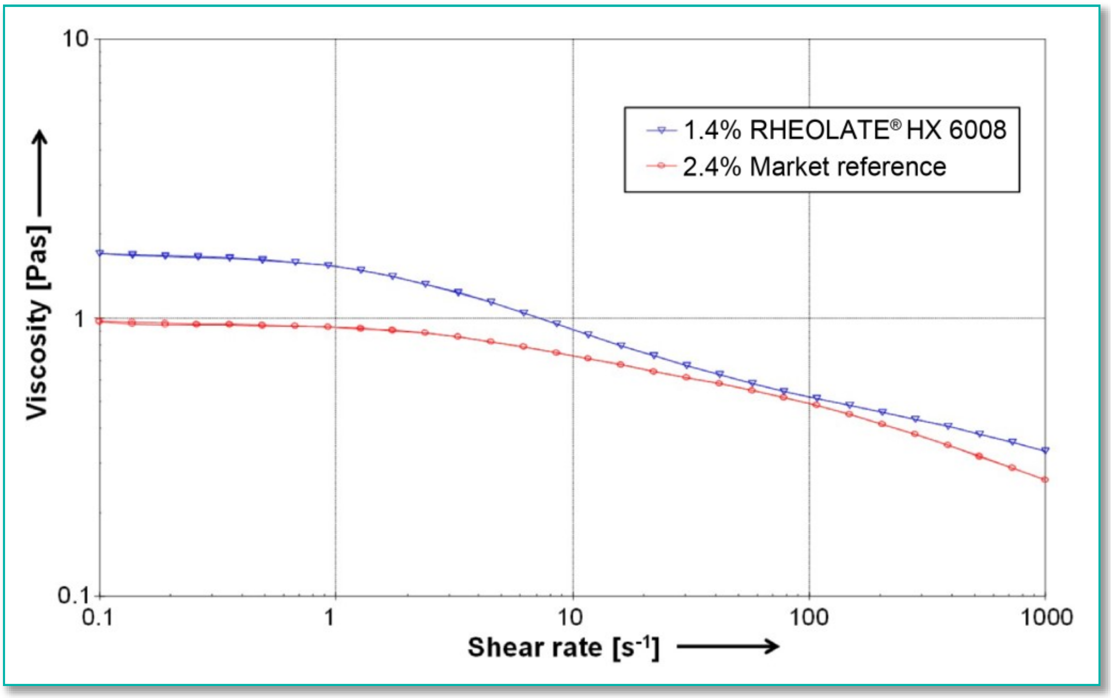
RHEOLATE® HX 6008 requires markedly lower concentration then the market reference thickener to achieve the required DIN 4 cup viscosity of 100 s^{-1}.

Figure 18: Efficiency - acrylic parquet lacquer



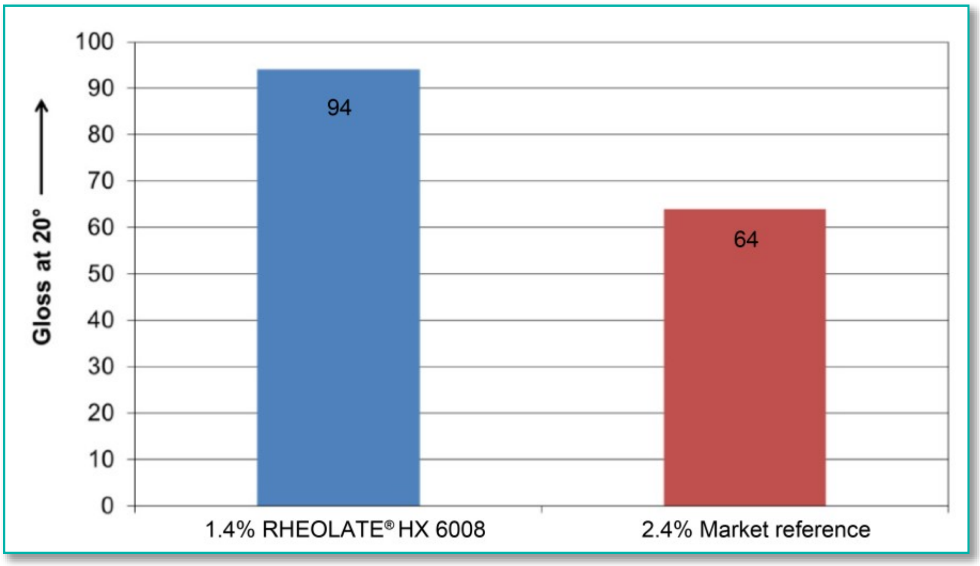
Both samples, with RHEOLATE® HX 6008 and the market reference, demonstrate equal high viscosities at high-shear rates when adjusted to equal DIN 4 cup viscosity.

Figure 19: Rheograms - acrylic parquet lacquer



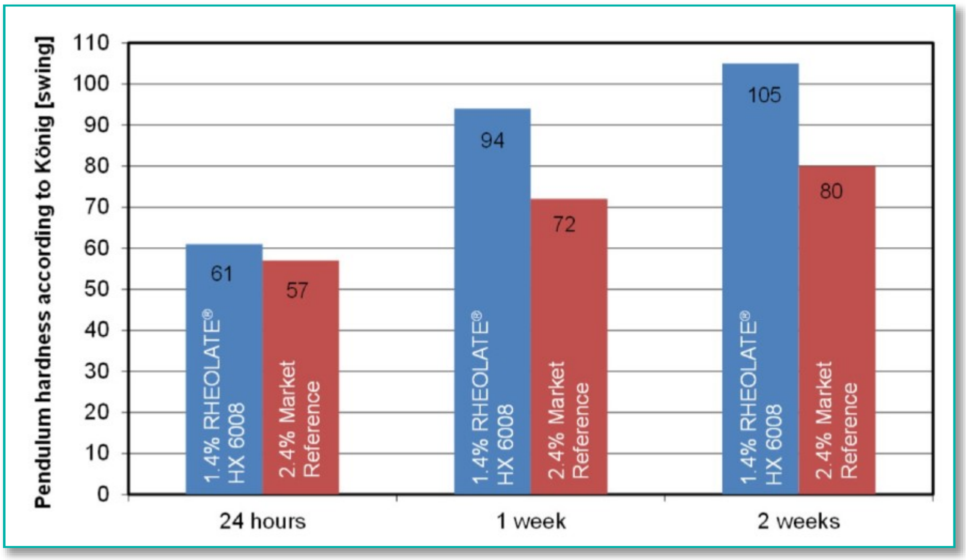
RHEOLATE® HX 6008 provides higher viscosities at lower and higher shear rates compared to the market reference sample. In the range of the mid-shear rates, both samples display equal viscosity values.

Figure 20: Gloss at 20° - acrylic parquet lacquer



The sample formulated with RHEOLATE® HX 6008 displays markedly better gloss than with the market reference product.

Figure 21: Pendulum hardness - acrylic parquet lacquer



Parquet lacquers formulated with RHEOLATE® HX 6008 show enhanced film hardness after all tested time periods in comparison to the market reference.

Part 3: Summary

In this part of the study, it was shown that RHEOLATE® HX 6008 displays, besides less or a even slightly beneficial influence on the performance of the cured coating, a significantly higher efficiency in comparison to the market reference product.

The higher efficiency of RHEOLATE® HX 6008 provides up to 40% savings in relation to the required quantity compared to the market reference.

Conclusion

RHEOLATE® HX 6008 and RHEOLATE® HX 6050 are extremely high efficient next generation nonionic synthetic associative thickener for waterborne systems providing:

- Excellent high-shear rate viscosity build (ICI) with additional low and mid-shear contribution
- Savings up to 60% of the amount of thickener depending on the latex chemistry
- Complexity in formulation and production so that less raw materials might be required to achieve the desired systems performance.
- Less effects on paint film properties or can even improve them.

Both, RHEOLATE® HX 6008 and RHEOLATE® HX 6050, work across a wide range of binder chemistries. However, each of them has specific strength in certain binder chemistries.

RHEOLATE® HX 6008	RHEOLATE® HX 6050
Acrylic	VAE
Styrene-acrylic	Vina-Veova
—	Styrene-acrylic

As a consequence out of the previously shown results, the following data have been extracted by calculation to furtherly guide the paint formulator. Both graphs below can use to read of on how much high-shear/ICI viscosity and mid-shear/KU viscosity with the addition of 1% RHEOLATE® HX 6008 and RHEOLATE® HX 6050 in paints based on various binder chemistries (for the relevant guide formations of the used paints please refer to part 1).

Figure 22: High-viscosity increase with 1% of RHEOLATE® HX 6008/6050

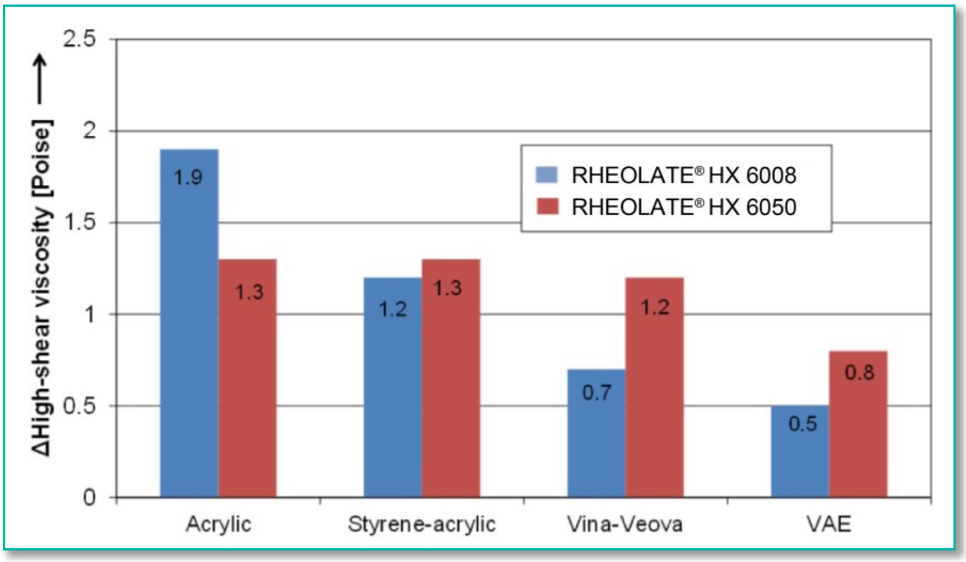


Figure 23: High-viscosity increase with 1% of RHEOLATE® HX 6008/6050

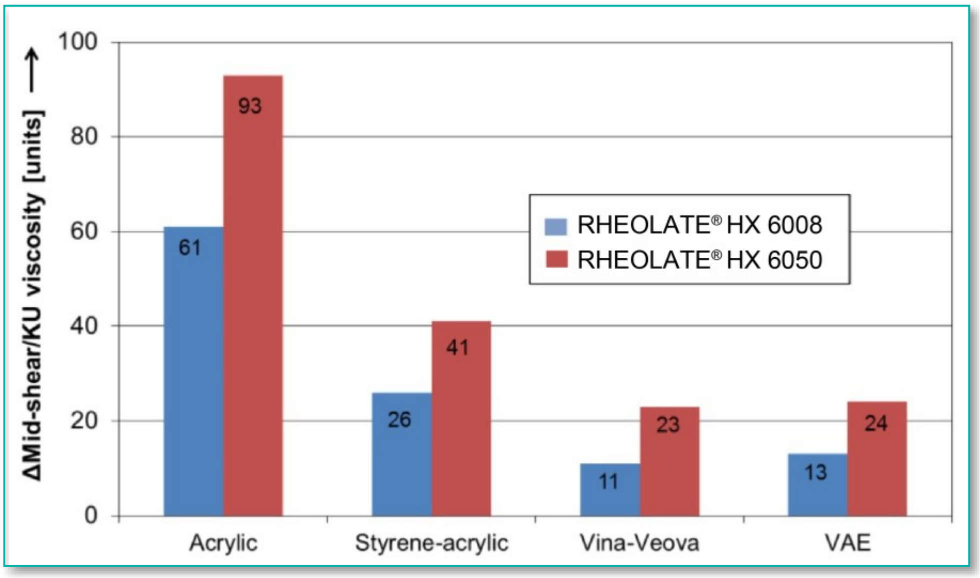
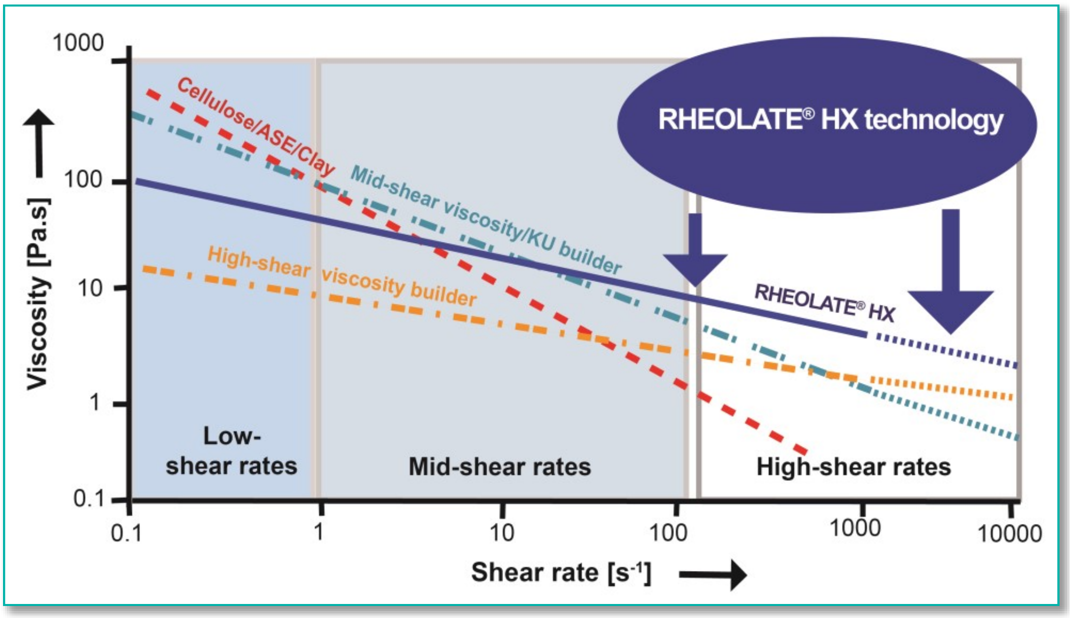


Figure 24: Comparison of the provided flow with RHEOLATE® HX 6008/6050



The flow characteristics provided by the RHEOLATE® HX grades are predominately Newtonian with a strong enhancement of the viscosity at high shear rates. However, also a noticeably beneficial effect on the mid and lower shear viscosity was noticed in all tested systems. This is the main performance provided by both, RHEOLATE® HX 6008 and RHEOLATE® HX 6050, is differentiating those products from other usual commercially available thickener classes.

Appendix

Test methods

- The rheograms are determined using the Anton-Paar MCR 301 rheometer, equipped with measuring geometry PP 50, at a gap width of 1 mm and at a temperature of 23 °C.
- Mid-shear/KU (Krebs-Stormer), high-shear/ICI (at 10000 s^{-1}) and DIN 4 cup viscosity is measured in accordance with the Elementis standard methods of testing, 24 hours after manufacturing the paints.
- Leveling was determined using test blade 419 and after brush application. The characteristics were judged visually on a scale from 0 to 10 (in case of blade testing) and 1 to 5 (in case of brush-out testing). The higher the mentioned number indicates better performance.
- Sag was tested using a test blade with applicable ayer thicknesses of 100 - 1000 μm. The displayed values indicate the maximum applicable layer thickness without runners.
- To test the roller spattering performance, 40 g of the individual paint are rolled on a vertical wall in 10 cycles. The spatters are collected on a black leneta chart positioned underneats. The number of spatters are judged visually on a scale from 1 to 10. The higher the mentioned number indicates better performance.
- Gloss is measured in accordance with DIN EN ISO 2813 using the Byk-Gardner Haze/Gloss tester at an measuring angle of 20 °C.
- Pendulum hardness is determined in accordance with DIN EN ISO 1522 according to König.

North America
Elementis
469 Old Trenton Road
East Windsor,
NJ 08512, USA
Tel:+1 609 443 2500
Fax:+1 609 443 2422

Europe
Elementis UK Ltd.
c/o Elementis GmbH
Stolberger Strasse 370
50933 Cologne, Germany
Tel:+49 221 2923 2066
Fax:+49 221 2923 2011

Asia
Deuchem (Shanghai) Chemical Co., Ltd.
99, Lianyang Road
Songjiang Industrial Zone
Shanghai, China 201613
Tel:+86 21 5774 0348
Fax:+86 21 5774 3563