Application Leaflet

Elementis Additive Opacity Toolbox

Improving opacity, sustainability and reducing cost-in-use.

Unique chemistry, sustainable solutions

Key Benefits

- Improve hiding power **up to One-Coat Hide.**
- Optimise dispersion and spacing of TiO_2 and **Increase 25% spread rate.**
- Significant **reduction of TiO_2** content in formulation **by up to 15%** with the optimized additive package.
- Improve sustainability and lower product **CO_2 footprint**

Features

- **RHEOLATE® HX 6025** — VOC- and PFAS-free branched NiSAT thickener delivering rapid **ICI** build-up and improved wall transfer.
- **RHEOLATE® 666 IF** — Low-to-medium shear NiSAT for **smooth coverage** and balanced application profile (MIT/BIT-free).
- **NUOSPERSE® HIDE 1000** — Hydrophobic polymeric dispersant enhancing **TiO_2 spacing** and spread rate.
- **NUOSPERSE® HIDE 1100** — Hydrophobic polymeric dispersant with **superior spread rate** at 98% opacity.

Target Application

- Interior **architectural** water-based coatings (matte, eggshell, semi-gloss).
- Broad **PVC range** from low to high; compatible with all common **binder systems**.
- Formulations aiming for **one-coat hide** and **high spread rate**; **low/zero-VOC** designs.

Introduction

In today's competitive coatings landscape, formulators must balance cost-efficiency, sustainability, compliance and performance, while meeting contractor demands for faster application and greater coverage. Hiding power is a key driver: Titanium Dioxide (TiO_2), the industry standard for opacity, is costly and environmentally intensive, making additive-driven efficiency increasingly important.

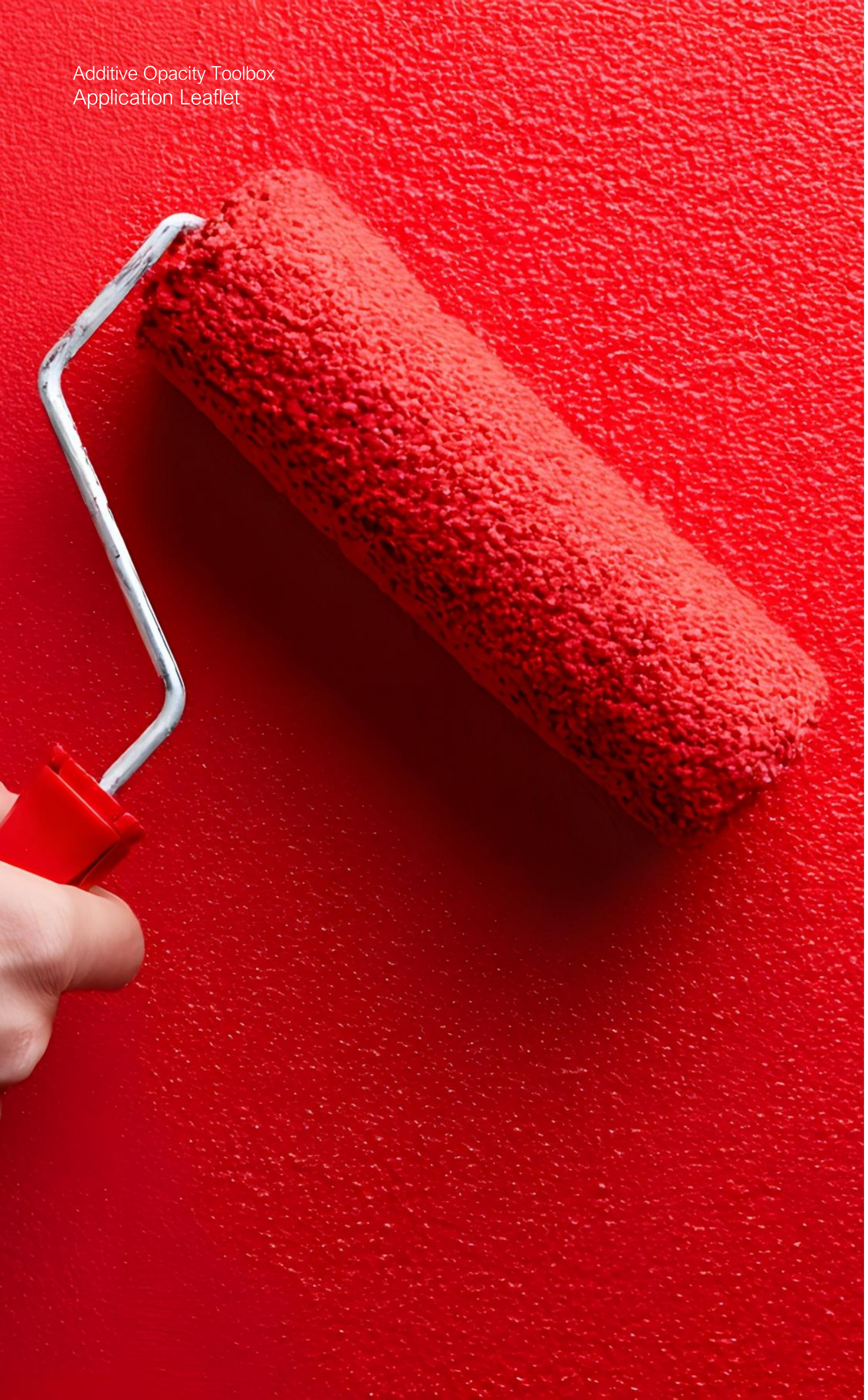
Achieving high opacity in architectural coatings is a multi-factor challenge. Application method, surface preparation, rheology, TiO_2 level, dispersants, wetting agents, volume solids, dry-film thickness, and the choice of extenders and binders all affect final hiding power. Among these, additives are pivotal: effective TiO_2 dispersion and spacing maximise light scattering, while linear rheology systems can limit uniform coverage and roller application quality.

Two latex systems were benchmarked to highlight technology differences: styrene-acrylic (50% PVC, 5.8% TiO_2) and acrylic core-shell (30% PVC, 11% TiO_2). The study included dispersant demand curves, theoretical spreading rates to 98% contrast ratio (ISO 6504-03), and real spreading rates by roller and brush on gypsum boards. All paints were standardised to 100 KU and ICI 0.8P, 1.0P and 1.4P, and evaluated for ease of application, opacity, spread rate, leveling and roller-nap marking.

Chemical & Physical Properties

Table 1 - Formulation-Relevant Properties of Selected Additives

Product	Composition	Appearance	Solids	Viscosity (25 °C)	Recommended Use	Notes
RHEOLATE® HX 6025	Branched polyether polyurethane (HEUR)	Clear to slightly turbid	20%	<3,000 cP (RVT sp4, 20 rpm)	0.5–3.5% (TSW)	VOC-free; higher efficiency with smaller latex size
RHEOLATE® 666 IF	Polyether urea polyurethane (HEUR)	Cloudy off-white	20% / 28.5%	<8,000 cP (RVT sp4, 20 rpm)	0.4–2.0% (TSW)	VOC-free; MIT/BIT/CIT-free
NUOSPERSE® HIDE 1000	Hydrophobic copolymer (ammonium)	Clear/slight yellow	35%	>1,500 cP	2% to 5% over pigment and filler content	Enhances opacity and spread rate
NUOSPERSE® HIDE 1100	Hydrophobic copolymer (ammonium)	Clear/slight yellow	22%	<1,500 cP	2% to 5% over pigment and filler content	Optimises TiO_2 spacing; boosts spread rate



Formulation

Both formulations used in this study are shown in Images 1 and 2.

Image 1 - PVC 50%, St/Ac formulation

Test Formulation Emulsion Paint
PVC 50% Styrene Acrylic based on Acronal S 790

Pos.	Raw Material	Weight (%)	Function	Supplier
	Millbase Stage			
1	Tap Water	14.80	Diluent	
	Add Pos. 2-11 under stirring in the denoted order			
2	Calgon N neu, 10% H_2O	0.10	Softener	BK Giulini
3	Acticide SR 3388	0.20	Biocide	THOR
4	Dispersing Additive	0.10	Wetting Agent	Elementis Specialties
5	DAPRO® BIO 9910	0.30	Defoamer	Elementis Specialties
6	Kronos 2190	5.80	Pigment	Kronos International
7	Omyacarb 2 GU	9.60	Extender	Omya
8	Omyacarb 5 GU	11.70	Extender	Omya
9	Hydrocarb	5.80	Extender	Omya
10	Micro Talc - IT Extra	3.40	Extender	
11	Socal P2	3.80	Extender	Solvay
12	Sipernat 820 A	1.50	Extender	Evonik
	Grind Pos. 1-12 for 15 min. at 10 m/s			
13	Texanol	0.80	Org. Co-Solvent	Eastmann
14	Acronal S 790	32.10	Resin	BASF
15	DAPRO® BIO 9910	0.10	Defoamer	Elementis Specialties
16	Tap Water	9.70	Diluent	
	Add Pos. 13 and 16 and stir for further 10 min. at low speed			
	Add Pos. 13-16 under stirring			
	Add Pos. 17-18 and stir slightly for 10 min.			
17	Rheological Additive	X	Rheo. Additive	Elementis Specialties
18	Ammonia Solution w=25%	0.20	pH Adjustment	
		100.00		
		6390		

Image 2 - PVC 30%, Pure Ac formulation

Test Formulation Emulsion Paint
PVC 30% pure Acrylic based on Mowilith LDM7717

Pos.	Raw Material	Weight (%)	Function	Supplier
	Millbase Stage			
1	Tap Water	10.00	Diluent	
	Add Pos. 2-11 under stirring in the denoted order			
2	Dispering Additive	0.60	Dispersing Agent	
3	DAPRO® BIO 9910	0.20	Defoamer	entis Speci
4	Calgon N neu, 10% H_2O	0.50	Softener	BK Giulini
5	Kronos 2190	11.00	Pigment	os Internat
6	Omyacarb 2 GU	4.00	Extender	Omya
7	Omyacarb 5 GU	3.00	Extender	Omya
8	Hydrocarb-OG	4.00	Extender	Omya
9	Micro Talc - IT Extra	2.55	Extender	
10	Socal P2	2.55	Extender	Solvay
11	Sipernat 820 A	2.00	Extender	Evonik
	Grind Pos. 1-11 for 15 min. at 10 m/s			
12	DAPRO® BIO 9910	0.05	Defoamer	entis Speci
13	Tap Water	7.40	Diluent	
	Add Pos. 12 and 13 and stir for further 10 min. at low speed			
	Add Pos. 14-15 under stirring			
14	Mowiith LDM 7717	51.25	Binder	Celanese
15	Dowanol DPnB	0.55	Coalescing agent	Dow
	Add Pos. 16-19 and stir slightly for 10 min.			
16	Rheological Additive	X	Rheo. Additive	entis Speci
17	Ammonia Solution w=25%	0.15	pH Adjustment	
19	Acticide SR 3388	0.20	Biocide	THOR
		100.00		

Incorporation & Recommended Use Levels

All associative thickeners primarily build viscosity by associating with the binder, while other raw materials in the formulation can generate synergistic effects. **Dispersants** were added **before TiO_2 and mineral fillers**, and the **thickener package** was added during **let-down.**

- Combine **low/medium-shear** and **branched high-shear** NiSAT for a balanced KU/ICI profile and improved transfer/leveling.
- Standardise paints to **100 KU** and target **ICI** levels as per test design (0.8P / 1.0P / 1.4P) for comparative work.

Performance Data & Comparative Testing

The evaluation program was designed to understand how different dispersant chemistries and rheology packages influence opacity development, spreading efficiency, and application properties in waterborne architectural coatings. Two representative paint systems were selected to highlight formulation-dependent behaviour: a **styrene–acrylic coating at 50% PVC with 5.8% TiO_2** and an **acrylic core-shell coating at 30% PVC with 11% TiO_2**. These systems were used to benchmark **six dispersants** and **four rheology packages** under controlled and comparable conditions.
To ensure rigorous comparison, the study followed three clearly defined phases:

1. **Determination of Dispersant Demand Curves (DDC)** to establish the optimal loading for each dispersant chemistry.
2. **Calculation of the theoretical spreading rate** required to reach **98% contrast ratio**, following **ISO 6504-03**.
3. **Assessment of real spreading rate** through **roller and brush application**, replicating typical end-user conditions.

All paints were standardised to a **Stormer viscosity of 100 KU** and **ICI viscosities of 0.8 P, 1.0 P, and 1.4 P**, ensuring that rheology-driven differences came solely from the thickener packages under evaluation.
Application testing was performed on **carefully prepared gypsum boards**, assessing:

- hide/opacity
- ease of application
- spreading rate
- leveling
- roller-nap marking tendencies

To amplify performance differences, **TiO_2 levels were reduced** in the study formulations. Lower opacity makes variations in pigment spacing, film uniformity and application behaviour easier to detect.
This methodology can be applied to any waterborne architectural formulation, either to:

- **increase spreading rate at constant TiO_2**, or
- **maintain spreading rate while reducing TiO_2**, reinforcing sustainability and cost-efficiency.

Image 3 — Dispersion Demand Curve (DDC) for all six dispersants chemistries studied

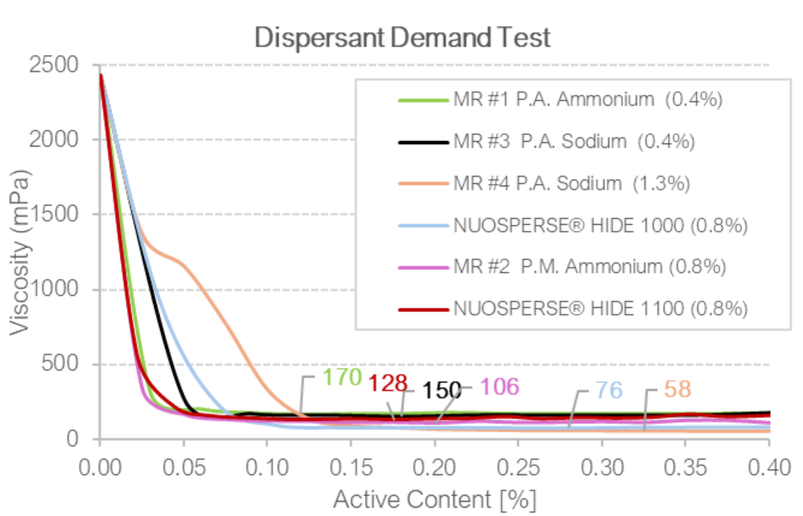
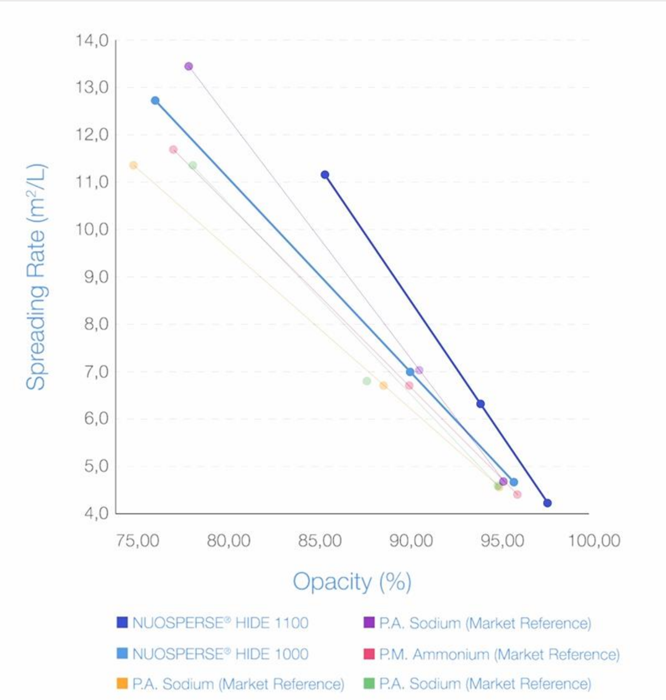


Image 4 – Opacity Measurement



Achieving high opacity relies on the interaction of multiple formulation variables—including application tool, substrate preparation, rheology structure, TiO_2 content, dispersant type, wetting agent efficiency, extender selection and film thickness. Among these, **additives play a decisive role**: effective dispersants maximize TiO_2 separation and light scattering, while non-linear rheology systems improve transfer efficiency and coverage uniformity. Poor TiO_2 spacing or linear rheological behaviour can lead to **pigment crowding**, inefficient hiding and roller-application defects.

Dispersion Demand Curve (DDC)

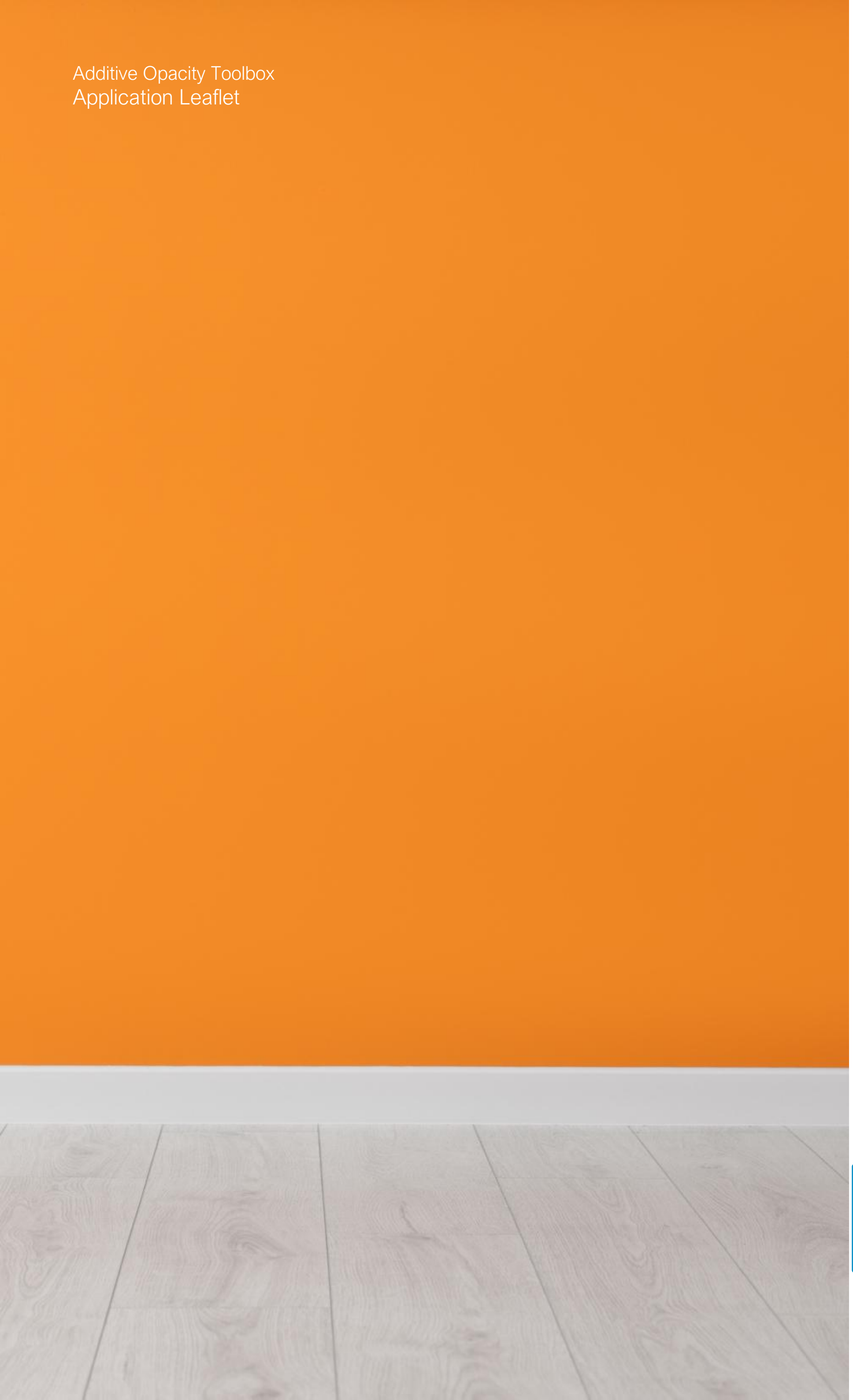
The first analytical step consisted of generating a **Dispersion Demand Curve** for all six dispersant chemistries. As shown in **Image 3**, viscosity was plotted against active dispersant content to identify the minimum achievable viscosity point. This minimum corresponds to the **optimal dispersant loading** for each chemistry and was used as the dosage for all subsequent tests. **All formulations from this point forward were prepared using this optimised dispersant loading.**

Spreading Rate at 98% Opacity (ISO 6504-03)

Using the optimised dispersant levels, theoretical spreading-rate requirements for **98% contrast ratio** were calculated.
As summarised in **Table 2** and visualized in **Image 4**, the combination of **RHEOLATE® 666 IF + RHEOLATE® HX 6025** together with **NUOSPERSE® HIDE 1100** consistently delivered the highest spread-rate performance. This synergistic package allows paints to cover **approximately 25% more surface area** compared to market references, an effect directly linked to enhanced TiO_2 spacing and optimised mid-/high-shear rheology.

Table 2 — Spreading rate to achieve 98% opacity (ISO 6504-03) | MR - Market Reference | Units m2/L

	Market Reference #1 P.A.Ammonium	Market Reference #2 P.M. Ammonium	Market Reference #3 P.A. Sodium	Market Reference #4 P.A. Sodium	NUOSPERSE® HIDE 1000	NUOSPERSE® HIDE 1100
Spread Rate 98% Opacity m²/L ISO EN 13300, ISO 6504-3	2,61	2,69	2,76	2,89	3,23	3,28
Spread Rate 98% Opacity sq.ft. per gallon ISO EN 13300, ISO 6504-03	106,35	109,61	112,46	117,76	131,61	133,65
Increase	100%	103%	106%	111%	124%	126%



Rheology Modifier Effectiveness

We evaluated KU and ICI efficiency across different dispersant chemistries, starting from a base viscosity of 100 KU and 0.8 Poise and building up to 100 KU and 1.4 Poise. The study covered rheology packages ranging from linear NiSAT structures to more hydrophobic, branched systems.

Table 3 shows the KU and ICI builder demand using NUOSPERSE® HIDE 1100 as the reference dispersant, with the same performance trend confirmed across all other dispersant types.

Conclusion: More hydrophobic, branched rheology chemistries, such as RHEOLATE® HX 6025, deliver up to 50% higher ICI efficiency, enabling stronger high-shear viscosity build at significantly lower dosage.

Table 3: Efficiency of NiSAT to increase ICI viscosity from 0.8 to 1.4 Poise.

	Loading %	KU Units	ICI Poise	Effectivity	Loading %	KU Units	ICI Poise	Effectivity	Loading %	KU Units	ICI Poise	Effectivity
L. Market Reference #1 KU L. Market Reference #1 ICI	0,90 1,00	102	0,8	-- --	0,90 1,60	111	1,0		0,90 2,80	115	1,4	
B.Market Reference #2 KU/ICI (2-1 NiSAT)	1,00	69	0,8	--	1,40	81	1,0		1,50	87	1,4	
B, Market Reference #3 KU B. Market Reference #3 ICI	0,94 0,94	109	0,8	4% -6%	0,94 1,20	112	1,0	+4% -25%	0,94 1,60	120	1,4	+4% -43%
RHEOLATE® 666 IF RHEOLATE® HX 6025	0,90 0,70	107	0,8	0% -30%	0,90 0,90	114	1,0	0% -44%	0,90 1,40	118	1,4	0% -50%

Image 5 — Linear Market Reference #1

Image 6 — Market Reference (2-1 NiSAT) #2

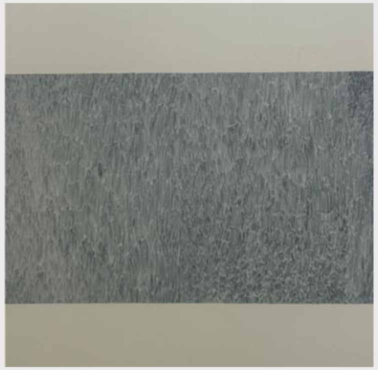


Image 7 - Branched Market Reference #3

Image 8 - RHEOLATE® 666 IF + RHEOLATE® HX 6025

Image 9 – Close-up comparison between Linear Market Reference #1 and the Elementis Opacity Toolbox

Practical Spreading Rate – Roller Application

To validate laboratory predictions, paints were applied on gypsum boards using controlled **roller application**, mirroring real user behaviour. This final step links the **theoretical spread rate** (ISO 6504-03) to **actual spreading performance**, observed coating uniformity, the number of coats required for opacity, and the presence or absence of roller-nap marks.

The visual comparison aside demonstrates the clear advantage of the optimised Elementis package in delivering improved uniformity, opacity development and roller-mark reduction.

As shown in Images 5–8, both RHEOLATE® HX 6025 and RHEOLATE® 666 IF deliver a visibly improved roller pattern and stronger hiding power compared to the linear reference system. To highlight these differences in more detail, **Image 9** provides a close-up comparison between Linear Market Reference #1 and the Elementis Opacity Toolbox.

Image 10 – Leveling Test

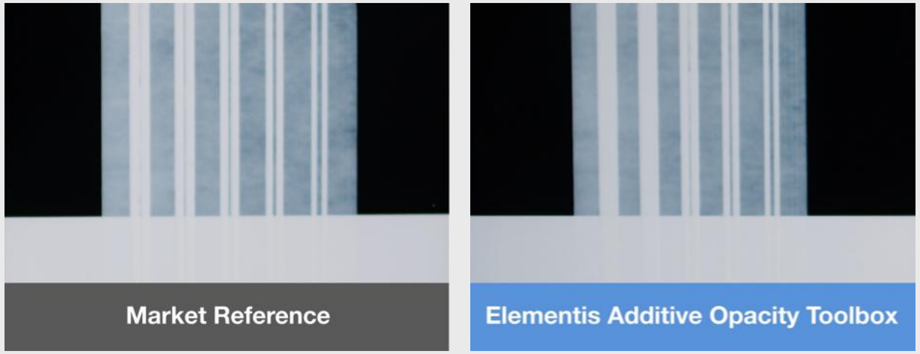


Image 11 - Sag Resistance Test

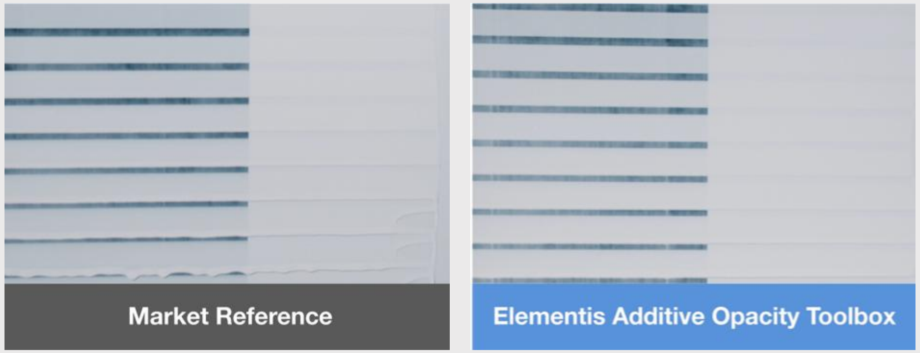
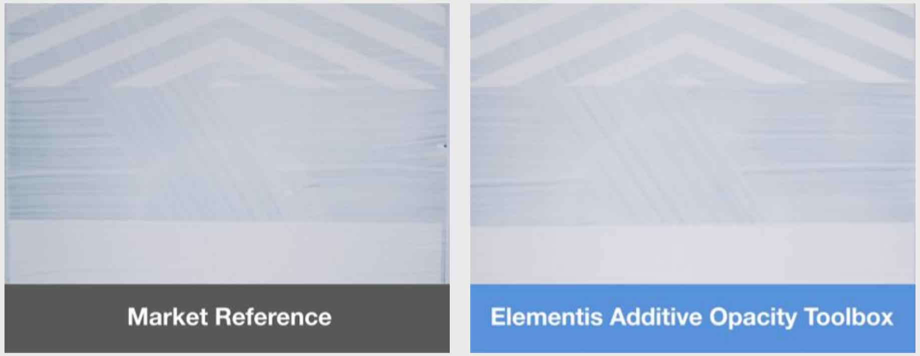


Image 12 – Brush-Out Test



Application Tool Influence

To further understand the interplay between formulation and application tool, Elementis conducted additional evaluations in collaboration with a roller manufacturer. Several roller constructions were tested for their impact on:

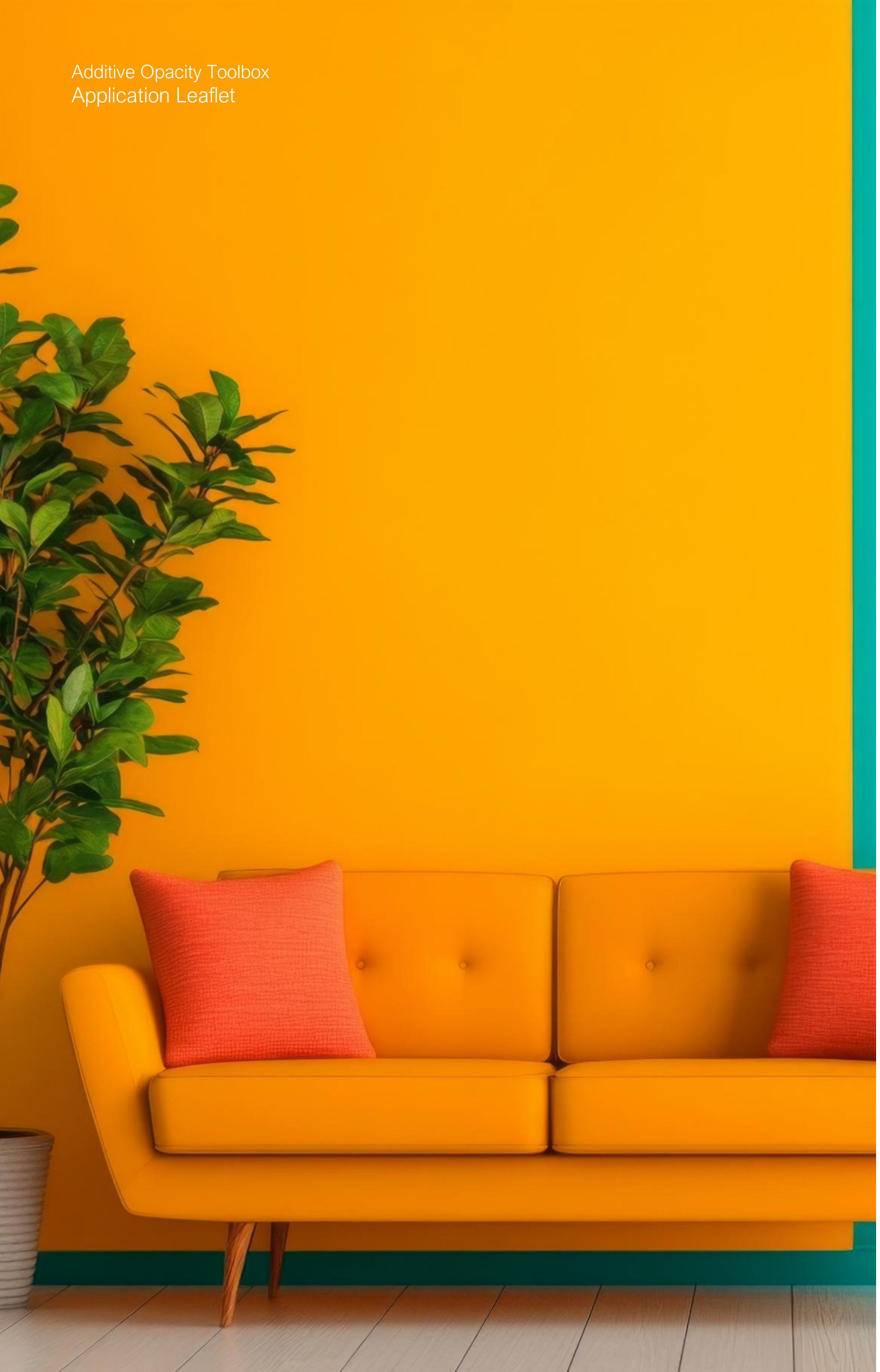
- opacity and coverage
- roller-mark formation
- spattering tendencies
- ease of roller cleaning
- uniformity of dry-film thickness

As confirmed across multiple tests using microfiber rollers, the **choice of application tool significantly influences opacity and roller-mark behaviour**. Brush application showed similar tool-dependent effects on film smoothness and coverage uniformity. Detailed protocols are provided in the appendix of the study.

Other Performance Tests

Smooth flow and leveling are essential for both professional painters and consumers. To assess application quality, we performed a broad set of performance tests across all samples. The comparison aside highlights results from the Linear Market Reference versus the branched rheology system, including RHEOLATE® HX 6025.

Conclusion: The optimized rheological package including RHEOALTE ® 666 IF and RHEOLATE ® HX 6025 is providing enhanced performance on flow, leveling and sag resistance.



Conclusion

Improving spreading rate is a powerful lever to address one of the key challenges outlined in today's architectural coatings landscape: maintaining high hiding power while reducing TiO_2 cost and environmental impact. By optimising pigment dispersion, TiO_2 spacing and rheological control through the Elementis Opacity Toolbox, formulators can significantly increase coverage efficiency without compromising opacity or application quality.

In a representative eggshell formulation, this approach enabled a reduction of TiO_2 from 24% to 21% (≈15%) while maintaining the same spreading rate and hiding performance, directly lowering raw-material use and carbon footprint. Alternatively, the same improvement in spreading efficiency can be leveraged to maximise coverage at constant TiO_2, supporting reliable One-Coat Hide performance in systems where productivity and ease of application are critical.

Achieving true One-Coat Hide remains a multifactorial challenge, requiring not only efficient TiO_2 use but also controlled pigment spacing, uniform wet-film laydown and balanced paint transfer. The synergistic combination of advanced dispersant and NiSAT rheology technologies addresses these interdependencies, improving film uniformity, roller and brush application efficiency, and overall formulation robustness.

Together, these results demonstrate how the Elementis Opacity Toolbox translates formulation science into measurable, on-the-wall benefits—delivering higher coverage efficiency, reduced TiO_2 dependency and improved sustainability.

Key Benefits at a Glance

- Improve hiding power, up to One-Coat Hide
- Optimize TiO_2 dispersion and spacing, enabling up to +25% spread rate
- Reduce TiO_2 content by up to 15% with the optimized additive package
- Increase formulation sustainability with a lower product CO_2 footprint

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Image 10 - Load / Unload of paint and spreading rate

Load / Unload and spreading rate

Total Load (gr)	563	Util Load (gr):	158	Util Load (%):	28,1
η load (m^2):	2,4	Unload deviation (%):	35,1	Spreading rate (m^2/coat)	25,7
F(x) unload:	$-10,475X^3 + 54,726X^2 - 112,99x + 98,825$			m^2 per coat	2,2

Util Load 0,4 m^2 (%):	59,5
Util Load 0,8 m^2 (%):	38,0
Util Load 1,2 m^2 (%):	27,8
Util Load 1,6 m^2 (%):	15,2
Util Load 2,0 m^2 (%):	5,7
Util Load 2,4 m^2 (%):	0,0

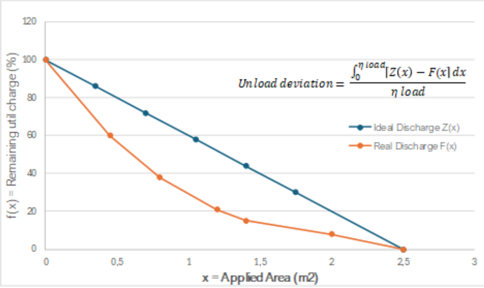
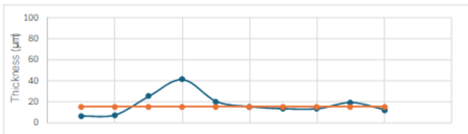


Image 11 - Dry film thickness

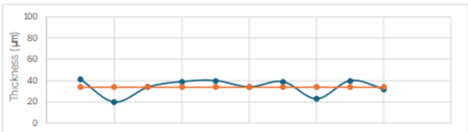
Dry thickness first coat

Max Thickness (μm):	41
Min Thickness (μm):	7
Avg Thickness (μm):	15
Std Deviation (μm):	8,56



Dry thickness second coat

Max Thickness (μm):	48
Min Thickness (μm):	23
Avg Thickness (μm):	34
Std Deviation (μm):	7,66



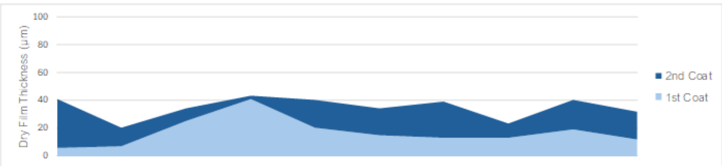


Image 12 - Gray Scale opacity reading

Opacity and Leveling (two coats):

Visual judgment:

Level: 9,5 /10

Observations:

Appendix

This document provides an overview of the roller-application protocol implemented to evaluate the performance of different roller types.
Numerous rollers are available on the market, varying in dimensions, fabric type, and fiber length. In this study, we exclusively utilized rollers constructed with 11mm microfiber fabric, featuring a diameter of 40mm and a width of 20cm.

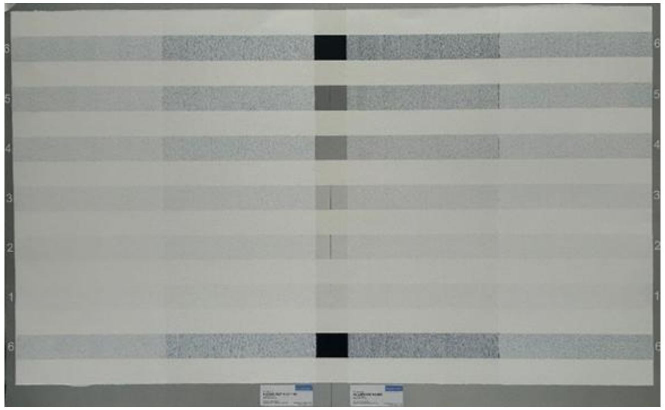
To determine optimal paint transfer, the number of coats required for full opacity, and effective leveling without visible roller marks, a series of tests were conducted using various roller configurations. The interaction between paint formulation—considering aspects such as rheology, binder type, solvent or co-solvent composition, and density—and roller characteristics significantly influences the end result.

At Elementis, five key attributes were assessed in this study:

1. Volume of paint transferred from tray/pail to roller and subsequently from roller to wall (see image 10)
2. Variability in film thickness across successive coats (see image 11)
3. Opacity achieved over a grayscale area (see image 12)
4. Ease of roller cleaning post-application (see image 13)

These four tests facilitate evaluation of paint transfer efficiency to the substrate, consistency of wet/dry film thickness, achieved opacity, and the ease of cleaning determined by residual paint remaining on the roller after cleaning.
Upon completion and drying of the application, dry leveling assessments are performed, typically through comparative analysis of several samples.

Image 13- Gray Scale opacity chart



Appendix

Image 14 - Cleaning and easy to re-use

Cleaning and Re-Use

Saturation load (gr):	337	Saturation load / Total Load (%):	59,9
Dry Residuo (gr):	8	Dry Residuo / Saturation Load (%):	2,4
Easy to clean:	8,5/10	Stetic look after cleaing:	8,5 / 10
Observations:			

Image 15 - Overall Roller Classification

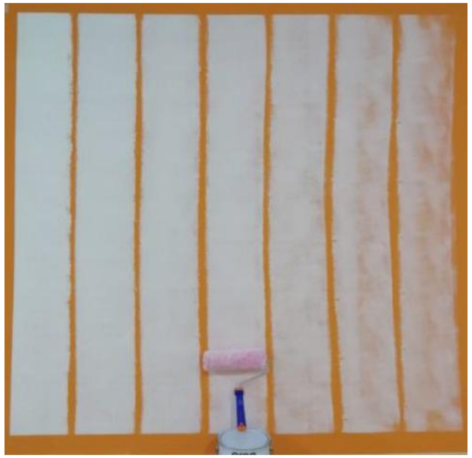
Overall Classification

Opacity	6,0
Spreading Rate	8,3
Levelling	9,7
Spattering	8,5
Easy to Clean	7,7

8,0

Finally, by dipping the roller in paint once, we can count how many stripes it will cover.

Image 16 - number of stripes



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