Architectural Paint and Coatings solutions

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Sustainability also plays a key role in our innovation efforts

Sustainability sub-platforms

Cleaner label paints and coatings

Next-generation paints and coatings

Environmental impact

Value proposition

- Enable the removal of harmful/toxic ingredients from paints and coatings formulations while maintaining **paint quality**
- Enhance the quality and aesthetic properties of the finished paint in emerging **eco-friendly** paint segments
- Introduce solutions which enable the development of paints and coatings **with reduced environmental impact**

VOC FREE

APEO

Biocide free coatings

Cool roof coatings & paints

BLUE ANGEL THE GERMAN ECOLABEL

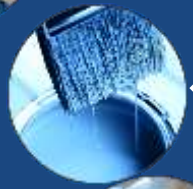
Strengthen **sustainable offerings** through **innovation** and external partnerships to drive competitive differentiation with **new to the world** solutions

Novel Multifunctional

Open Time Extender

AGENDA

Film Formation Process

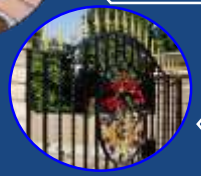


OTE Properties Desired

Novel Multifunctional Additive Concept

Paint Data with Novel Multifunctional Additive

Open Time Extender Results

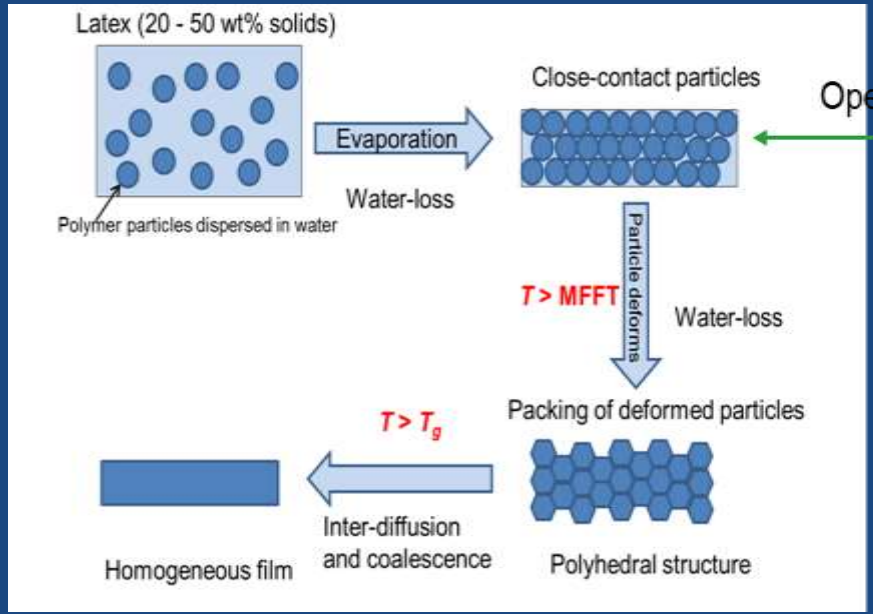


Other properties of the Novel Multifunctional Additive

Technical update- Open Time science

Open time

- Initially free moving particles
- As evaporation occurs, particles come in close contact, with limited amount of water in between each particle
- If all water is removed from between the particles, voids will form. This causes the particles to irreversibly deform to fill the voids and consequently form a thin film
- If the surface is re-worked, the thin film will be disturbed which causes visual imperfections
- **The crucial step in the open time** is to retain the water between the particles, or to add a co-solvent/lubricant that aids free movement of the particles



✓ **Evaporation and diffusion are key to improve particle interaction and film formation**

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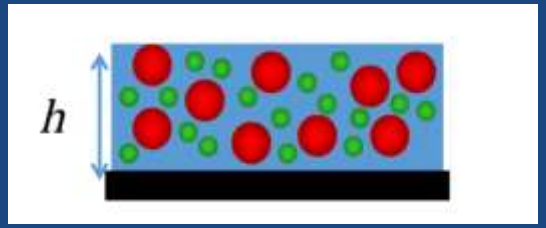
THE IMPORTANCE OF EVAPORATION AND DIFFUSION IN THE FILM FORMATION

- Binder Particle Size Distribution is an average – narrow or wide

- Time for evaporation is T = h1/E
- Time for evaporation does not depend on Large and Small PS, E and h1 will be the same



- Time for Diffusion is T= hi2/Do
- Diffusion is different, Large PS, are expected to accumulate at the top to diffuse, or

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✓ Evaporation and diffusion are key to improve particle interaction and film formation

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THE IMPORTANCE OF EVAPORATION AND DIFFUSION IN THE FILM FORMATION

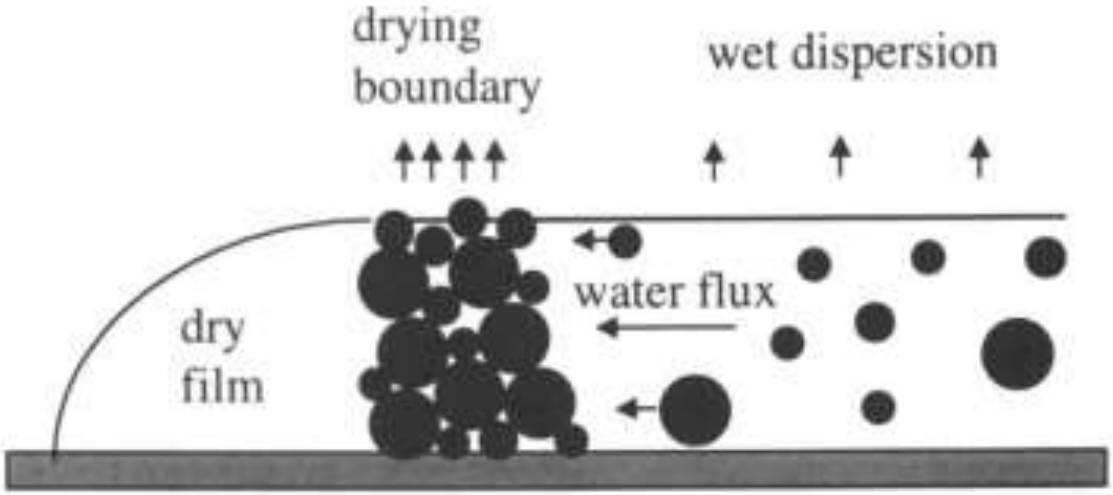

Figure 3: Representation of the drying front for a latex dispersion. Adapted, with permission, from Winnik and Feng (37). Copyright Federation of Societies for Coatings Technology 1996.

✓ During application, Architectural paint has different h1 which can affect evaporation and diffusion

OPEN TIME EXTENDER ADDITIVE

Existing Additives

- APE free & low VOC
- Low odor
- Replace glycols
- Improve open time
- Compatible with all binder
- For lower PVC as 30%

Keep the benefits

- ✓ APE free and Zero VOC
- ✓ No odor
- ✓ Replace glycols
- ✓ Extended Open Time
- ✓ Compatible with all binders

Targets for improvement

- ✓ Easy to incorporate
- ✓ Scrub resistance
- ✓ Color development
- ✓ Viscosity retention on tinting
- ✓ Synergy with rheology modifier
- ✓ Effective in different sheens from low to high PVC
- ✓ Dirty pick-up resistance
- ✓ Freeze/thaw and heat stability

✓ Open Time Extender bringing improved properties to the paint is key to simplify the formula

Novel Multifunctional Additive prototypes

Sample ID	% Polymer solids*	pH	Degree of hydrophobicity in backbone	Length of side chains
OTE #1	32.0	7.5	+++	+
OTE #2	32.4	7.4	++++	+
OTE #3	30.4	7.6	++++	++
OTE #4	31.6	8.1	++++	++++

* The rest is water

✓ Each prototype was designed to improve Open Time extension

Formulas with Novel MF Additives

	High Gloss	Semi Gloss	Satin	Flat
Ingredients	A	B	C	D
PIGMENT GRINDING	Lbs	Lbs	Lbs	Lbs
Water	11	11	11	13
In can preservative	0.1	0.1	0.1	0.1
wetting	0.4	0.4	0.4	0.4
thickener	0.15	0.15	0.15	0.15
neutralizer	0.1	0.1	0.1	0.1
Reference or OTE prototypes	1.28	1.28	1.28	1.28
PIGMENT TiO2	22.5	20	22.5	25
FILLER CaCO3		4.0	7.0	9.0
EXTENDER nepheline		1.0	1.0	1.0
EXTENDER Talc		5.0	8.6	10.0
LETDOWN				
Acrylic Binder (50% SOLIDS)	60	53	46.5	35
ICI Builder	2.5	2.0	2.0	1.0
Wetting post add	0.1	0.1	0.1	0.1
Water	2	1.4	1.0	4.0
Total	100	100	100	100
PVC	16%	25%	35%	45%

✓ Standard & Prototypes were used in the pigment dispersion stage at the same level of solids

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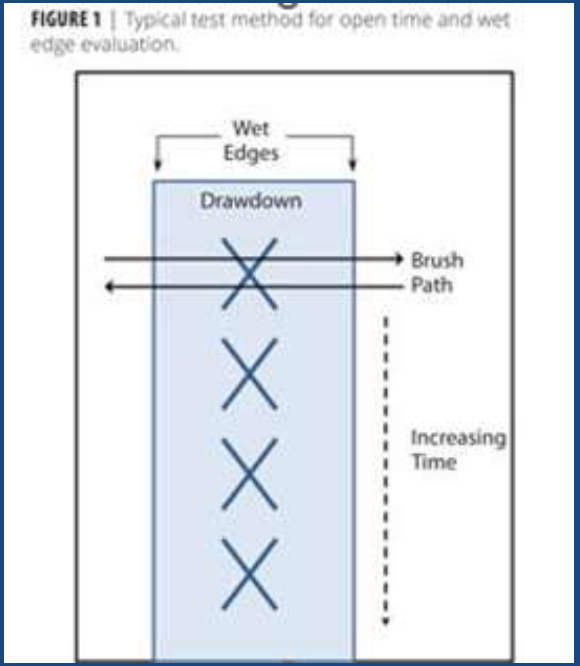
Open Time Results of Novel Multifunctional Additives

Formula	High Gloss 0.5% PD	Semi Gloss 0.5% PD	Satin 0.5 % PD	Flat 0.5 % PD
Reference	4	4	4	6
OTE 1	10	10-12	8	8
OTE 2	10	10-12	8	8
OTE 3	8	10	8	8
OTE 4	8	10	4	4



✓ OTE #1 to #2 provided longer Open Time while OTE #4 provided shorter Open Time due to MW

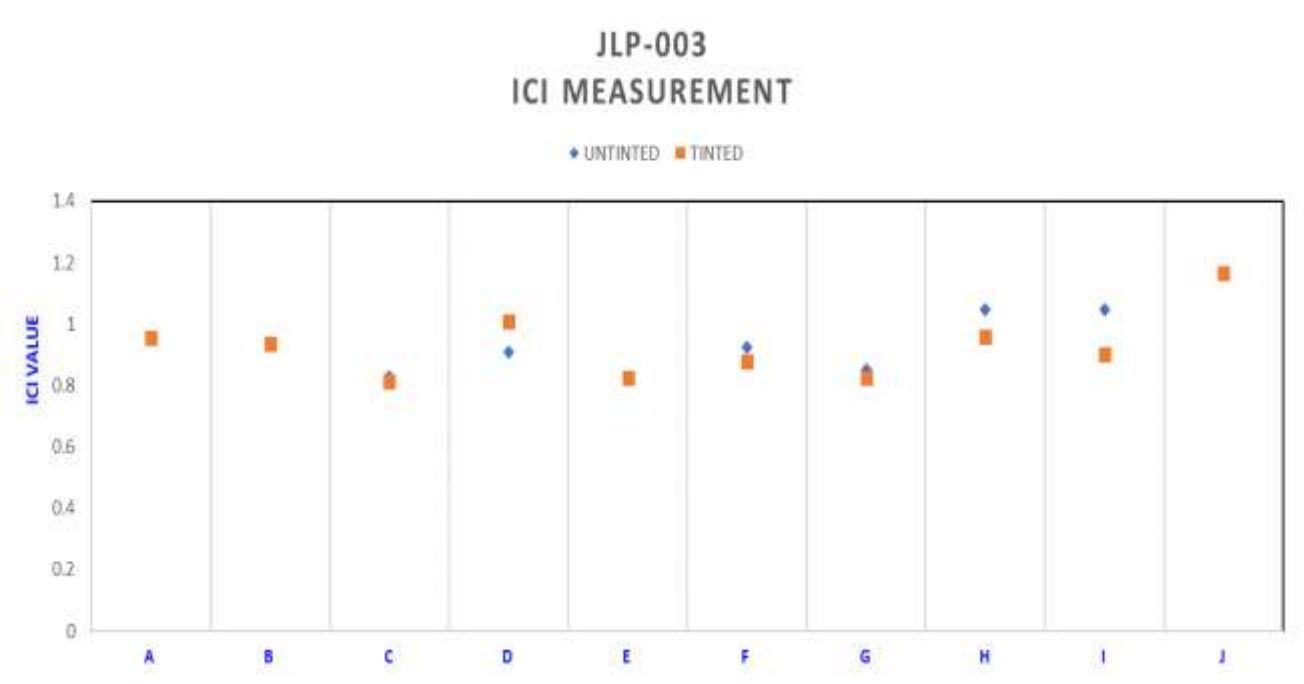
Other Properties with Novel Multifunctional Additives

Formula	Freeze/Thaw & Heat stability 0.5% PD	Color Development 0.5% PD	Hiding Power 0.5 %PD	Scrub Resistance (abrasion solution)	Scrub Resistance (abrasion solution)	Scrub Resistance (abrasion solution)	Scrub Resistance (abrasion solution)
				High gloss %	Semi-gloss %	Satin %	Flat %
Reference	pass	pass	2	100	100	100	100
OTE 1	pass	pass	3	105	105	105	105
OTE 2	pass	pass	4	105	110	120	125
OTE 3	pass	pass	5	104	110	120	125
OTE 4	pass	pass	5	113	115	105	100

✓ OTE #2 & #3 provided higher scrub resistance for Satin and Flat

Color acceptance

Viscosity Retention on Tinting



	JLP-003	Binder
	Prototype	
A	#1	All acrylic – 0.3
B	#2	All acrylic – 0.3
C	#3	All acrylic – 0.3
D	#4	All acrylic – 0.3
E	#1	All acrylic – 0.2
F	#2	All acrylic – 0.2
G	#3	All acrylic – 0.2
H	#4	All acrylic – 0.2
I	#4	Styrene/acrylic - 0.3
J	#4	Vinyl/acrylic – 0.3

✓ OTE #1 and #2 developed higher ICI and preserved viscosity after tinting

Formulas with Balanced Pigment/fillers

	High Gloss	Semi Gloss	Satin	Flat
Ingredients	A	B	C	D
PIGMENT GRINDING	parts	parts	parts	parts
Water	12	12	15	15
In can preservative	0.1	0.1	0.1	0.1
Surfactant	0.2	0.2	0.2	0.2
Thickener	0.16	0.16	0.16	0.16
AMP 95	0.1	0.1	0.1	0.1
OTE #2	1.3	1.3	1.3	1.3
TiO2	20	15	12.5	10.5
CaCO3		6.0	10.0	14.0
ENTENDER nepheline		2.0	2.0	2.5
EXTENDER Talc		5.0	8.5	10.5
LETDOWN				
Acrylic Binder (50% SOLIDS)	60	52	42	33
KU and ICI Builder	0.5/0.8	0.5/0.8	0.5/0.8	1.5/1.5
Surfactant	0.1	0.1	0.1	0.1
coalescent	1.0	1.0	1.0	1.0
Water	3.75	3.75	5.75	8.5
Total	100	100	100	100
PVC	14%	25%	35%	45%

✓ OTE #2 was used in formulas with balanced pigment/fillers for properties confirmation

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Binder Specification

Binder	Type	% solids	PS µm	Weight per gallon lbs	MFFT °C
Binder #1	All acrylic	58.0	0.3	8.9	14
Binder #2	All acrylic	50.0	0.13	8.9	0
Binder #3	Vinyl acrylic	55.0	0.3	9.05	12
Binder #4	Styrene acrylic	48.0	0.08	8.7	0

✓ OTE #2 was formulated with different binders with different PS to understand interaction

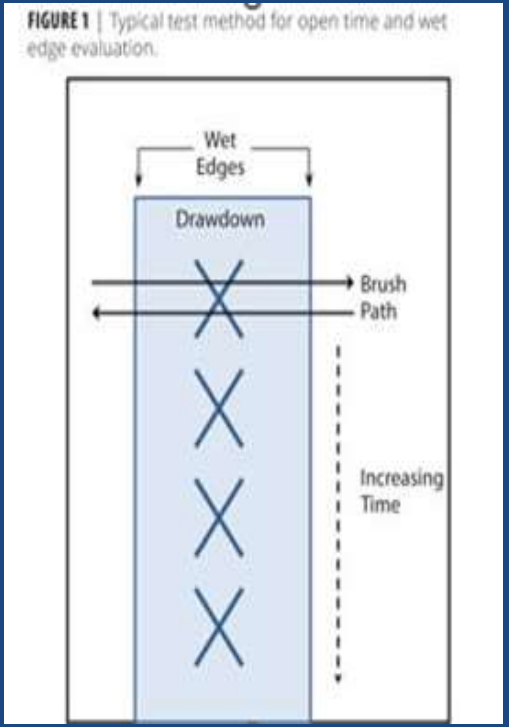
Rheology Behavior

Binder	High Gloss		Semi-Gloss		Satin		Flat	
	KU	ICI	KU	ICI	KU	ICI	KU	ICI
Binder #1	100	1.2	100	1.0	100	0.9	100	1.1
Binder #2	100	0.9	100	0.9	100	1.0	100	0.9
Binder #3	100	1.2	100	1.3	100	1.3	100	1.3
Binder #4	100	0.9	100	1.1	100	1.1	100	1.0

✓ OTE #2 provided very similar viscosity in all formulas sheens with different binders

OTE #2 as Open Time Extender Results in the grind stage

Formula	High gloss	Semi-gloss	Satin	Flat
	Open Time	Open Time	Open Time	Open Time
Binder #1	6	12	12	10
Binder #2	12	12	14	14
Binder #3	12	12	14	14
Binder #4	14	14	14	14



✓ OTE #2 in formulas with balanced pigment/fillers provided longer Open Time than previously

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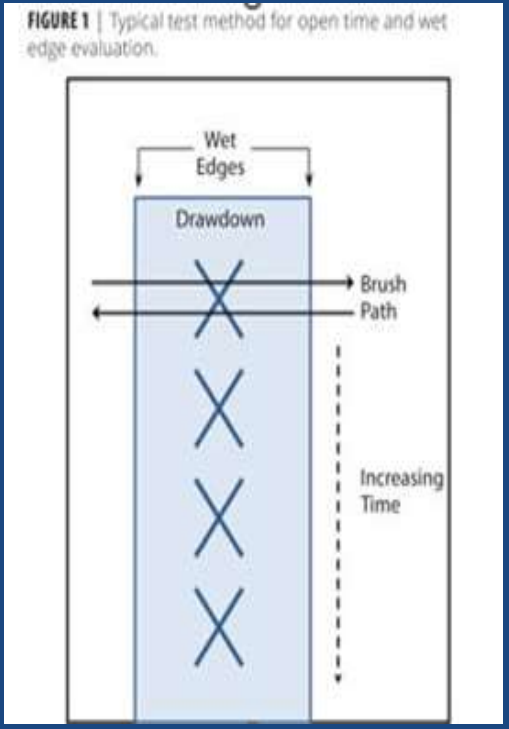
OTE #2 Sagging and Leveling Results

Formula	High gloss		Semi-gloss		Satin		Flat	
	Sagging	Leveling	Sagging	Leveling	Sagging	Leveling	Sagging	Leveling
Binder #1	24	0	24	0	24	2	20	4
Binder #2	24	4	24	4	24	4	12	6
Binder #3	8	8	8	8	8	6	6	8
Binder #4	6	8	8	8	6	8	2	8

✓ OTE #2 with longer Open Time was provided with sagging and leveling balanced

OTE #2 Open Time Results as post add

Formula	High gloss	Semi-gloss	Satin	Flat
	Open Time	Open Time	Open Time	Open Time
Binder #1	14	14	12	12
Binder #2	14	14	16	14
Binder #3	14	16	14	18
Binder #4	14	16	16	18



✓ OTE #2 can also be used as a post add providing longer Open Time than previously

OTE #2 Color Acceptance

OTE #2 in High Gloss | Semi Gloss | Satin | Flat

✓OTE #2 showed excellent color development

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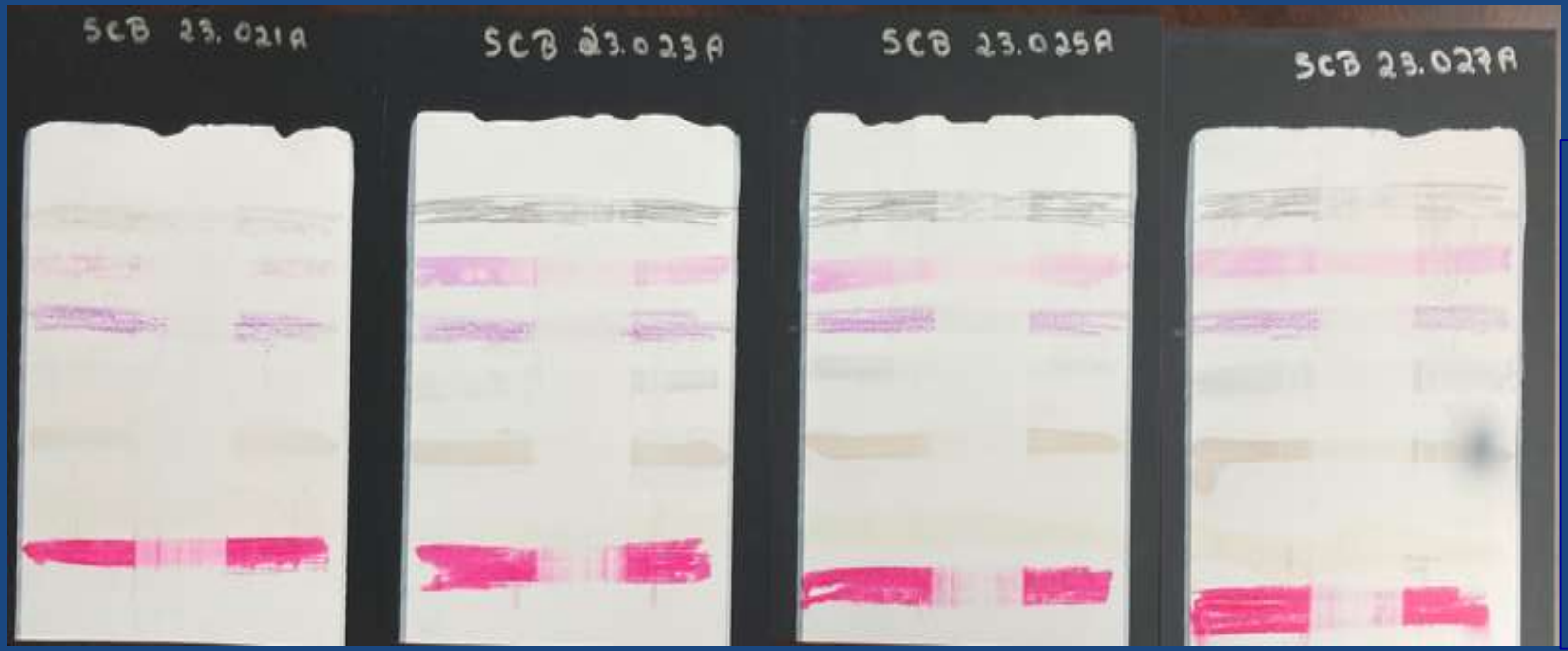
OTE #2 Stain Resistance



- Pencil
- Pink pencil
- Pink crayon
- Black pencil
- Wine
- Coffee
- Lipstick

OTE #2 in High Gloss | Semi Gloss | Satin | Flat

✓OTE #2 stain resistance depends on the type of binder

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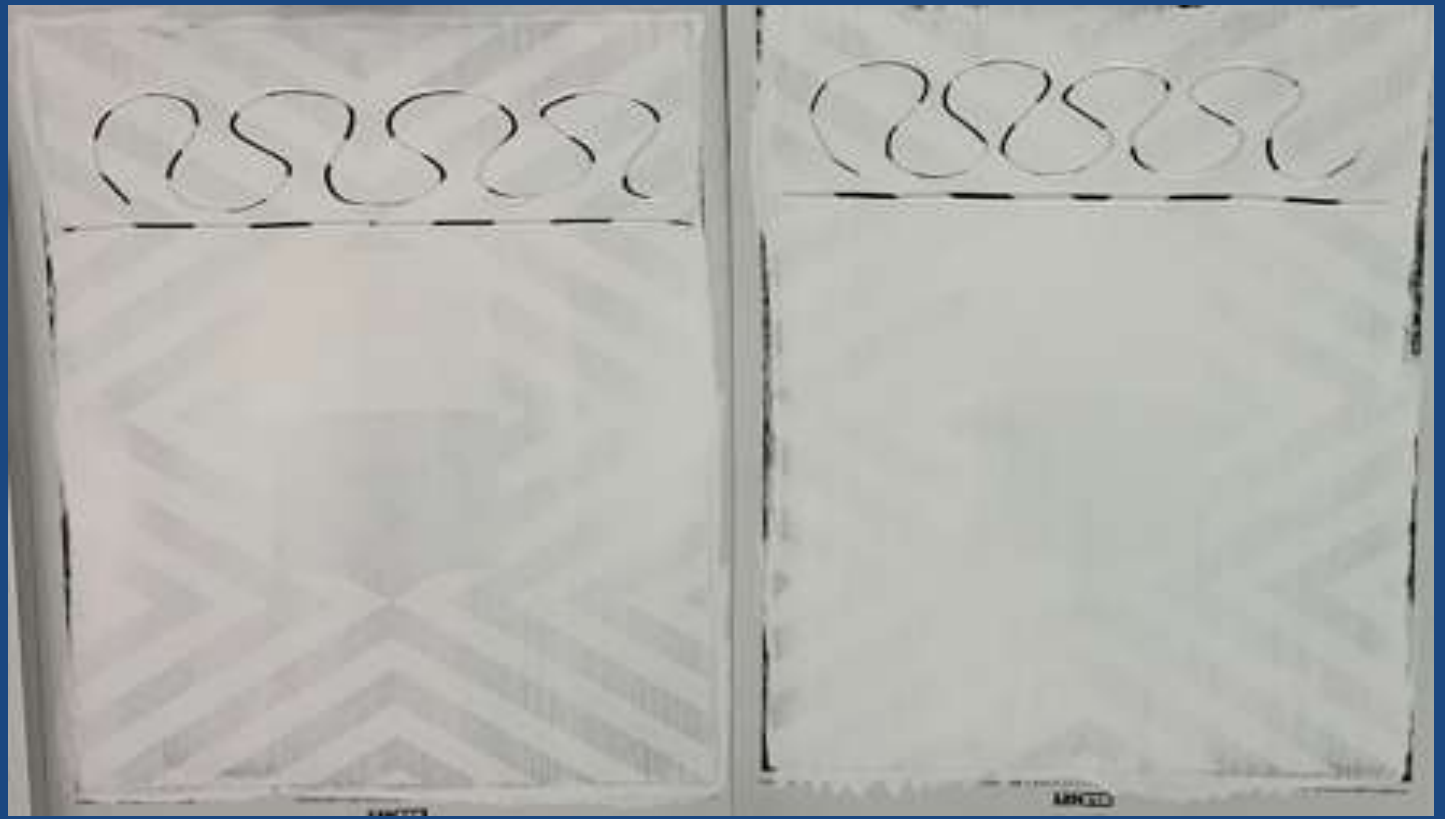
Hiding Power of the New MF additive at 0.65% in a 75% PVC at



Reference formula

OTE #2

✓ OTE #2 lower percentage improved hiding power

Dirt Pick Up Resistance of the New MF Additive at 1.0%

Test made after 24 hours at 60C

All Acrylic Satin & Flat
Reference

Vinyl/acrylic Satin and Flat
Reference

All Acrylic Satin & Flat
OTE #2

Vinyl/acrylic Satin and Flat
OTE #2

✓ OTE #2 improved dirt pick-up resistance with iron oxide for 2 hours

CONCLUSIONS

The Novel Multifunctional Additive provided the benefits:

- ✓ **Extended Open Time replacing glycols**
  - Evaluating robustness in multiple formulations in real world application
- ✓ **- Improved Hiding Power**
- ✓ **- Excellent color development**
- ✓
- ✓ **- Viscosity retention on tinting**
- ✓ **- Improved scrub resistance**
- ✓ **- Improved Dirt Pick Up resistance**

Thank you for your attention.

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