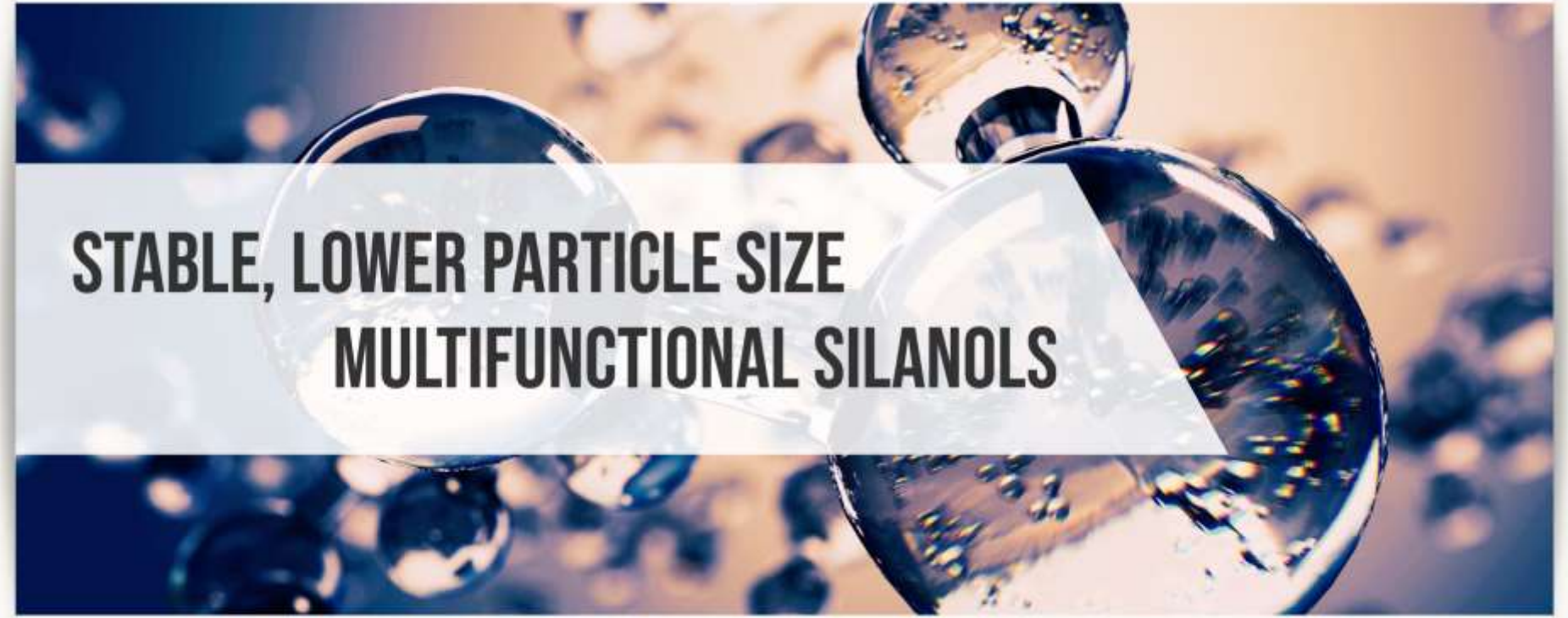
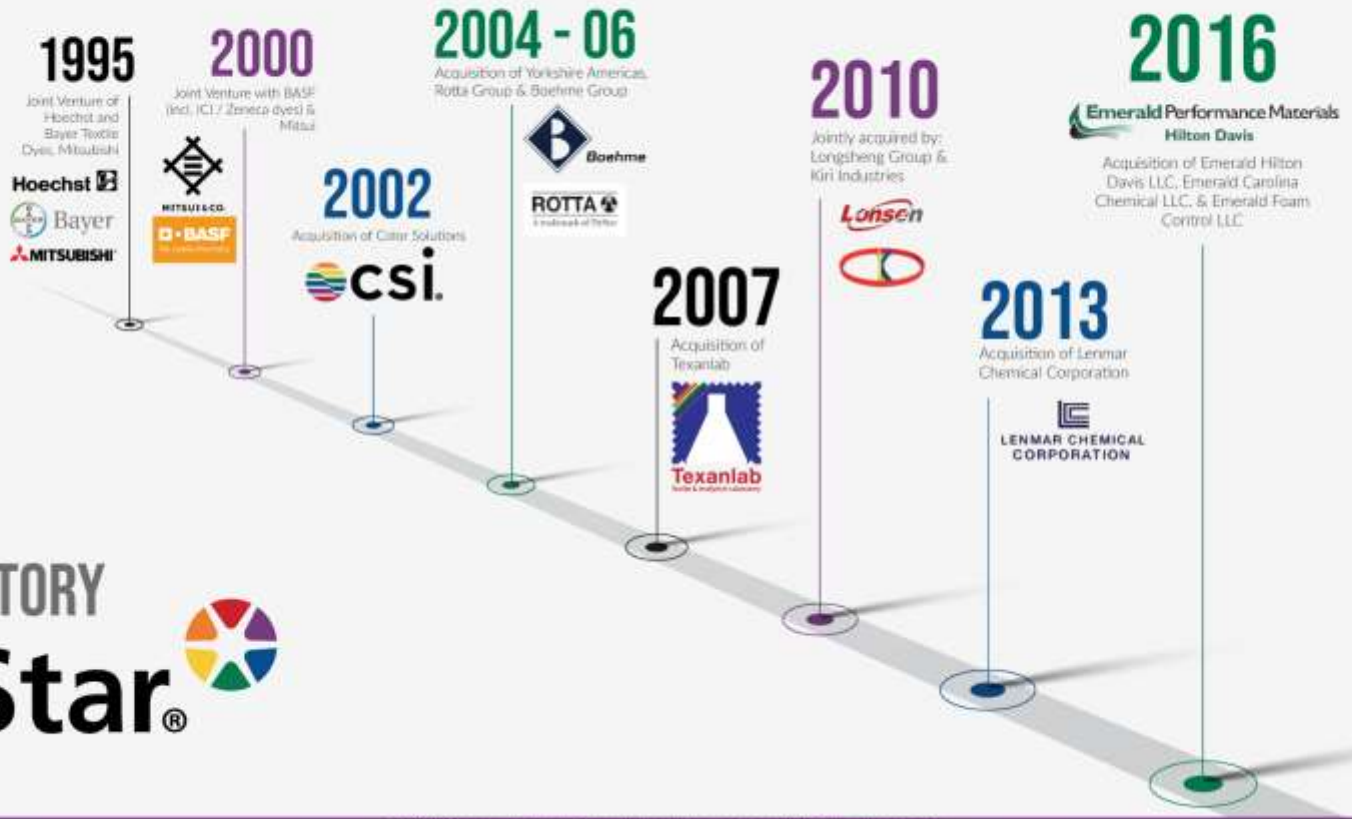
DyStar



STABLE, LOWER PARTICLE SIZE MULTIFUNCTIONAL SILANOLS



OUR HISTORY

DyStar®

DYSTAR'S APPROACH » SILOXANE EMULSIONS

DyStar

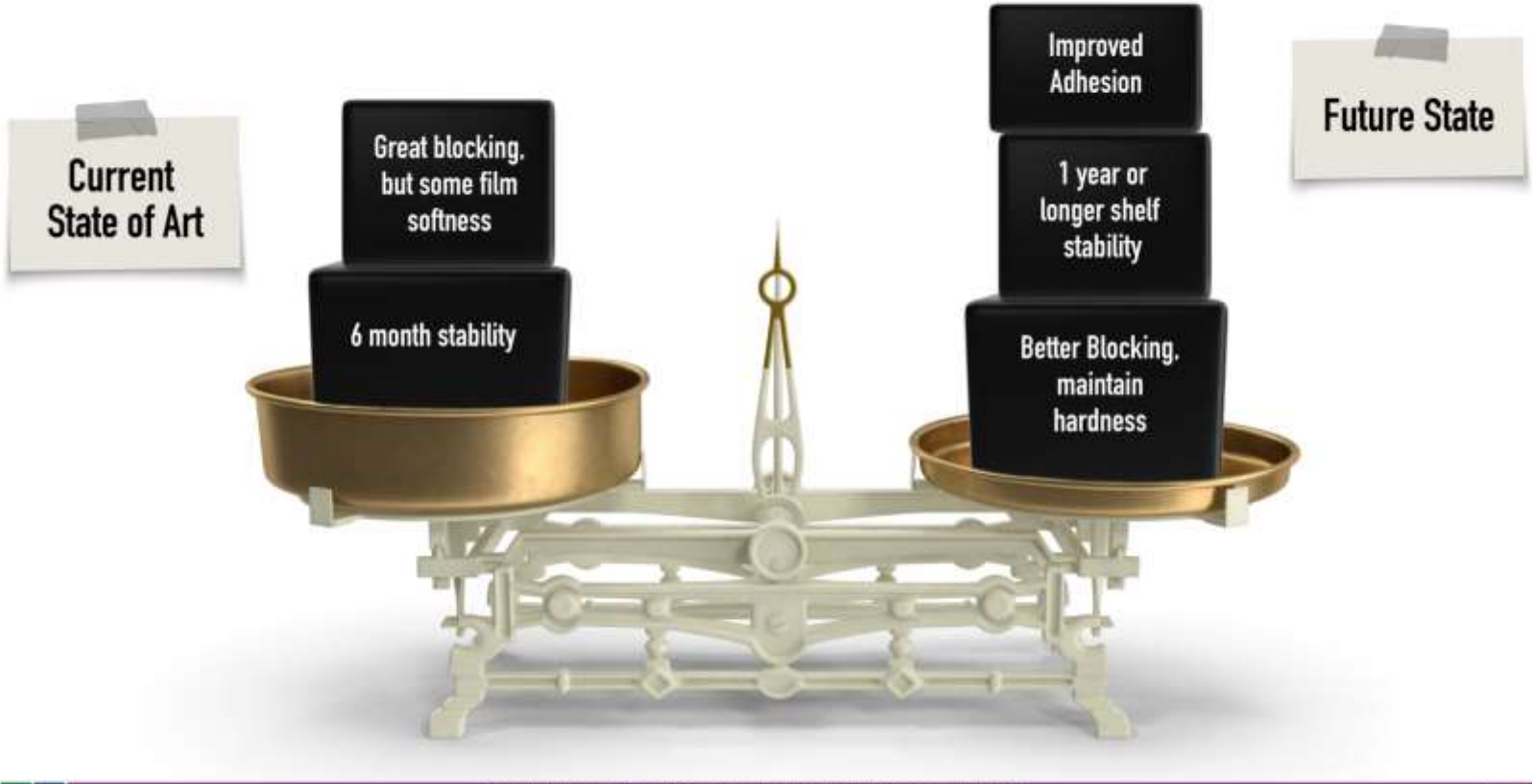
VOC REGULATIONS AND **CONSUMER** PREFERENCES HAVE PUSHED COATINGS MANUFACTURERS TO INNOVATE USING **LOW TG RESINS**, BUT WITH **NEGATIVE** TRADE-OFFS

- » BLOCK
- » TACKINESS
- » IMPRINTING
- » DIRT PICK UP
- » OPEN TIME
- » EXTERIOR GLOSS LOSS
- » STAIN RESISTANCE

ADDITIVES CAN HELP, BUT THEY CAN BE ***EXPENSIVE***, ***INCOMPATIBLE***, OR CREATE OTHER ***ISSUES***

DYSTAR'S APPROACH » SELF-CROSSLINKING SILANOL EMULSIONS

DyStar



SYNTHESIS AND EMULSIFICATION OF THE MULTIFUNCTIONAL SILANOLS

GENERAL REACTION SCHEMATICS FOR HYDROLYSIS

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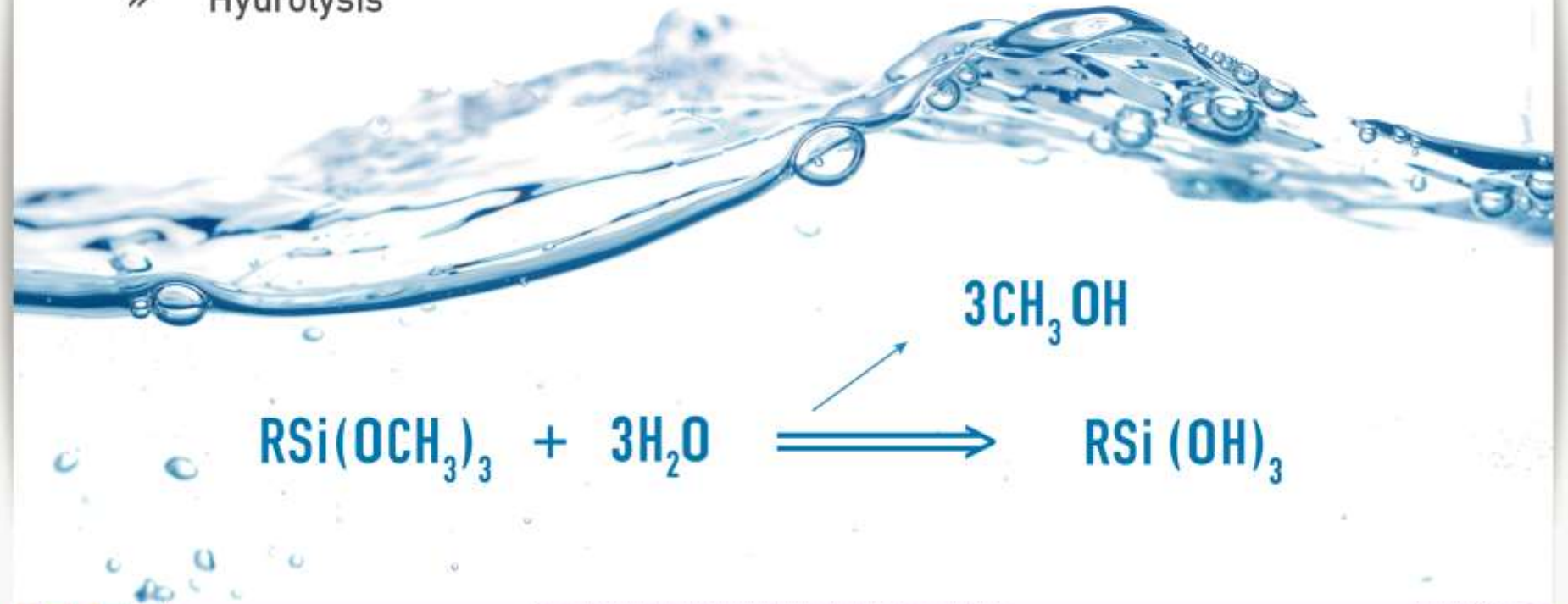
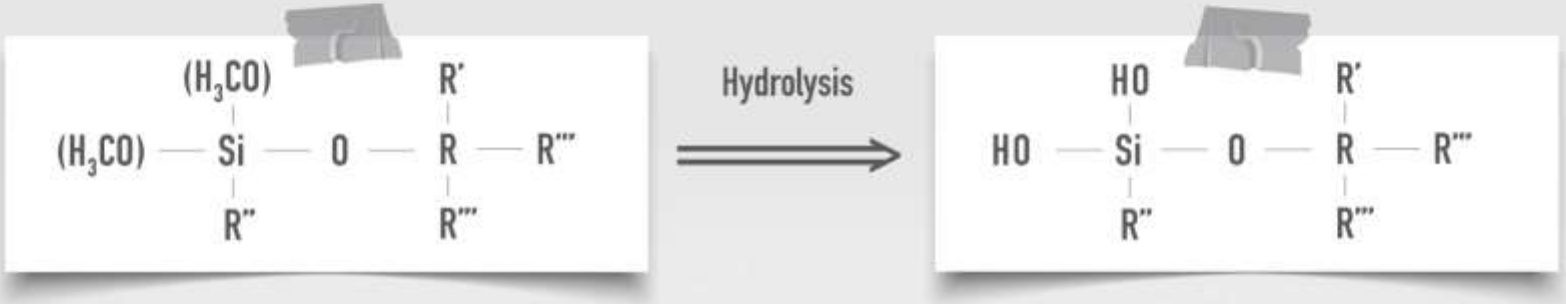
» Hydrolysis



GENERALIZED STRUCTURES OF SILANES STUDIED

(R = silane repeat units / R'= alkyl or hydroxyl / R"= alkyl/functional / R"'= alkyl)



Idealized Structure
Multi-functional alkoxy silanes

Silicone R" variations studied:

- Methyl
- Octyl
- Phenyl
- Epoxy functional

EMULSIFICATION CONSIDERATIONS

- » **pH** (generally 4-7 needed for WB dispersion)
- » **Water** sufficient quantity (< 20% active)
- » **Temperature** (heat can cause unwanted reaction)
- » **Degree of Functionality & Molecular Weight** (as increases, becomes more difficult to stabilize as water-based dispersion)
- » **Anionic, Cationic, Amphoteric, Nonionic**
- » **Means to Emulsify** (rotor-stator, high pressure, etc)
- » **Surfactant HLB** (we used 12)
- » **Surfactant Selection** critical to stabilization due to the organic/inorganic nature of the product

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GENERALIZED STRUCTURES OF SURFACTANTS

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» Linear Alcohol Ethoxylates
(LAE)

» Silicone Polyether higher MW
(HMWSP)

» Silicone Polyether lower MW
(LMWSP)

EMULSIFICATION PROCESS

DyStar

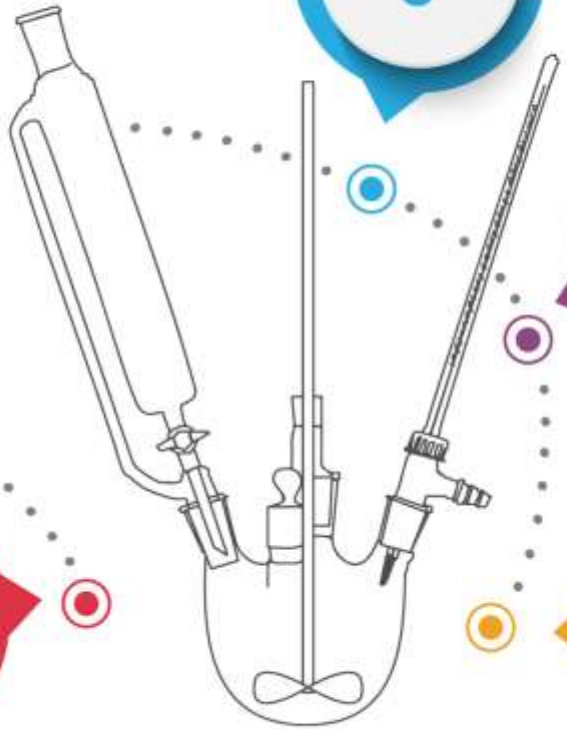
3 Emulsify in water

2 Addition of surfactant

1 Reaction of components in flask

5 Biocide and solids adjustment

4 Homogenize (check particle size)



WET PROPERTIES »

SAMPLE ITEM	LAE	HMWSP	LMWSP
% Solids (130˚, 60min, 0.3 - 0.4 g samp, 2 ml of H_2O)	49.4	47.2	47.8
pH	6.11	6.43	6.25
Viscosity, cps (RVT, #3 spin, 100 RPM, 25˚C)	49.0	55.0	40.0
Comments	Smooth, white opaque, homogeneous	Smooth, white opaque, homogeneous	Smooth, white opaque, homogeneous

2 MIL WET FILMS » ON ALUMINUM

Linear Alcohol Ethoxylates
(LAE)

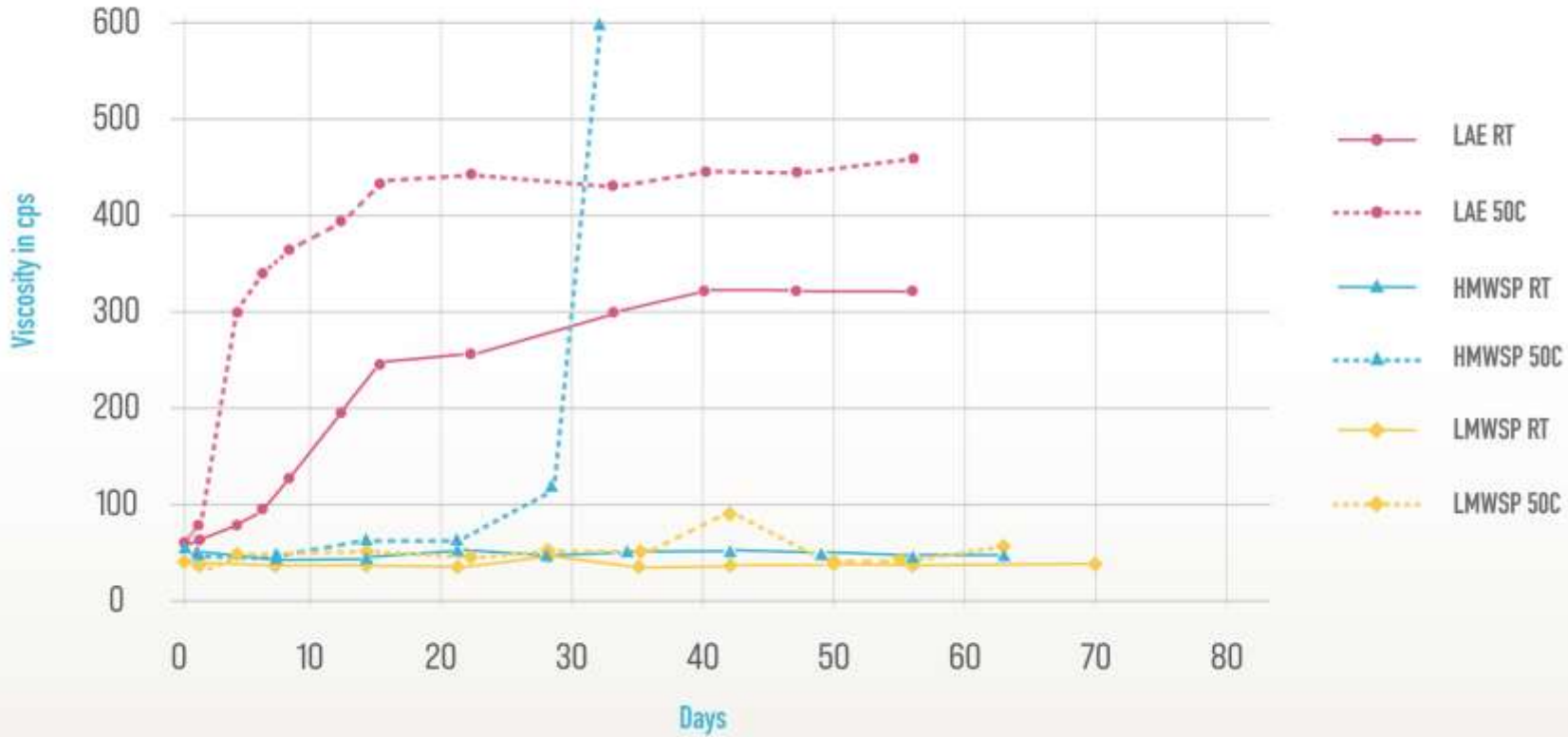
Silicone Polyether higher MW
(HMWSP)

Silicone Polyether lower MW
(LMWSP)

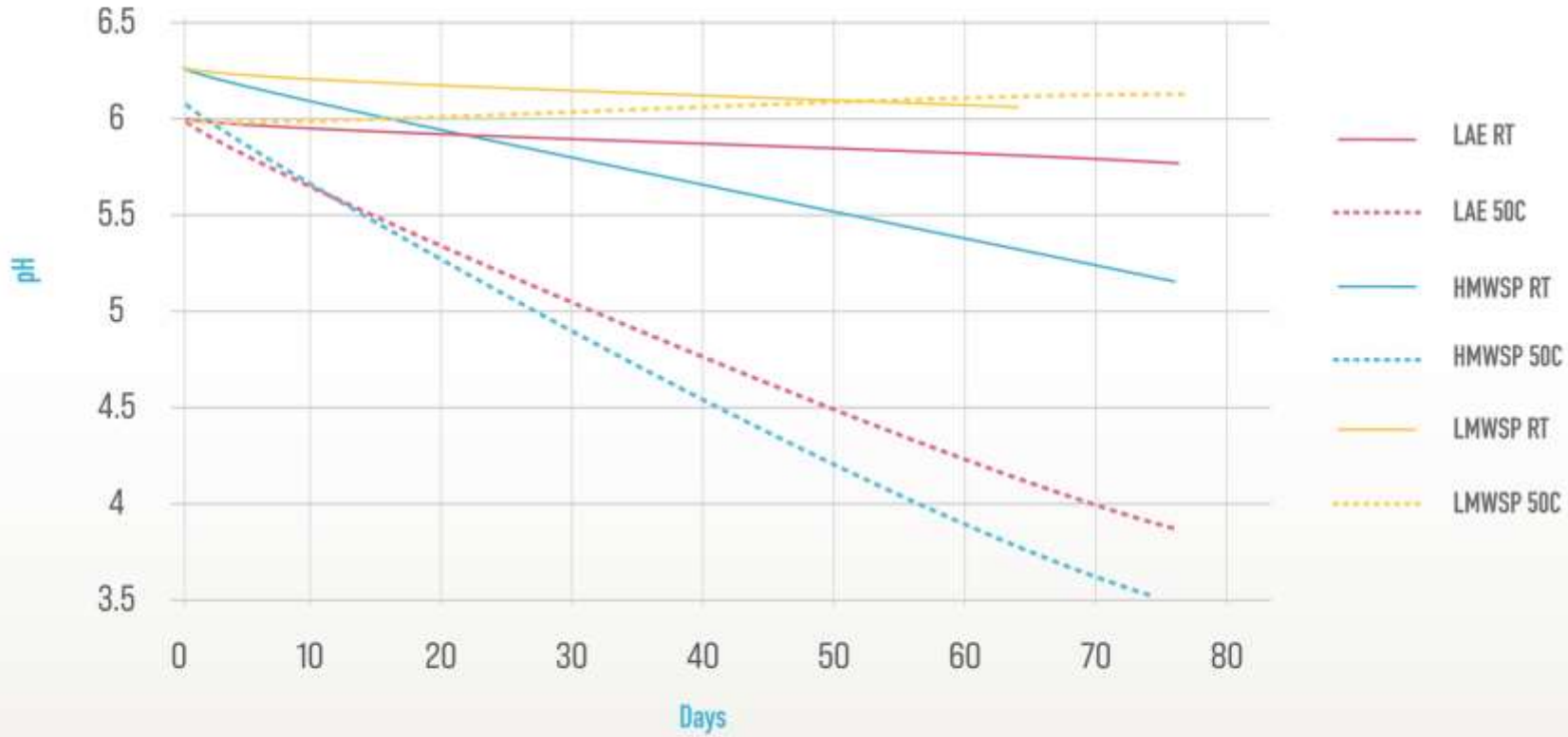
STABILITY

STUDY OF THE EMULSION

SURFACTANT STUDY » VISCOSITY vs TIME



SURFACTANT STUDY » pH vs TIME



PARTICLE SIZE » LAE STABILITY

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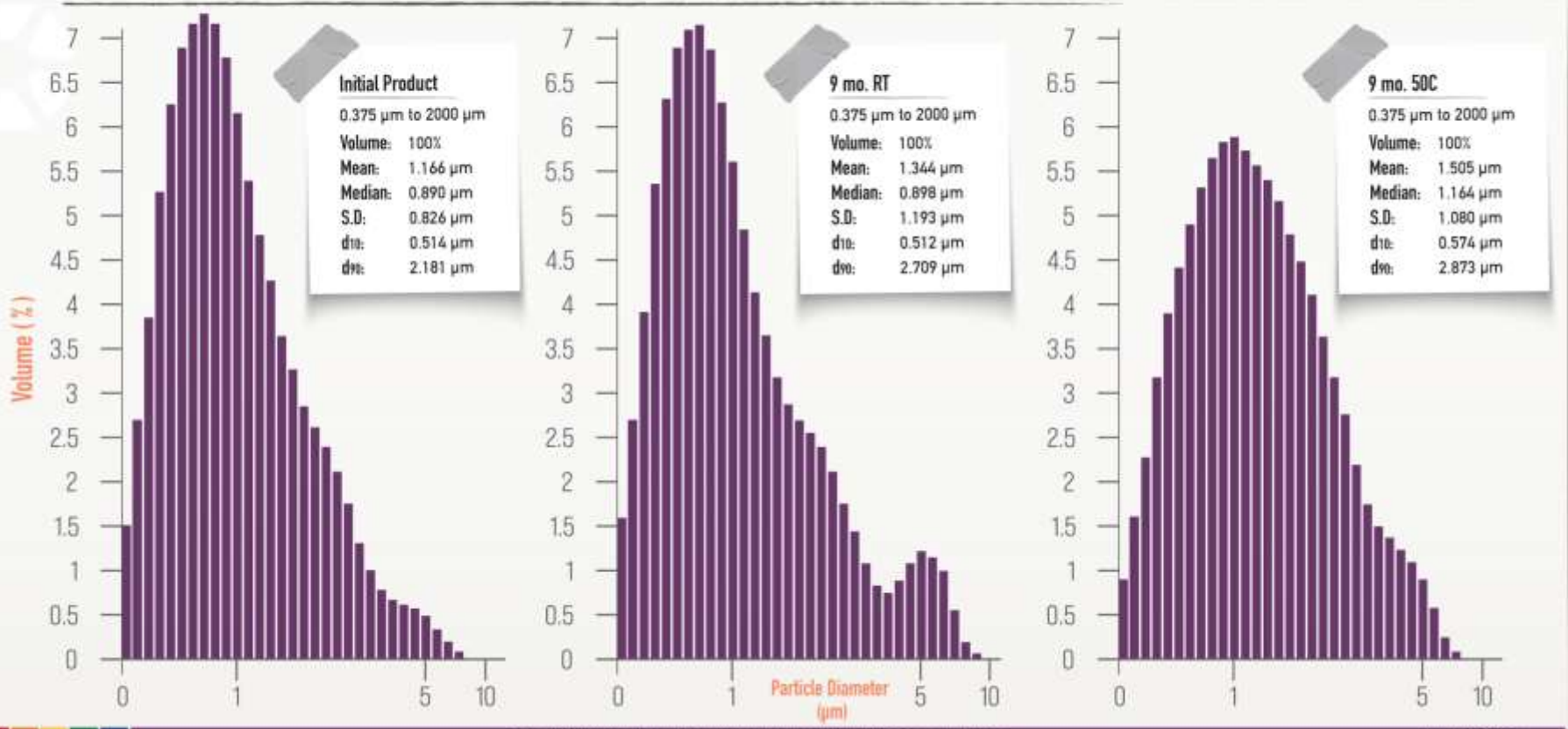
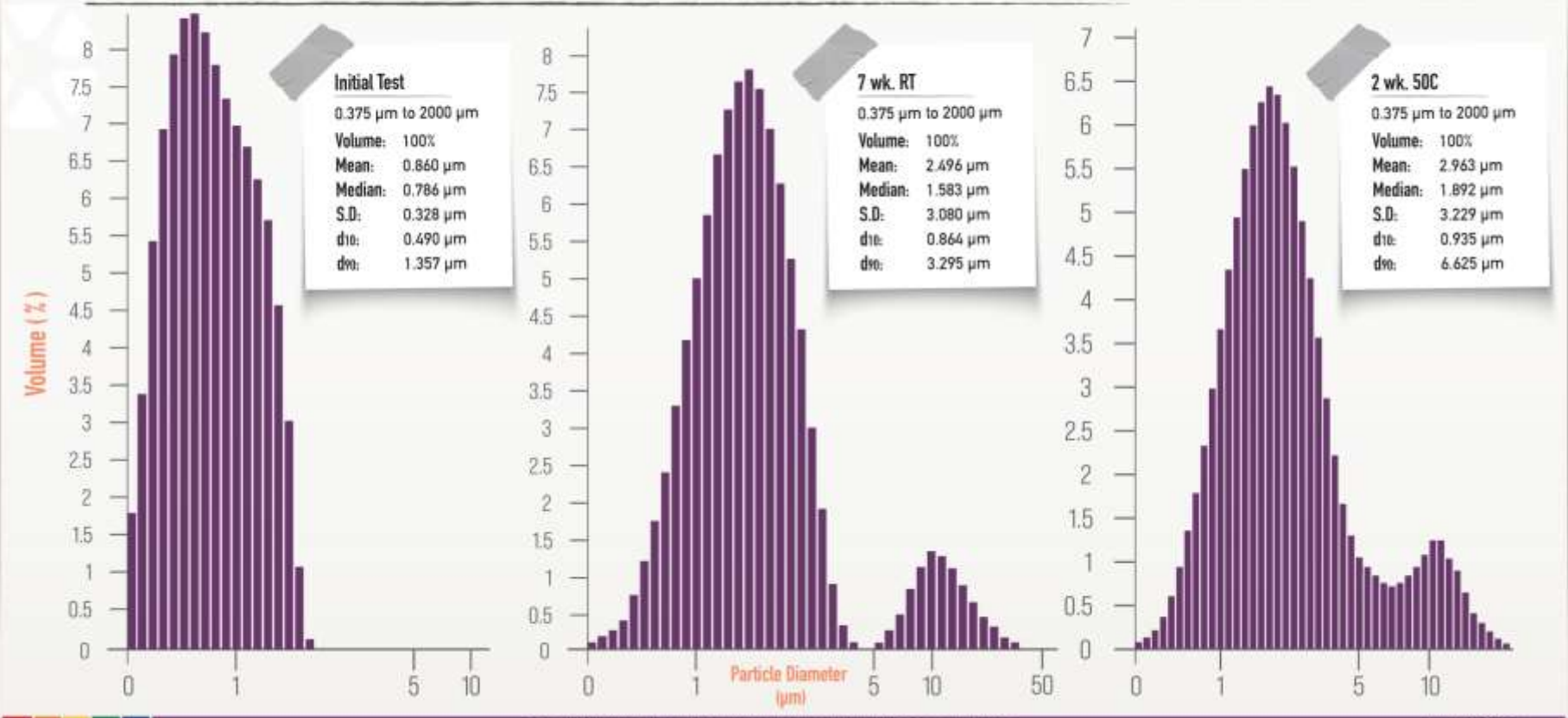


PARTICLE SIZE » HMWSP STABILITY

DyStar



PARTICLE SIZE » LMWSP STABILITY

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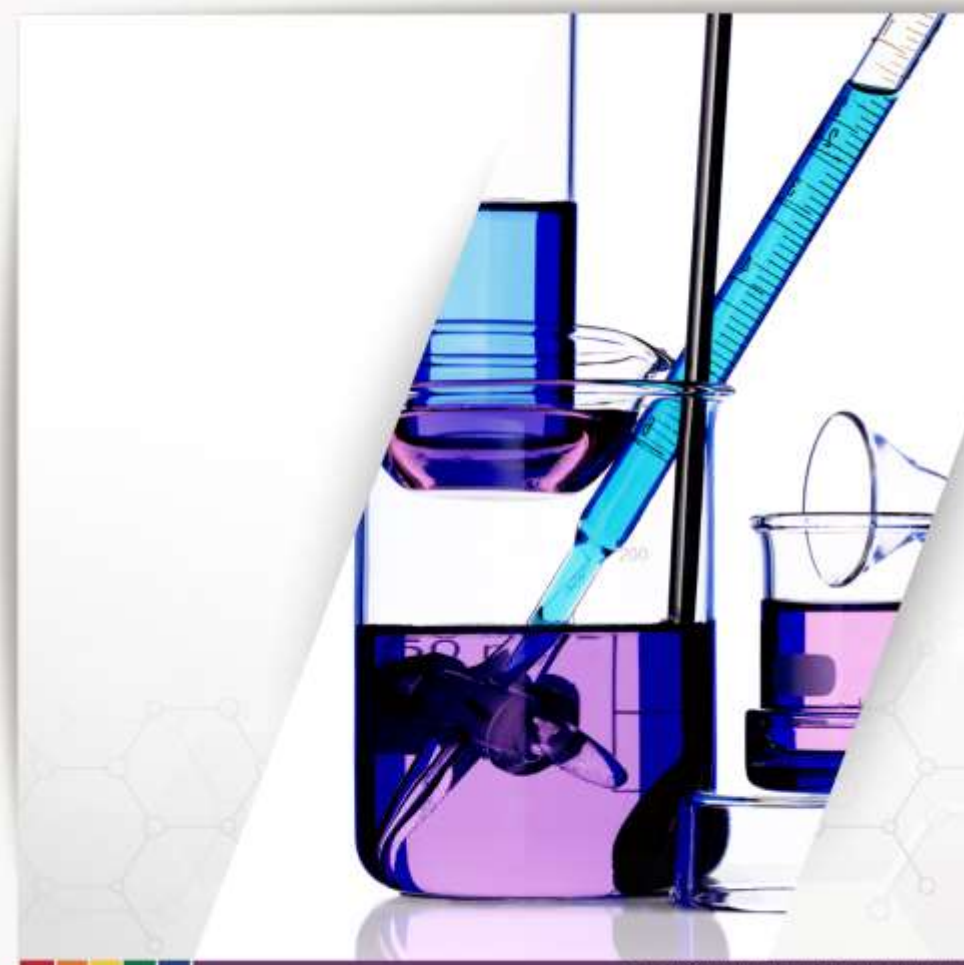
STABILITY » 6 months (RT)



TESTING OF THE EMULSION

in various Applications

APPLICATION » PAINT FORMULATION

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	FUNCTION	- 1 % ADDITIVE	- 2 % ADDITIVE	- 3 % ADDITIVE
GRIND	Water	13.80	13.80	13.80
	Coalescing aid	1.56	1.56	1.56
	Biocide	0.20	0.20	0.20
	Antifoam	0.20	0.20	0.20
	Dispersing Aid	0.20	0.20	0.20
	Pigment	23.40	23.40	23.40
	Rheology thickener	0.49	0.49	0.49
	Water	1.66	1.66	1.66
	Rheology thickener	0.20	0.20	0.20
PRE-LETDOWN	Water	2.93	2.93	2.93
	Binder	45.90	44.92	43.95
	Additive	0.98	1.95	2.93
	Water	2.34	2.34	2.34
LETDOWN	Antifoam	0.15	0.15	0.15
	Water	3.91	3.91	3.91
	Rheology thickener	2.00	2.00	2.00
	pH adjustment	0.10	0.10	0.10

LADDER STUDY » APPLICATION TESTING

DyStar®

White Paint (Pigment)	Control (No Additive)		1 % Additive with LAE		2 % Additive with LAE		3 % Additive with LAE	
Days of Testing	**1 day**	**7 day**	**1 day**	**7 day**	**1 day**	**7 day**	**1 day**	**7 day**
Block (on Leneta)								
1000g, 30min, 40C, 1/2hr cooling, (10 is best), (% removed at 7 days)	Rating 2 40% Removed		Rating 2 25% Removed		Rating 2 50% Removed		Rating 8 Very Slight Tack	
500g, 24hrs, 25C, (10 is best), (% removed at 7 days)	Rating 8 Very slight tack		Rating 9 Trace tack		Rating 10 Perfect		Rating 10 Perfect	
Surface Testing (on Leneta)								
20 Deg	15.7	15.2	13.6	12.1	11.2	11.3	10.8	11.1
60 Deg	55.7	55	53.3	51.6	49.2	49.7	48.6	49.6
85 Deg	88	86.9	86.9	85.3	82.8	82.3	84	83.7
Surface tension, Dynes Pens (7 Day)	44		38		36		36	
Dirt Pick-Up Test (14 Day) color strength	133.04		122.13		116.57		110.40	
Paint Stain Testing (3 Day)	42		36		34		37	
Film Testing (on Aluminum)								
Pencil Hardness	F	F	HB	HB	B	B	5B	4B
Crosshatch Adhesion (% loss of material)	2B - 20	2B - 15	2B - 15	2B - 10	2B - 30	2B - 10	2B - 30	2B - 20
Koenig Hardness 3"	16	16	14	15	13	14	12	14
Contact Angle (7 Day)	75.7		80.1		85.4		82.1	

BLOCK » APPLICATION TESTING *on* LENETA

1000g, 30 min, 40°C, 1/2 hr cooling

CONTROL

1 %

2 %

3 %

CROSS HATCH » APPLICATION TESTING

CONTROL

1 %

2 %

3 %

SURFACTANT COMPARISON » APPLICATION TESTING

DyStar

White Paint (Pigment)	Control (No Additive)		1% Additive with LAE		1% Additive with LMWSP	
Days of Testing	**1 day**	**7 day**	**1 day**	**7 day**	**1 day**	**7 day**
Surface Testing (on Leneta)						
20 Deg	15.7	15.2	13.6	12.1	12.7	12.7
60 Deg	55.7	55	53.3	51.6	52.3	52.3
85 Deg	88	86.9	86.9	85.3	83.2	82.1
Surface tension, Dynes Pens (7 Day)	44		38		42	
Dirt Pick-Up Test (14 Day) color strength	133.04		122.13		114.20	
Film Testing (on Aluminum)						
Pencil Hardness	F	F	HB	HB	B	HB
Crosshatch Adhesion (% loss of material)	2B - 20	2B - 15	2B - 15	2B - 10	2B - 25	2B - 15
Koenig Hardness 3"	16	16	14	15	12	14
Contact Angle (7 Day)	75.7		80.1		75.6	

WATER-BASED SEALER » APPLICATION TESTING

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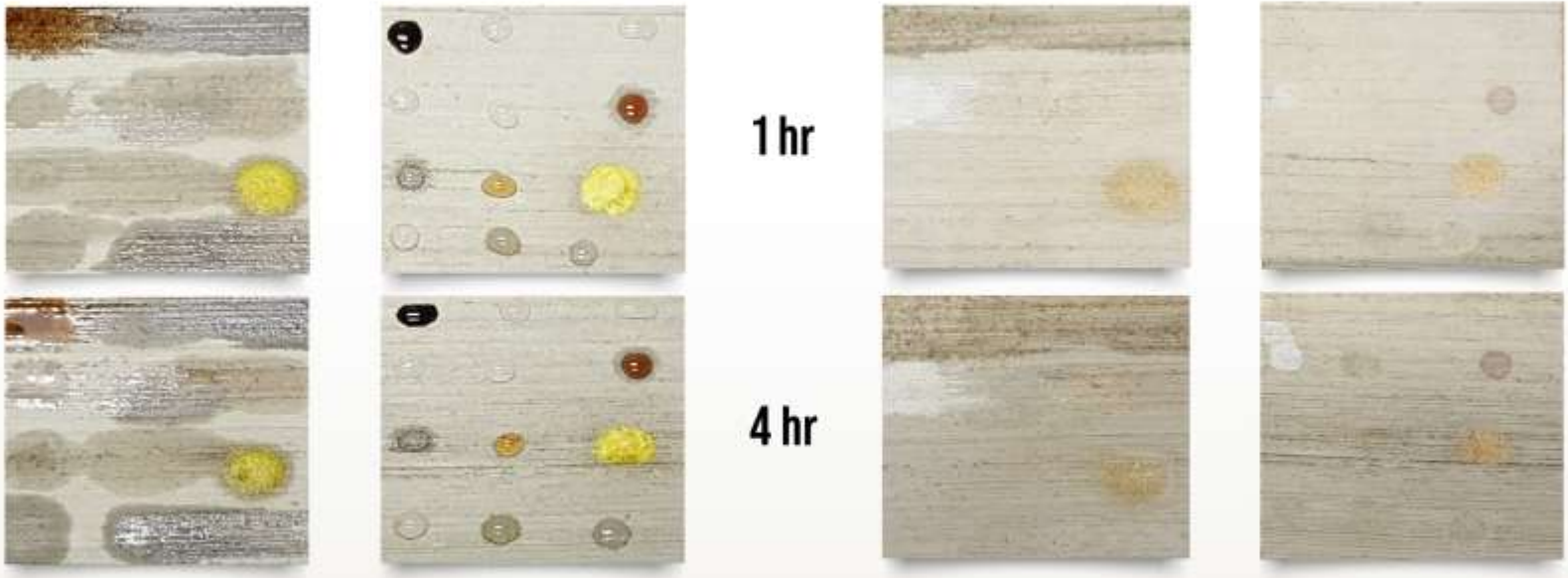
After stain application

After wash, rinse, & dry



WATER-BASED ANTI-GRAFFITI » APPLICATION

DyStar

DyStar®

CONCLUSIONS

- **Successful Production** of multifunctional self-crosslinking emulsion possible using novel surfactant package
- **Particle Size** significantly smaller than current technology
  - Opens up application space
    - Architectural and industrial coatings
    - Coatings and sealers for porous substrates
    - Future? Digital inks (sub-micron)
  - Allows for better distribution of additive throughout paint films
    - Improved blocking at lower levels possible
    - Improved DPUR at lower levels possible
- **Stability**/shelf-life significantly improved

PLEASE CONTACT US WITH ANY QUESTIONS:

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