Formulating Defect-free Epoxy Coatings with Patcham Additives

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All About Epoxy Coatings

- Epoxy coatings are used because of their outstanding chemical resistance, durability, low porosity and strong bond strength
- A chemical reaction occurs between the two parts (base + curing agent) generating heat (exotherm) and hardening the mixture into an inert, hard ‘plastic’
- Epoxy flooring has a great adhesive capability which is estimated at 1.5 thousand pounds of adhesive power for every square inch of flooring
- Epoxy can also be used to provide a protective layer to any hard surface, including metal and wood sub-flooring

Challenges of Formulating Epoxy Coatings

- Demand in the market

  performance of the coatings – weather resistance, corrosion resistance

- Stability
- Handling

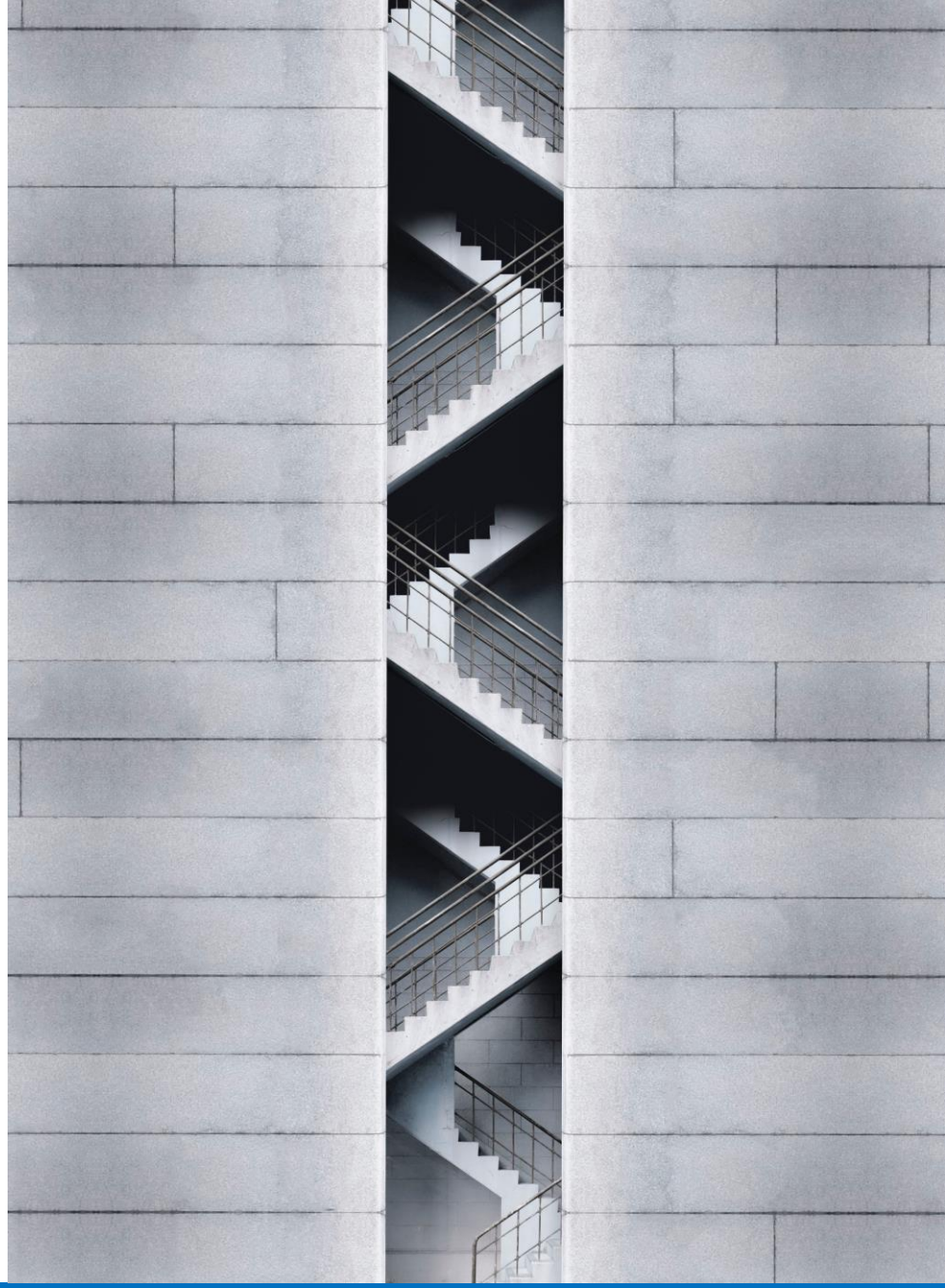
  mixing ratios, dilution of thinners, type of hardeners, compatibility to other coatings chemistry

- Application

  drying time, humidity, open-window of working

- Environmental regulations

  VOC limits, EPA, REACH, APEO, etc



Contents

Factors to keep in mind while formulating

- Selection of raw materials

  compatibility and need of resin, pigments, solvents, and additives

- Required performance

  warranty you will give to the market vs the ones already established

- Handling of the product

  trend in the market

- Potential Defects
- Environmental regulations

Contents

Defects and Issues

Three types of Paint Defects

Color

- Wrong color
- Shade, Tint, Saturation, Uniformity
- Illumination-Object-Observer

Appearance

- Observer Expectation
- Coverage
- Uniform Appearance
- Gloss, Texture, Color
- Curvature of Surface
- Substrate preparation

Protection

- Duration of exposure
- Service environment expectation, conditions
- Substrate to be protected from?
- Substrate preparation

Color and Appearance

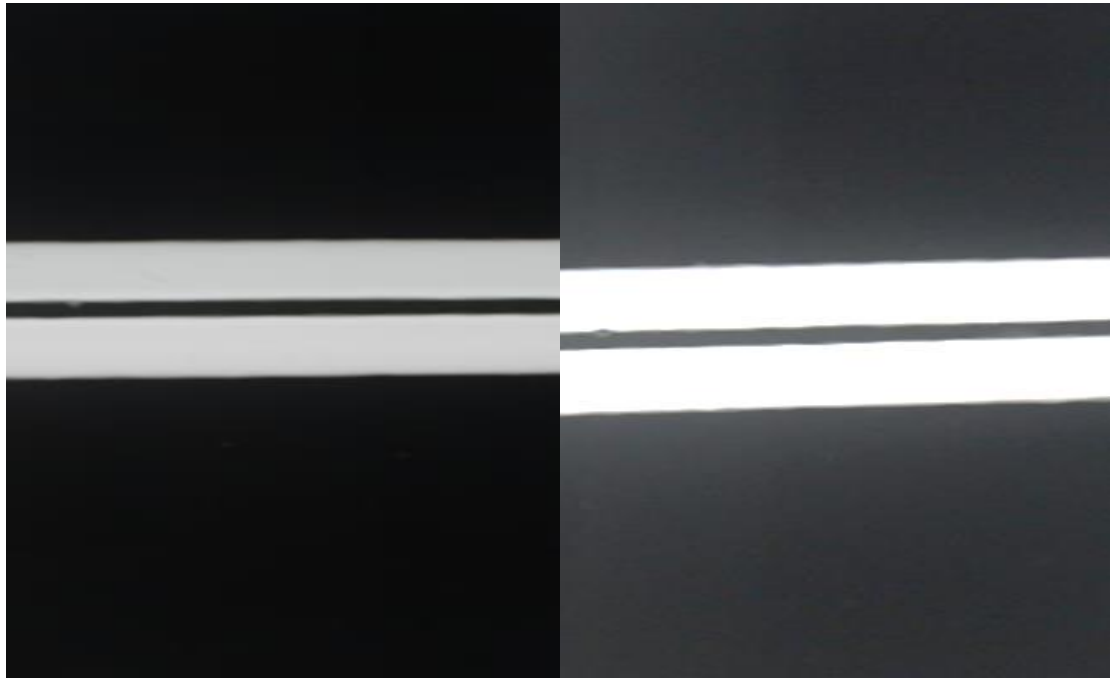
Poor Dispersion and Stabilization

Defect:

Poor color and gloss development

Cause:

Non homogenous dispersion of pigments



Color and Appearance

Poor Dispersion and Stabilization

Defect:

Flocculation/ Floatation

Cause:

Segregation of pigments, caused by surface tension gradients

Color and Appearance

Poor Dispersion and Stabilization

Defect:

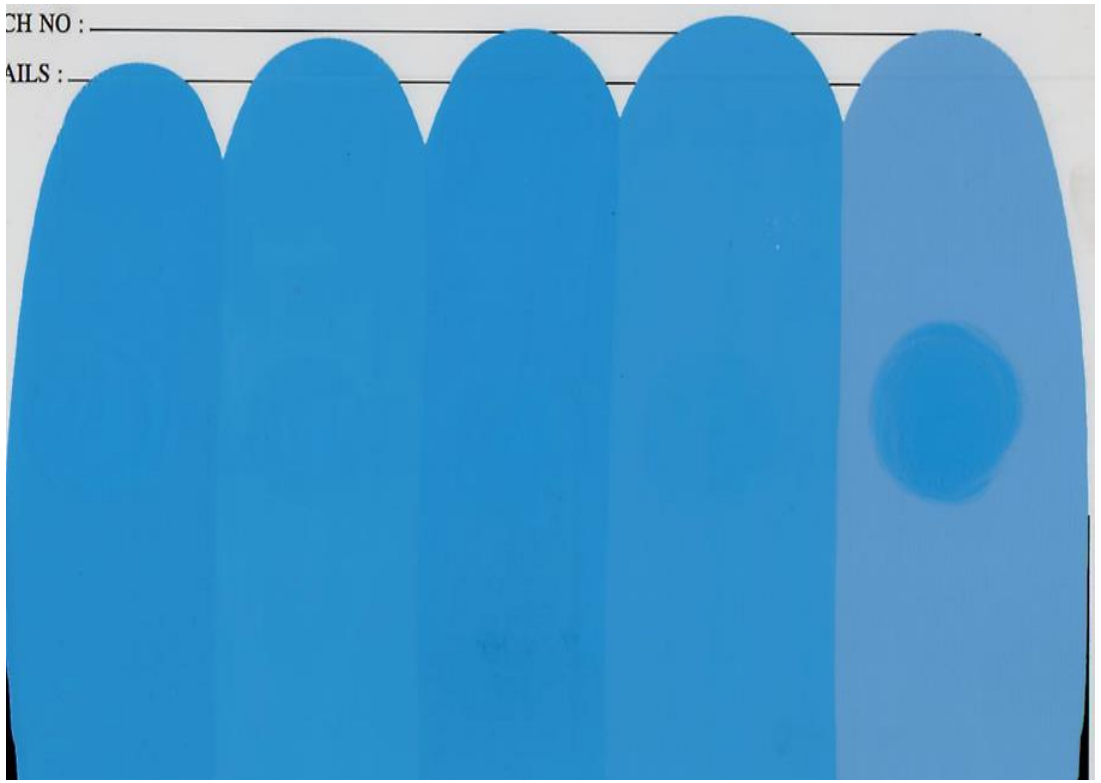
Shear dependent color development

Rub up color change

Inability to develop the proper color shade

Cause:

Optical effect, demonstrating color differences which results from inhomogeneous distribution of at least two different pigments



Color and Appearance

Poor Dispersion and Stabilization

Defect:

Dirty/poor grind, pigment paste, colorant or paint

Cause:

Re-agglomeration of pigments, poor anchoring performance of dispersants to the surface of pigments, incompatible dispersants

Color and Appearance

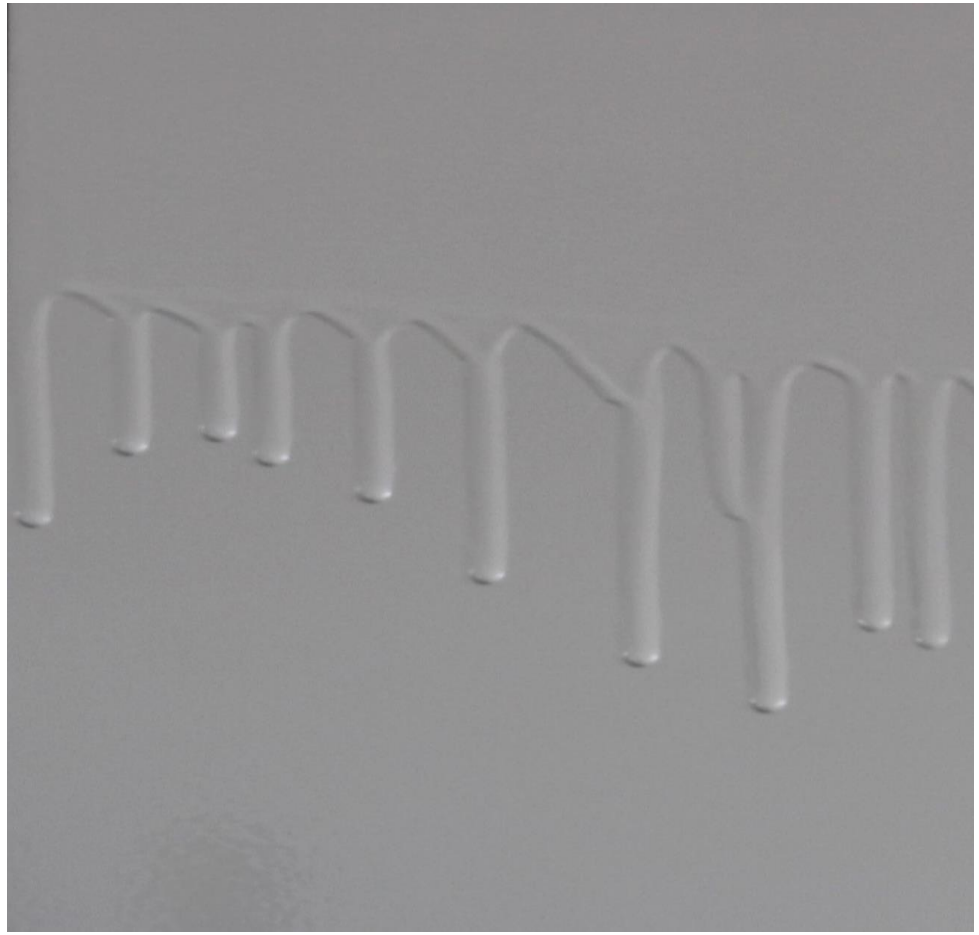
Poor Dispersion and Stabilization

Defect:

Sagging/curtaining

Cause:

Insufficient thixotropy to support the weight of the paint



Solve Color and Appearance Issues

Selecting the right Wetting and Dispersing Additive

- Provides proper stabilization
- Enhances quality of pigment dispersion
- Maximize gloss development
- Minimize color variations from shear or color change on rub-up
- Prevents flooding and floatation of pigments
- Shortens time to reach dispersion

Contents

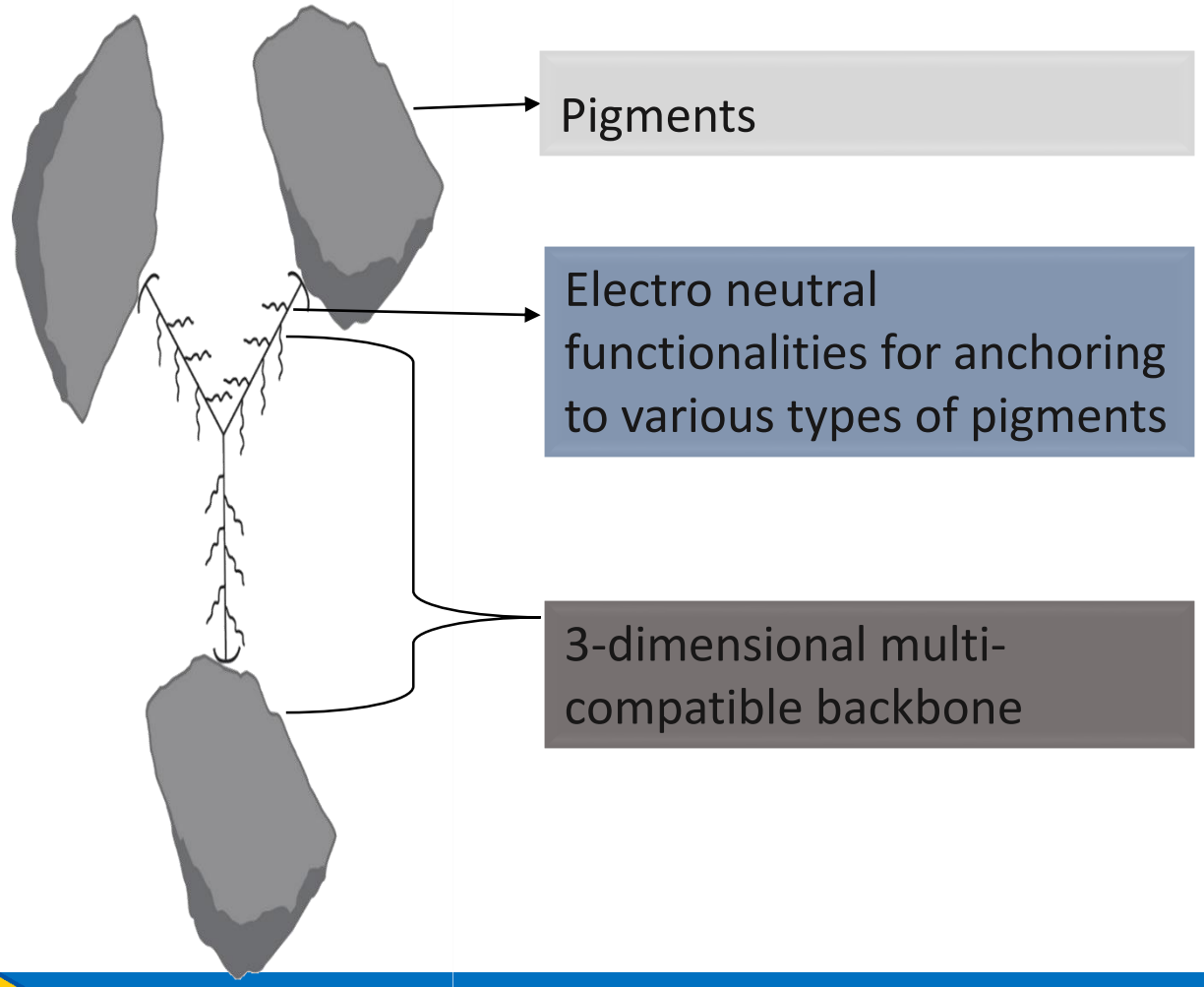
Honeycomb Multifunctional Technology

- Polymeric dispersing agents with electroneutral functionality that aid in good wetting to various types of pigment surfaces irrespective of the surface charges and treatments
- The network structure formed due to interactions of the polymeric dispersant with pigment, filler and resin particulates provides the anti-settling and sag resistance of the paint

Solventborne

Pat-Add DA 1666

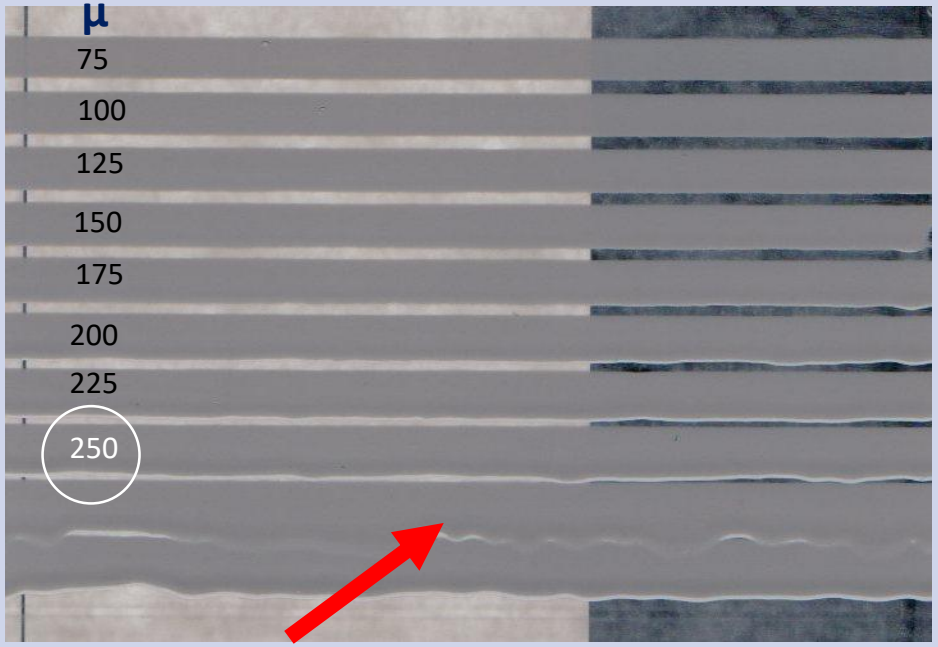
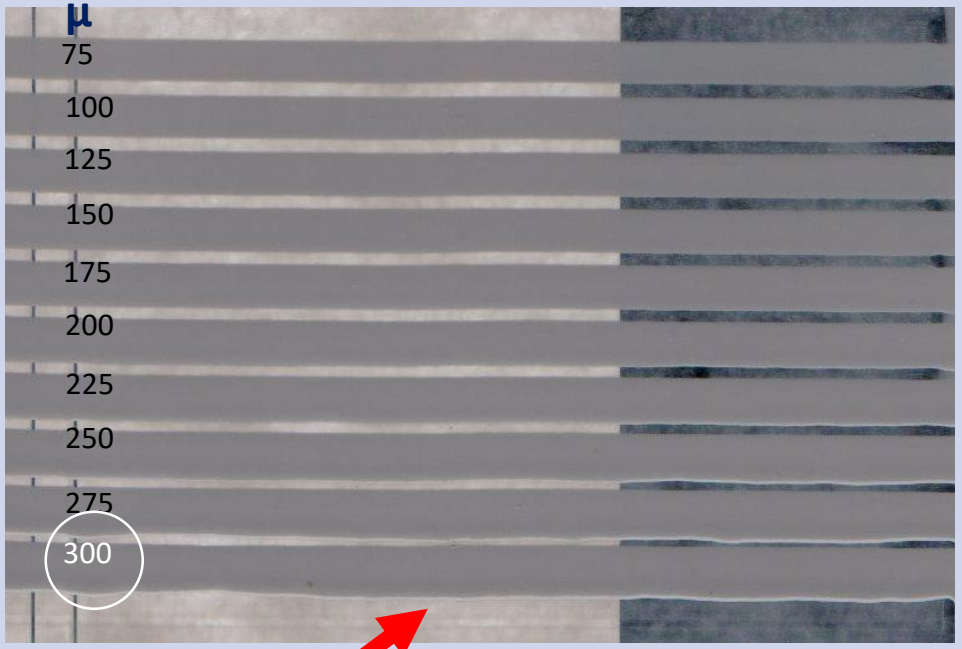
Pat-Add DA 1666



- Polyamide-polyester backbone is compatible with various binders
- Three-dimensional structure keeps pigment particles dispersed and does not allow pigments/fillers to settle or re-agglomerate

Pat-Add DA 1666 – Epoxy Zinc Phosphate Primer

Sag Resistance Test ASTM D4400

Reference + 0.3 % organo clay	Pat-Add DA 1666 + 0.3 % organo clay
	
Viscosity: 73 KU	Viscosity: 71 KU

Pat-Add DA 1666 – Epoxy Zinc Rich Primer

Settling test after 16 hrs at 30°C/ 86°F

Hard Settling	Soft settling	Soft settling	Very soft settling
			
Reference without organo clay	Pat-Add DA 1666 Without organo-clay	Reference + 0.3 % organo-clay	Pat-Add DA 1666 + 0.3 % organo-clay

Epoxy zinc rich primer	
Dispersing agent	0.50 %
Zinc dust	77.00 %

Pat-Add DA 1666- Epoxy Topcoat

Floatation after 1-month Incubator Stability- 50°C/122°F

Reference +
0.3 % organo-clay

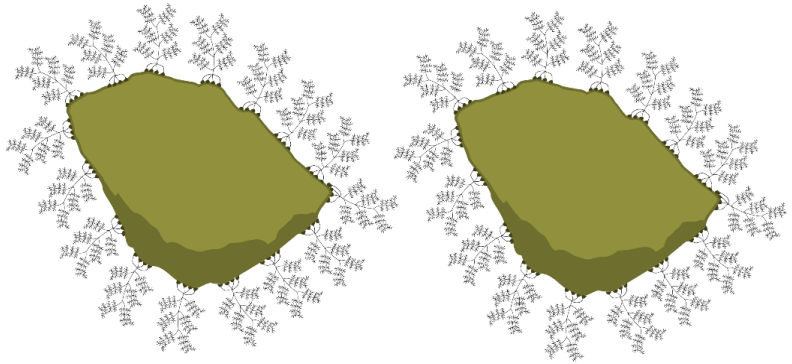
Pat-Add DA 1666
+ 0.3 % organo-clay

Reference +
0.3 % organo-clay

Pat-Add DA 1666
+ 0.3 % organo-clay

HMV Technology

- Technology based on highly branched polyurethane polymers for pigment dispersion and stabilization
- Its polymeric chain with higher volume, results in a thicker adsorbed layer around the pigment particle to increases resistance to flocculation



Solventborne/Solvent-free

Pat-Add DA 948

Patcham HMV Technology

Dispersion Stability of Higher Molecular Weight Additives

Broad Compatibility of Lower Molecular Weight Additives

=

H

M

V

High Molar Volume

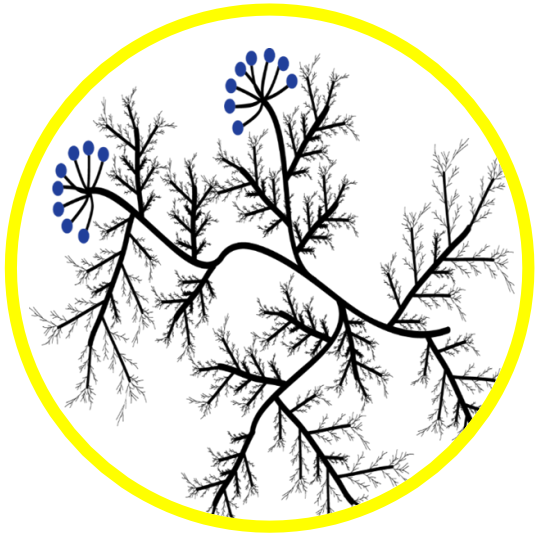
High Molar Volume Technology

Multiple anchoring groups

Faster wetting rate

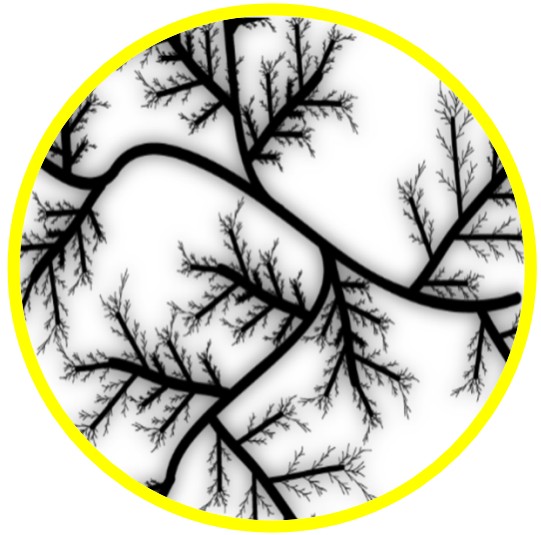
Lower mill base viscosity

Stronger Stabilization



Higher volume mass of polymer

Dense polymeric structure between the pigment particles creates steric repulsion

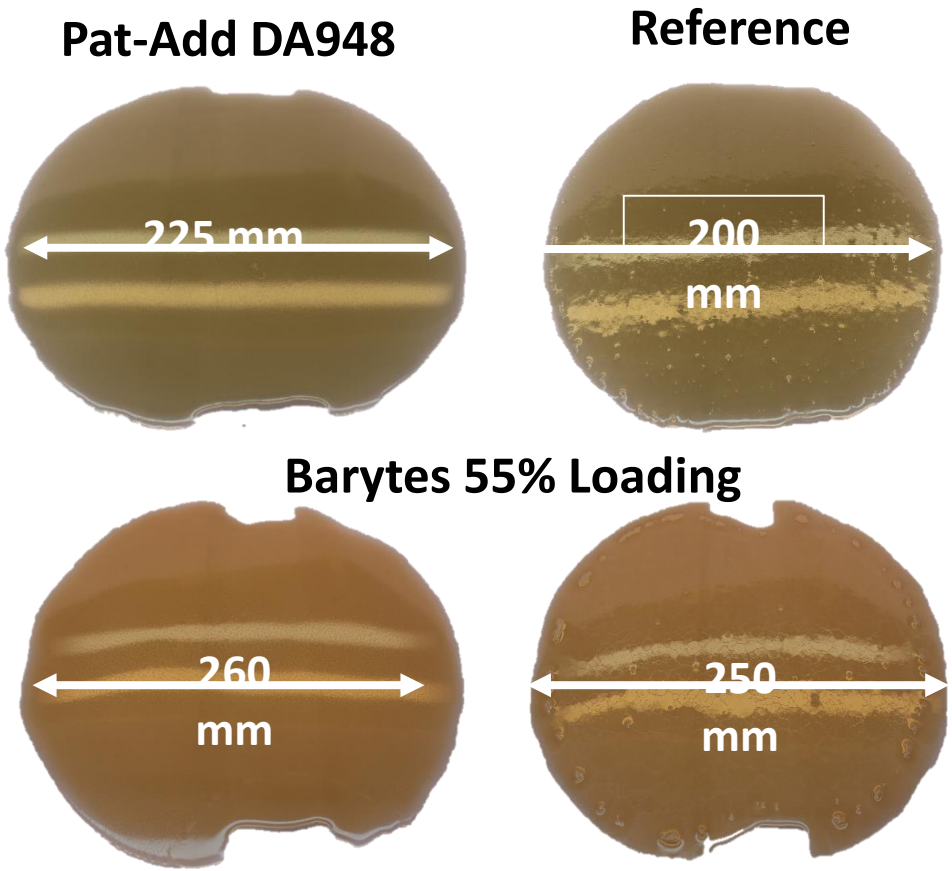


Lower MW Branched Polymeric Segments

Allows it to be used in a wider range of resin systems without incompatibility issues of similar MW linear or unbranched structures

Pat-Add DA 948

Solventfree Epoxy Spreading Index and Appearance



Type of Fillers	Loading	Spread index		Appearance	
		Pat-Add DA 948	Reference	Pat-Add DA 948	Reference
Silica Flour	55.0%	290 mm	265 mm	No Foam	Foam
Silica Sand		230 mm	225 mm	No Foam	Severe Foam
Barytes		225 mm	200 mm	No Foam	Foam
Talc	35.0%	260 mm	250 mm	No Foam	Foam

Pat-Add DA 948

White Base tinted with Colorants- Mid Grey

In Can Floatation

After 48 hours

Pat-Add DA 948 **Reference**

After 10 days

Pat-Add DA 948 **Reference**

Pat-Add DA 948

As a compatibilizer

Post-addition to Standard Epoxy Gray with severe floating application in 10 mil drawdown

Electroneutral 100% Active Dispersing Agents

- High polarity electroneutral dispersing agent
- Designed for high degree of wetting for pigments and provides steric stabilization with weaker electrostatic effects

Solvent-free

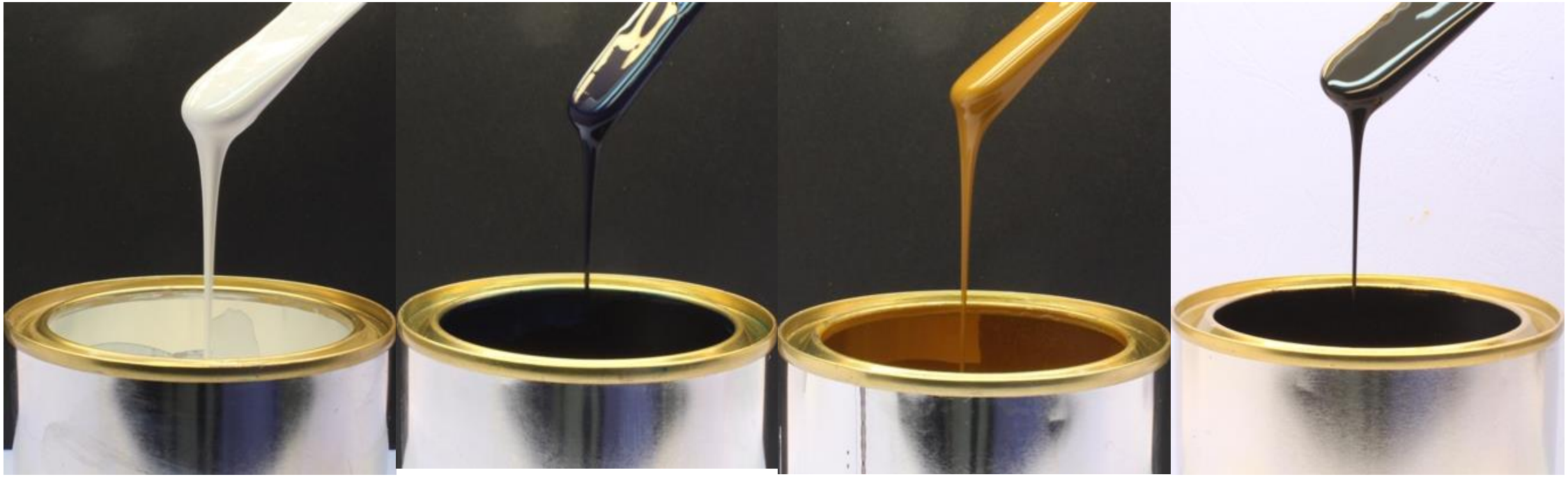
Pat-Add DA 895

Waterborne

Pat-Add DA 817

Pat-Add DA 895 Epoxy RMPC

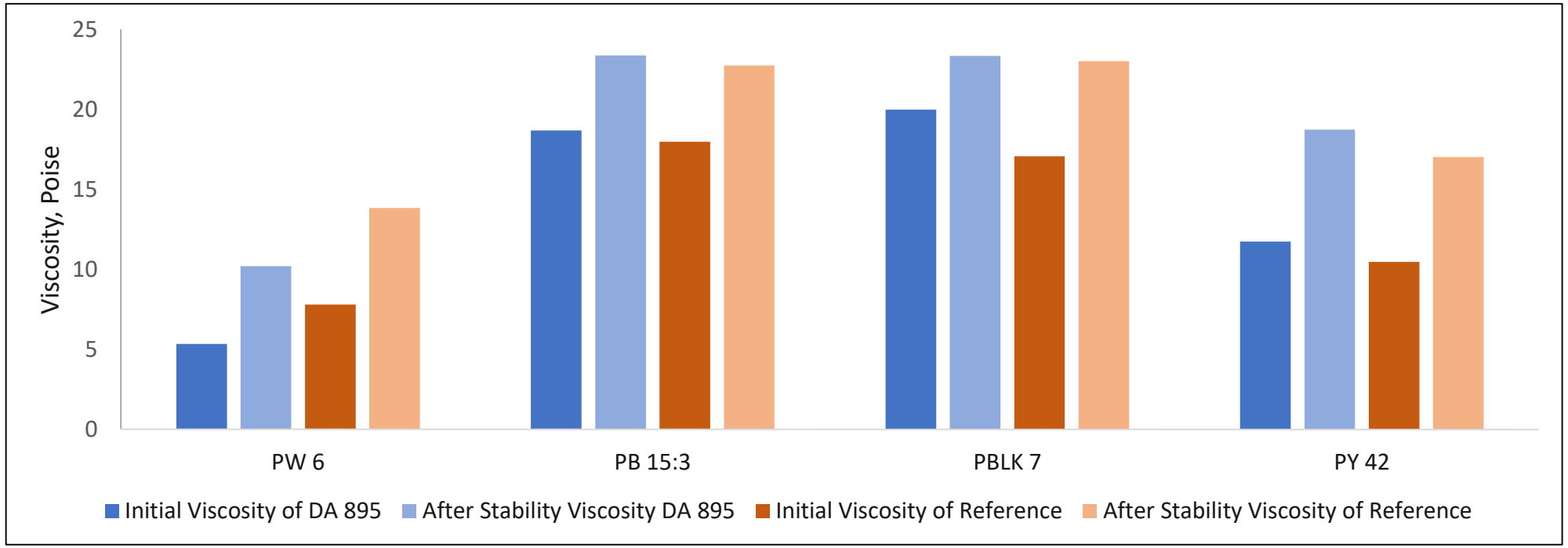
Flow and dispersion stability



TiO2-rutile 60% Loading	Phthalocyanine blue PB 15:3 22% Loading	Yellow iron oxide PY-42 50% Loading	Special black 4- PBlk-7 15% Loading

Pat-Add DA 895 RMPC Epoxy

Viscosity measurements



➢**All PC samples exhibited comparable viscosity profile from the reference samples**

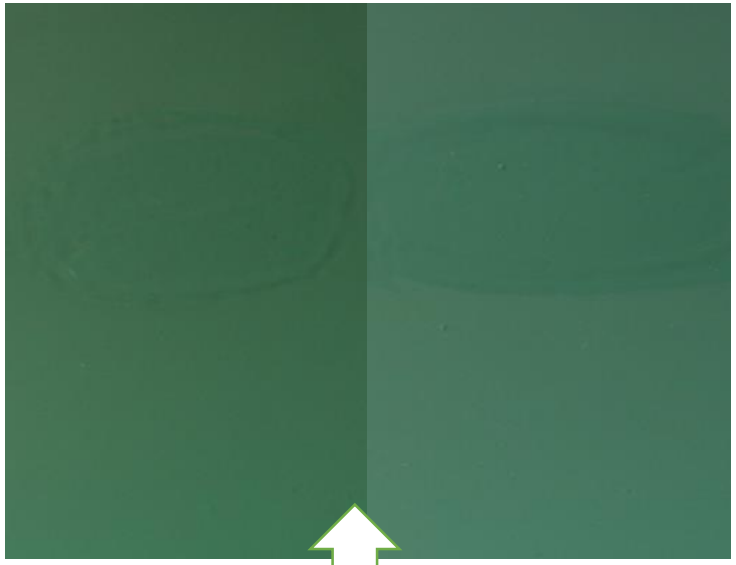
***Viscosity checked on Cone and Plate Brookfield viscometer, Spindle no. 3, RPM-250, at 25°C/77°F**

Pat-Add DA 895 RMPC Epoxy

Tinting with Epoxy 4-pack system

Avocado ripe green

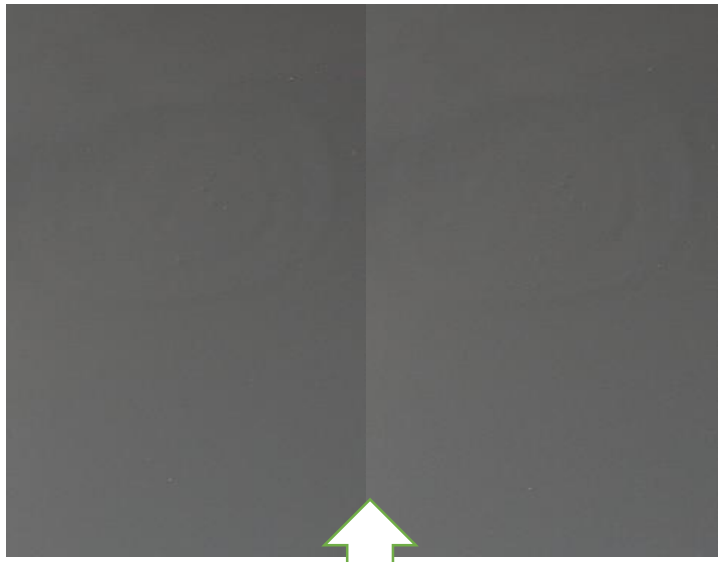
Pat-Add DA 895 Reference



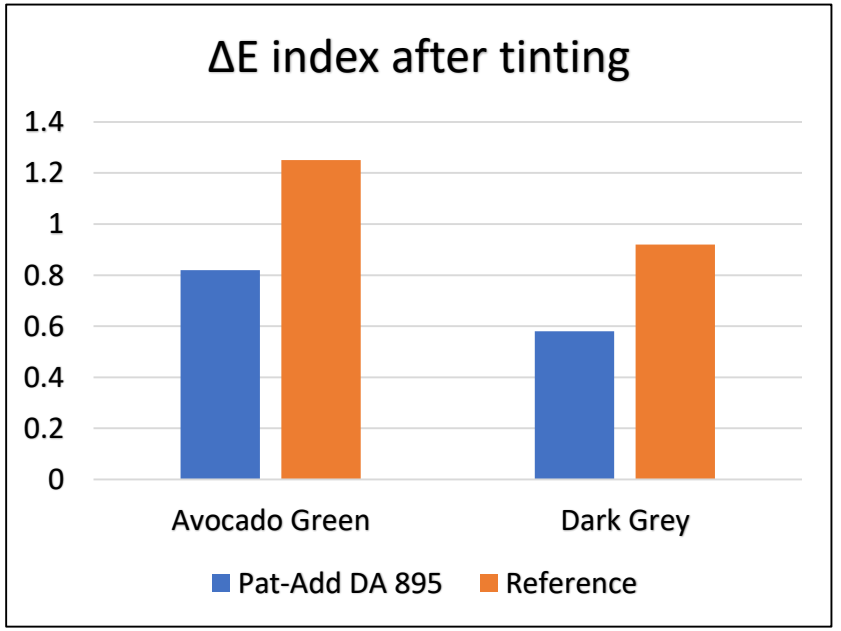
PG7 + PW 6

Dark grey

Pat-Add DA 895 Reference



PBLK 7+ PY 42 +
PR 130 + PW 6



Better color strength without flocculation as compared to reference when tinted in epoxy clear system

Pat-Add DA 817

Co-Grind Epoxy Topcoat Settling property

After 1 month of Incubator Stability 50°C/122°F

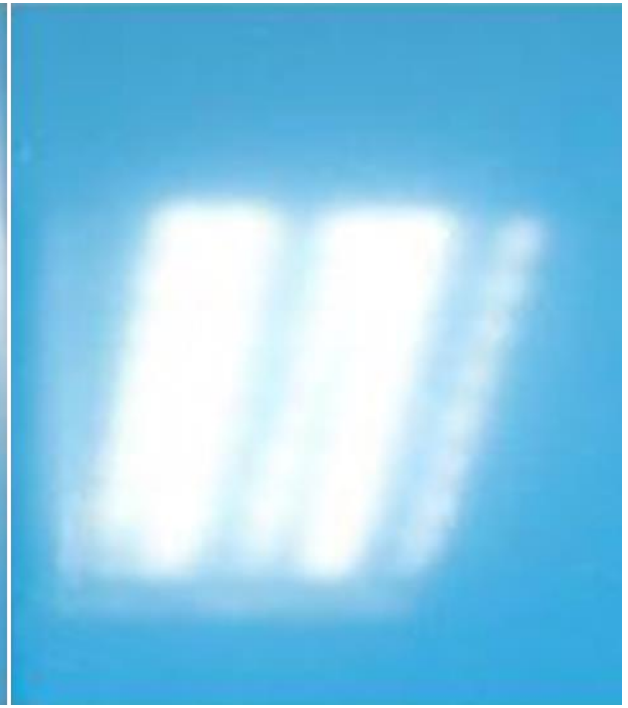
Reference

Pat-Add DA 817

Pat-Add DA 817

WB Co-grind Topcoat - Panel appearance and floatation

Reference



Pat-Add DA 817

Reference

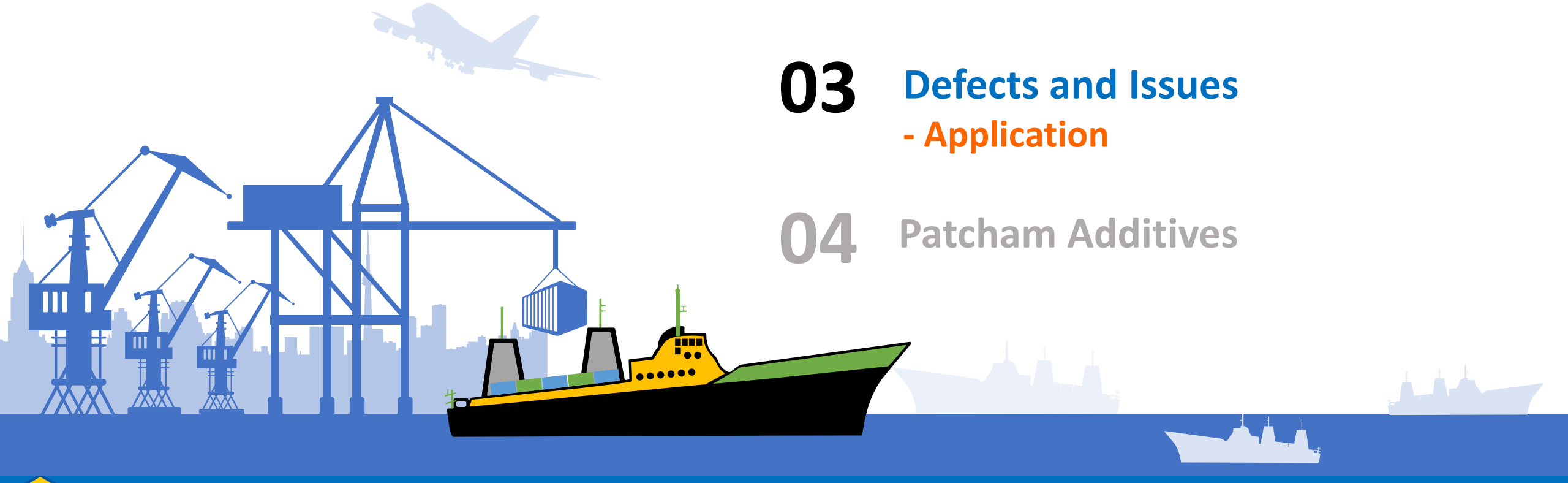
Pat-Add DA 817

Differentiating Attributes

- **Wetting & Dispersing Additive**

Pat-Add DA 1666	Honeycomb multifunctional, Solventborne Primers, Improve storage stability and sag resistance
Pat-Add DA 948	HMV, Solvent-free, direct and co grind, Compatibilizer
Pat-Add DA 895	100% Active Electroneutral, Solvent-free Epoxy colorants
Pat-Add DA 817	100% Active Electroneutral , Waterborne Epoxy
Pat-Add DA 603LV	Waterborne Resin Free Colorants

Contents

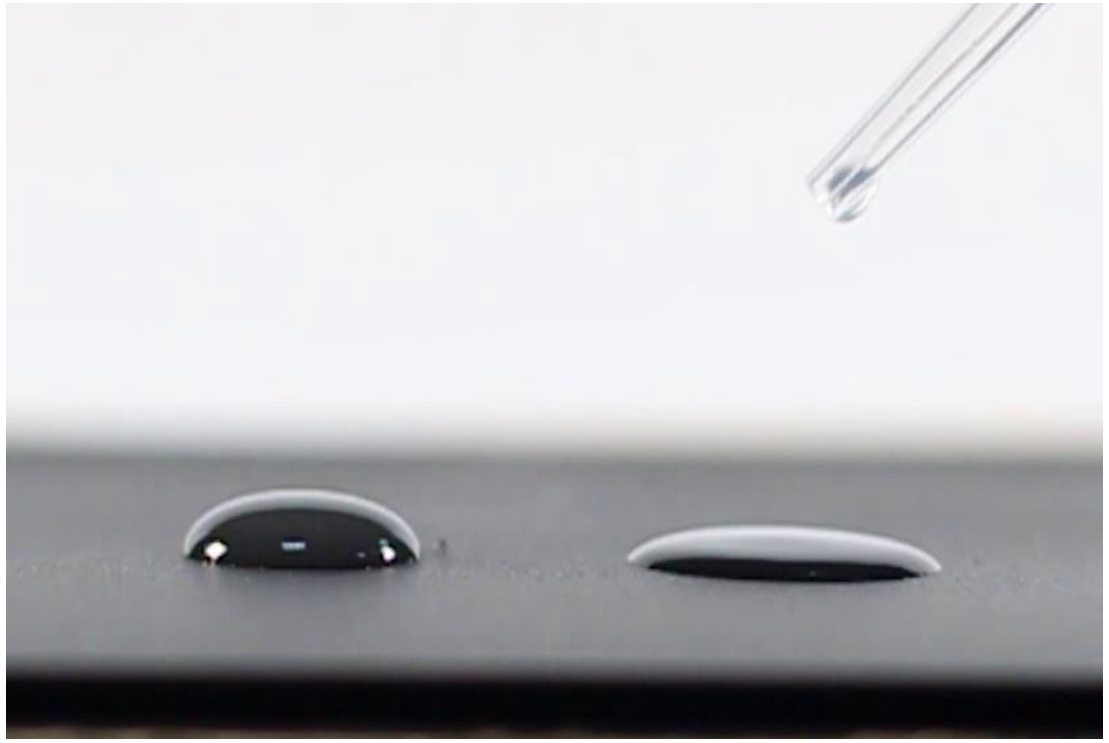


Appearance and Protection

Application Issues

- The application process increases the surface area of liquid coating
- Regions with different surface tensions are created – surface tension gradients
- Surface tension difference is enough to cause movement within the freshly applied film

Spontaneous Wetting



- A term to describe the behavior of a liquid when it contacts a surface that is equal or higher surface energy than the liquid
- Contact angle of the liquid leading edge is zero

Substrate Wetting Requirements

Approx. Surface Energy of different coatings in mN/m

Substrate	Surface Energy mN/M
Glass	70
MS Panel	50
Aluminum	40
ABS	42
Nylon	38
Polypropylene	29
Wood	Depends on the type of wood

- Coating surface tension must be equal to or less than the surface tension of the substrate
  - Wetting does not guarantee adhesion; but adhesion cannot occur without wetting
  - Coating ST must be lower than contaminant's surface energy

Waterborne Coatings	50-60
Solventborne Coatings	40-50
UV Coatings	55-65

Flow

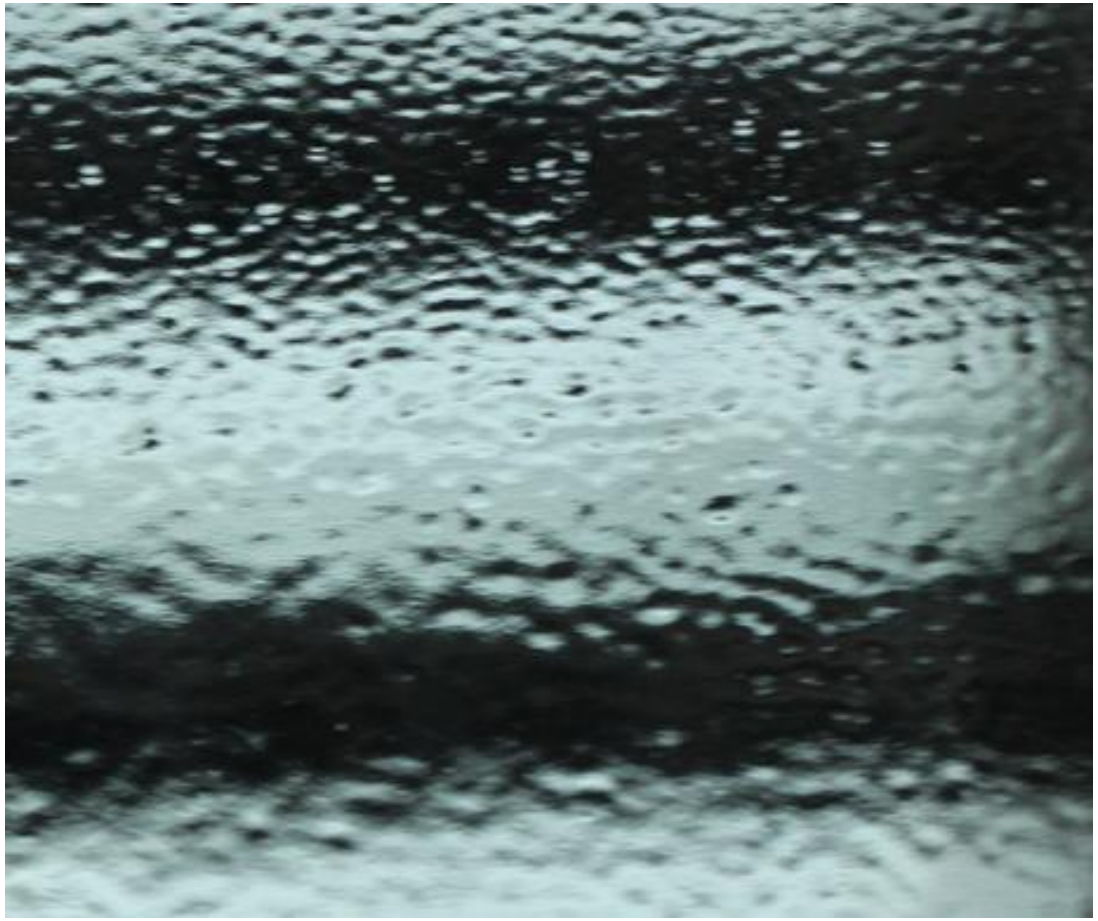
- Flow is the behavior of a liquid after it wets the substrate surface
- This can be also thought of as spreading
- Occurs at low shear rates – gravity
- Surface tension dependent behavior

Leveling

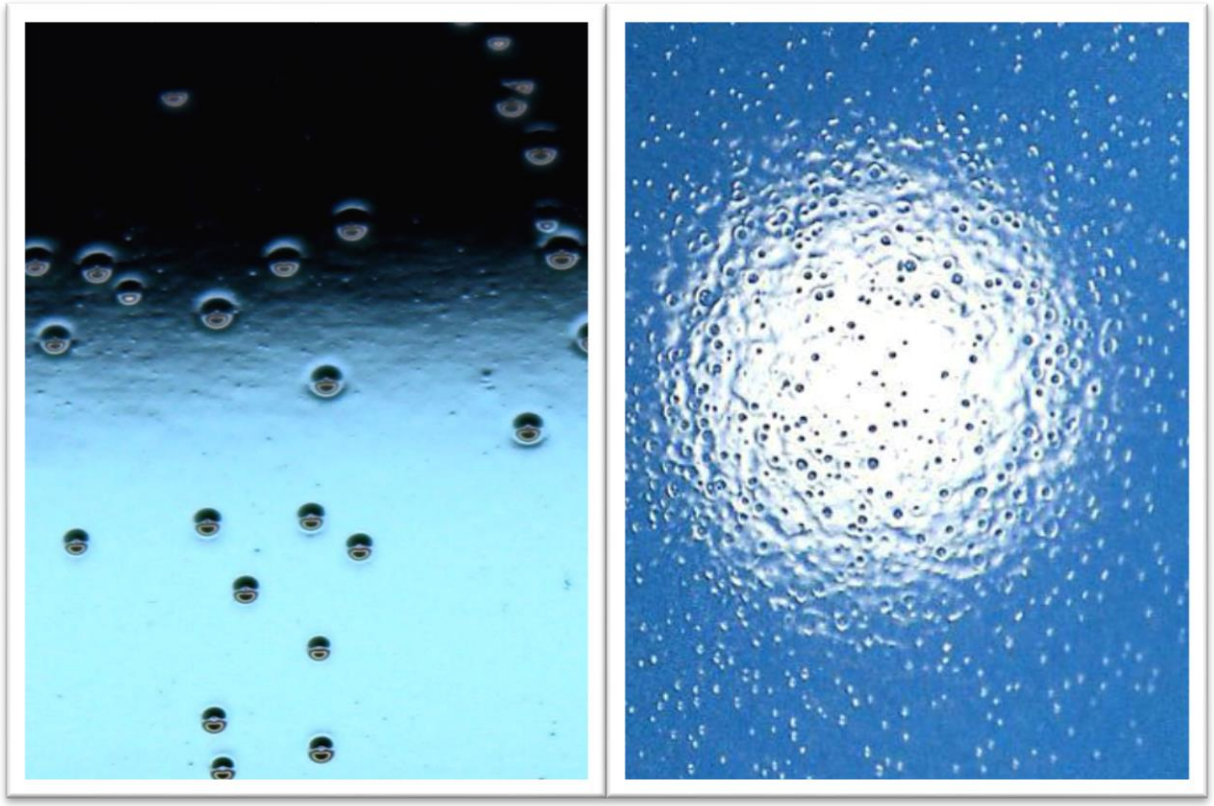
- High ST – minimum surface area
- Low ST – higher surface area
  - film thickness applied
  - time dependent
  - Viscosity change during drying
  - ambient conditions

Orange Peel, Surface Roughness

- Caused by poor surface flow or leveling
- Flow due to ST differences
- Too rapid surface dry
- Poor application techniques
- Inappropriate ambient conditions
- Improper application viscosity
- Lower surface tension leads to higher surface area



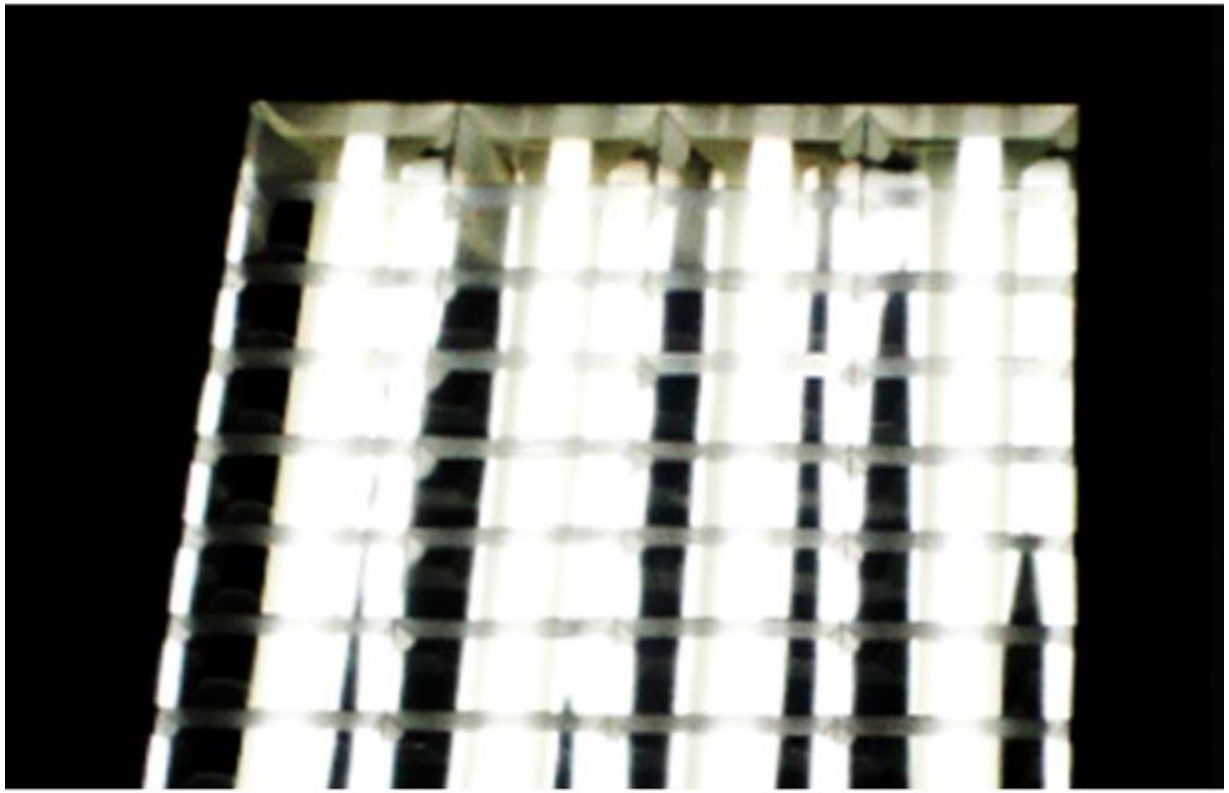
Fisheyes and Craters



- Fisheyes - incompatibly within applied wet film
- Fisheyes are indentations in the paint film
  - Substrate not visible
- Craters - incompatibility on substrate surface
- Craters go to the surface of the substrate

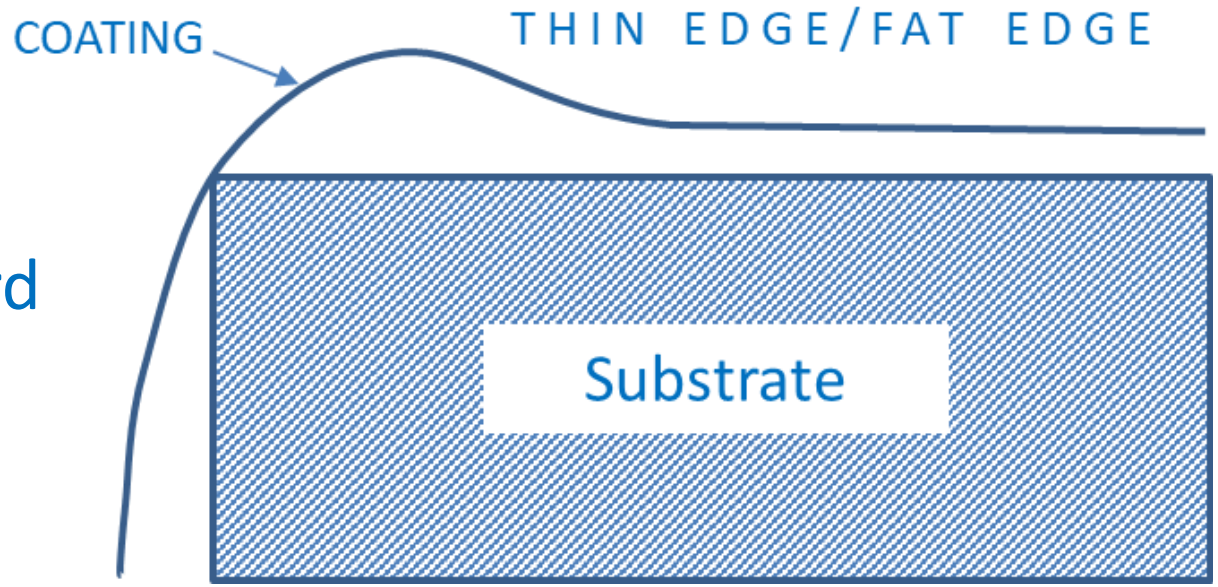
Leveling Additives

- Leveling additives are similar to coating resins
- They do not lower surface energy
- Can equalize small differences in surface energy
- Controlled incompatibility to go to film surface
- Maintain high ST to create downward surface leveling force



Uncontrolled Flow

- Undesirable flow is main cause of defects
- Movement always towards higher ST region
- Craters, picture framing, Bénard Cells, ghosting and dewetting are surface tension related common defects
- Sagging due to unsuitable rheology control



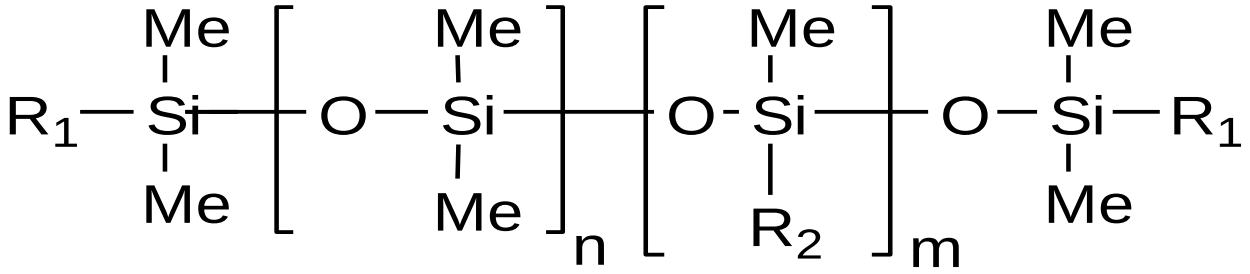
Flow Control Additives

- Typically are polyacrylates, modified polymeric PDMS, or fluoro modified
- Act to equalize the ST differences causing material movement
- May also provide some wetting, leveling and/or defoaming benefits

Contents

Modified Polysiloxane Leveling Agents

- Modified siloxanes are derived from low molecular weight polydimethylsiloxanes by replacing individual methyl groups with very diverse organic side chains



Solventborne

Pat-Add LE 1020

Solvent-free

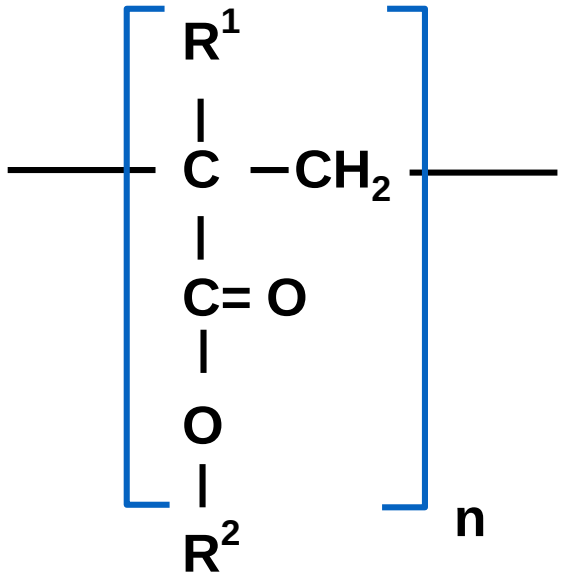
Pat-Add LE 1019

Pat-Add LE 1066

Waterborne

Pat-Add LE 1030

Polymeric Flow Agents



- Responsible for localized homogeneity of the surface tension refer to as flow
- Polymers are oriented and active inside the coating and little on the interface of liquid/solid

Solventborne/ Solvent-free

Pat-Add FL 7

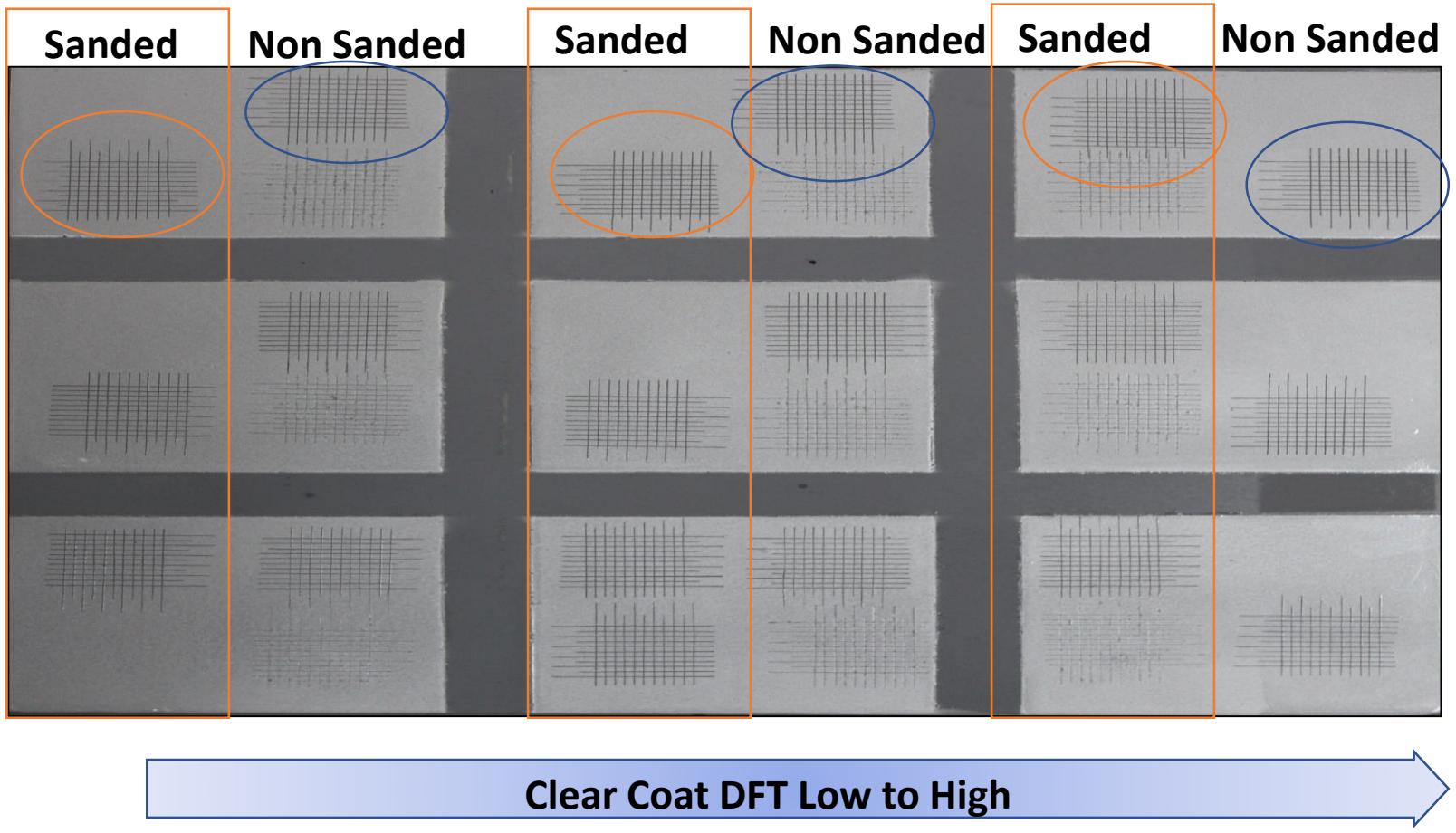
Pat-Add FL 9

Pat-Add LE 1020 *PDMS*

Epoxy White Base coat Adhesion test ASTM D 3359

1st Recoat Adhesion – Sanded part

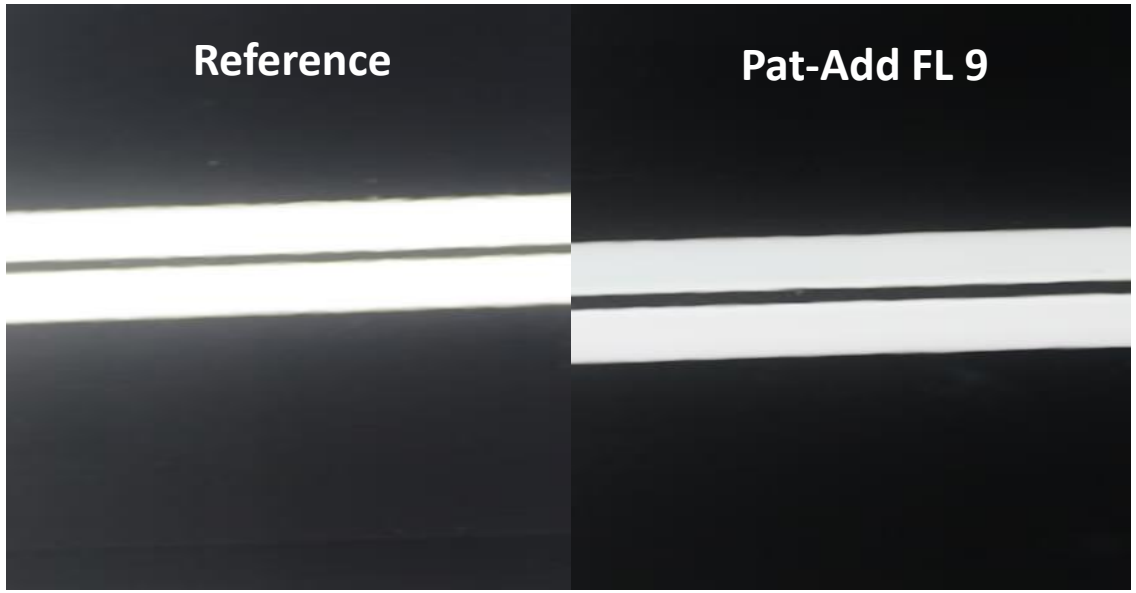
2nd Recoat Adhesion – Non-sanded part

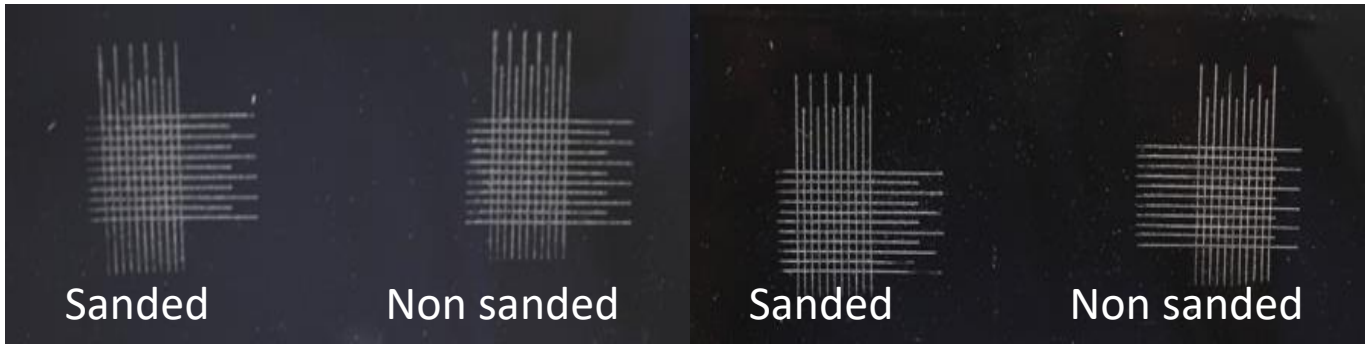


NO ADVERSE EFFECT ON INTERCOAT ADHESION

Pat-Add FL 9 *POLYMERIC*

Epoxy Solventborne Black Topcoat Adhesion test ASTM D 3359 and DOI

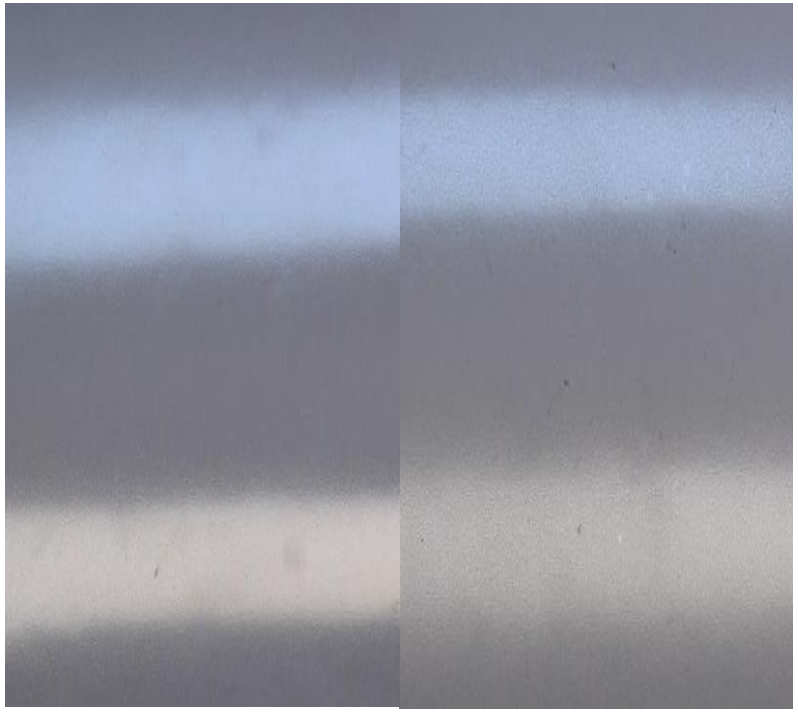




Pat-Add LE 1066 *PDMS*

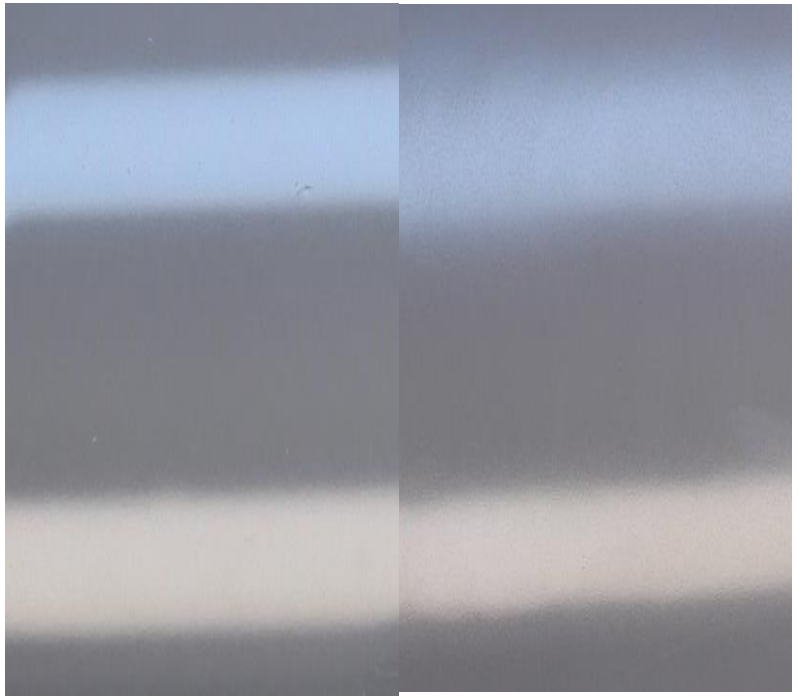
Epoxy Co-grind topcoat Film Appearance and Gloss

Initial

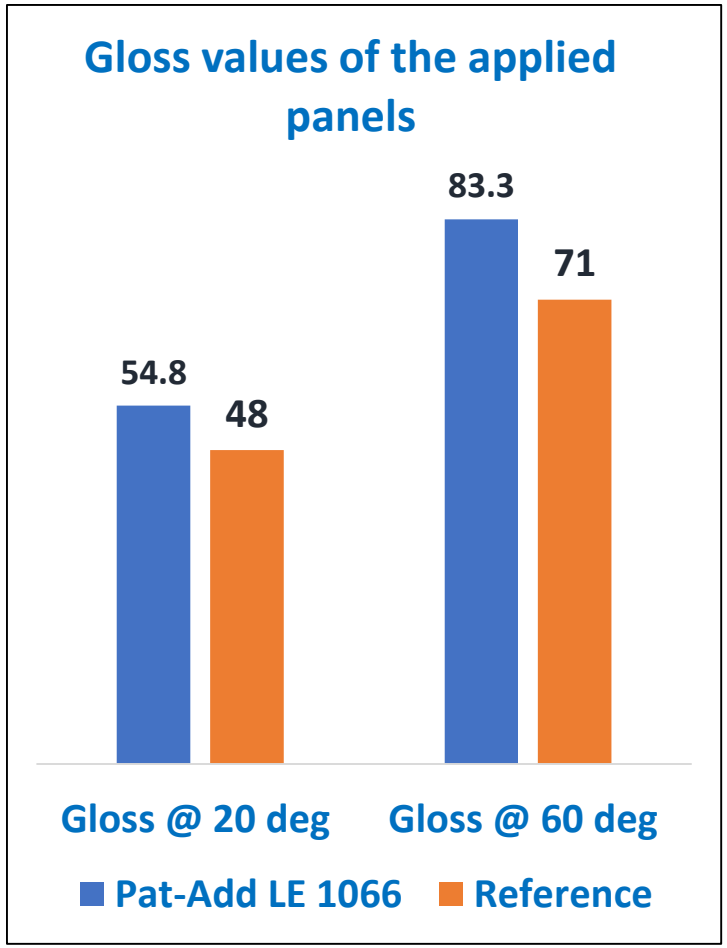


Pat-Add LE 1066 Reference

After 4 week Incubator Stability @ 50°C /122°F



Pat-Add LE 1066 Reference



Pat-Add LE 1019 *PDMS*

Epoxy solvent-free topcoat Film Appearance

Pat-Add LE 1019

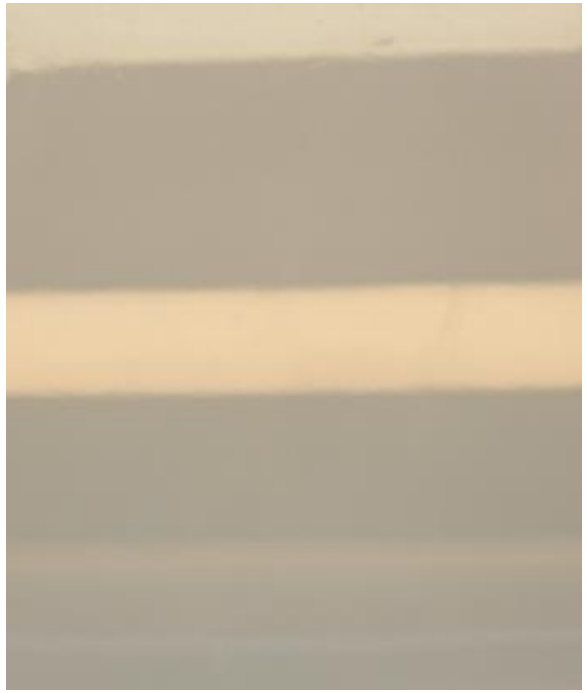
Blank

Pat-Add LE 1019

Blank

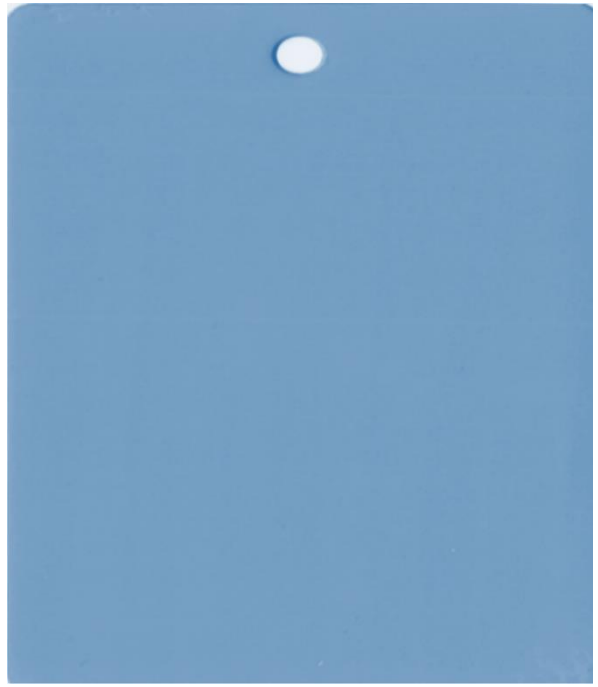
Pat-Add LE 1030 *PDMS*

Epoxy Waterborne Co-grinding Topcoat Film appearance

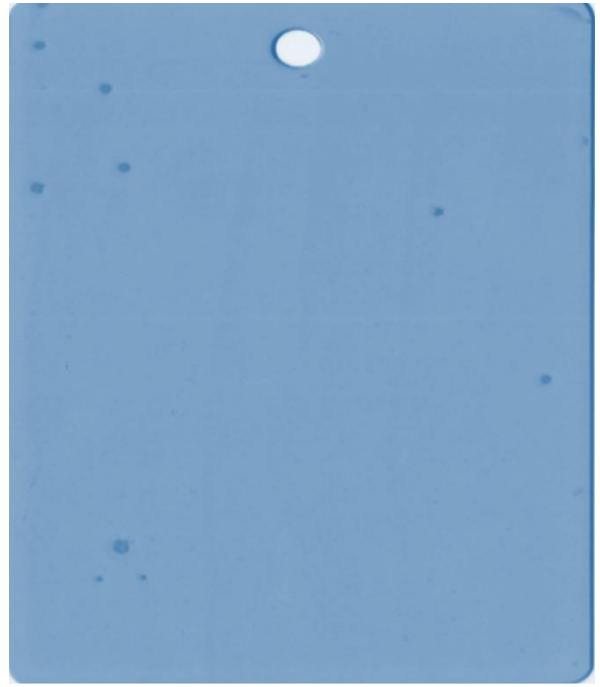


Pat-Add LE 1030

Blank



Pat-Add LE 1030



Blank

Pat-Add LE 1030 *PDMS*

Waterborne Epoxy Clear Coat Film appearance

Pat-Add LE 1030

Blank

Differentiating Attributes

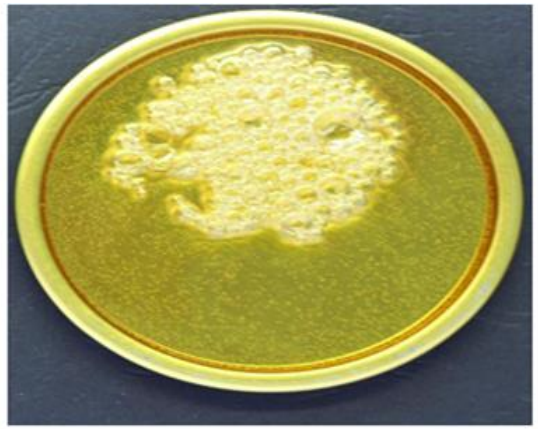
- **Flow and Leveling Additives**

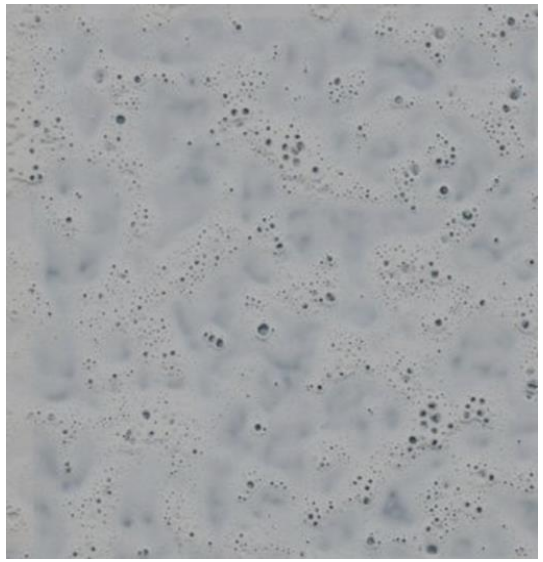
Pat-Add LE 1020	PDMS, Solventborne applications, leveling and slip
Pat-Add FL 9/ FL 7	Polyacrylate, Solvenborne, flow, leveling, DOI
Pat-Add LE 1066	PDMS, Solvent-free, leveling and flow
Pat-Add LE 1019	PDMS, Solvent-free, leveling and compatibilizer
Pat-Add LE 1030	PDMS, Waterborne, substrate wetting, leveling and flow

Contents

Foam and Air Entrapment

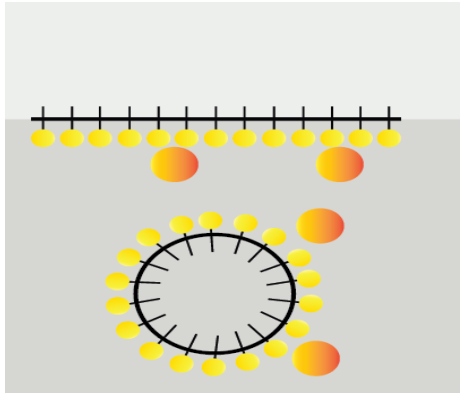
- Creates visible defects in the applied film
- Alters flow behavior of the liquid
- Severely downgrades protective properties
- Micro foam lowers gloss
- Dirt entrapment on use and exposure
- Entrapped air lowers clarity and protection
- Dry foam creates insoluble particulates



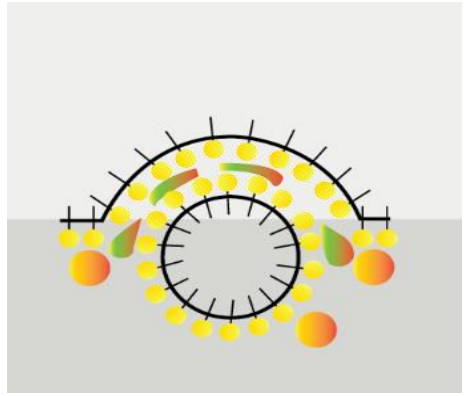


Defoamers and Deaerators

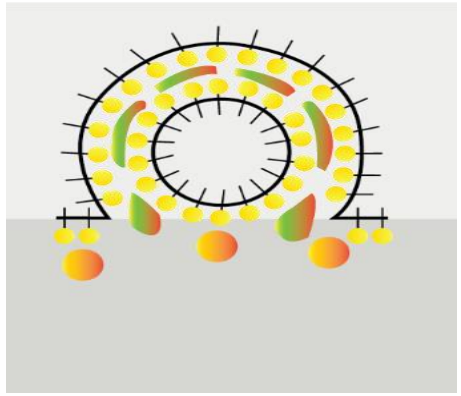
- Defoamers destroy air bubbles at the surface
- Renders the foam lamella unstable
- Deaerators allow smaller bubbles to fuse to form larger bubbles; increase speed to surface
- Defoamers are low ST; Deaerators are low polarity



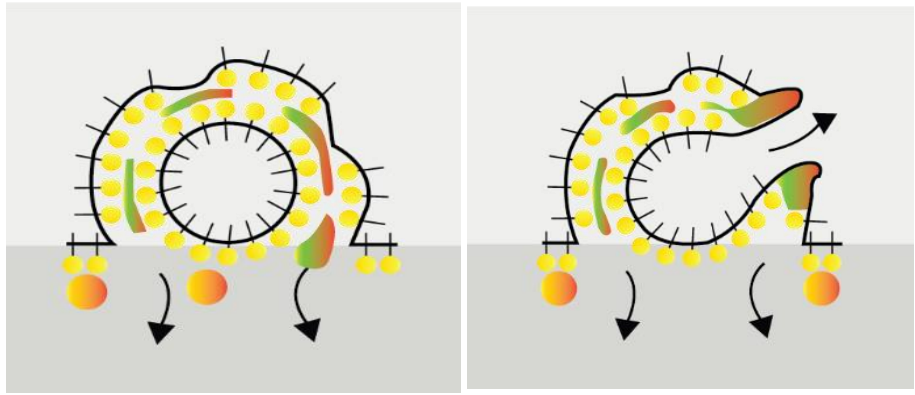
Stable foam moves towards the liquid surface



Positive spreading and entering coefficients drives defoamer into lamella



Displacing surfactants to make lamella unstable



Unstable lamella collapse = Defoaming

Defoamers/ Deaerators

Defoamers are incompatible/insoluble blends of

- Mineral Oil
- Modified Poly dimethyl siloxane
- Polymeric

Deaerators are low polarity molecules that are soluble in the continuous phase

Compatibility

- Good compatibility will put additive within the bulk of the liquid formulation
- CONTROLLED INCOMPATIBILITY will cause the additive to concentrate at the interfaces to escape being in the bulk
- Extreme incompatibility will drive additive to the air interface to create film defects

Contents

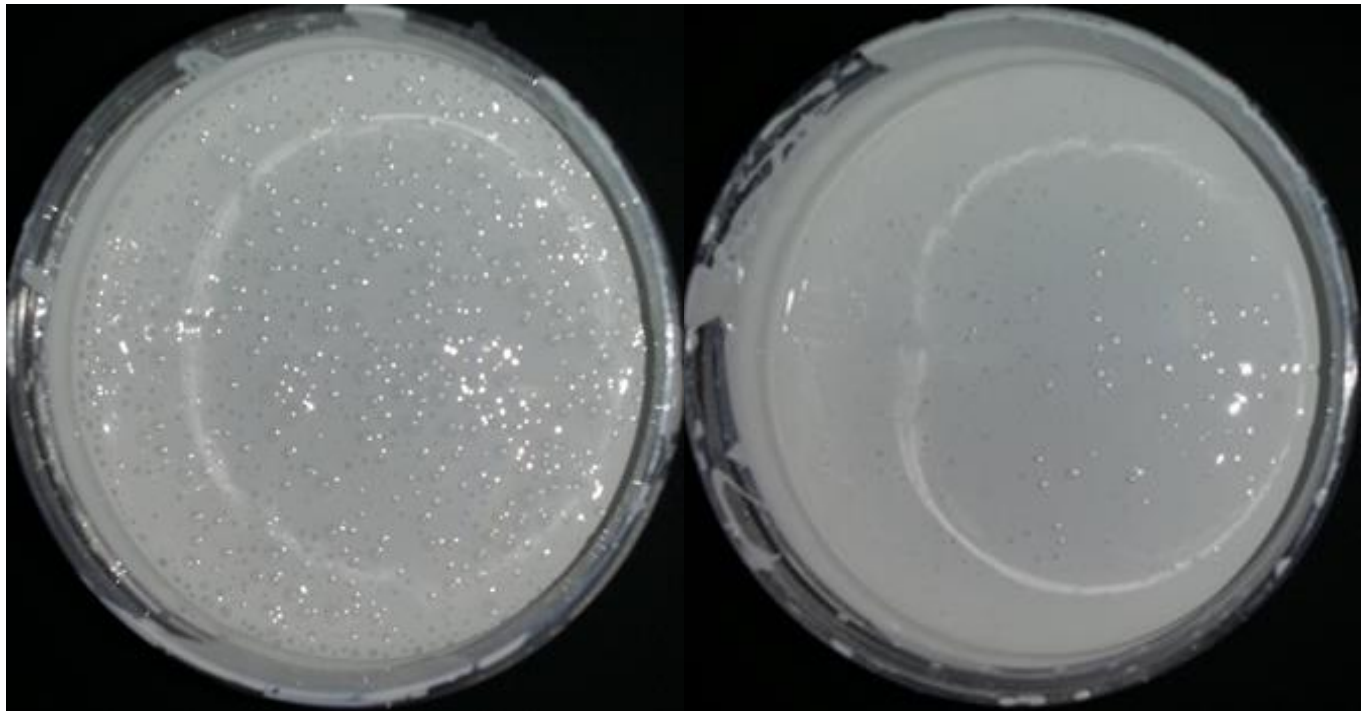
Modified Polysiloxane Defoamers

- Efficient defoaming properties due to the surface tension reduction, spreading capability, thermal stability, chemical inertness and solubility in water
- Organic modifications of polydimethylsiloxane with functional groups can render better compatibility with effective defoaming in various systems

Solventborne	Solvent-free	Waterborne
Pat-Add AF 72	**Pat-Add AF 70** **Pat-Add AF 81**	**Pat-Add AF 31**

Pat-Add AF 72 *PDMS*

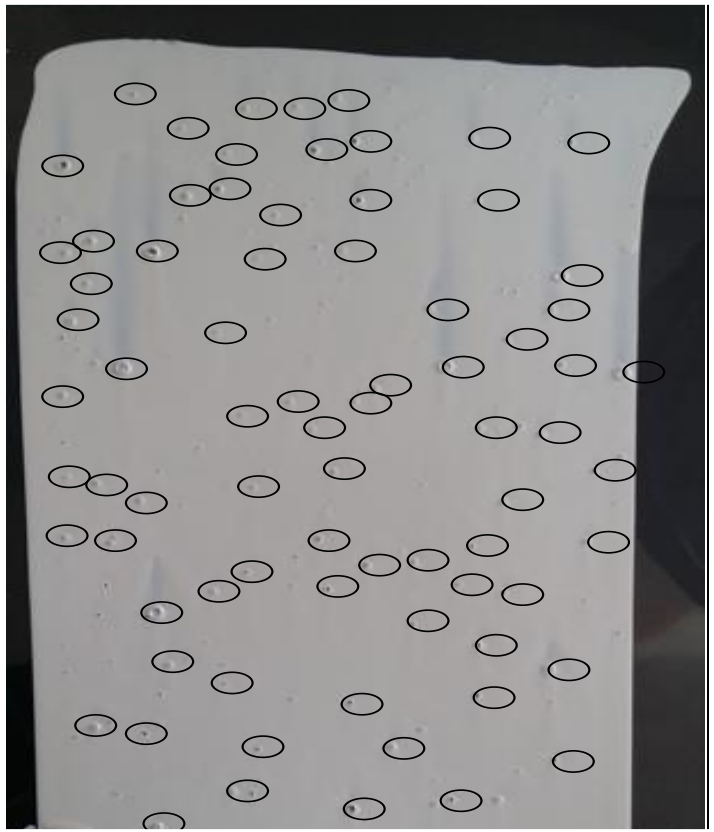
Epoxy white Topcoat Foam generation after Milling



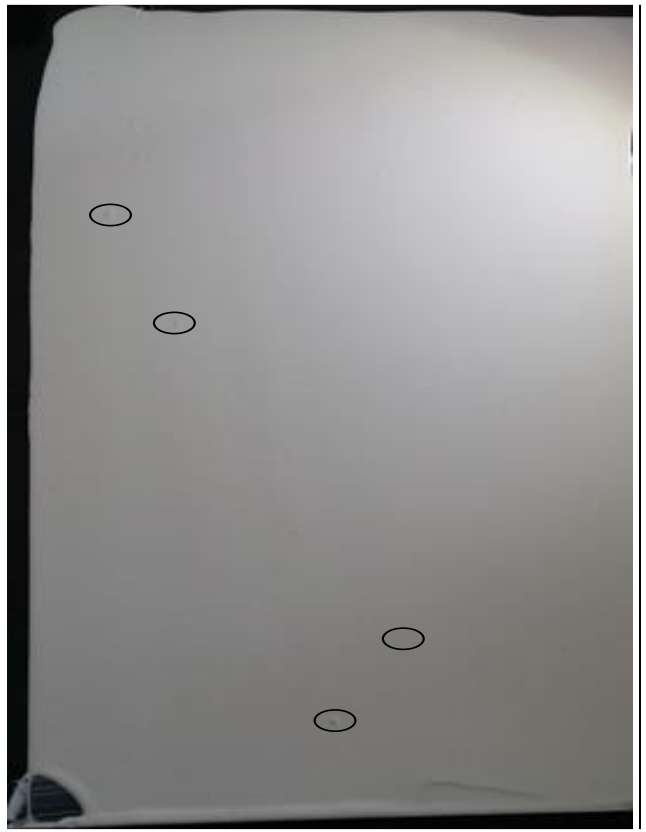
Reference **Pat-Add AF 72**

Pat-Add AF 72 *PDMS*

Epoxy white Topcoat Pour Out test



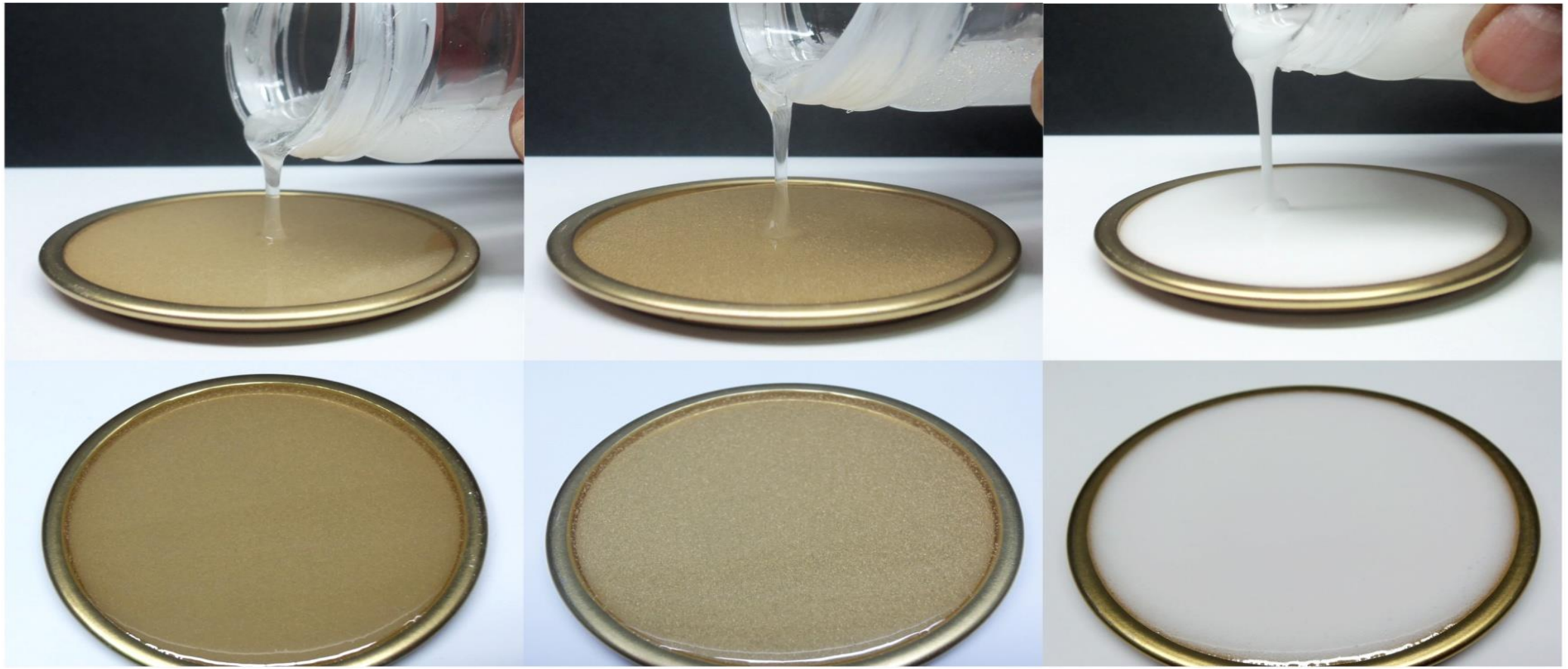
Reference



Pat-Add AF 72

Pat-Add AF 70 *PDMS*

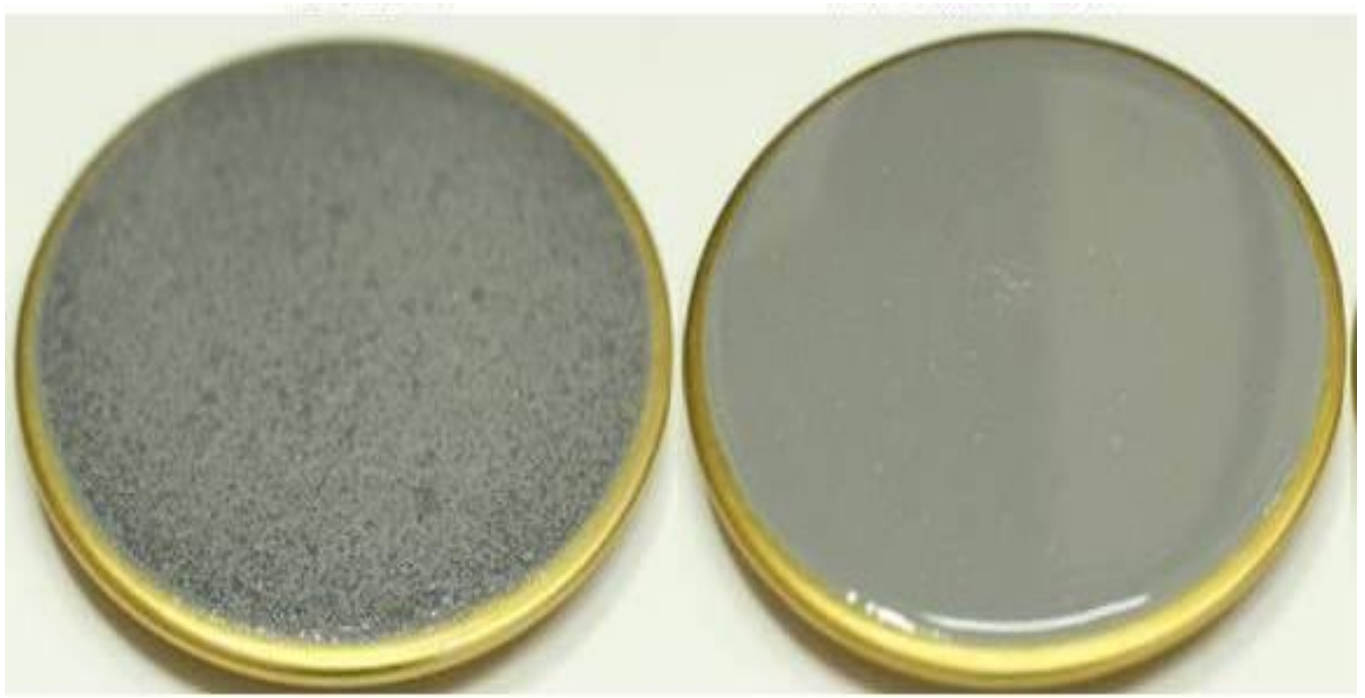
Epoxy Clear Foaming and Clarity



Pat-Add AF 70 **Reference** **Blank**

Pat-Add AF 70

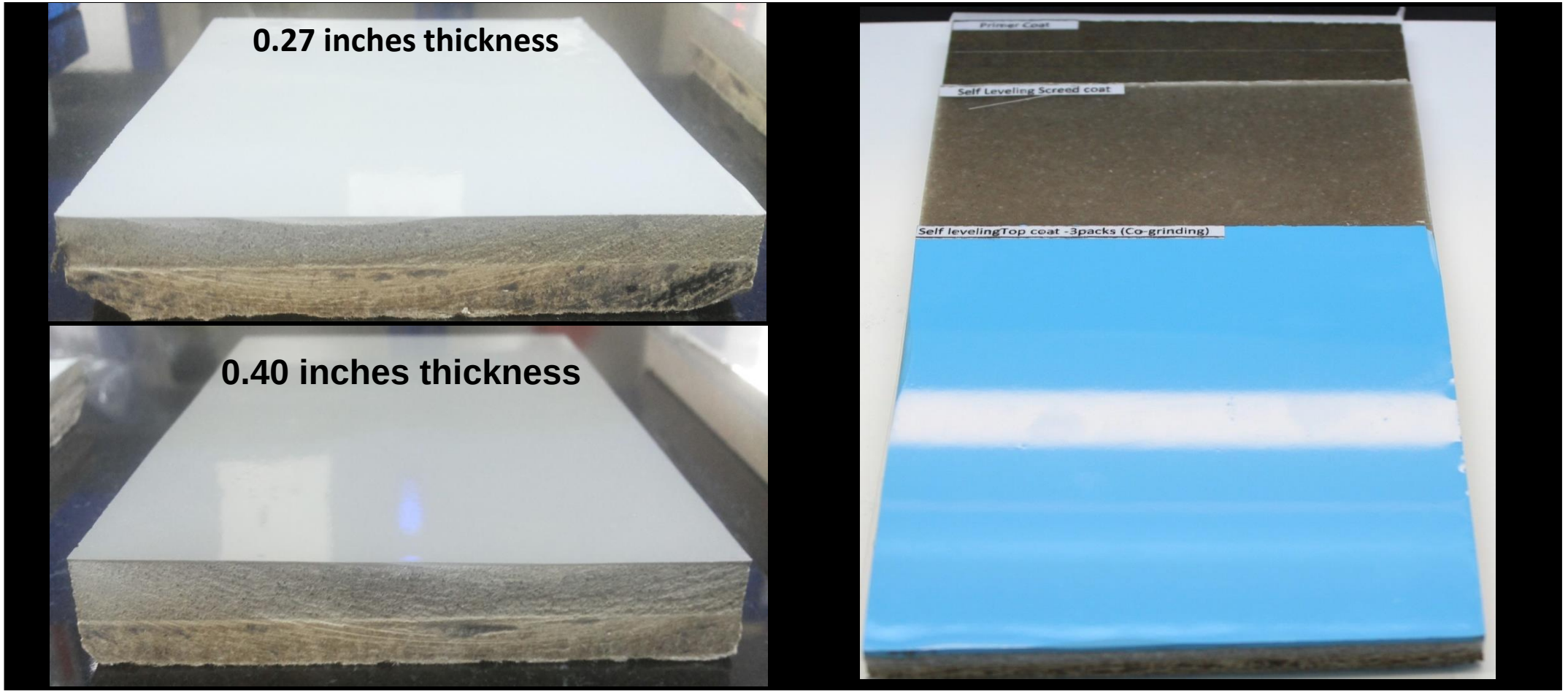
Performance- Epoxy Floor Coating



Blank **0.1% of Pat-Add AF 70**

Pat-Add AF 70

Performance- Epoxy floor Coating



Pat-Add AF 81 *PDMS*

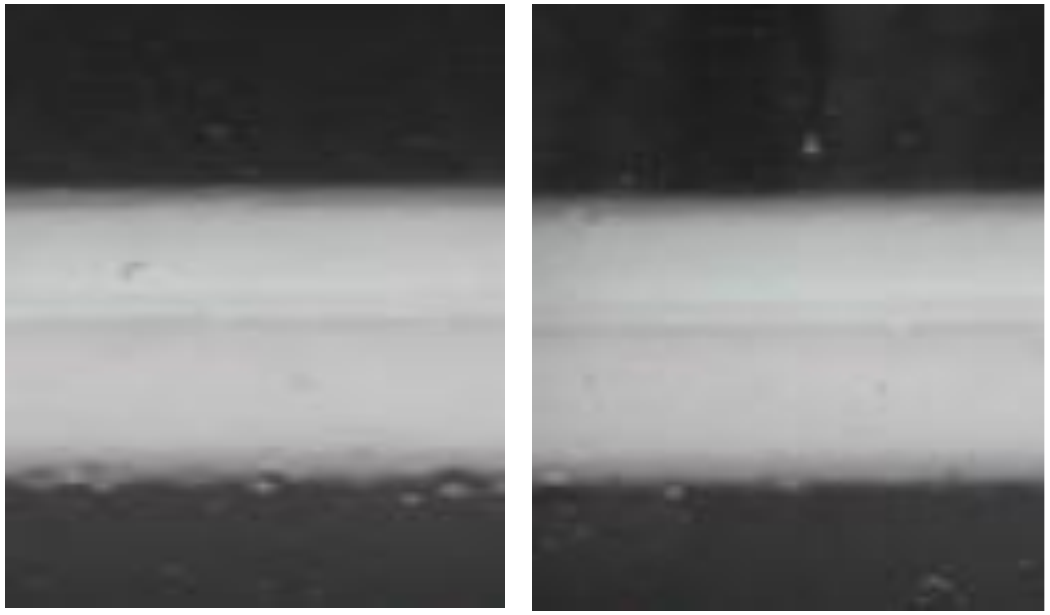
Epoxy Clear cast Foaming and Clarity

Epoxy Casting Thickness 0.40 inches = 10.2 mm

Pat-Add AF 31 *PDMS*

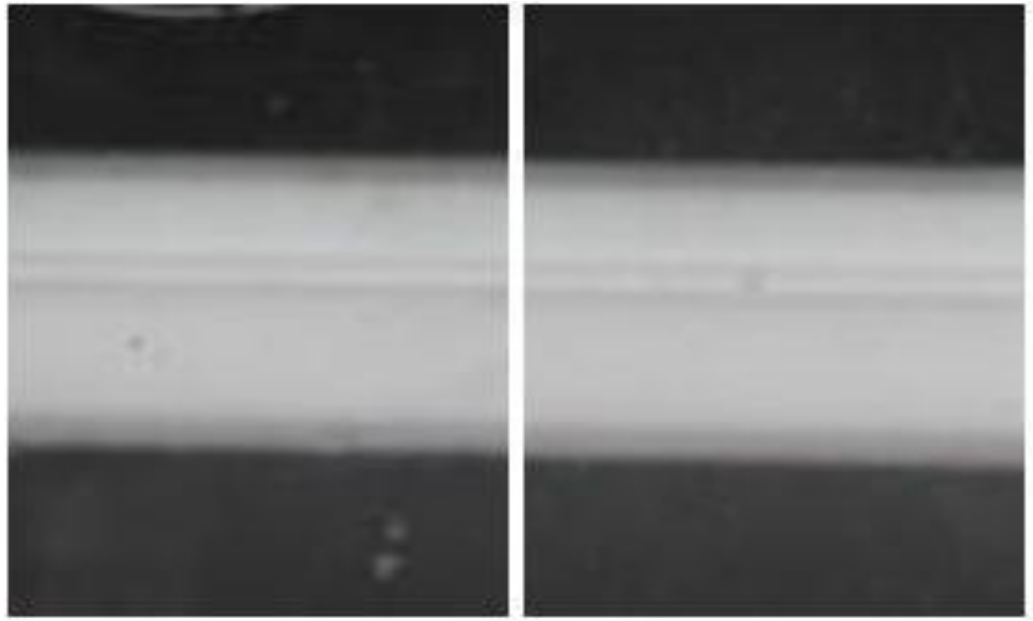
Waterborne Epoxy Clear

Mixing at 800 RPM



Blank **Pat-Add AF 31**

Mixing at 1800 RPM



Blank **Pat-Add AF 31**

Differentiating Attributes

- **Defoamer/ Deaerators**

Pat-Add AF 72	PDMS, Solventborne applications, defoamer and deaerator
Pat-Add AF 70	PDMS, Solvent-free, defoamer and deaerator
Pat-Add AF 81	PDMS, Solvent-free, deaerator and slight leveling
Pat-Add AF 31	PDMS, Waterborne, defoamer

To summarize…

Differentiating Attributes

- **Wetting & Dispersing Additive - Color and Appearance Defects**

Pat-Add DA 1666	Honeycomb multifunctional, Solventborne Primers, Improve storage stability and sag resistance
Pat-Add DA 948	HMV, Solvent-free, Floor Coatings, High build applications
Pat-Add DA 895	100% Active Electroneutral, Solvent-free Epoxy colorants
Pat-Add DA 817	100% Active Electroneutral , Waterborne Epoxy bases
Pat-Add DA 603 LV	Waterborne Colorants

Differentiating Attributes

- **Flow and Leveling Additives – Appearance and Protection Defects**

Pat-Add LE 1020	PDMS, Solventborne applications, leveling and slip
Pat-Add FL 9/FL 7	Polyacrylate, Solvenborne, flow, leveling, DOI
Pat-Add LE 1066	PDMS, Solvent-free, leveling and flow
Pat-Add LE 1019	PDMS, Solvent-free, leveling and compatibilizer
Pat-Add LE 1030	PDMS, Waterborne, substrate wetting, leveling and flow

Differentiating Attributes

- **Defoamers/ Deaerators – Appearance and Protection Defects**

Pat-Add AF 72	PDMS, Solventborne applications, defoamer and deaerator
Pat-Add AF 70	PDMS, Solvent-free, defoamer and deaerator
Pat-Add AF 81	PDMS, Solvent-free, deaerator and slight leveling
Pat-Add AF 31	PDMS, Waterborne, defoamer

Additive Selection is not a simple or easy process

- Where should the additive to be located to function
- What is the impact of adding too much of …
- What is the proper amount of additive
- Compatibility vs controlled incompatibility
- Small percentage of total composition (1-5%)
- Dependent on interaction of all components


Additive selection is easy and simplified by partnering with Patcham Additives!

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