EVALUATIONS OF WETTING AND DISPERSING ADDITIVES FOR USE IN WATERBORNE ANTI-CORROSIVE PAINTS

Golden Gate Society for Coatings Technology

A member of ALTANA

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Outline

- **Market trends**
- **Review of wetting and dispersing fundamentals**
- **Recent developments**
  - Tailor-made dispersing additives based on novel chemical structures.
- **Application results**
- **Summary**

EVALUATIONS OF WETTING AND DISPERSING ADDITIVES FOR USE IN WATERBORNE ANTI-CORROSIVE PAINTS

Why is this topic of relevance?

Key Technologies for VOC Reduction

Technology	VOC (g/l)
Conventional paint systems	400-500
High solids	250-340
Solvent free	0-100
Powder	0
Waterborne systems	0-100

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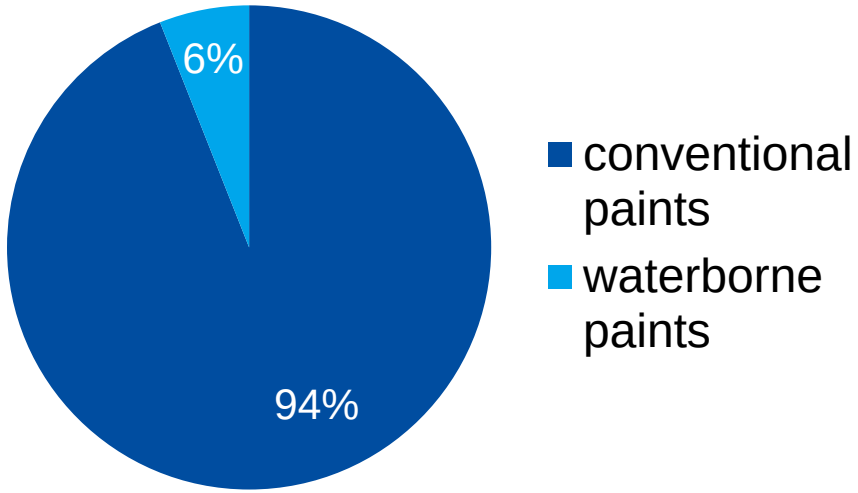
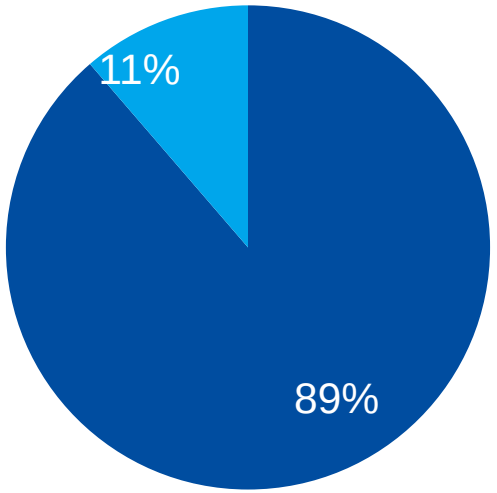
Waterborne Anti-Corrosive Paints

Market share 2012



Market share 2020 Est.



Advantages	Disadvantages
Low Volatile Organic Compounds (VOC)	Complex film formation process
Less odor than conventional systems	Application restrictions (low temperatures, high humidity…)
Non flammable	Flash rust
Fewer toxic compounds	More expensive
	Paint manufacturing process is more difficult

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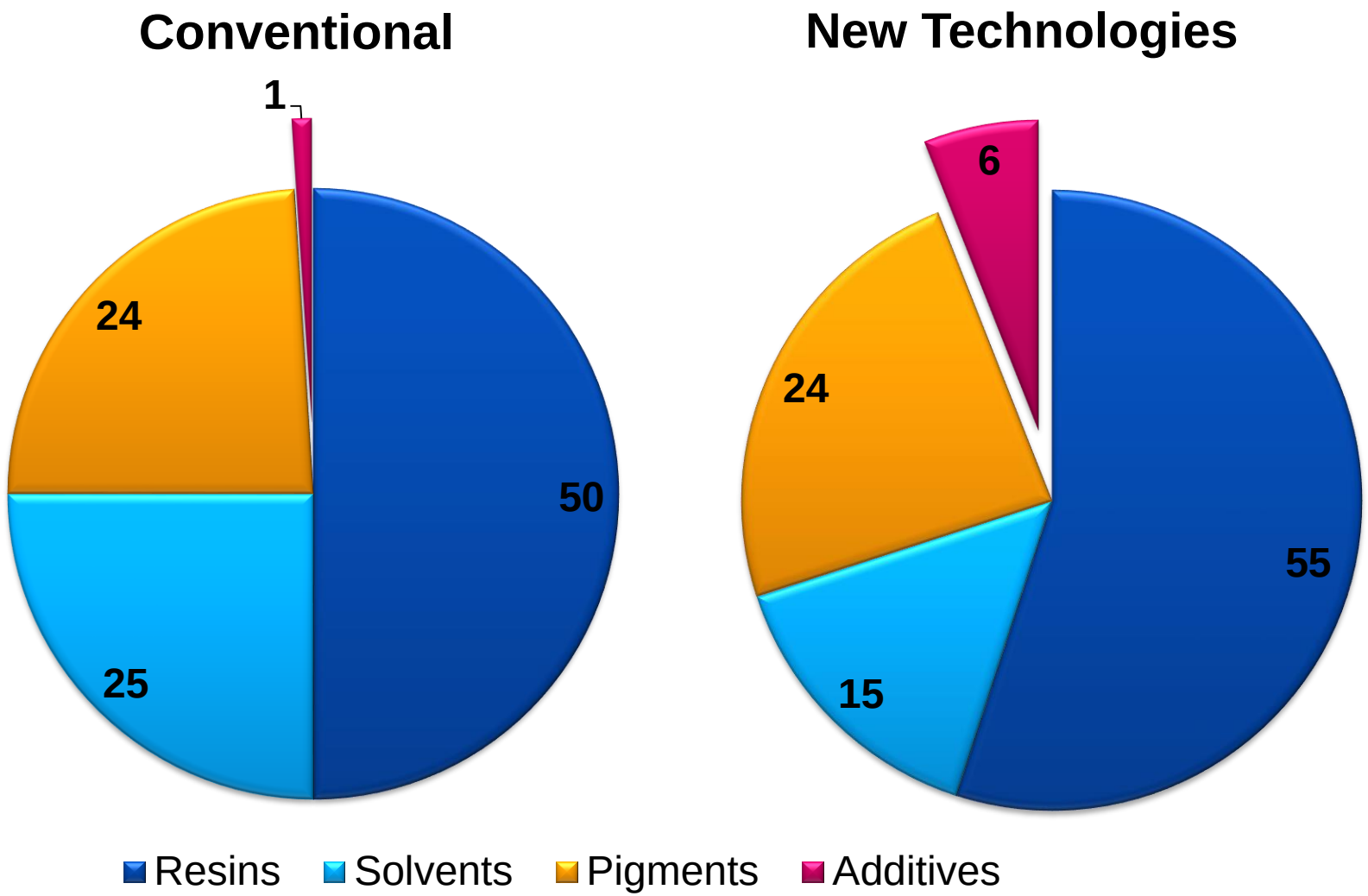
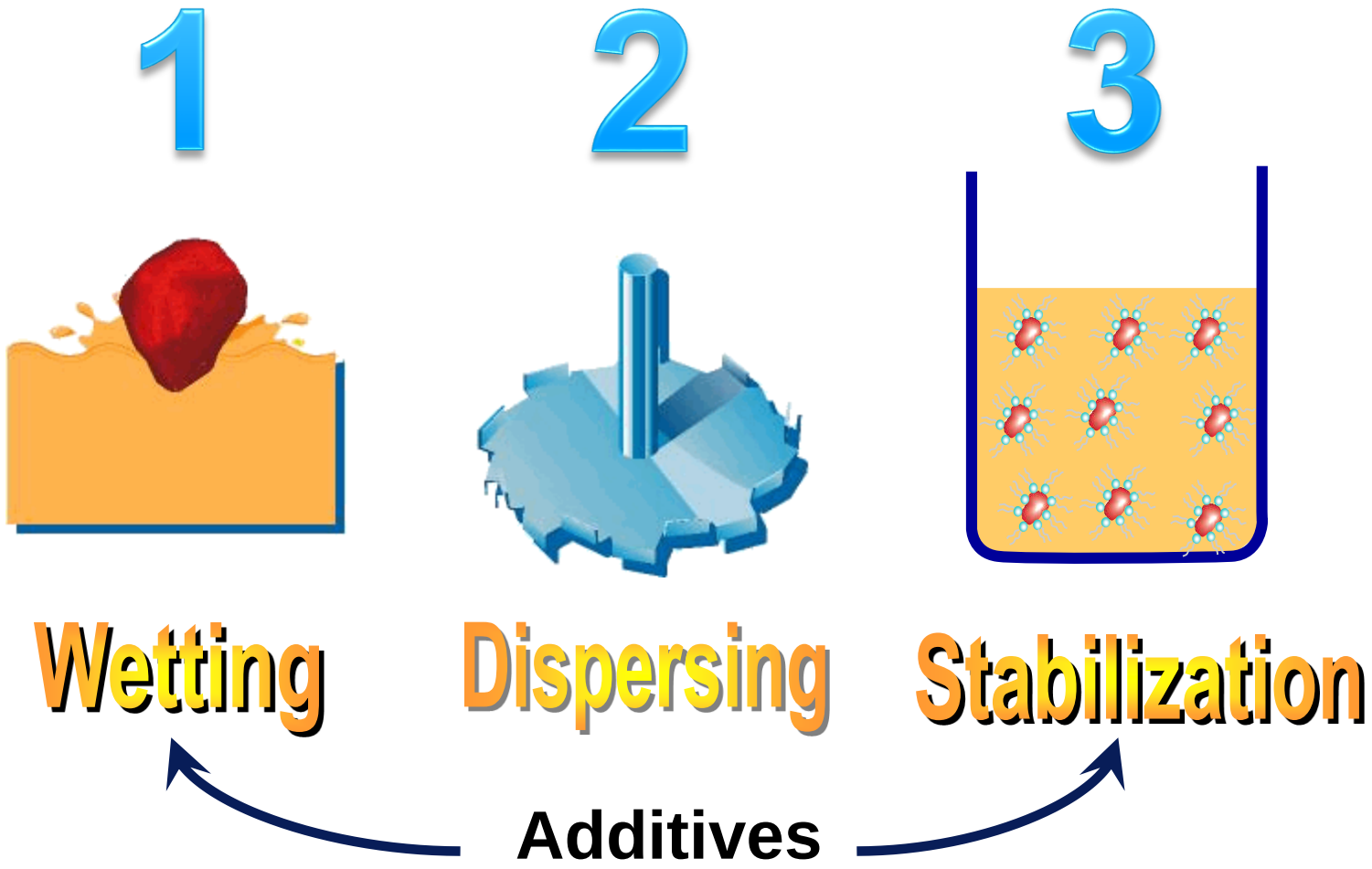
Typical Paint Formulations: Past & Present



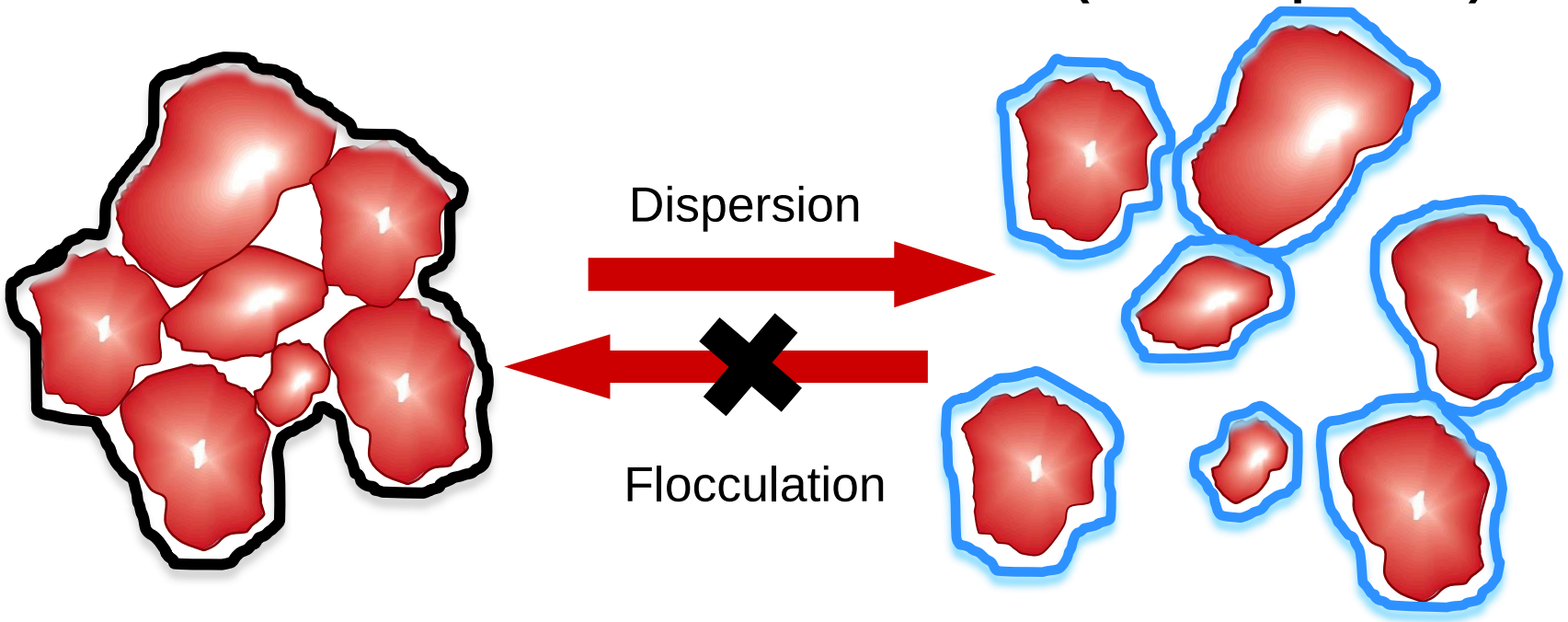
Wetting & Dispersing Process



Pigment Dispersion - Stabilization

Agglomerate
Flocculate

Primary Particle
(Ideal Dispersion)



Flocculated

Deflocculated

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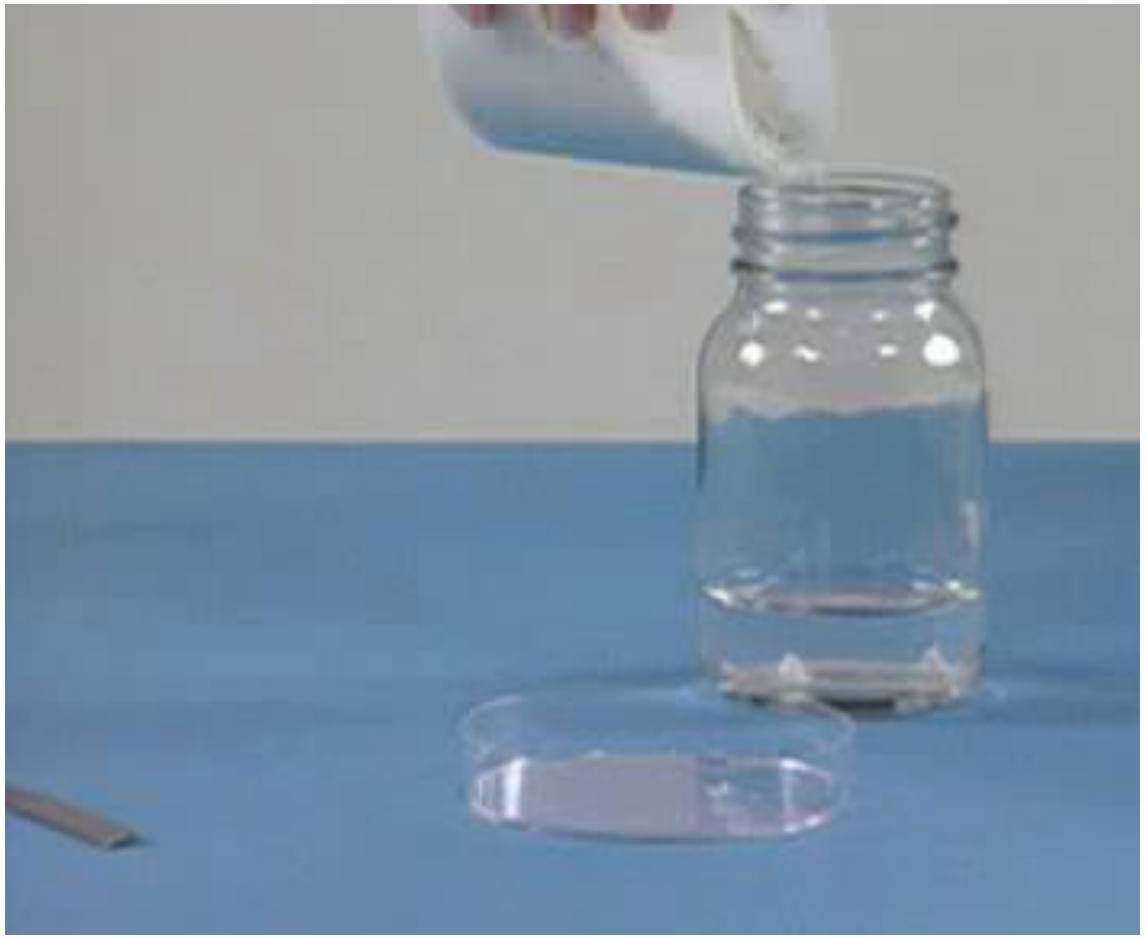
Wetting Additives

Dispersing Additives

“Processing Aids“

Without dispersing additive
Flocculated
High viscosity



With dispersing additive
Deflocculated
Low viscosity

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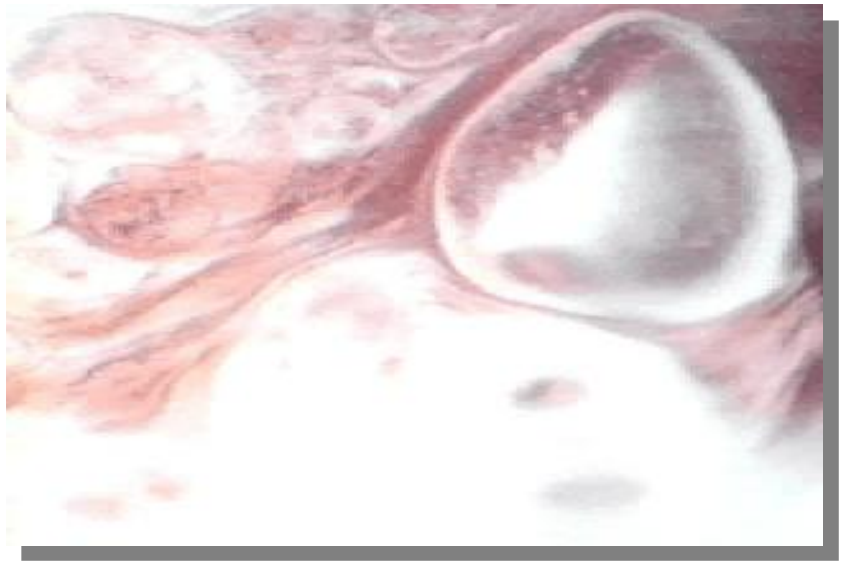
Flocculation vs Deflocculation

Flocculation:

Low Gloss
Poor transparency/hiding
Weak color development
High/unstable viscosity



Deflocculation:

High Gloss
Good transparency/hiding
Strong color development
Low/stable Viscosity

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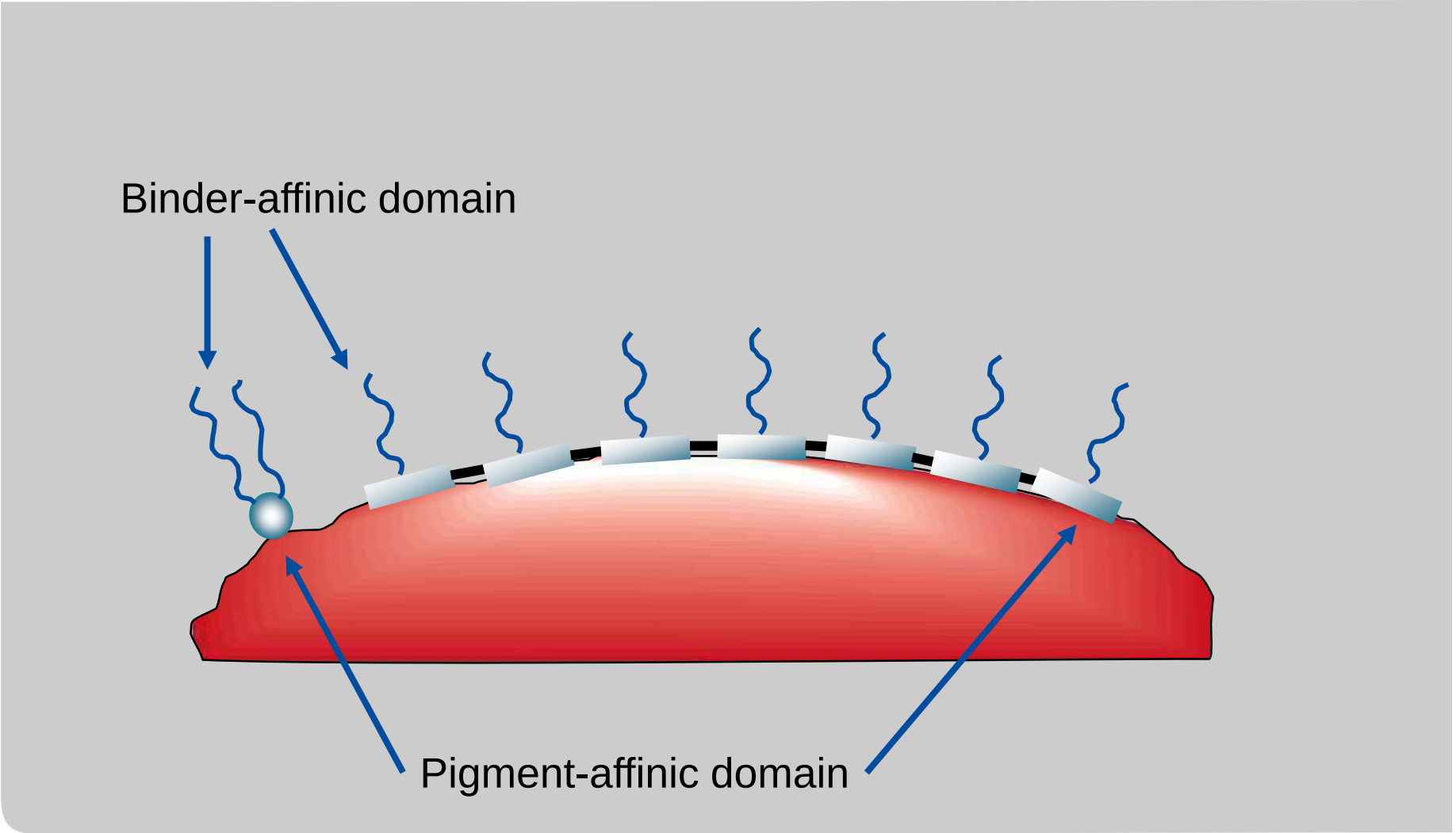
Wetting and Dispersing Additives Summary

Adding Value

- **Reduce viscosity** and enables the formulation of higher solids systems stabilize
- **Reduce grinding time** which speed up batch time and improves production costs
- **Stabilize the pigment dispersion** which results in good color acceptance, storage stability with regard to tint strength and viscosity
- **Uniformly disperse active pigments or other particles** throughout the film matrix

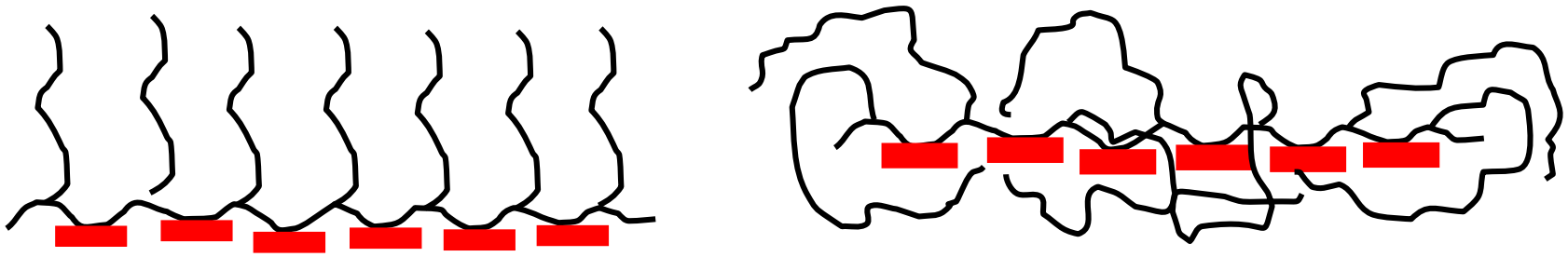
Domains of a wetting & dispersing additive



Wetting & Dispersing Additives Compatibility

Important factors: Binder system

- The additive must be compatible in the binder system(s) used
  - o Incompatibility leads to coiling and blocking of pigment-affinic groups/blocks
    - ⇒ reduced efficiency / total loss of effectiveness depending on the degree of incompatibility



compatible

incompatible

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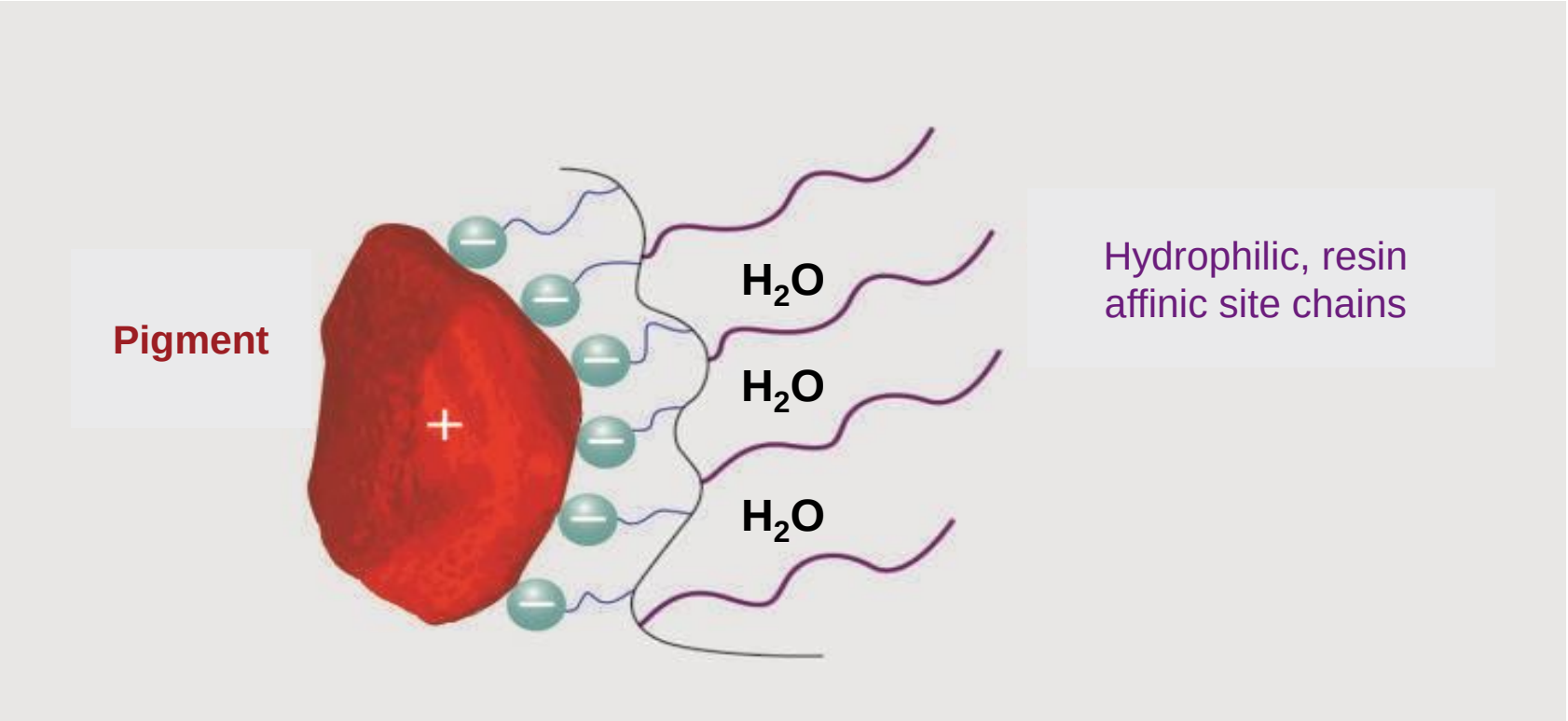
Architecture of Wetting and Dispersing Additives
Background

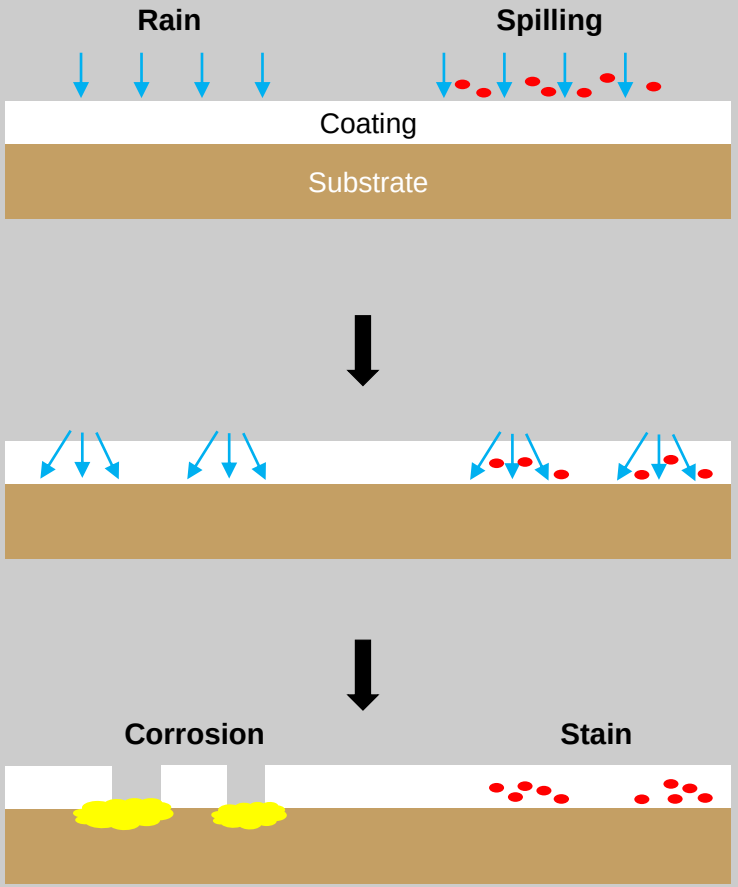


- Components remain present in the cured coating and bear the risk to increase the overall hydrophilicity

Impact of Wetting and Dispersing Additives

- Tailored domains (binder and pigment affinic) are needed for the best performance of the additive
- Solubility/ compatibility of the additive is achieved by polar binder affinic domains based on e.g. polyethers, acidic groups, salt structure
- These polar domains stay in paint film and make it easier for ions and water to penetrate

Corrosion and Stain



Recent Developments

Desired properties

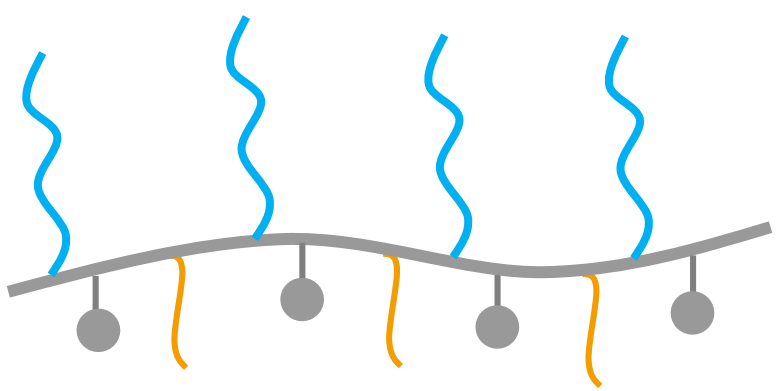
- Develop new wetting and dispersing additives, based on novel chemical structures and new synthesis techniques, that allow paint manufacturers to produce higher performance aqueous systems
- Environmentally friendly, APEO Free, Zero/Low VOC, etc.
- Show improved compatibility with various binder chemistries
- Show acceptable viscosity reduction, deflocculation, and stabilization properties with inorganic pigments
- Additives should have the “least negative” impact on critical film properties:
  - Corrosion resistance
  - Early water resistance properties
  - Stain resistance

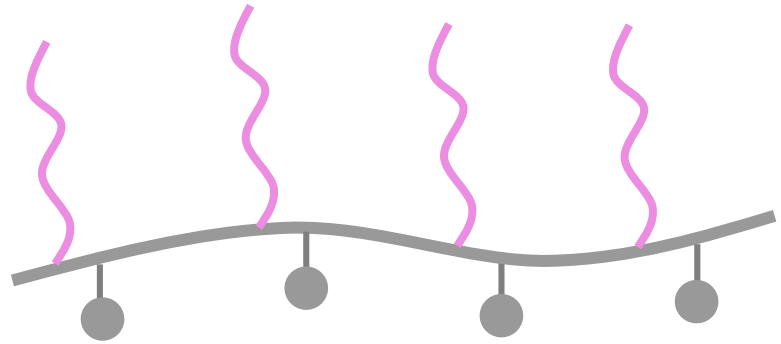
Concepts for W&D Agents to Reduce Water Sensitivity
I. Overall Increase of Hydrophobicity

Non-polar, hydrophobic groups

Polar, hydrophilic groups

Mixed Polarity





- Adjustment of overall hydrophobicity by varying resin affinic side chains and backbone
- Tailoring to the polarity sweet spot of a particular aqueous system, may jeopardize broad system applicability

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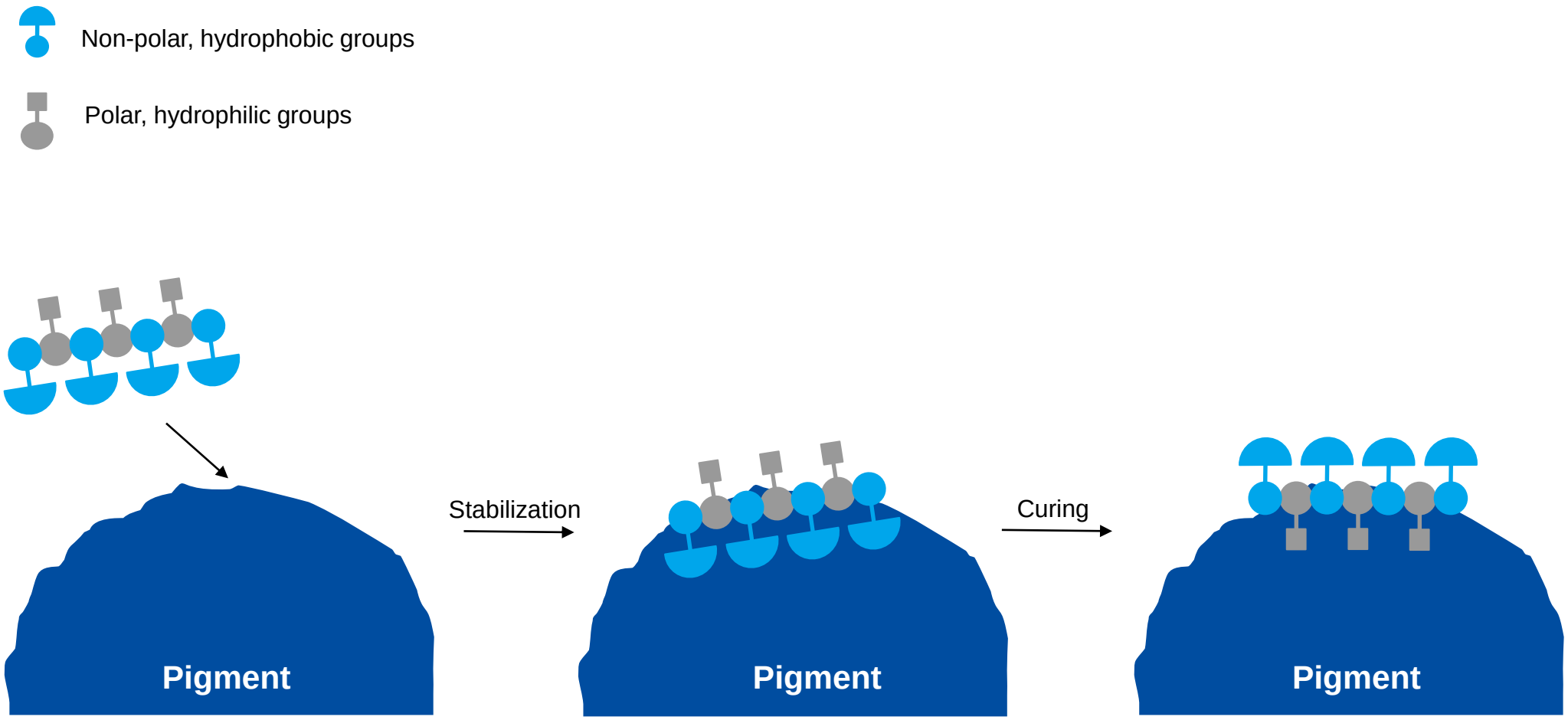
Concepts for W&D Agents to Reduce Water Sensitivity
II. Structural Rearrangement



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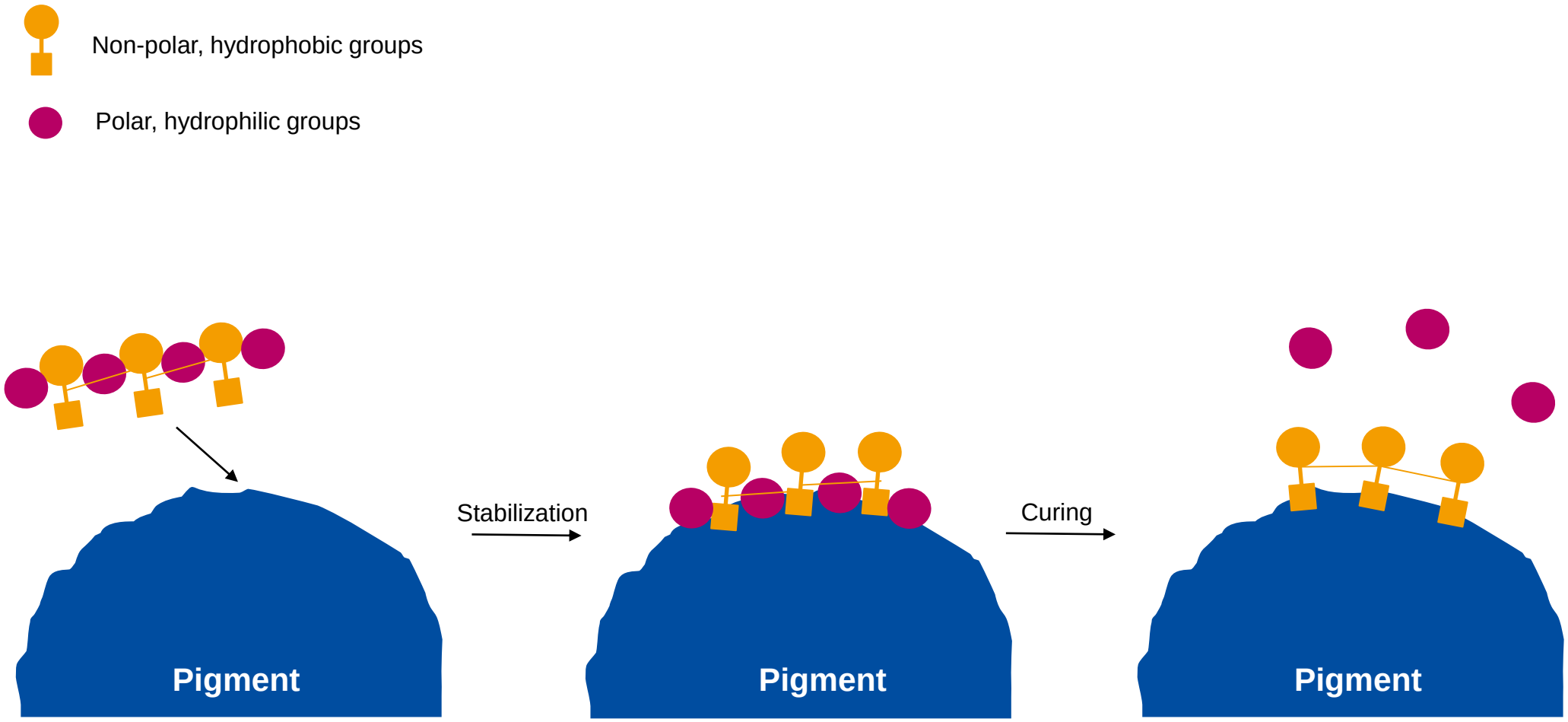
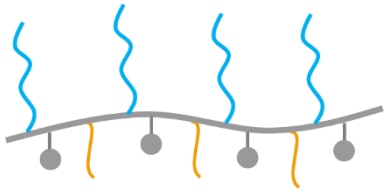
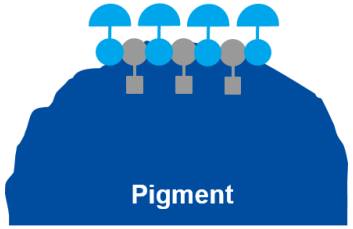
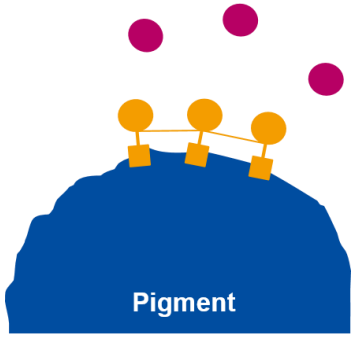
Concepts for W&D Agents to Reduce Water Sensitivity
III. Smart Adaptation



Wetting & Dispersing Agents to Reduce Water Sensitivity

Exciting new Entries into the Sector of Multifunctional Additives

	I. Overall increase of Hydrophobicity	II. Structural Rearrangement	III. Smart Adaptation
			
Proposed Working Mechanism	• Incorporation of resin affinic side chains with a lower polarity in W&D additive	• Architecture undergoes a structural change and adapts its polarity during the drying process	• Polar & non-polar components are combined. During the curing process, the polar component separates and leaves the hydrophobic part behind

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Wetting and Dispersing Additives Summary

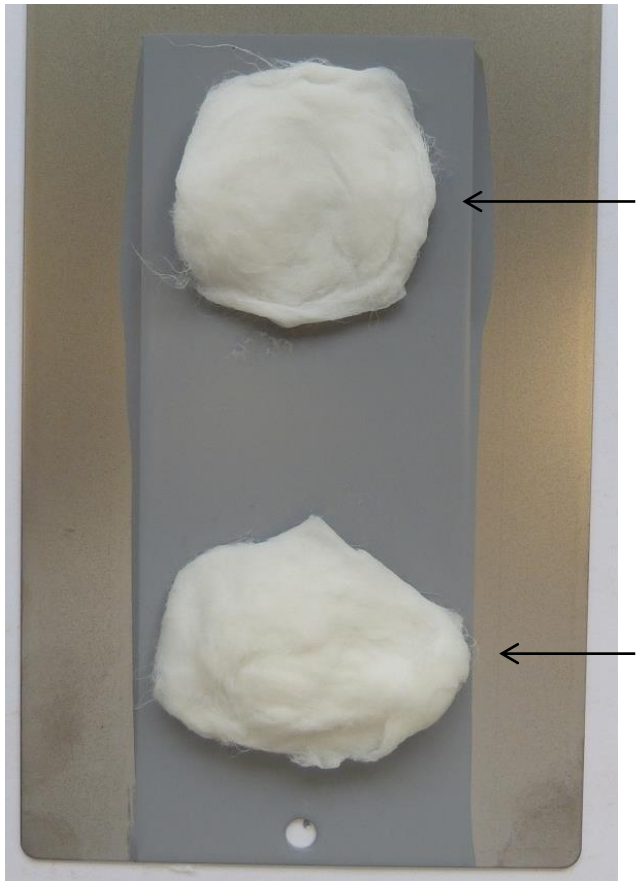
Basic Additive Chemistries

In order for wetting and dispersing additives to be compatible in the system and build up sufficient interactions to the liquid matrix, the binder reactive groups need to have some hydrophilic properties. These hydrophilic or ionic domains are necessary to make the wetting and dispersing additive usable for its actual purpose.

Since they stay in the paint film after curing and film formation processes they may influence parameters like early water resistance, water uptake and corrosion resistance.

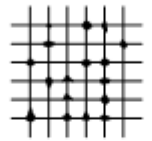
- Fatty Acids (FS series)
- Phosphoric acid esters (PS series)
- Polyurethane (PU series)
- Polyacrylates (AC series)

Early water resistance



Water application after 4h drying

Water application after 24h drying

Gitterschnitt-Kennwert	Aussehen der Oberfläche im Bereich des Gitterschnittes, an der Abplatzung aufgetreten ist (Beispiel für sechs parallele Schnitte)
0	—
1	
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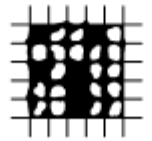
3	
4	
5	—

DIN EN ISO 2409

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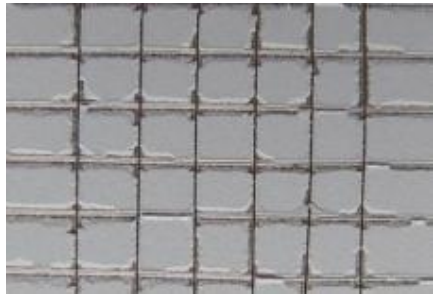
Early Water Resistance - Adhesion

Additive	4h drying [GT]	24h drying [GT]	Salt Spray
Control	1	1	600
FS-1	5	1	384
PS-1	2	2	500
PU-1	0	0	700
AC-2	5	5	140
AC-1	5	5	140
AC-3	2	3	700
AC-4	0-1	0-1	384
AC-5	0	0	700
AC-6	0	0	700

Control after 24h



AC-1 after 24h

AC-5 after 24h

Test formulation: Waterborne Alkyd Anti-corrosive Primer

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Electrochemical Impedance Spectroscopy (EIS)
Screening Method for Water Uptake

- Allows fast screening of many samples

- Measuring impedance
  - Indication of water uptake and corrosion resistance
  - Higher water uptake → lower impedance

- Correlation to salt spray and condensation test
  - Detect worst and best results

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Electrochemical Impedance Spectroscopy (EIS)

Higher Impedance → Less Water Uptake

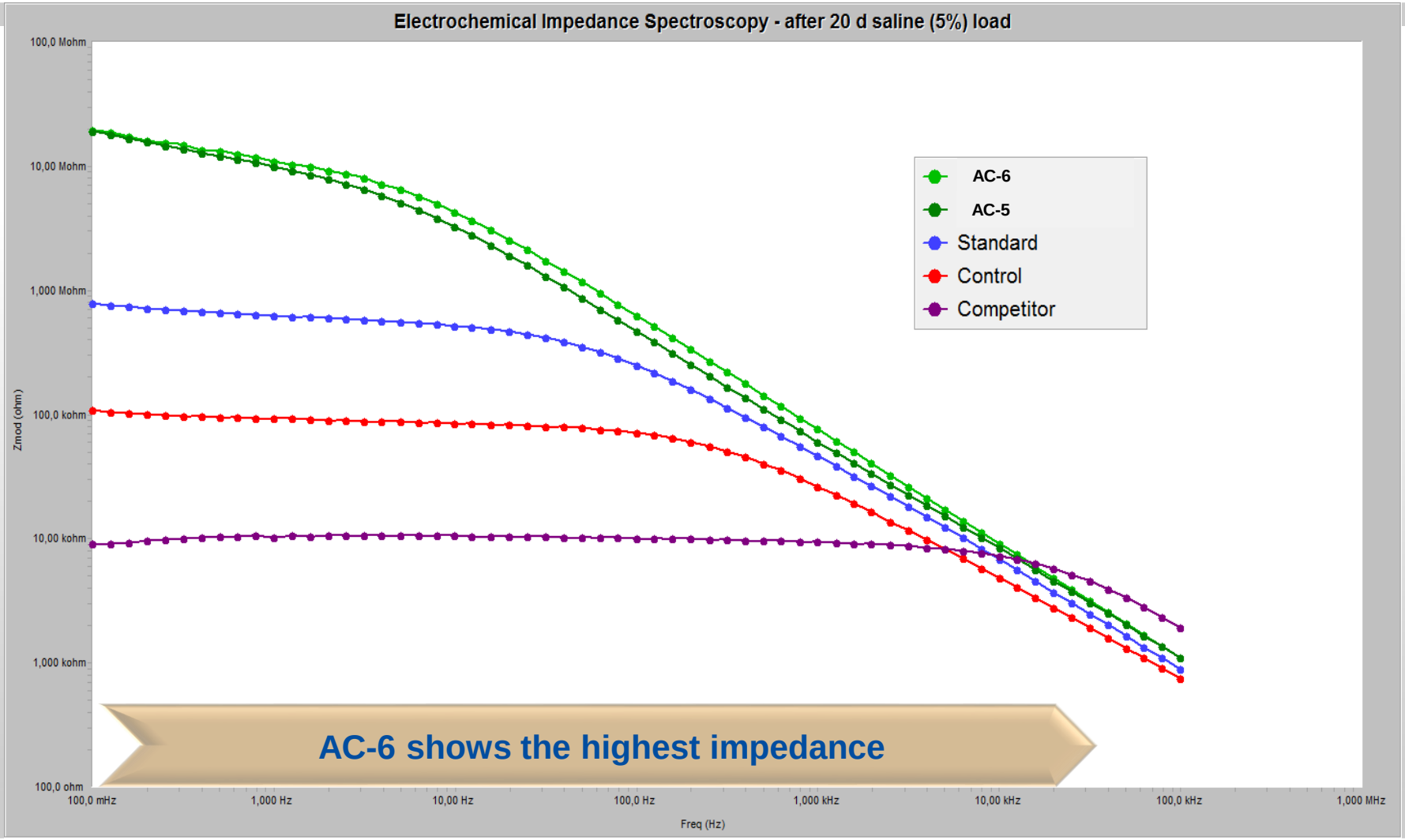
Electrochemical Impedance Spectroscopy

Test formulation:
Water-borne alkyd anticorrosive primer

Substrate: smooth steel
DFT: **80 µm**
Drying: **7 d ambient**
NaCl Load: **20 d**

Measuring Parameter:

AC Voltage: 15 mV
Initial Frequency: 100 kHz
Final Frequency: 0,1 Hz
Points / decade:10
Area (cm^2): 1



Test formulation: Waterborne alkyd anti-corrosive primer

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Test Methods to Determine the Influence of W&D on Coatings Performance

ID	Water Pickup	IR Diffusion	Permeability	Early Water Resistance	Salt Spray
Blank					
FS-1					
PS-1					
PU-1					
AC-1					
AC-2					
AC-3					
AC-4					
AC-5					
AC-6					

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Condensation Atmosphere

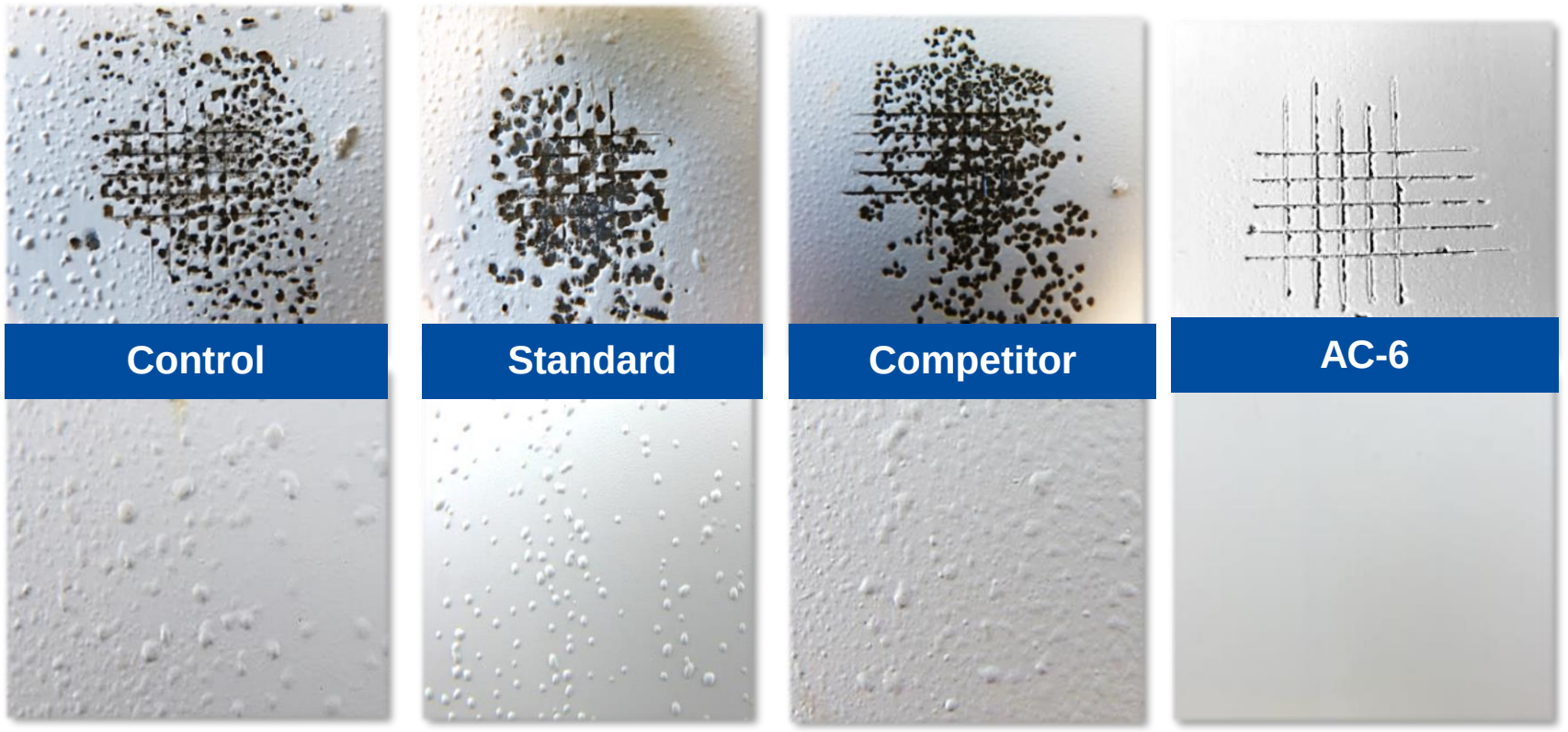
Condensation atmosphere with constant humidity (ISO 6270-2)

Substrate: smooth steel
DFT: 80 µm
Drying: 7 d ambient

Cross Cut (ISO 2409)

Immediately after condensation test

After 240 hr condensation test



Positive influence on water resistance AC-6

Test formulation: Waterborne Alkyd Anti-corrosive Primer

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Condensation Atmosphere

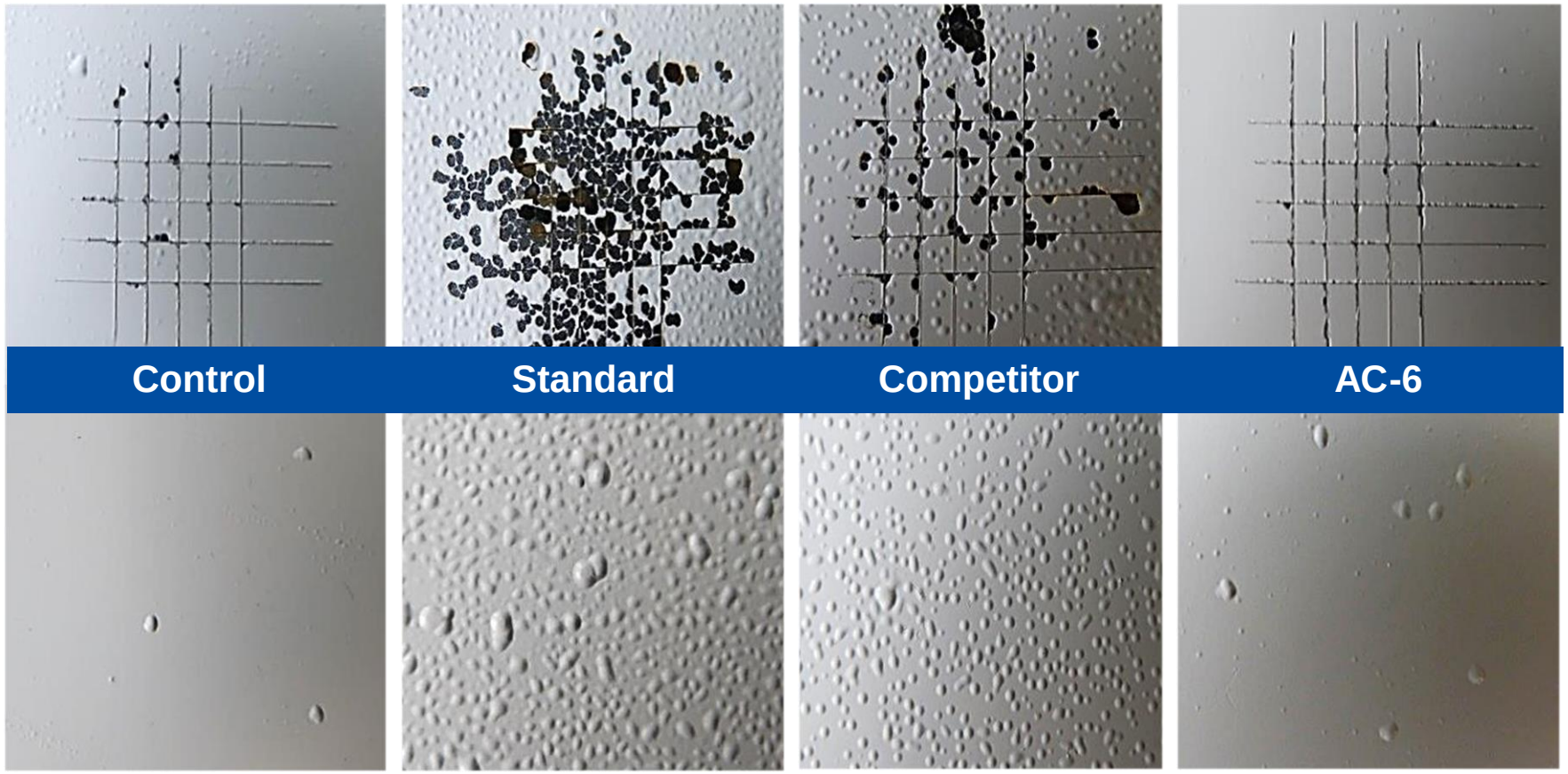
Condensation atmosphere with constant humidity
(ISO 6270-2)

Substrate: smooth steel
DFT: 80 µm
Drying: 7 d ambient

Cross Cut
(ISO 2409)

Immediately after condensation test

After 480 hr condensation test



No negative influence on water resistance for AC-6

Test formulation: Waterborne 2-pack Epoxy Primer

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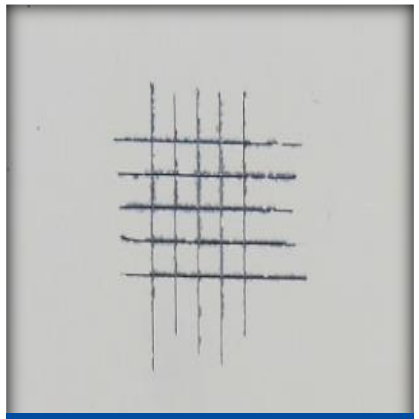
Early Water Resistance

Early water resistance:

Water load for 24 h after 24 h drying at ambient conditions

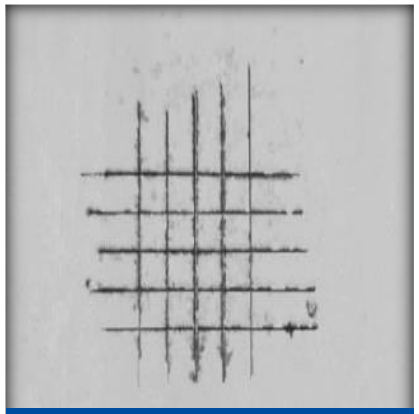
→ Cross cut according to ISO 2409

Test formulation: Waterborne Alkyd Anticorrosive Primer

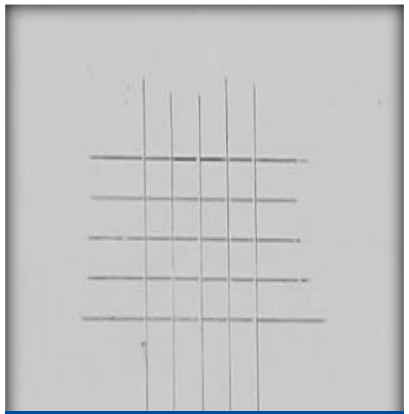


Control

Standard



Competitor

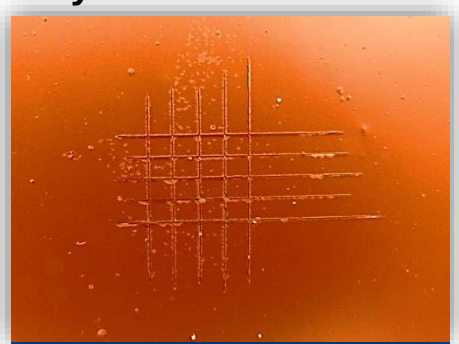


AC-6

Positive influence on early water resistance

Test formulation: Waterborne Acrylic Primer

Standard



AC-6

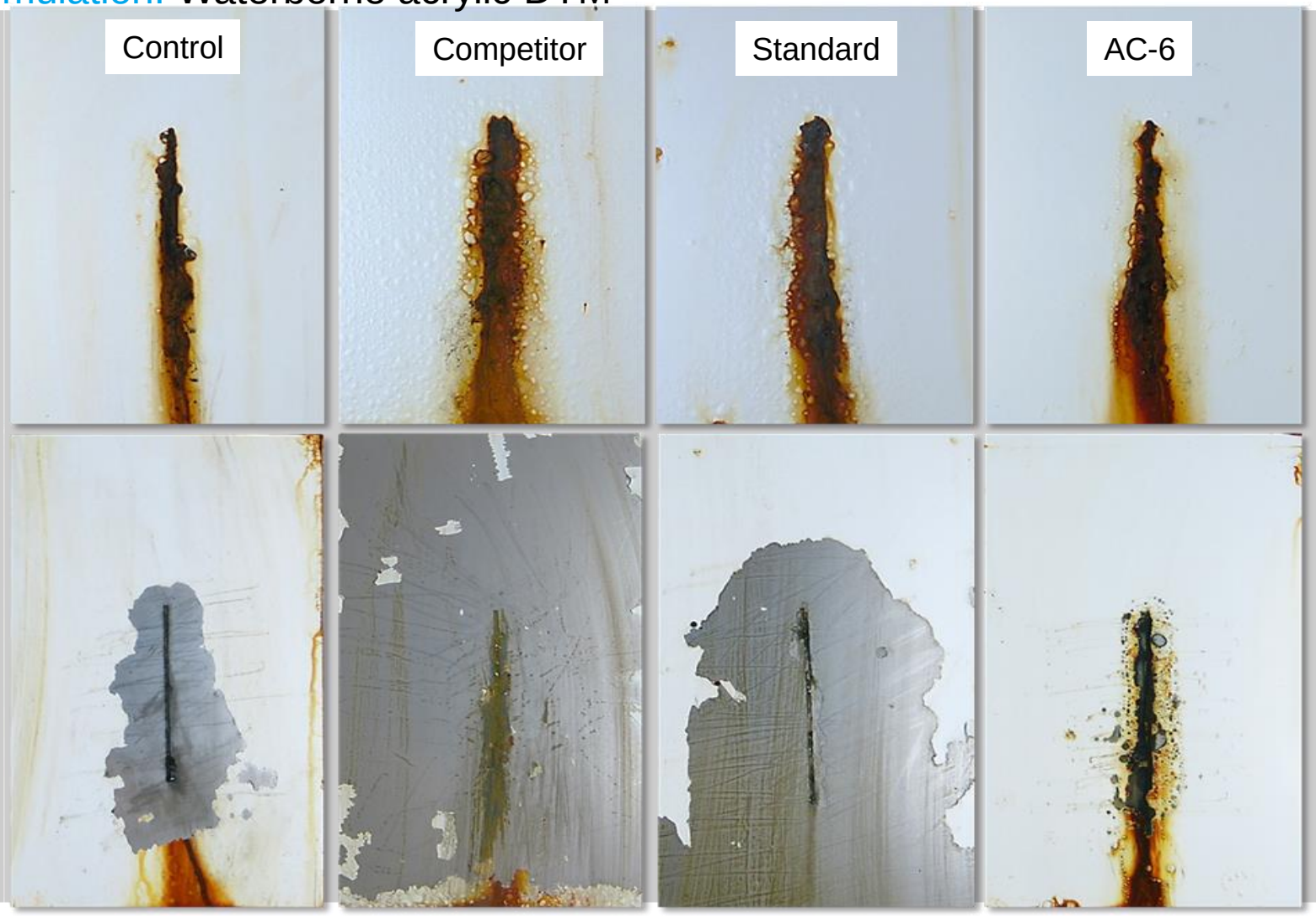
No Negative Influence on Salt Spray Resistance

Test formulation: Waterborne acrylic DTM

Corrosion tests in artificial atmospheres – Salt spray tests
(ISO 9227:2006)

Test formulation:
Water-borne acrylic DTM

Substrate: smooth steel
DFT: **80 µm**
Drying: **7 d ambient**
Duration: **720 h**



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Neutral Salt Spray Test

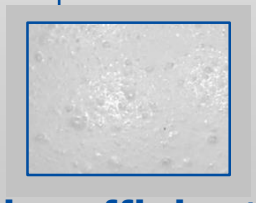
No Negative Influence on Salt Spray Resistance and Adhesion

Corrosion tests in artificial atmospheres – Salt spray tests
(ISO 9227:2006)

Test formulation:
Water-borne acrylic DTM coat

Substrate: smooth steel
DFT: 80 µm
Drying: 7 d ambient
Duration: 720 h

Gloss measurement at 60°



Test formulation: Waterborne acrylic DTM

No rust, no blisters, minimal delamination or corrosion creep with AC-6

→ **insufficient dispersion without w/d additive**

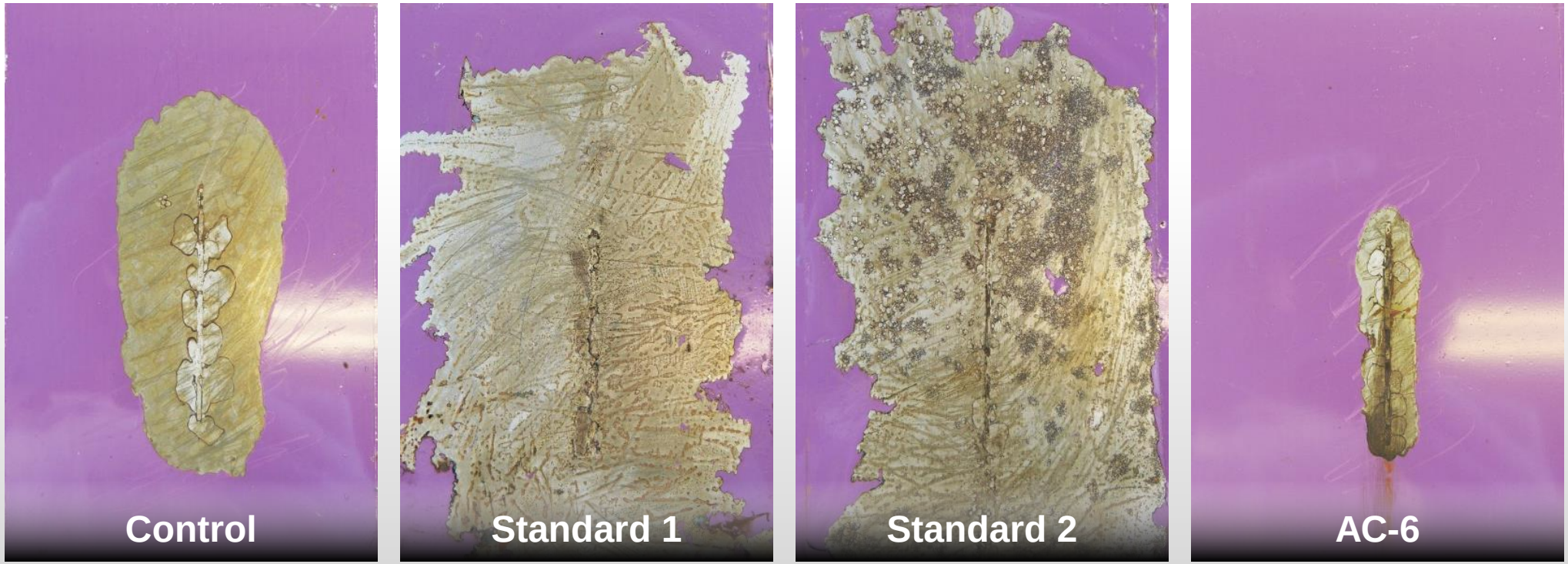
Neutral Salt Spray Test

Positive Influence on Adhesion after Neutral Salt Spray Test

Corrosion tests in artificial atmospheres – Salt spray tests
(ISO 9227:2006)

Test formulation:
Baking enamel acrylate / melamine

Substrate: smooth steel
DFT: 60 µm
Drying: 20 min. ambient
25 Min. 140°C
Further 2 d ambient
Duration: 240 h



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Impact on Stain Resistance in Acrylic Emulsion I

Test system:
Resin-free aqueous pigment dispersion (slurry 70% pigment load) & 3.5% additive (solids on pigment)

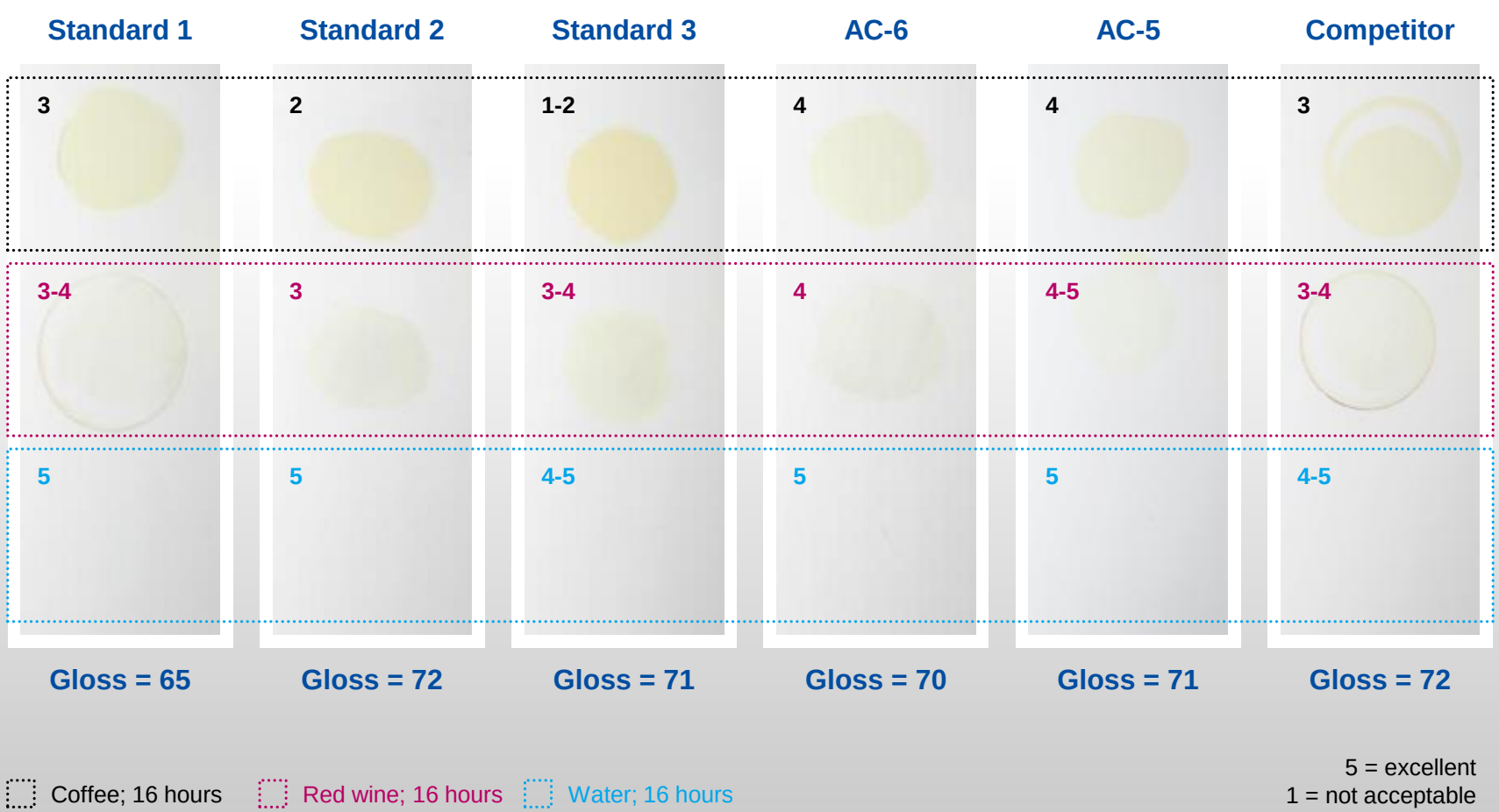
Letdown system:
Water-borne acrylic emulsion

Application:
Doctor blade onto glass panel 100µm wet film thickness

Drying conditions:
Room temperature, 1 week

Test procedure:
Stain resistance test in accordance with DIN 68861-1 (DIN EN 12720).

Gloss measurement at 60°



Impact on Stain Resistance in Acrylic Emulsion II

Test system:
Resin-free aqueous pigment dispersion (slurry 70% pigment load) & 3.5% additive (solids on pigment)

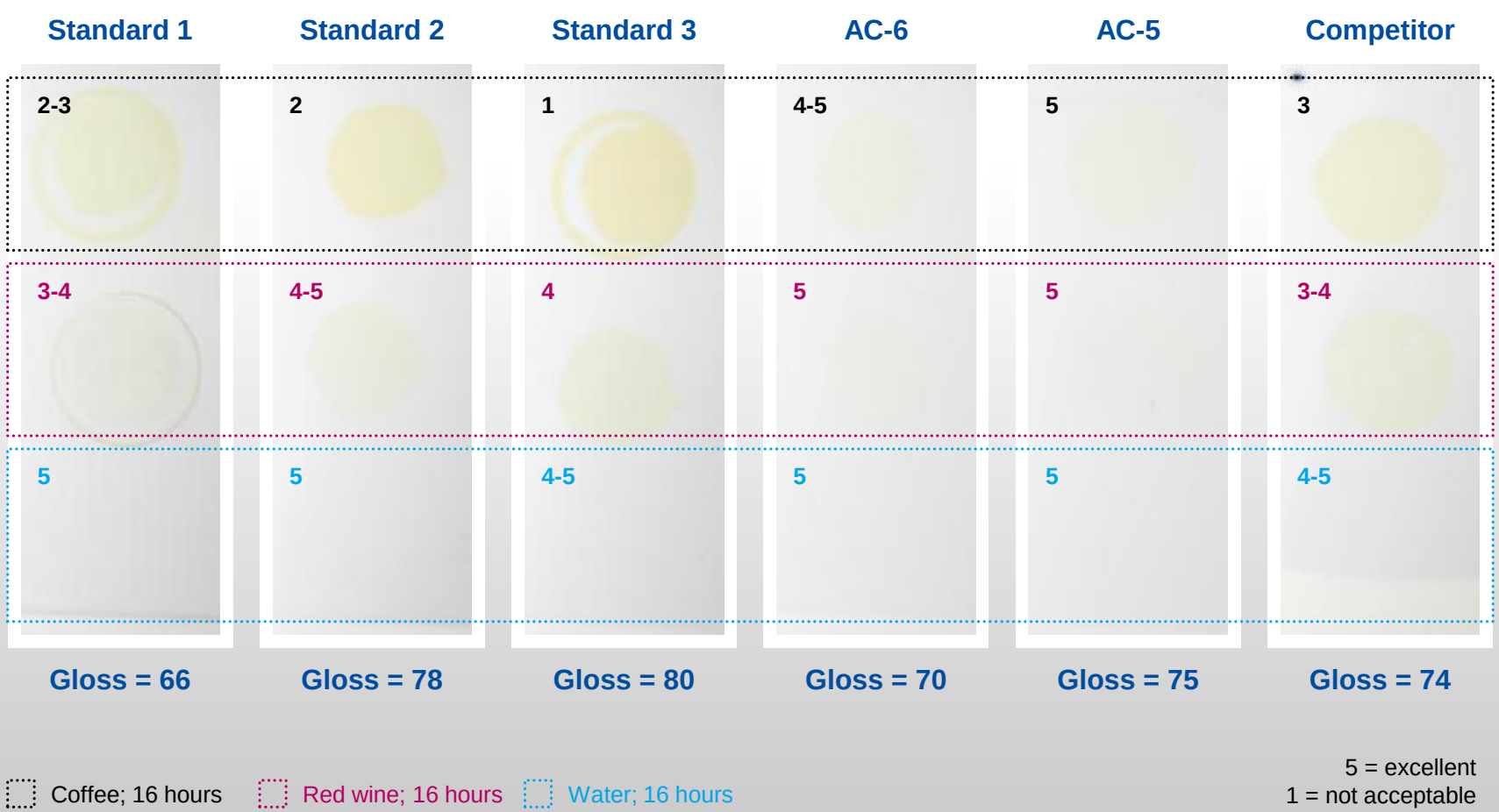
Letdown system:
Water-borne acrylic emulsion

Application:
Doctor blade onto glass panel 100µm wet film thickness

Drying conditions:
Room temperature, 1 week

Test procedure:
Stain resistance test in accordance with DIN 68861-1 (DIN EN 12720).

Gloss measurement at 60°



Impact of Use Level on Stain Resistance

Test system:
Resin-free aqueous pigment dispersion (slurry 70% pigment load) and **2.0%** as well as **3.5%** additive (solids on pigment)

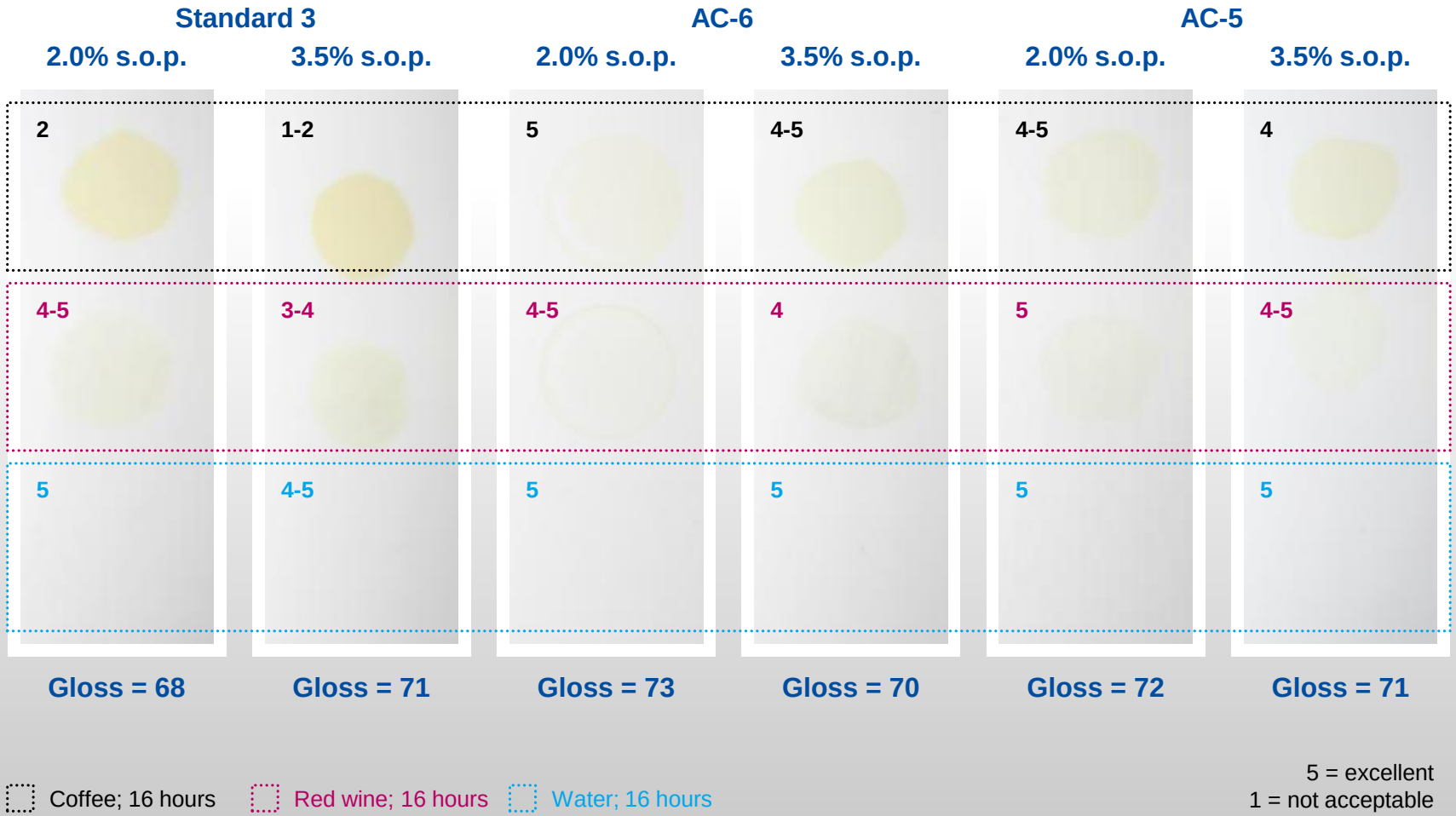
Letdown system:
Water-borne acrylic emulsion

Application:
Doctor blade onto glass panel 100µm wet film thickness

Drying conditions:
Room temperature, 1 week

Test procedure:
Stain resistance test in accordance with DIN 68861-1 (DIN EN 12720).

Gloss measurement at 60°



Impact on Stain Resistance in Hybrid System

Test system:
Resin-free aqueous pigment dispersion (slurry 70% pigment load) & 3.5% additive (solids on pigment)

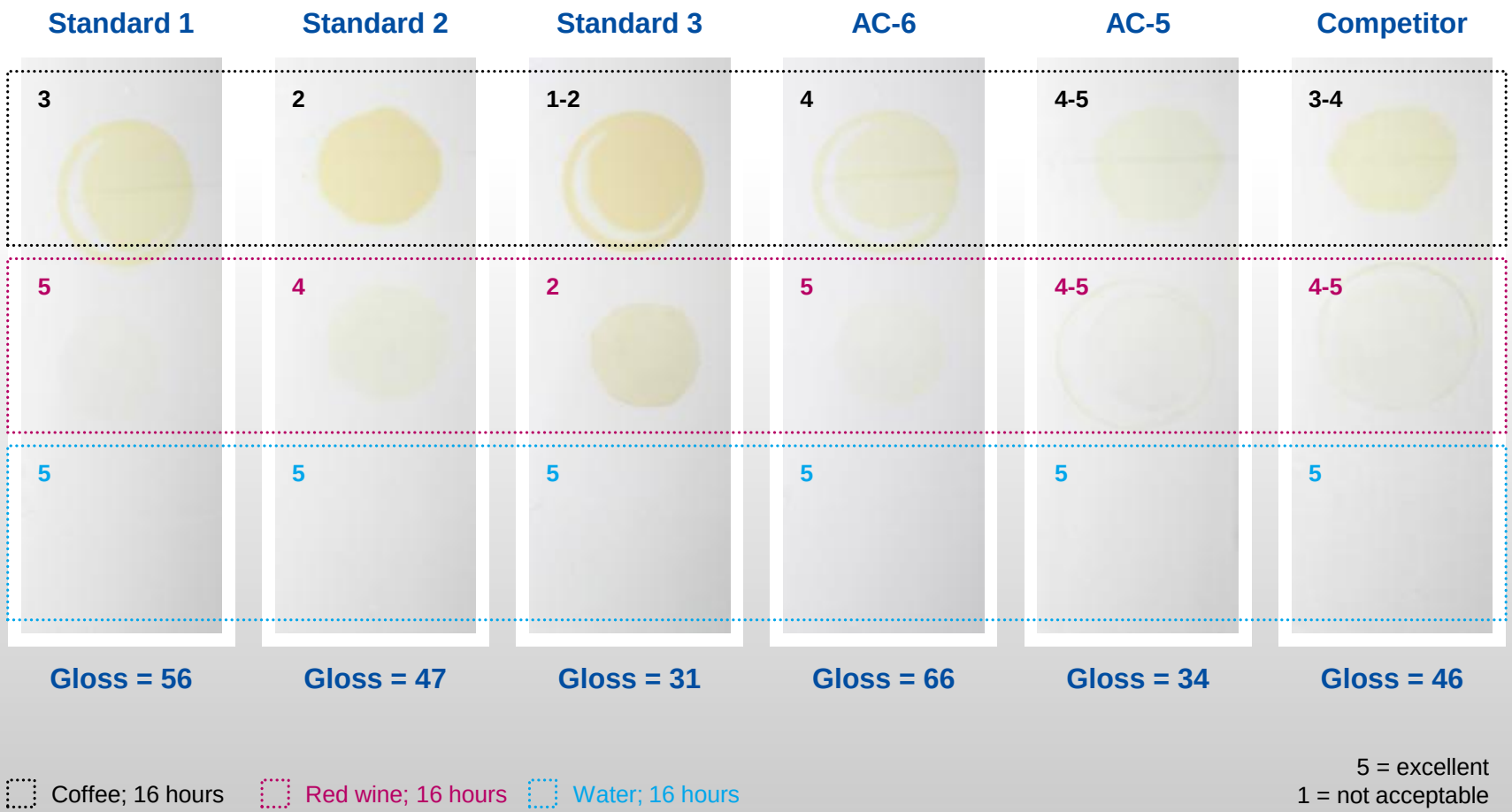
Letdown system:
Water-borne urethane-acrylic

Application:
Doctor blade onto glass panel 100µm wet film thickness

Drying conditions:
Room temperature, 1 week

Test procedure:
Stain resistance test in accordance with DIN 68861-1 (DIN EN 12720).

Gloss measurement at 60°



DISPERBYK-2080 & DISPERBYK-2081
Applications





DISPERBYK-2080

Marine & Protective Coatings	Wood & Furniture Coatings	Decorative Coatings	General Industrial Coatings	Automotive Coatings

DISPERBYK-2081

Marine & Protective Coatings	Wood & Furniture Coatings	Decorative Coatings	General Industrial Coatings	Automotive Coatings

highly recommended recommended

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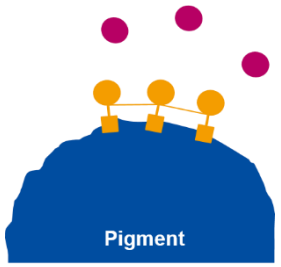
Summary



Good wetting and dispersing properties with excellent viscosity reduction (TiO_2, inorganic, anticorrosive pigments, fillers, organic limited)

Especially developed for:
- Wood and furniture coatings
- Anticorrosive primers and DTM coats

Less hydrophilicity in the cured paint result in:
- Improved corrosions resistance
- Improved water & early water resistance
- Improved stain resistance

Positive side effects
- Gloss retention
- Improved adhesion

Recommended for water-borne acrylics, hybrids, alkyds and epoxies

Conclusions

- Despite relatively low use levels in the paint formulation and the cured films, wetting and dispersing additives can have significant influence on different paint parameters such as corrosion resistance, water pickup, and early water resistance.

- Wetting and dispersing additives should not be picked solely on their ability to reduce paint viscosity. The pigment stabilization properties as well as their impact on film and barrier properties including corrosion and water resistance must factor into the equation.

- Recent developments are allowing waterborne systems to significantly improve their overall corrosion resistance performance.
    - Use the right additive at the correct use level

Thank you
for your attention!