ANGUS®
CHEMICAL COMPANY

Improving Performance of Waterborne Industrial Coatings with Amino Alcohols

Coating Trends & Technologies

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Lombard, IL

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DISCOVER A **BETTER** WAY™

Outline

- Brief Introduction to ANGUS Chemical Company
- Amino Alcohols as Dispersants for Pigments
- Evaluations in a Waterborne Acrylic Direct-to-Metal (DTM) Formulation
  - Amino Alcohols as a Co-dispersant
  - Further Formulation Optimizations
- Summary

What We Do

ANGUS uses proprietary propane nitration technology to create a unique set of specialty chemistries.

MULTIFUNCTIONAL
Performance
and Value

PIGMENT DISPERSION

METAL CHELATING

FORMULATION STABILIZATION

SURFACE WETTING

OXYGEN/RADICAL SCAVENGING

PH BUFFERING

ANTI-CORROSION

CROSSLINKING

MOISTURE SCAVENGING

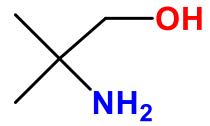
PH ADJUSTING

An Industry Standard

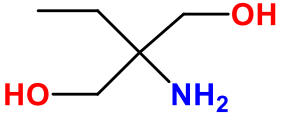
ANGUS AMINO ALCOHOLS

- 1° and 3° amino alcohols with amine group bonded to tertiary carbon
- Effective pigment co-dispersants
- Highly efficient neutralization
- Enables formulation optimization

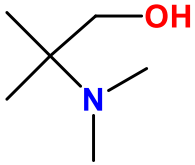
Monofunctional Primary Amine
2-Amino-2-methyl-1-propanol



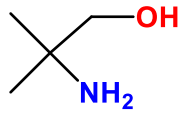
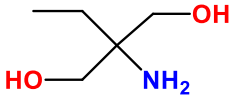
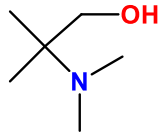
Difunctional Primary Amine
2-Amino-2-ethyl-1,3-propanediol



Monofunctional Tertiary Amine
2-Dimethylamino-2-methylpropanol



Unique Physical-Chemical Properties

	Material	Molecular Weight (g/mol)	pKa	pH of 1% Amine Solution	Boiling Point (°C)	Melting Point (°C)	Flash Point (°C)	Density, 20°C (g/mL)
	Monofunctional Primary Amine	**89.1**	9.7	**11.7**	165	-11	86	0.93
	Difunctional Primary Amine	119.2	8.8	11.0	**283**	-24	>100	1.08
	Monofunctional Tertiary Amine	117.2	**10.2**	**11.9**	160	-20	67	0.95

VOC Status and Green Certifications

Monofunctional Primary Amine (2-Amino-2-Methyl-1-Propanol)**:**

- Only organic amine VOC exempt by the US EPA
- VOC exempt by the Government of Canada
- Low emissions in CDPH V1.2 emissions testing

Difunctional Primary Amine (2-Amino-2-Ethyl-1,3-Propanediol)**:**

- A non-VOC additive in Europe and China and a low-VOC additive in the US
- With a boiling point >280°C it is considered VOC exempt in Green Seal certification
- Non-emissive in CDPH V1.2 emissions testing

Interactions of Amino Alcohols with Coating Ingredients

Biostability

Formaldehyde Scavenging

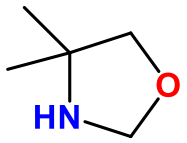
Neutralization

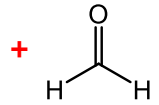
Synergy with Registered Biocides

\+ Registered Biocide

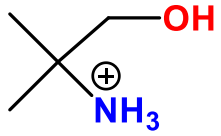
Ex. BIT, MIT/CMIT

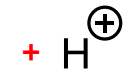
Formaldehyde Capture

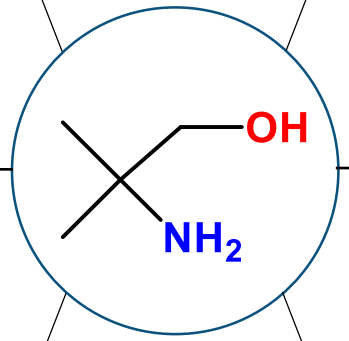




Neutralization

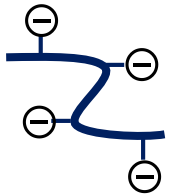






Pigments

Dispersing Agents

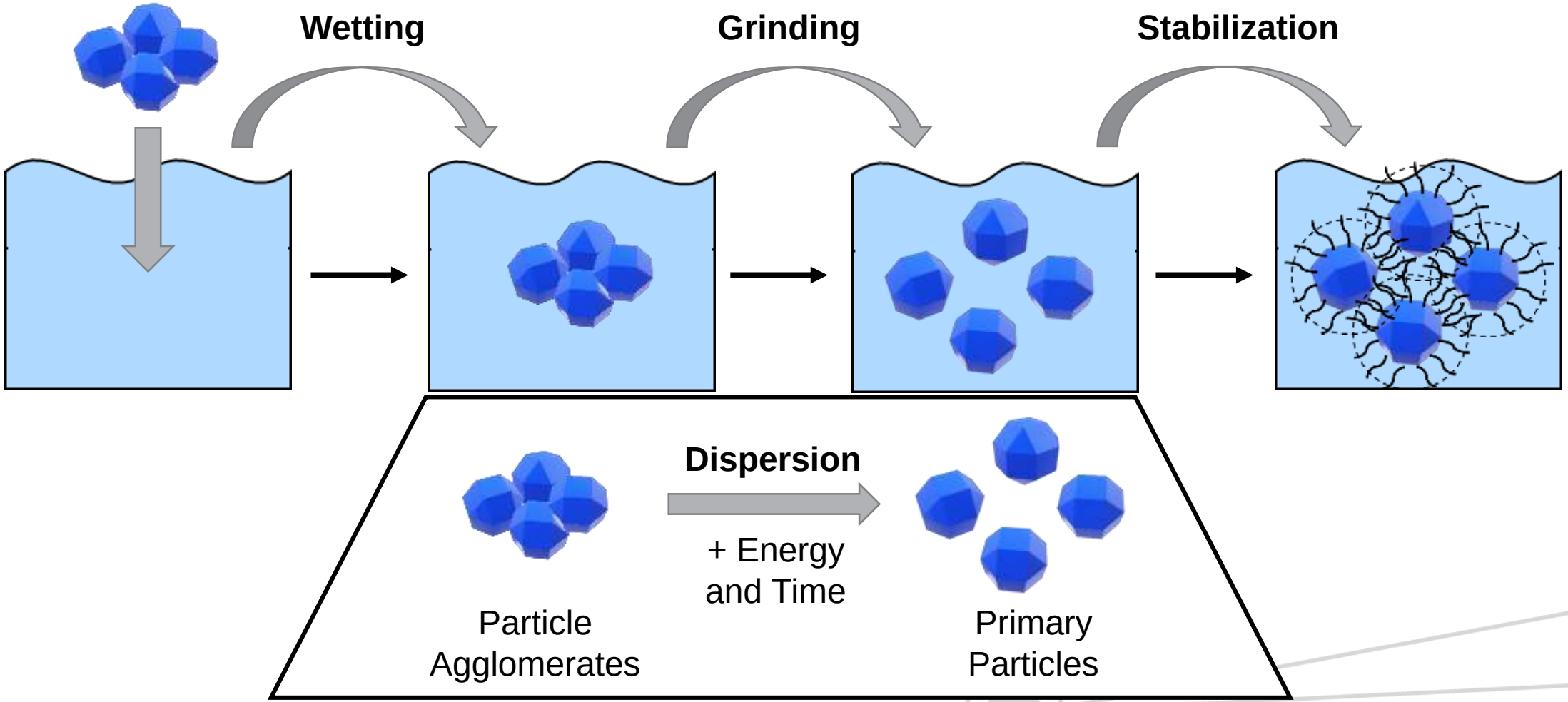


Binders

Pigment Dispersion

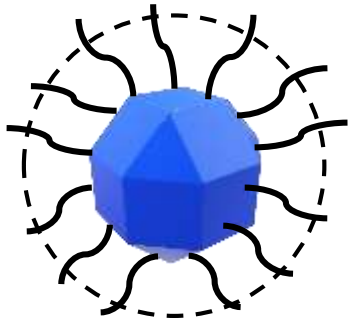
Paint Stability

Pigment Dispersion Process



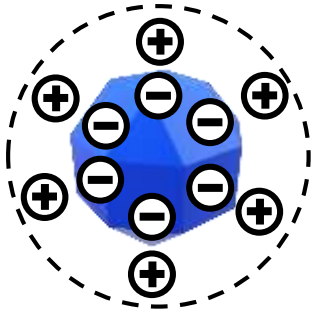
Stabilization Mechanisms for Pigments and Extenders

Steric Stabilization



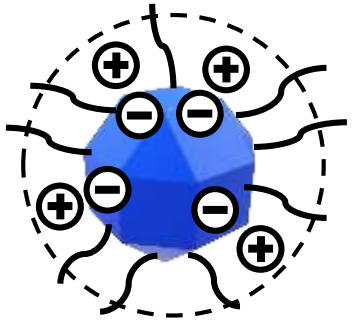
- Adsorbed polymer or surfactant chains
- Steric hinderance prevents particle re-agglomeration

Electrostatic Stabilization



- Ionic species attracted to charges on particle surface
- Electrical repulsive force prevents particle re-agglomeration

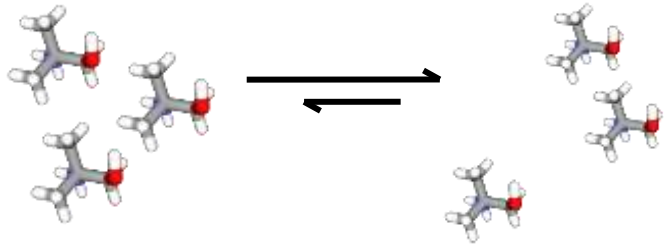
Electrosteric Stabilization



- Polymers and ionic species adsorbed to surface
- Combination of steric hinderance and electrical repulsive forces prevents particle re-agglomeration

Adsorption of Amino Alcohols onto Pigments

Amino Alcohol ⇌ Pigments

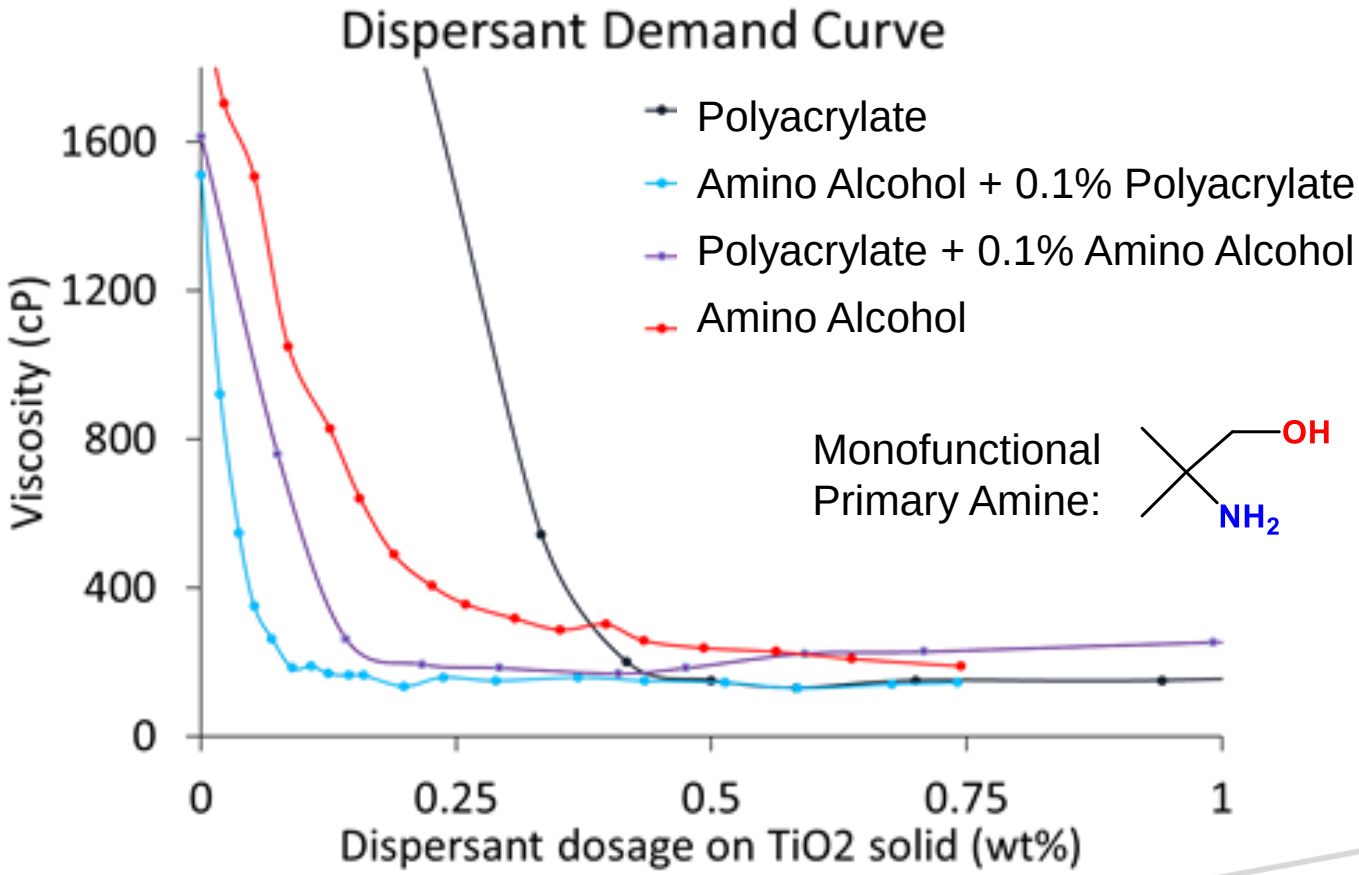


Pigment	Weight % Amino Alcohol on Pigment in Slurry	% Amino Alcohol Adsorbed on Pigment Surface
Titanium Dioxide	0.12%	**85%**
	0.50%	34%
	1.00%	21%
Copper Phthalocyanine Blue	0.35%	**90%**
	0.65%	**90%**
	1.30%	69%

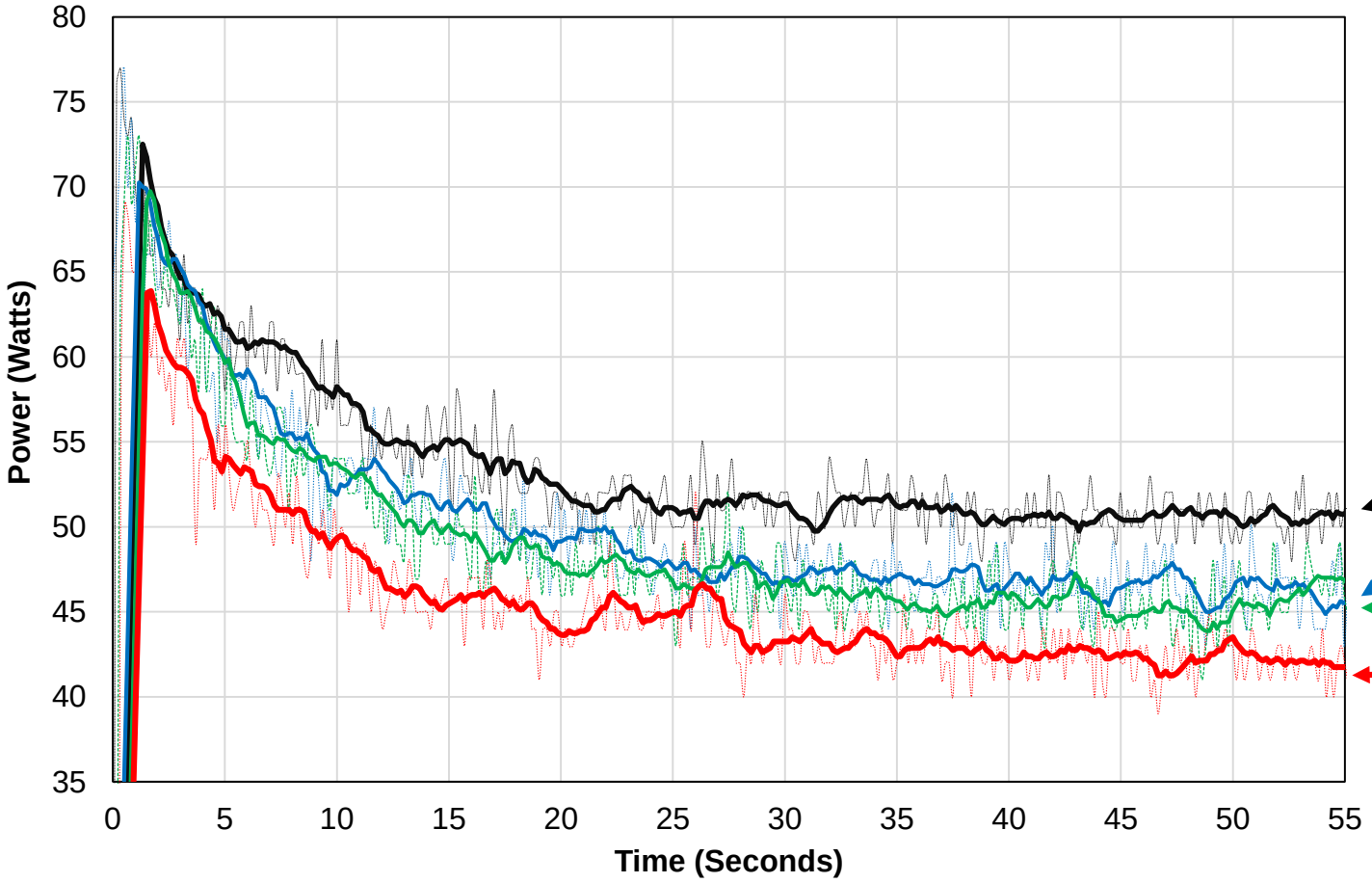
Adsorption of Monofunctional Primary Amine

Amino Alcohol Impact on Dispersant Demand

- As a main dispersant, amino alcohol is more effective than polyacrylate.
- Combination of amino alcohol and polyacrylate dispersant is much more effective than polyacrylate alone in dispersing TiO_2.
- Polyacrylate dispersant overdosing increases slurry viscosity.
- Amino alcohol as main dispersant is more tolerant to overdosing than polyacrylate dispersant.



Time and Energy Savings Potential



- Power draw on a Cowles-blade disperser versus time
- Pigment grinds dispersed with various amino alcohols

Ammonia

Monofunctional Primary Amine

Difunctional Primary Amine

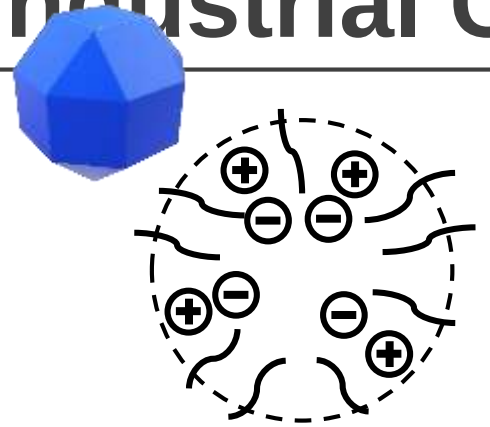
Monofunctional Tertiary Amine

Increasing Energy and Time Savings Potential

Challenges for Waterborne Industrial Coatings

Metal Coating Key Performance Criteria:

- Corrosion resistance
- Adhesion
- Weather/UV protection
- Aesthetics
  - Color
  - Gloss
  - Hardness
- Durability
  - Length of service
  - Resistance to water, chemicals, cleaning, etc.
- Application robustness
  - Can be applied in all kinds of conditions



Pigment dispersion step has a significant influence on many of these coating performance properties.

A good quality pigment dispersion can provide:

- More efficient use of pigments
- Better optical properties
  - Improved aesthetics
- Better barrier properties
  - Corrosion resistance
  - Water resistance

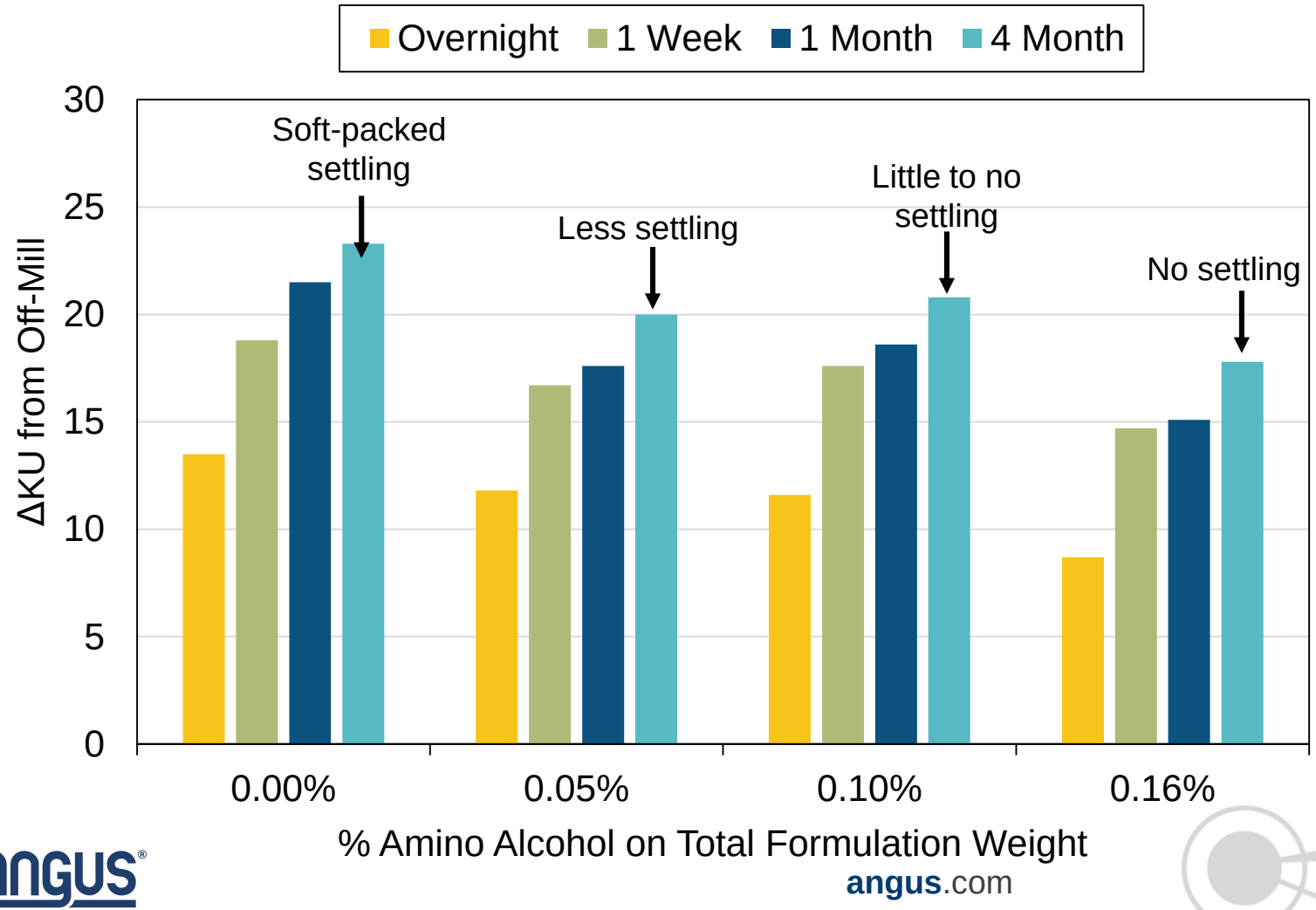
Formulating with Amino Alcohol Co-Dispersants

Material	Pounds
Grind	
Water	61.00
Dispersant	9.00
Amino Alcohol	Variable
Surfactant	4.00
Defoamer	1.00
Titanium Dioxide	210.00
Grind Total	**285.00**
Letdown	
Acrylic Resin	527.79
Water	139.84
(Grind)	*(285.00)*
Coalescent	15.36
Flash Rust Inhibitor (Sodium Nitrite)	9.00
High-Shear Associative Thickener	20.00
Low-Shear Associative Thickener	3.00
Ammonia	Variable
Grand Total	**1000.00**

- Monofunctional Primary Amine evaluated as a dispersant in the grind
  - Replaced 17%, 30%, and 50% of dispersant with monofunctional primary amine
  - 1:1 replacement of dispersant active on pigment solids
    - Dispersant = 35% active
    - Monofunctional primary amine = 95% active
- Ammonia used to adjust the final pH in the let-down

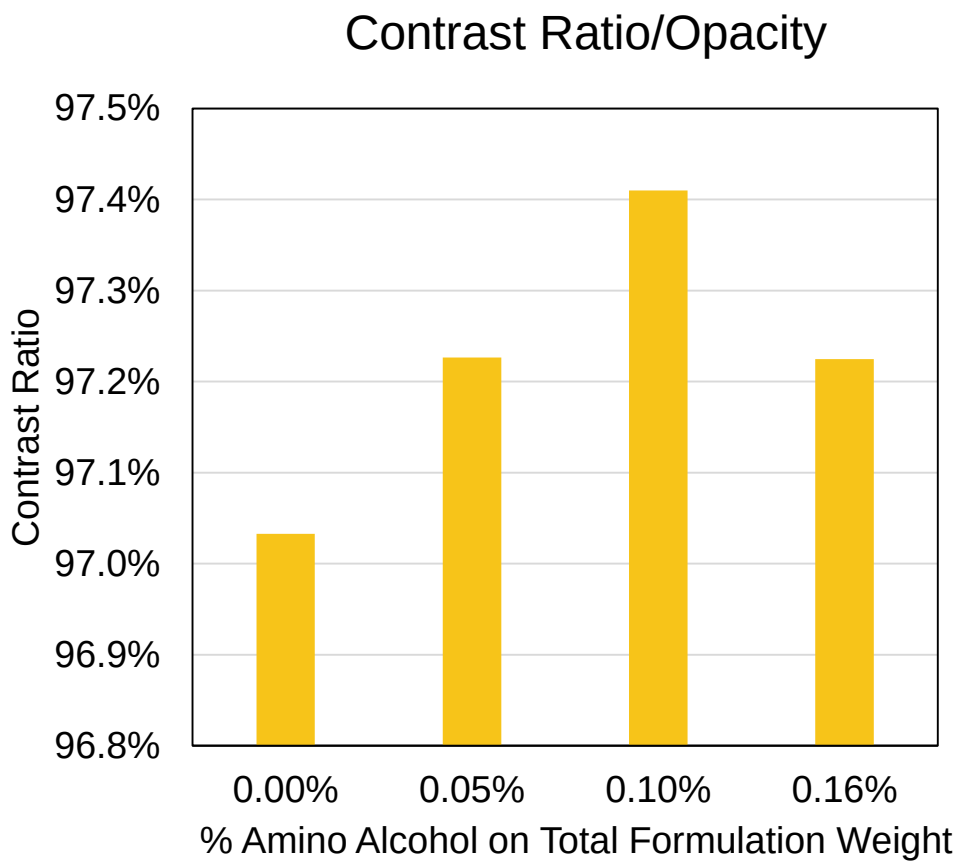
Dispersant Removed:	0%	17%	30%	50%
Active on Pigment Solids:				
Dispersant	1.50%	1.25%	1.00%	0.75%
Monofunctional Primary Amine	0.00%	0.25%	0.50%	0.75%
As-Supplied on Total Formulation Weight:				
Dispersant	0.90%	0.75%	0.60%	0.45%
Monofunctional Primary Amine	**0.00%**	**0.05%**	**0.10%**	**0.16%**

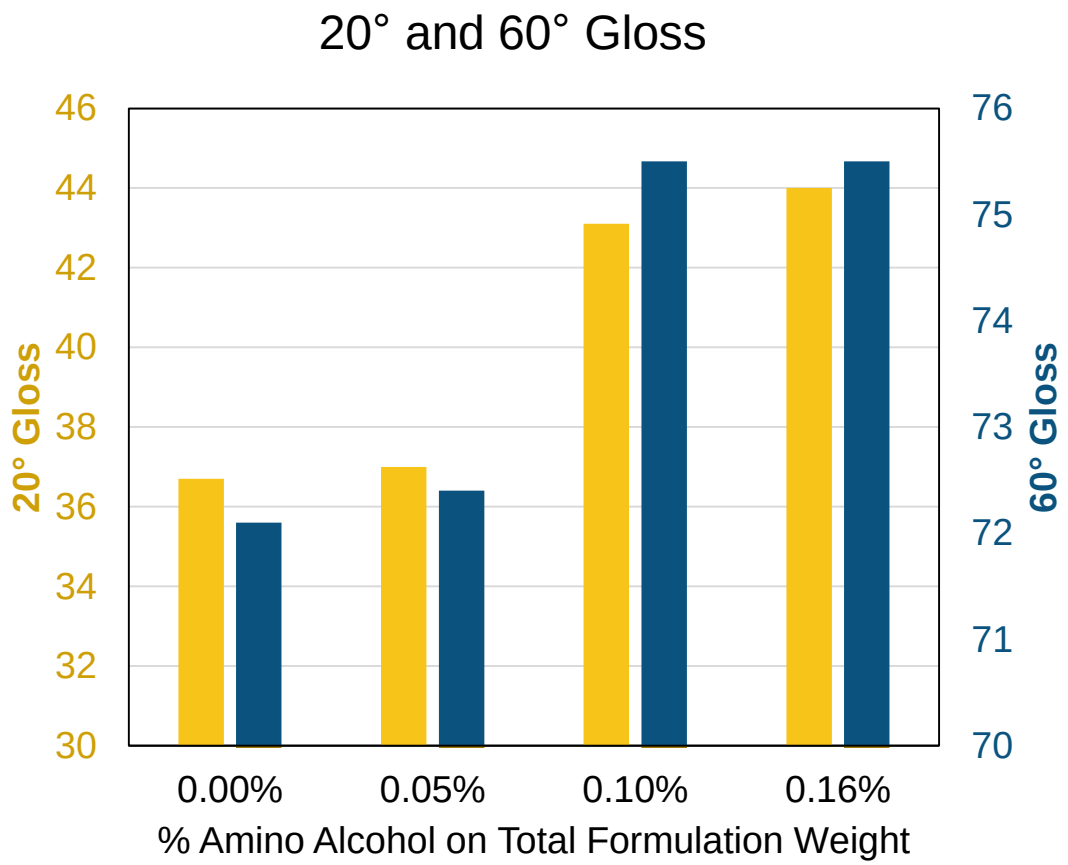
Amino Alcohols Improve Viscosity Stability



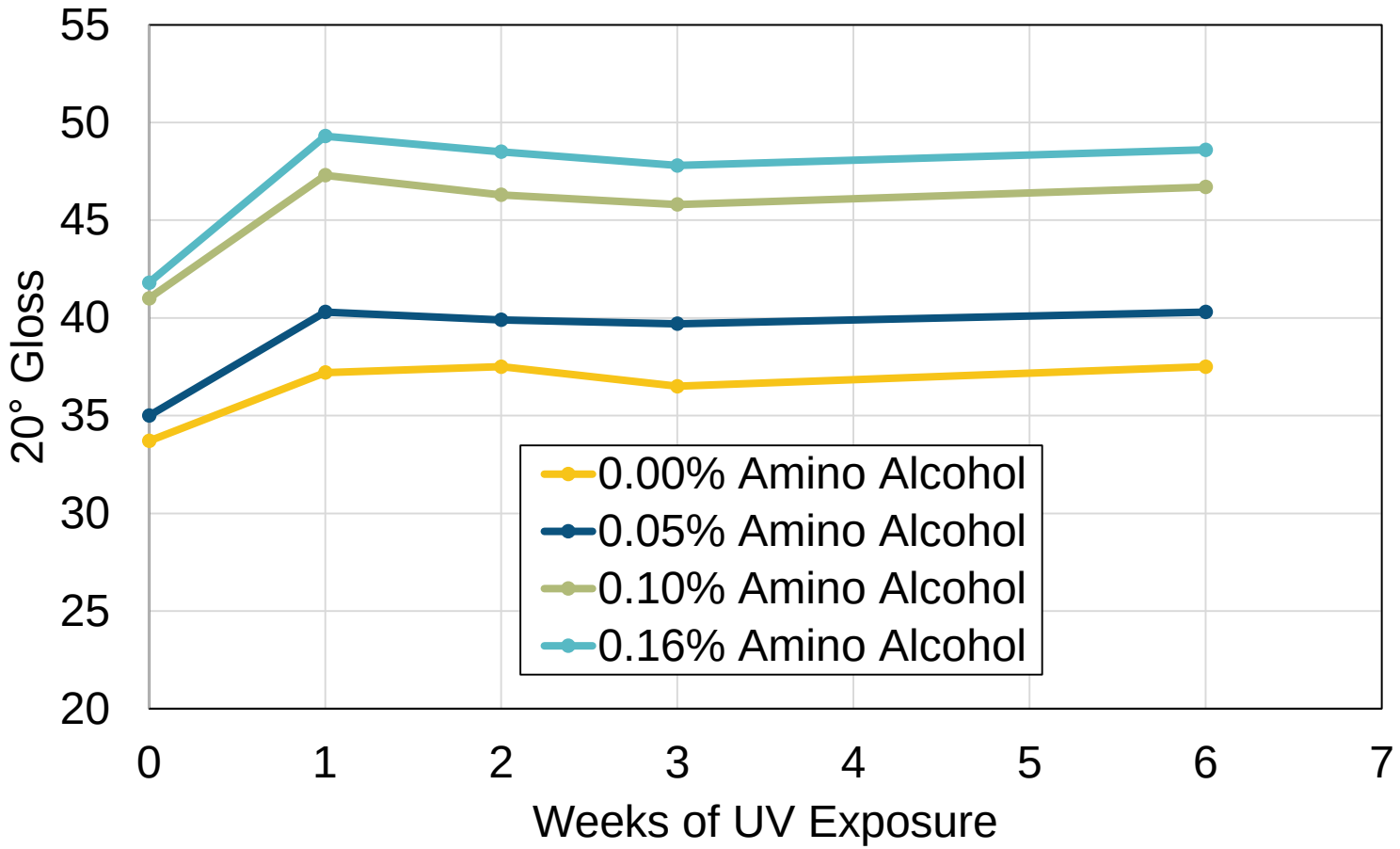
- Amino alcohol reduced the large overnight viscosity rise seen with this reactive latex systems
- Rheology is more stable over time, ensuring consistent application properties
- Higher levels of amino alcohol show greater viscosity stability
- Prevents soft-packed settling during longer term storage

Amino Alcohols Improve Contrast Ratio and Gloss





Amino Alcohols Deliver Excellent Gloss Retention



Test Method:

- 6 mil wet film thickness drawdown on aluminum panels (R36)
- Continuous exposure to UVA in a QUV chamber for 6 weeks

Results:

- Amino alcohol not only increases gloss, but maintains gloss over time
- Higher levels of Amino Alcohol yield higher gloss values

Amino Alcohols Improve Corrosion Resistance

0.00% 0.05% 0.10% 0.16%

% Amino Alcohol on Total Formulation Weight

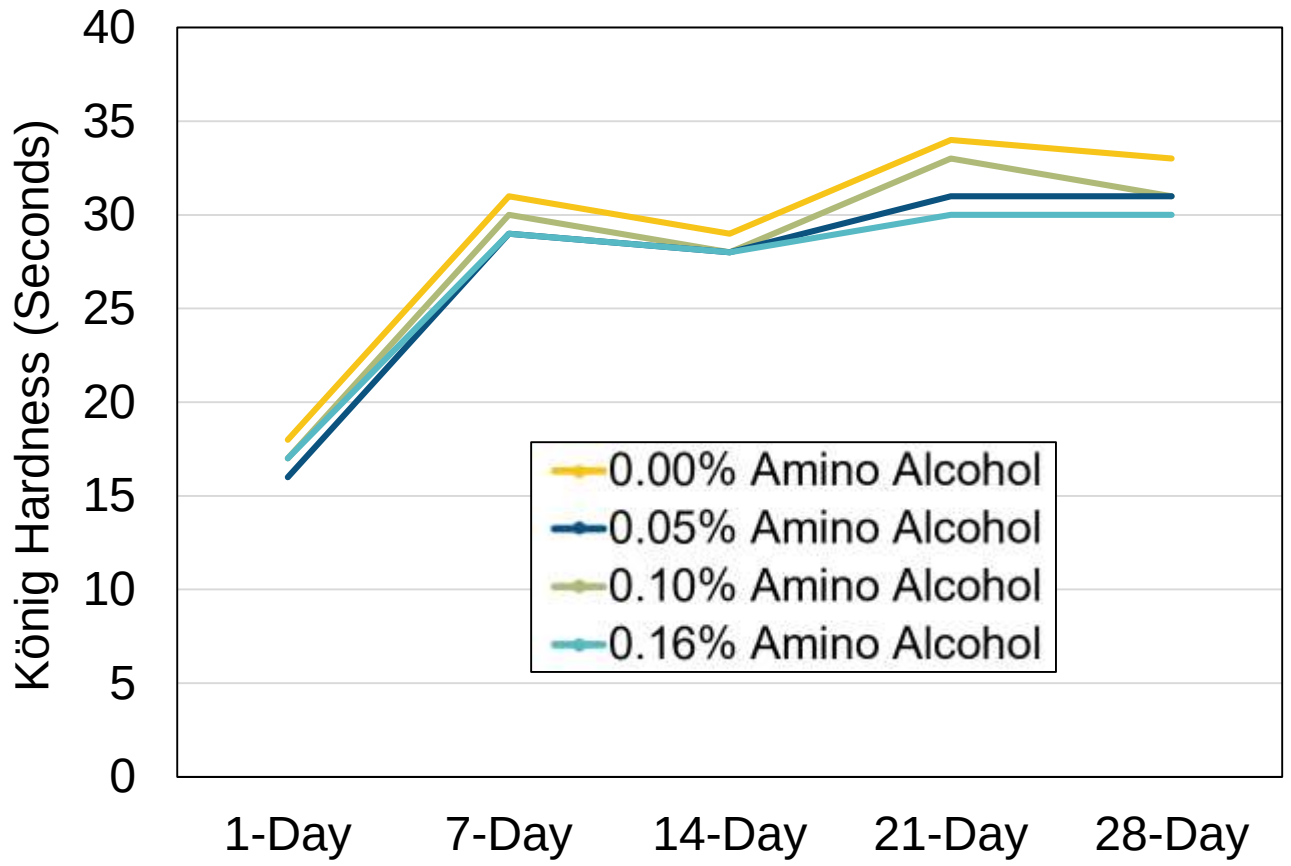
Test Method:

- ~2 mil dry film thickness on steel panels (R36)
- ASTM B117 testing
- 336 hours
- Vertically scribed

Results:

- Amino Alcohol co-dispersed grind has reduced blistering and rust creepage along the scribe

Amino Alcohols Have Minimal Impact on König Hardness



Test Method:

- 3 mil wet film thickness drawdowns on aluminum (A36)
- König hardness monitored over 28-days

Results:

- König hardness values of Amino Alcohol-formulated samples typically remain within 1-2 seconds of the control formulation

Minimal Effect on Early Water Sensitivity

Test Method:

- 3-mil wet drawdowns on aluminum panels dried at room temperature for 2 hours and then submerged under tap water for 24 hours

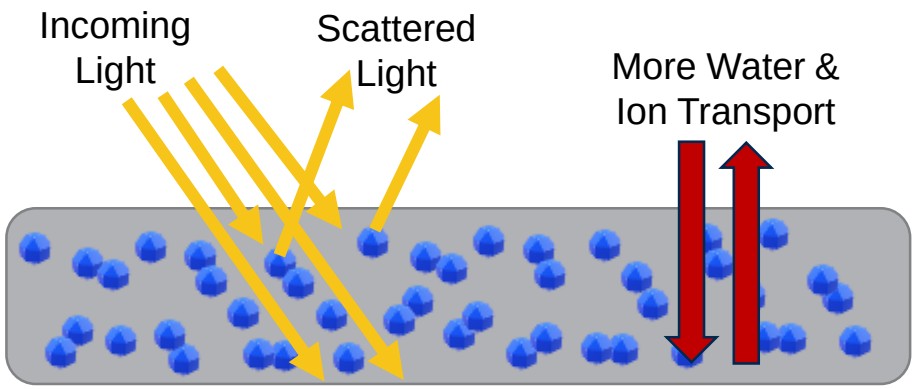
Results:

- Amino alcohol levels typical for dispersancy use yield coatings with favorable early water resistance
- Higher use levels of Amino Alcohol may negatively affect early water resistance

Improvements Driven by a Better Pigment Dispersion

Without Amino Alcohol Co-Dispersants

Optical Properties



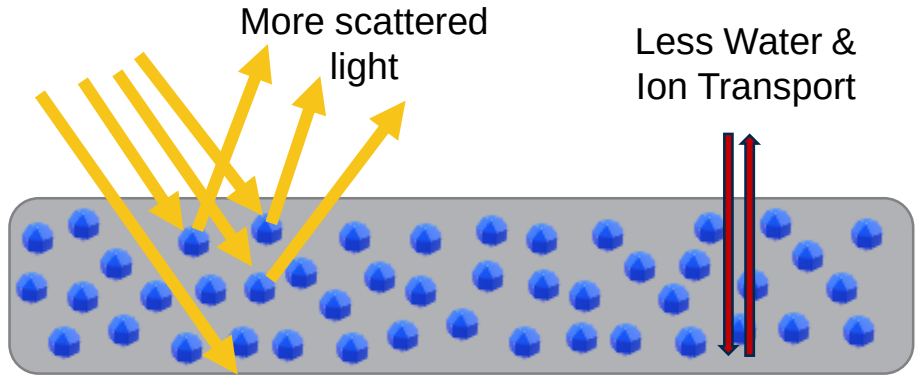
- Lower opacity
- Lower gloss

Barrier Properties

- Poor corrosion resistance
- Poor water resistance

With Amino Alcohol Co-Dispersants

Optical Properties



- Higher opacity
- Higher gloss

Barrier Properties

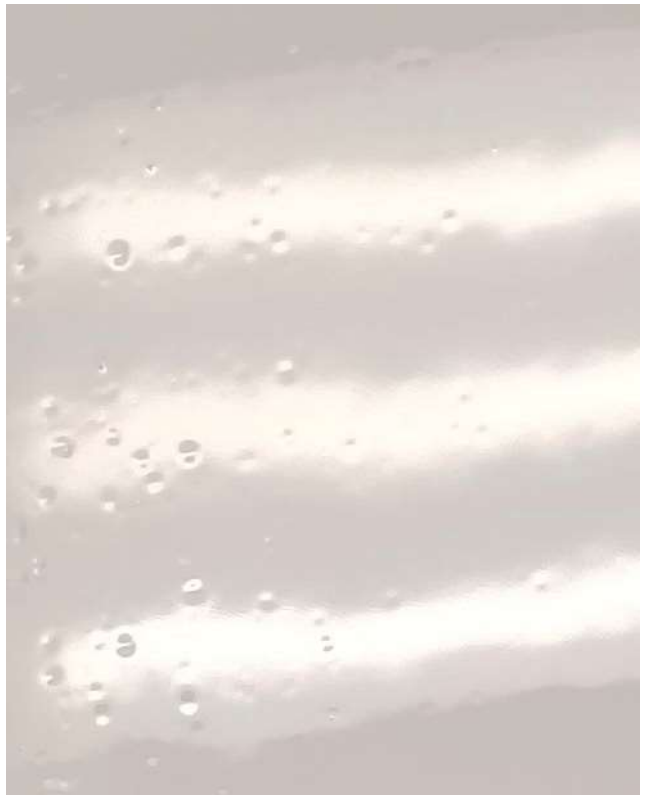
- Better corrosion resistance
- No loss of water resistance

Wetting Properties of Amino Alcohols

0.0% Amino Alcohol
(Control)

Few surface defects

0.0% Amino Alcohol
25% Reduction in Surfactant



Many surface defects

0.1% Amino Alcohol / -30% Dispersant
25% Reduction in Surfactant

Very few surface defects

Formulation Adjustments to Improve Corrosion Resistance

0.0% Amino Alcohol
(Control)

0.0% Amino Alcohol
25% Reduction in Surfactant

0.1% Amino Alcohol / -30% Dispersant
25% Reduction in Surfactant

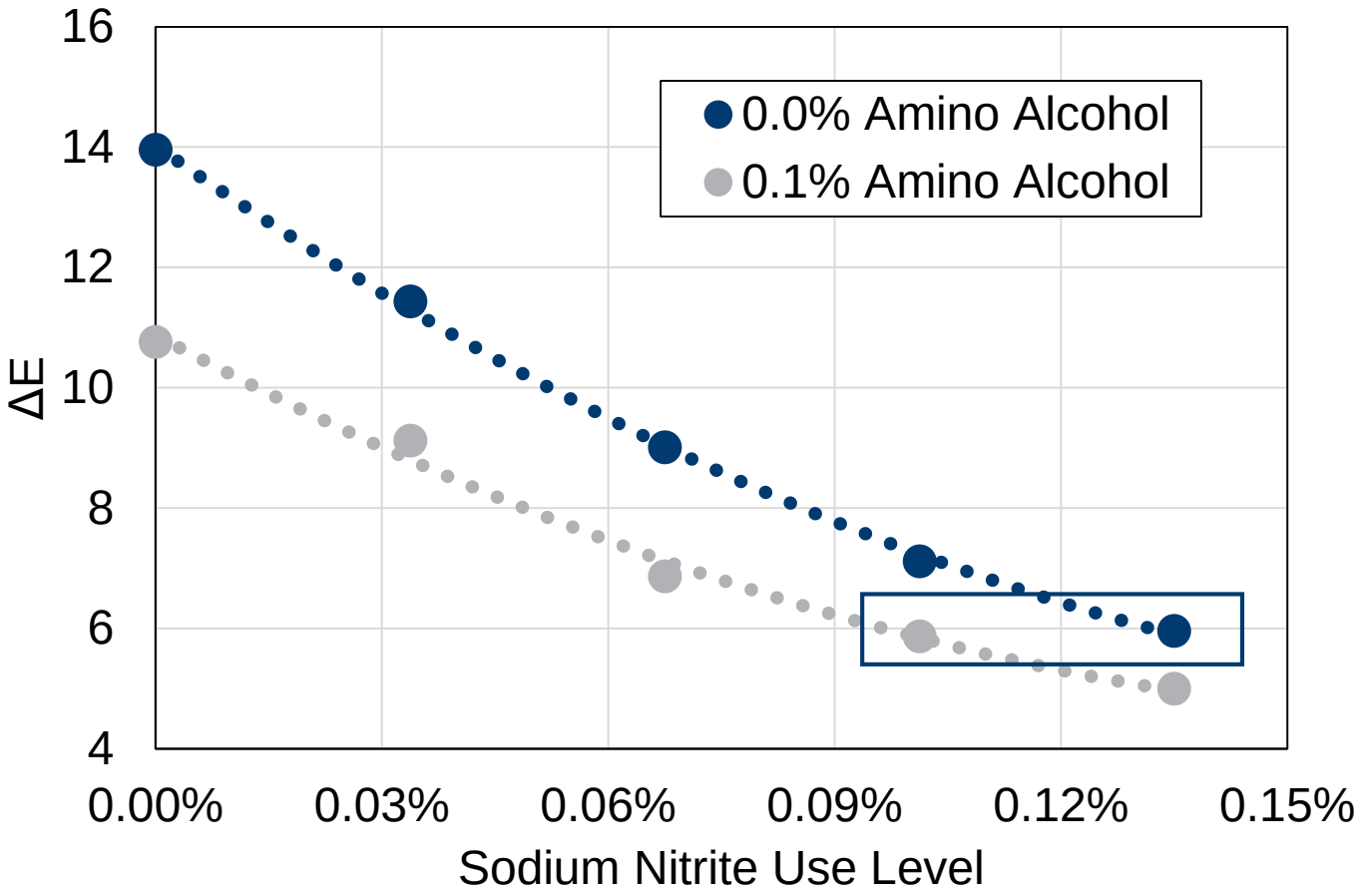
Test Method:

- ~2 mil dry film thickness on steel panels (R36)
- Vertically scribed
- ASTM B117
- 168 hours

Results:

- Amino Alcohol-enabled reformulations show best corrosion resistance – fewest blisters

Amino Alcohols Improve Flash Rust Resistance



Testing Conditions: Coatings on steel panels are dried in a controlled temperature/humidity chamber at 25°C and 90% relative humidity

- Flash rust discolors white coating, and this color change is plotted as a ΔE versus a drawdown on a non-rusting aluminum substrate
- 0.1% of Amino Alcohol in the grind can enable a 25% reduction in flash rust inhibitor and still achieve the same flash rust resistance

Summary: Benefits of Amino Alcohols to DTM Coatings

- Improved contrast ratio and gloss
- Excellent gloss retention
- Improved paint stability
- Improved corrosion resistance
- Minimal impact on film hardness and early water resistance
- Opportunities for further formulation optimization:
  - Reduced dispersant (and defoamer) level (30-50% reduction)
  - Reduced surfactant level (25% reduction)
  - Reduced flash rust inhibitor level (25% reduction)
- Starting point recommendation: Use 0.1% of Amino Alcohol on total formulation weight as a replacement for 30-50% of the existing dispersant

THANK YOU

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