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IMPROVING PERFORMANCE OF WATERBORNE INDUSTRIAL COATINGS WITH AMINO ALCOHOLS

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ABSTRACT

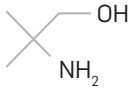
Amino alcohols, such as 2-amino-2-methyl-1-propanol (AMP™), are commonly used as stabilizing agents in a wide range of waterborne coating formulations. Through their multitude of interactions with different coating ingredients, amino alcohols enhance storage stability, provide pH control, and enable better dispersions of pigments. In particular, the strong interaction of amino alcohols with pigment surfaces makes them powerful co-dispersants to control pigment particle size and stability, which critically affects optical, mechanical, and rheological properties. Industrial waterborne coatings face challenging performance criteria and amino alcohols are an effective formulating tool to help meet those challenges. We show in a waterborne direct-to-metal (DTM) coating formulation how the co-dispersancy properties of amino alcohols can be utilized to improve hiding, gloss, and corrosion resistance. Amino alcohols can also be used to reduce the number and level of other coating ingredients, further enabling formulators to optimize the performance of DTM protective coatings.

INTRODUCTION

Waterborne metal coatings face challenging performance requirements, but as water-based technologies improve they are replacing an increasing number of solvent-borne systems.
A growing sub-segment of the metal coating market is direct-to-metal (DTM) coatings, which aim to reduce the application time, complexity, and cost of a multi-coat system with a single coating that meets the same performance criteria. All waterborne metal coatings need to use the highest performing raw materials in their most effective manner to achieve their performance goals. In the case of a DTM coating, properties such as corrosion resistance and outdoor durability are critically important, but must also be balanced with aesthetic requirements for high gloss and opacity. Here we demonstrate how to maximize the performance of waterborne acrylic metal coatings using amino alcohols as highly efficient dispersants for pigments.

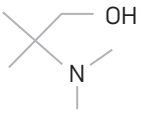
Amino Alcohols as Dispersants for Pigments

The unique properties of ANGUS amino alcohols offer a multitude of benefits to waterborne formulations, including efficient pH control and enhanced formulation stability, but one of the key benefits for waterborne metal coatings is their strong interaction with pigment surfaces, making them powerful dispersants that enable high quality pigment grinds and enhanced coating performance.



AMP-95™
2-amino-2-methyl-1-propanol

AEPD™ VOX 1000
2-amino-2-ethyl-1, 3-propanediol

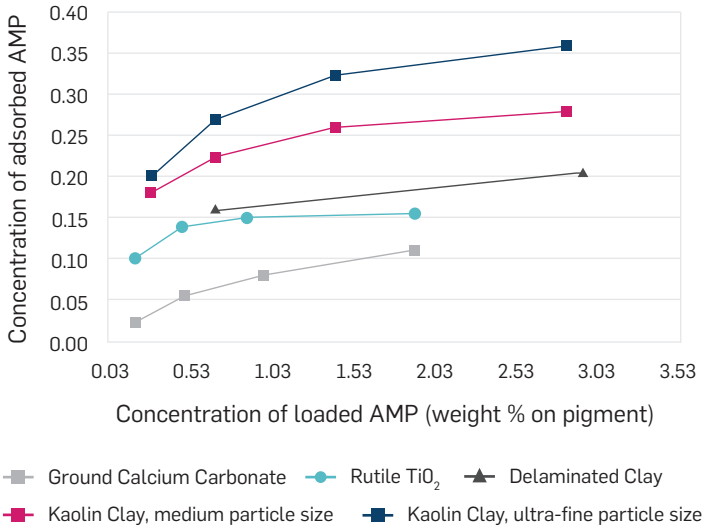


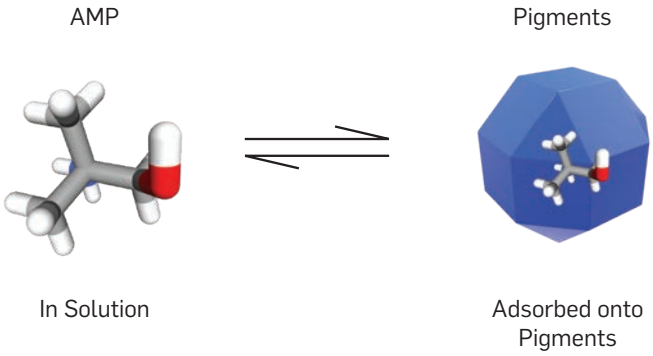
DMAMP-80™
2-dimethylamino-2-methylpropanol

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)
AMP-95	89.1	9.7	11.7	165	-11	86	0.93
AEPD VOX 1000	119.2	8.8	11.0	283	-24	>100	1.08
DMAMP-80	117.2	10.2	11.9	160	-20	67	0.95

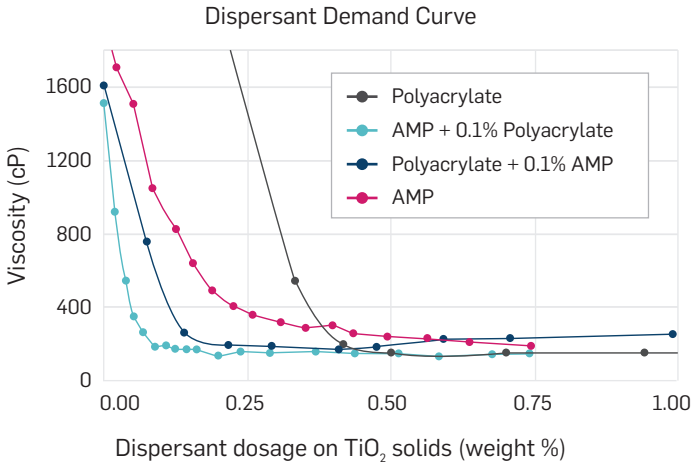
AMP-95 is VOC exempt by the U.S. EPA and by the Government of Canada. AEPD VOX 1000 is considered a low-VOC additive in the U.S., but with a boiling point > 250°C it is not considered a VOC in Europe or China and can be used to formulate zero-VOC coatings in those regions. These additives can, therefore, be used to make waterborne industrial coatings that meet low and zero-VOC regulations.

	Pigment	Weight % AMP on Pigment in Slurry	% AMP Adsorbed on Pigment Surface
Titanium Dioxide	Kronos 2190 (Kronos)	0.12%	**85%**
		0.50%	34%
		1.00%	21%
Copper Phthalocyanine	Hostaperm Blue B2G (Clariant)	0.35%	**90%**
		0.65%	**90%**
		1.30%	69%





AMP adsorbs strongly onto pigment and extender surfaces. Of the total concentration of AMP added to a pigment or extender slurry, a significant percentage of the AMP is found at the pigment particle surface.



Pigment slurries can be optimized by conducting dispersant demand curves, where the viscosity of the grind is measured as a function of dispersant dosage. Lower grind viscosities suggest a higher level of pigment deagglomeration and a better quality pigment dispersion.

- As a main dispersant, AMP is more effective than polyacrylate
- A combination of AMP and polyacrylate dispersant is much more effective than polyacrylate alone
- Polyacrylate dispersant overdosing increases slurry viscosity
- AMP as main dispersant is more tolerant to overdosing than a polyacrylate dispersant

REFORMULATING WATERBORNE ACRYLIC METAL COATINGS WITH AMINO ALCOHOLS

Amino alcohols can be formulated as co-dispersants into waterborne industrial coatings by incorporating 0.10 – 0.15% of amino alcohol on total formulation weight into the grind before the addition of pigments. The addition of amino alcohol into the grind enables a reduction of primary dispersant level by 30-50%.

Material	Pounds
Grind	
Water	61.00
TAMOL™ 681	Variable
AMP-95	Variable
TRITON™ HW-1000	4.00
TEGO® FOAMEX 1488	1.00
Ti-Pure™ R-706	210.00
Grind Total	**285.00**
Let Down	
MAINCOTE™ 4950	527.79
Water	139.85
Grind	*(285.00)*
DOWANOL™ DPnB	15.36
Sodium Nitrate (15%)	9.00
ACRYSOL™ RM-5000	20.00
ACRYSOL™ RM-8W	3.00
Ammonia (15%)	Variable
Grand Total	**1000.00**

A representative waterborne acrylic DTM formulation at 17.5% PVC and 36% VS used to evaluate amino alcohols in this work.

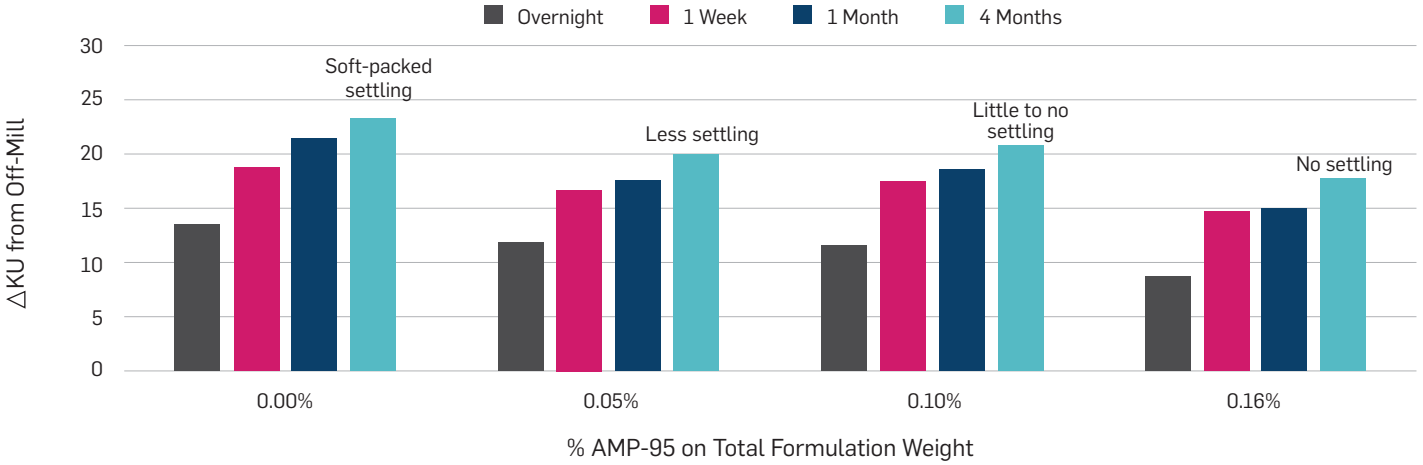
Primary Dispersant Removed:	0%	17%	30%	50%
Active on Pigment Solids:				
TAMOL 681	1.50%	1.25%	1.00%	0.75%
AMP-95	0.00%	0.25%	0.50%	0.75%
As-Supplied on Total Formulation Weight:				
TAMOL 681	0.90%	0.75%	0.60%	0.45%
AMP-95	**0.00%**	**0.05%**	**0.10%**	**0.16%**

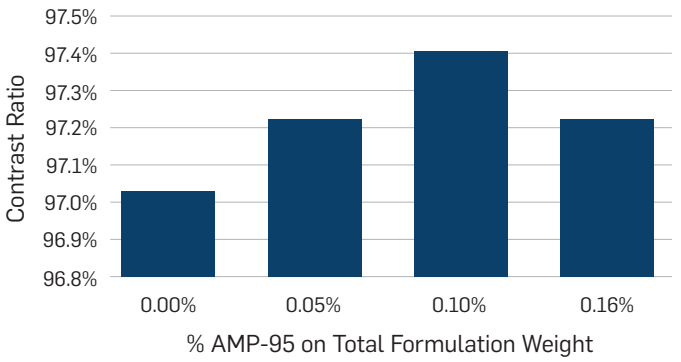
AMP-95 was evaluated as a co-dispersant in the pigment grind of a DTM formulation

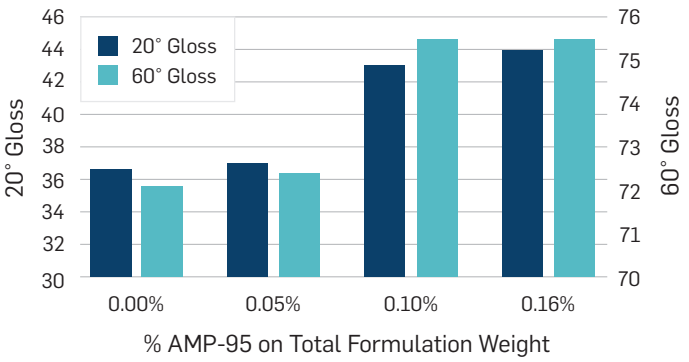
- Replaced 17%, 30%, and 50% of dispersant with AMP-95
- 1:1 replacement of dispersant active with AMP-95
- Final formulations contained 0.00%, 0.05%, 0.10%, or 0.16% of AMP-95 on total formulation weight
- Ammonia was used in the let-down to adjust the formulation pH to 9.2 – 9.3

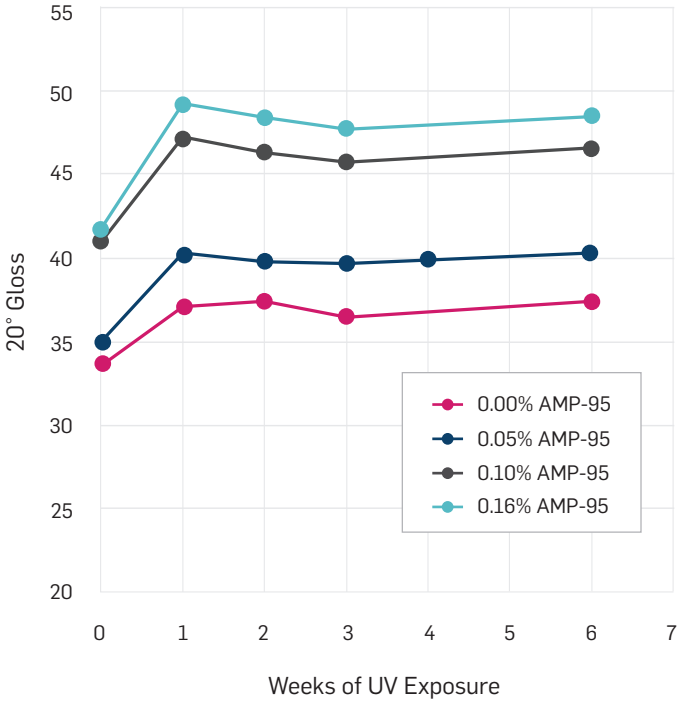
PERFORMANCE EVALUATIONS

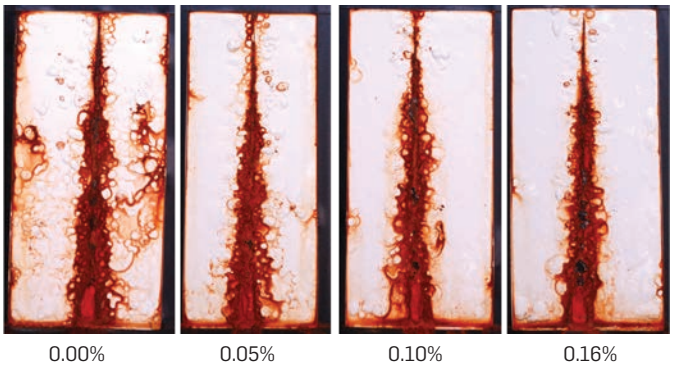
Coating performance properties were evaluated following industry standard test methods. The use of AMP-95 as a co-dispersant was found to improve formulation stability, hiding, gloss, and salt spray corrosion resistance.









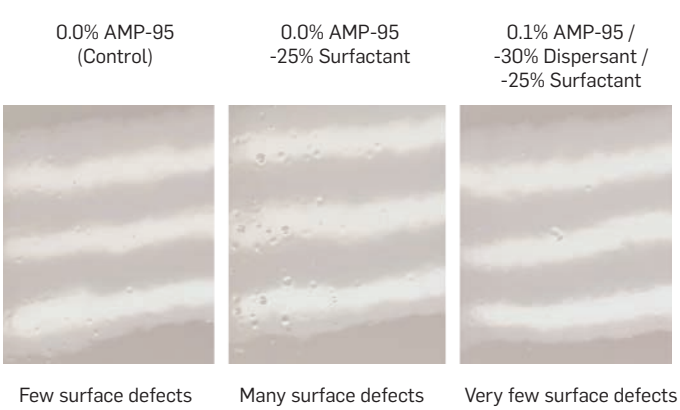


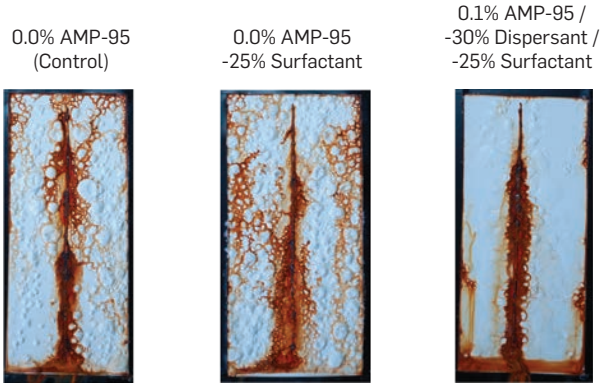
The co-dispersancy properties of AMP were found to offer the following benefits to a waterborne acrylic DTM formulation:

- Improved contrast ratio and gloss
- Excellent gloss retention
- Improved paint stability
- Improved corrosion resistance
- Minimal impact on film hardness and early water resistance (data not shown)

WETTING PROPERTIES OF AMINO ALCOHOLS CAN ENABLE SURFACTANT LEVEL REDUCTIONS

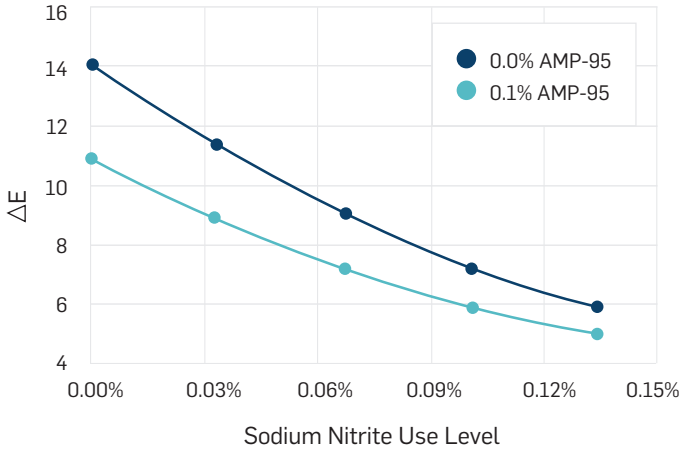
In addition to their dispersancy properties, amino alcohols also have wetting properties that can enable reductions in the level of surfactant required to achieve adequate substrate wetting. Lower levels of surfactants in a waterborne metal coating formulations can reduce water sensitivity and improve performance properties such as corrosion resistance.





IMPROVEMENTS TO FLASH RUST RESISTANCE

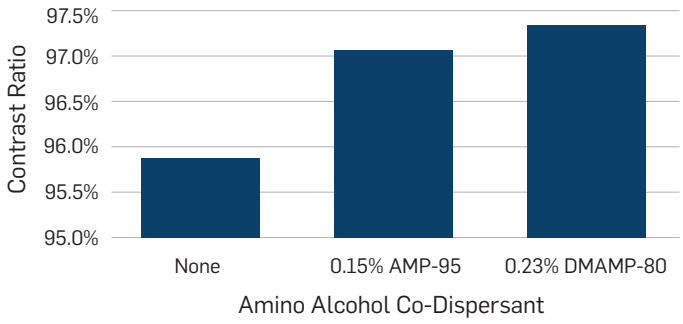
Even when used in the grind as a co-dispersant, amino alcohols can provide improvements to the flash rust resistance of the formulation. This benefit can be used to enhance the flash rust resistance of the coating or the flash rust inhibitor level can be reduced by 25% to match the flash rust resistance of the original formulation.

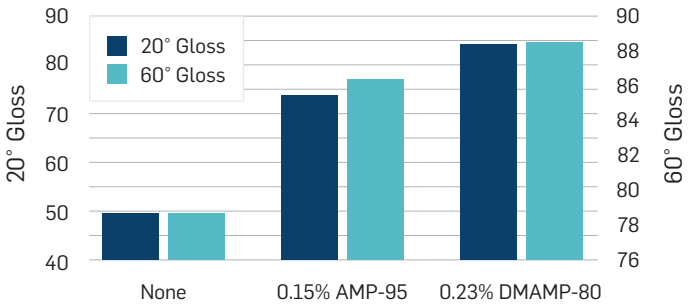


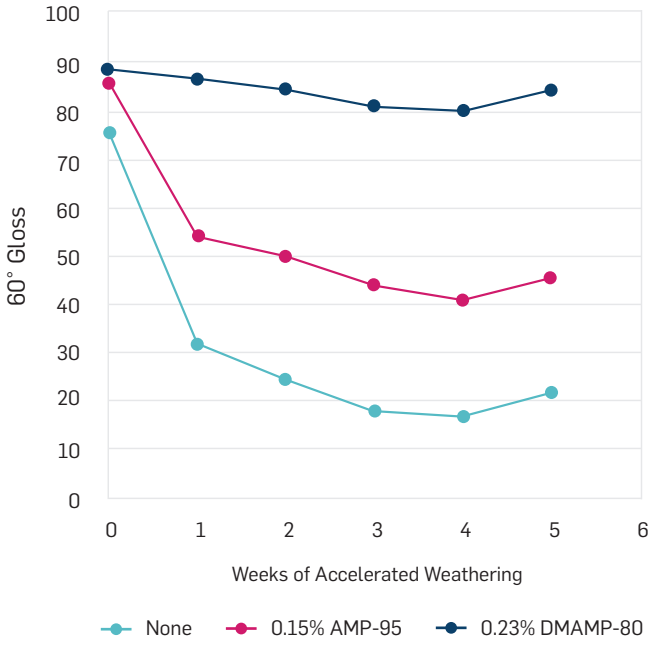
Flash rust resistance was measured by the degree of rust staining that occurred on samples cured at elevated humidity conditions. A ΔE was calculated between coatings cured on steel panels versus the same coatings cured on aluminum panels in a controlled temperature and humidity chamber set to 25°C and 90% relative humidity. Greater flash rust resistance is observed as a lower ΔE value (less rust staining). The formulation containing 0.1% AMP and a 30% reduction in primary dispersant consistently shows a lower ΔE value than the control, indicating greater resistance to flash rusting, or an equivalent flash rust resistance as the control paint at a 25% reduced level of sodium nitrite.

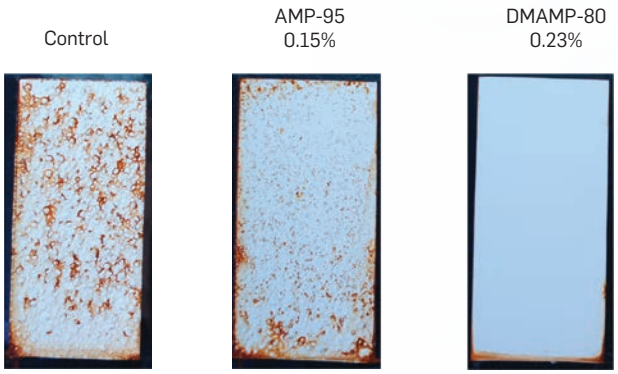
ADVANTAGES OF DMAMP-80 IN WATERBORNE INDUSTRIAL COATINGS

Some formulations may find that DMAMP-80 can provide a greater degree of formulation enhancement than AMP-95. The following results from a styrene acrylic DTM formulation highlight some of the potential benefits of using DMAMP-80 as a co-dispersant to improve contrast ratio, gloss, gloss retention, and corrosion resistance.









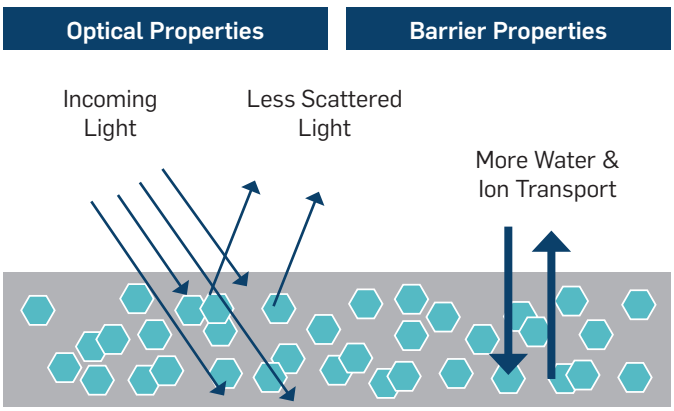
Paints were formulated with either 0.15% AMP-95 or 0.23% DMAMP-80 on total formulation weight as a replacement for 50% of the primary dispersant. In this formulation, DMAMP-80 has the following advantages:

- Enhanced gloss values
- Improved opacity
- Significantly improved gloss retention
- Significantly improved salt spray corrosion resistance

CONCLUSIONS

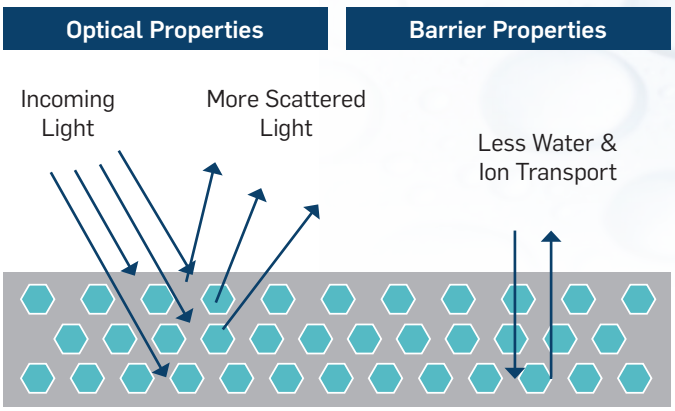
Many performance challenges faced by waterborne industrial coatings are related to barrier and optical properties, which are both critically dependent on having an optimized pigment dispersion. Amino alcohols are powerful formulating tools for achieving high-quality pigment dispersions through their strong interaction with pigment surfaces. Importantly, they also enable the removal of 30-50% of the primary dispersant. Other possible formulation optimizations include a 25% reduction in surfactant level and a 25% reduction in flash rust inhibitor level, due to the wetting and anti-corrosive properties of amino alcohols, respectively. Taken together, these changes can help reduce the total amount of water-sensitive materials in the formulation, thereby further enhancing coating performance. Amino alcohols like AMP-95 and DMAMP-80 are effective multifunctional formulating tools that can help formulators design waterborne industrial maintenance coatings that meet today's demanding performance expectations.

Without Amino Alcohols as Co-Dispersants



- Lower opacity
- Lower gloss
- Poor corrosion resistance
- Poor water resistance

With Amino Alcohols as Co-Dispersants



- Higher opacity
- Higher gloss
- Better corrosion resistance
- No loss of water resistance