NovoColor® SF – Transparent Water-Borne Pigment Dispersions

Jacob S. Donlon[1], *Mark W. Ellsworth, Sarah M. Arcella, Patricia L. Olofsson-Elkow*

Color Corporation of America

[1]jdonlon@ccofa.com

Abstract

NovoColor® SF transparent pigment dispersions are specifically formulated and manufactured to provide transparent, vibrant, and durable colors in water-borne wood stains, metal coatings, and glass coatings. As retail and commercial paint and coatings suppliers have shifted from solvent-based systems to water-borne and water reducible systems, there is a growing need for water-borne, transparent tinting options. For transparent water-borne coatings, the choice in tinting is either to use conventional water-borne pigment dispersions, or water/alcohol soluble metal complex dyes. Through a series of benchmark tests, we have shown that NovoColor® SF transparent pigment dispersions provide important performance improvements such as a high degree of transparency versus conventional water-borne pigment dispersions, and superior lightfastness and durability compared to water/alcohol soluble metal complex dyes.

Introduction

Transparent wood stains, metal coatings, and glass coatings are commonly formulated with high performance polymeric resins such as urethanes and alkyds that are only soluble in polar and non-polar solvents. Tinting of these coating systems while maintaining transparency is achieved by using solvent soluble metal complex dyes. In general, metal complex solvent dyes provide high transparency and durability to compliment the durability of the resin systems. Recent advances in functionalized acrylic and urethane resins have resulted in latex emulsion formulations for wood stains, metal coatings, and glass coatings with gloss and durability that rival the high performance of the solvent soluble resin coating formulations. Water-borne color concentrates are needed to tint these new high-performance latex emulsions. The desire for transparent water-borne coatings, such as wood stains, typically make the formulator choose between using small amounts of conventional high-opacity, water-borne colorants, or water/alcohol soluble metal complex dyes.

Water-borne pigment dispersions, or colorants, typically used in architectural paint and coatings have traditionally been formulated for a high degree of opacity and durability. For the majority of architectural paint applications high opacity is a crucial functional element to minimize number of coats and cover surface defects once applied. Several structural and processing variables can impact the opacity and transparency of pigments. Typically, the larger the particle size, the higher the degree of opacity. In addition to the particle size, the refractive index of the pigment impacts opacity, where typically dense inorganic metals, such as TiO_2 have good hiding power. Colorants formulated with these large particle size, highly refractive pigments, typically have good opacity and work well in traditional architectural paint applications. Pigments in general have excellent lightfastness and durability, and there are specific pigment chemistries, such as the metal oxide pigments, that have the greatest lightfastness and durability. In this paper, we demonstrate that the manufacturing process plays a critical role in producing transparent pigment dispersions. High speed dispersers and media milling are used to provide mechanical energy to break apart the pigment clusters, aggregates, and agglomerates, reducing the particle size. This reduction in particle size increases the surface area of the pigment increasing tinting strength and increasing transparency. We also demonstrate that the transparent pigment dispersions show lightfastness and durability similar to conventional pigment dispersions.

Dyes provide a superior degree of transparency compared to high-opacity pigments used in colorants. As mentioned above, smaller particle size equals greater transparency. Dye solutions are typically very small particle size, and more typically, dyes are solubilized to the molecular level, which further increases transparency. Water/alcohol soluble metal complex dyes are typically not as durable or lightfast as pigment dispersions and metal complex solvent dyes. In order to make them water soluble, these dyes are synthesized with additional carboxylate, amino and or sulfonate groups which improve water solubility, but also reduce lightfastness. Comparisons of transparency and durability of NovoColor® SF transparent pigment dispersions versus water/alcohol soluble dyes are provided in this paper to demonstrate the overall benefit of using NovoColor® SF transparent pigment dispersions in transparent coating applications.

Systematic Study of Pigment Dispersions

Experimental

CCA NovoColor® SF 8100 transparent colorants (Figure 1) were compared to CCA NovoColor® HP II 8600 water-only colorants (Figure 2) for transparency. Samples of a commercially available latex clear base were tinted at equal pigment weight percent using CCA NovoColor® SF 8100 transparent colorants and CCA NovoColor® HP II 8600 water-only colorants. Tinted samples were mixed on a Hauschild SpeedMixer™ DAC 600.1 FVZ for 1 minute at 1800 rpms. Using a 3-mil bird type film applicator, drawdowns were made over BYK opacity charts and allowed to dry at room temperature. Contrast ratio was measured using an X-Rite ColorEye 7000A spectrophotometer.

CCA

NovoColor® SF

Transparent Pigment Dispersions

Technical Data Sheet

				Typical Properties				
PRODUCT NUMBER	MASS TONE	COLORANT NAME	CI PIGMENT NAME	DENSITY LB/GAL	DENSITY g/cc	% PRIME PIGMENT BY WT.	% TOTAL SOLIDS BY WT.	% WATER BY WEIGHT
8100		White	PW6	16.7	2.0	66.2%	76.9%	23.1%
8113		Organic Yellow	PY13	9.4	1.1	35.0%	46.8%	53.2%
8114		Medium Yellow	PY83	9.3	1.1	34.9%	45.6%	54.4%
8115		Golden Yellow	PY110	10.2	1.2	36.4%	53.4%	46.6%
8122		Phthalo Green	PG7	10.2	1.2	32.0%	50.8%	49.2%
8132		Phthalo Blue	PB15:3	9.8	1.2	34.0%	50.7%	49.3%
8138		Trans Oxide Red	PR101	11.2	1.3	30.6%	40.3%	59.7%
8140		Carbazole Violet	PV23	9.6	1.2	34.0%	49.7%	50.3%
8142		Organic Red	PR166	9.7	1.2	40.0%	52.8%	47.3%
8144		Rubine Red	PR184	9.7	1.2	35.0%	54.7%	45.3%
8146		DPP Red	PR254	9.3	1.1	25.0%	46.5%	53.5%
8149		Magenta	PR122	9.0	1.1	20.0%	31.3%	68.7%
8170		Trans Oxide Yellow	PY42	12.0	1.4	39.7%	50.2%	49.9%
8188		Brown	PBR25	9.3	1.1	25.0%	44.2%	58.0%
8194		Carbon Black	PBK7	9.9	1.2	30.7%	49.5%	50.5%

The data on this sheet represent typical values. Since application variables are a major factor in product performance, this information should serve only as a general guide. CCA assumes no obligation or liability for use of this information. UNLESS CCA AGREES OTHERWISE IN WRITING, **CCA MAKES NO WARRANTIES, EXPRESS OR IMPLIED, AND DISCLAIMS ALL IMPLIED WARRANTIES INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE OR FREEDOM FROM PATENT INFRINGEMENT. CCA WILL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES**. Your only remedy for any defect in this product is the replacement of the defective product, or a refund of its purchase price, at our option.

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Figure 1: CCA NovoColor® SF 8100 Technical Data Sheet

NovoColor® HP II

Low VOC Water-Only Colorant

Technical Data Sheet

PRODUCT NUMBER	MASS-TONE	TINT	PRODUCT CODE	COLORANT NAME	CI PIGMENT NAME	TYPICAL PROPERTIES: DENSITY lbs/gal	DENSITY g/cc	% PRIME PIGMENT BY WT.	% INERT PIGMENT BY WT.	% TOTAL SOLIDS BY WT.	Theoretical VOC (g/L)	% WATER BY WEIGHT
8600N			KX	White	PW 6	16.9	2.0	56.4	9.4	73.8	0.0	26.2
8613N			AX	Yellow	Blend	10.7	1.3	24.7	7.7	42.1	0.0	57.8
8614N			T	Medium Yellow	Blend	10.0	1.2	20.5	13.0	44.2	0.0	55.8
8621N			DU	Phthalo Green	PG 7	11.2	1.3	13.6	27.0	52.6	0.0	47.5
8632N			EU	Phthalo Blue	PB 15:2	10.5	1.3	9.6	26.3	46.9	0.0	53.1
8635N			F	Red Oxide	Blend	17.0	2.0	60.8	3.1	73.0	0.0	27.0
8647N			R	Red	Blend	11.6	1.4	10.9	32.1	51.5	0.0	48.5
8649N			V	Magenta	PR 122	10.5	1.3	12.2	24.7	49.5	0.0	50.5
8651N			RU	High Hide Red	Blend	12.3	1.5	20.7	31.4	64.7	0.0	35.3
8678N			C	Yellow Oxide	PY 42	14.7	1.8	54.2	1.6	67.2	0.0	32.8
8688N			L	Raw Umber	PB 7	11.3	1.4	21.9	13.7	52.7	0.0	47.3
8691N			B	Lamp Black	PBk 7	11.5	1.4	8.1	29.7	46.2	0.0	53.8
8697N			I	Brown Oxide	Blend	13.0	1.6	37.0	9.1	55.2	0.0	44.8

Figure 2: CCA NovoColor® HP II 8600 Technical Data Sheet

CCA NovoColor® SF 8100 transparent colorants (Figure 1) were compared to CCA NovoColor® HP II 8600 water-only colorants (Figure 2) for particle size distribution. Particle size was measured using a Malvern Panalytical Mastersizer 3000 instrument. The lower detection limit for this laser diffraction instrument is 20 nm. Particle size results for these samples are an average of at least five measurements each of at least four samples. Samples were prepared by dispersing approximately four drops of pigment dispersion in 10 ml of water. The samples were mixed for 10 seconds using a vortex mixer. The measurements were performed in water using the color appropriate settings and conditions while adjusting the instrument settings color source refractive index and absorption appropriately.

For the generic red analysis, instrument settings include a red source refractive index of 2.522, 0.01 and a blue source refractive index of 2.522, 0.01, general purpose model for irregular particles. For the generic organic yellow analysis, instrument settings include a red source refractive index of 1.600, 0.01 and a blue source refractive index of 1.600, 0.01, general purpose model for irregular particles. For the phthalo green analysis, instrument settings include a red source refractive index of 1.400, 0.1 and a blue source refractive index of 1.400, 0.1, general purpose model for irregular particles. For the yellow iron oxide analysis, instrument settings include a red source refractive index of 2.350, 0.00 and a blue source refractive index of 2.350, 0.00, general purpose model for irregular particles.

Lightfastness and durability of CCA NovoColor® SF 8113 Organic Yellow, CCA NovoColor® SF 8114 Medium Yellow, and CCA NovoColor® SF 8115 Golden Yellow were compared for lightfastness and durability using a Q-Lab QUV® Accelerated Weathering Tester. Each sample of liquid colorant was used to tint a commercially available deck stain at 6 fluid ounce per gallon. These tinted stains were then brushed in duplicate onto birch veneer QUV® panels and prepared for exposure. Exposure conditions were set to cycle 8 hours UVA-340nm at 60°C with 4 hours condensation at 50°C. Panels were observed at 500-hour increments of exposure through to 2000 hours total.

Following the same exposure conditions, CCA NovoColor® HP 8920 Phthalo Green and CCA NovoColor® SF 8122 Phthalo Green were tested in duplicate in various test bases for gloss and color retention. Test bases were tinted at the maximum recommended tint level and applied to an appropriate substrate before allowing to air dry for one week. For the latex emulsion paints, double coats using a 4-mil bird type film applicator and aluminum substrate Q-Panels were used. The stain panels were prepared following the same method previously mentioned. Gloss was measured at 20° and 60° both before exposure and after 1500 hours QUV exposure. CIELAB delta E was measured comparing the initial stored color readings as standard to the same panels after 1500 hours QUV exposure.

An additional comparison was performed following the same exposure conditions in a commercially available deck stain of CCA NovoColor® SF transparent colorants brown and black compared to commercially available colored dyes of the same color space.

Results and Discussion

Figures 3-7 show the comparative transparency of NovoColor® SF colorants compared to NovoColor® HP II colorants.

Figure 3: Transparency of organic yellow colorants. NovoColor® HP II (left) NovoColor® SF (right)

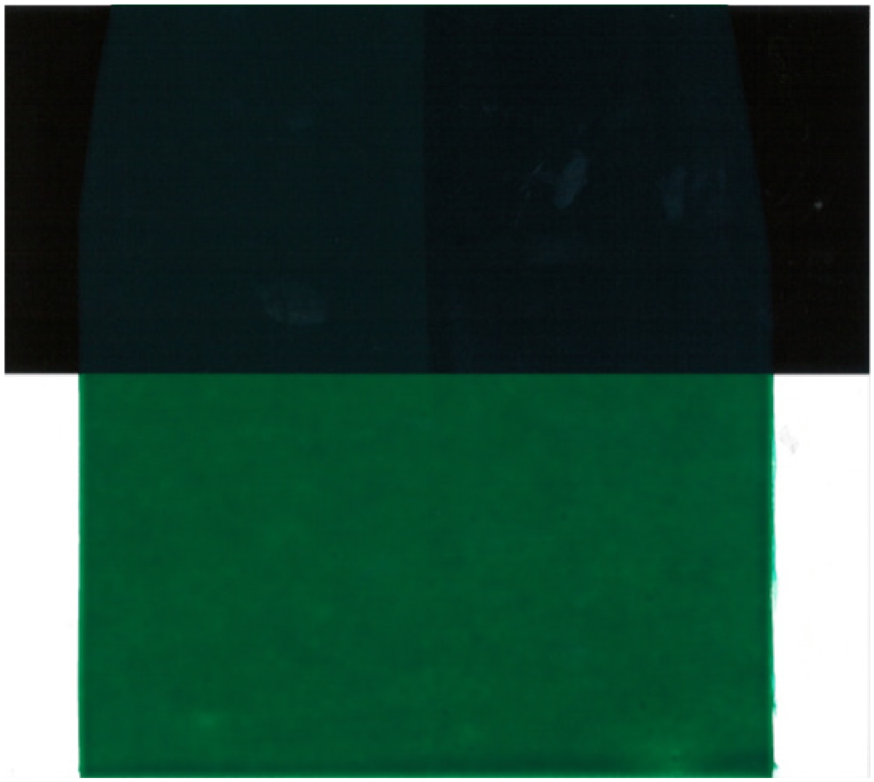

Figure 4: Transparency of phthalo green colorants. NovoColor® HP II (left) NovoColor® SF (right)

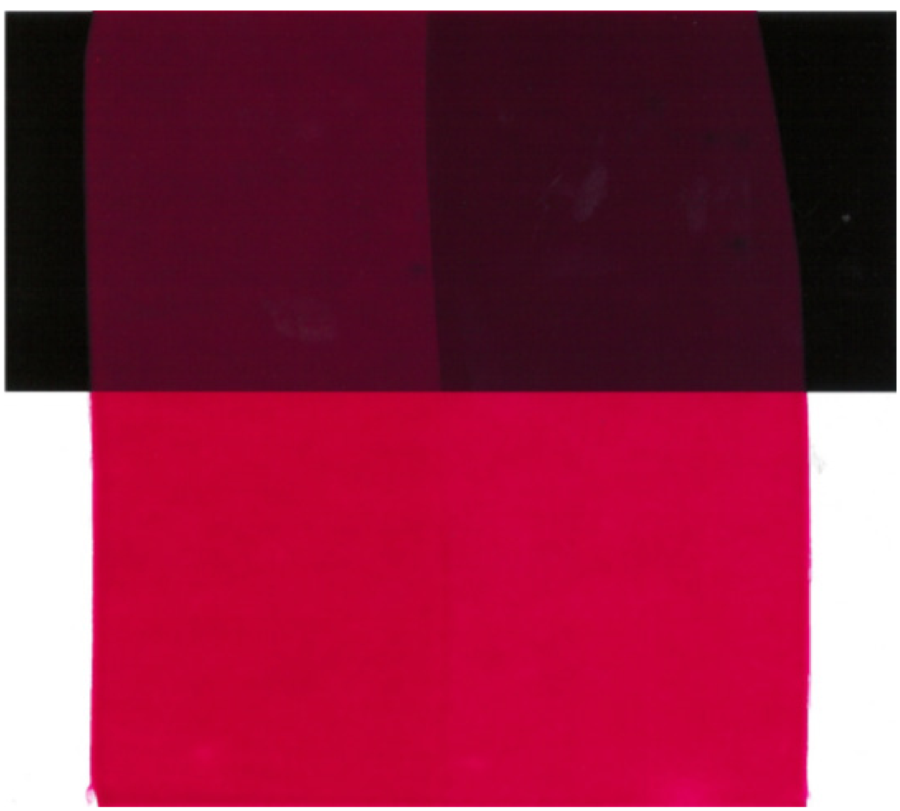

Figure 5: Transparency of magenta colorants. NovoColor® HP II (left) NovoColor® SF (right)

Figure 6: Transparency of red colorants. NovoColor® HP II (left) NovoColor® SF (right)

Figure 7: Transparency of yellow iron oxide colorants. NovoColor® HP II (left) NovoColor® SF (right)

Contrast ratio comparisons of CCA NovoColor® SF 8100 transparent colorants and CCA NovoColor® HP II 8600 water-only colorants are shown in Figure 8. Contrast ratio is calculated by taking the Y-tristimulus value of a coating over black substrate divided by the Y-tristimulus value of the same coating over white substrate. The lower the % contrast ratio of a coating, the more transparent the film is.

Sample		**% Contrast Ratio**	**Delta**
Organic Yellow	NovoColor® HP II 8613N	56.70	-15.08%
	NovoColor® SF 8113	48.15	
Phthalo Green	NovoColor® HP II 8621N	43.67	-6.57%
	NovoColor® SF 8122	40.80	
Magenta	NovoColor® HP II 8649N	56.60	-16.08%
	NovoColor® SF 8149	47.50	
DPP Red	NovoColor® HP II 8651N	85.73	-39.04%
	NovoColor® SF 8146	52.26	
Yellow Oxide	NovoColor® HP II 8678N	87.52	-39.97%
	NovoColor® SF 8170	52.54	

Figure 8: Contrast Ratio of colorants

The results in Figure 9 show the particle size comparison of NovoColor® SF transparent colorant line compared to the NovoColor® HP II water-only colorant line. Review of the $D_v(90)$ values in the table, where 90% of the particles are finer than the listed size in micrometers shows a significant decrease in particle size in the NovoColor® SF colorants compared to NovoColor® HP II colorants. By employing special grade performance pigments in combination with optimized manufacturing techniques, we have reduced the $D_v(90)$ and mean particle size by an order of magnitude or more. This decrease in particle size provides excellent transparency for specialty applications.

	$D_v(10)$ 10% Finer Than, µm	$D_v(50)$ Median, 50% Finer Than, µm	$D_v(90)$ 90% Finer Than, µm	D[4,3] Volume Weighted Mean, µm	Peaks, µm **(Primary Peak Bolded)**
HP II 8613N AX Organic Yellow	0.023	0.078	0.43	0.408	**0.07**, 0.93, 2.94, 5.56
SF 8113 Organic Yellow	0.018	0.051	0.17	0.079	**0.04**
HP II 8621N Phthalo Green	0.290	1.03	6.46	2.42	**0.43,** 3.79
SF 8122 Phthalo Green	0.169	0.318	0.614	0.397	**0.34,** 1.55
HP II 8649N Magenta	0.943	3.77	9.27	4.54	0.16, **4.90**
SF 8149 Magenta	0.018	0.048	0.732	0.449	**0.04,** 0.43, 1.37, 8.16
HP II 8651N DPP Red	0.418	0.877	1.77	0.999	**0.97**
SF 8146 DPP Red	0.017	0.043	0.127	0.139	**0.04,** 1.55
HP II 8678N Yellow Oxide	0.159	0.273	1.01	0.456	**0.23,** 0.82
SF 8170 Trans Yellow Oxide	0.015	0.034	0.099	0.047	**0.03**

Figure 9: Particle size comparison

Particle size distribution curves (Figures 10-14) were prepared as a visual representation of the significant reduction in particle size of the NovoColor® SF colorants compared to NovoColor® HP II colorants.

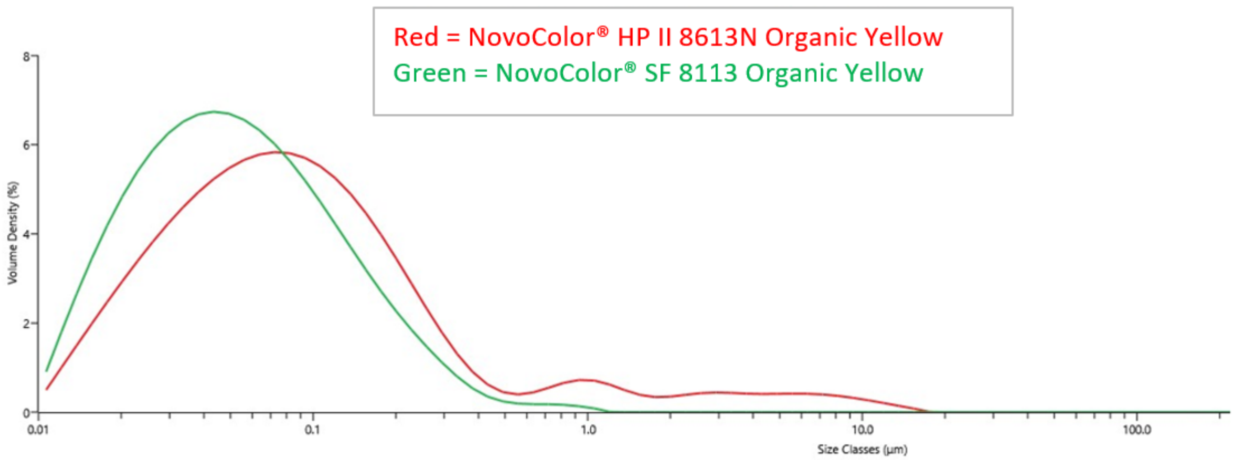

Figure 10: Particle size distribution of organic yellow colorants

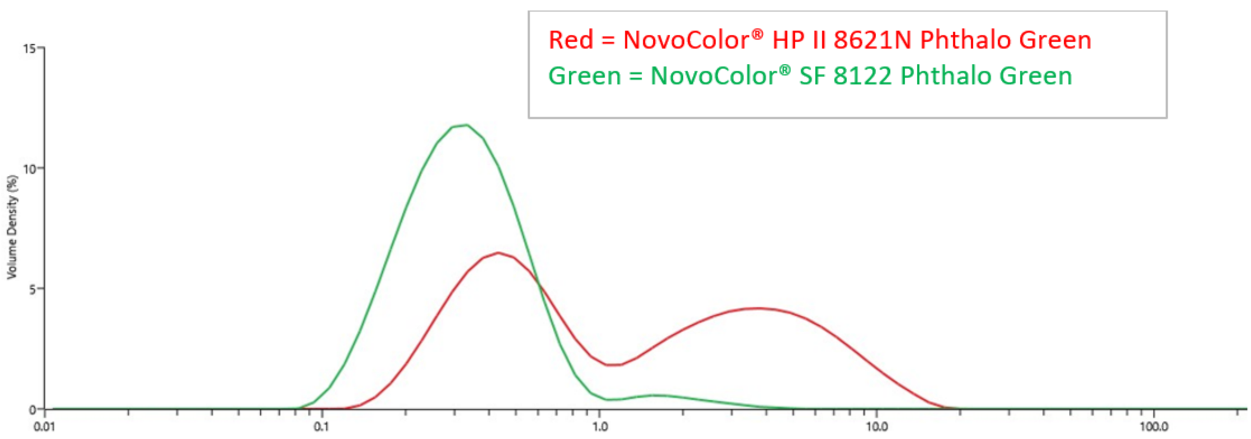

Figure 11: Particle size distribution of phthalo green colorants

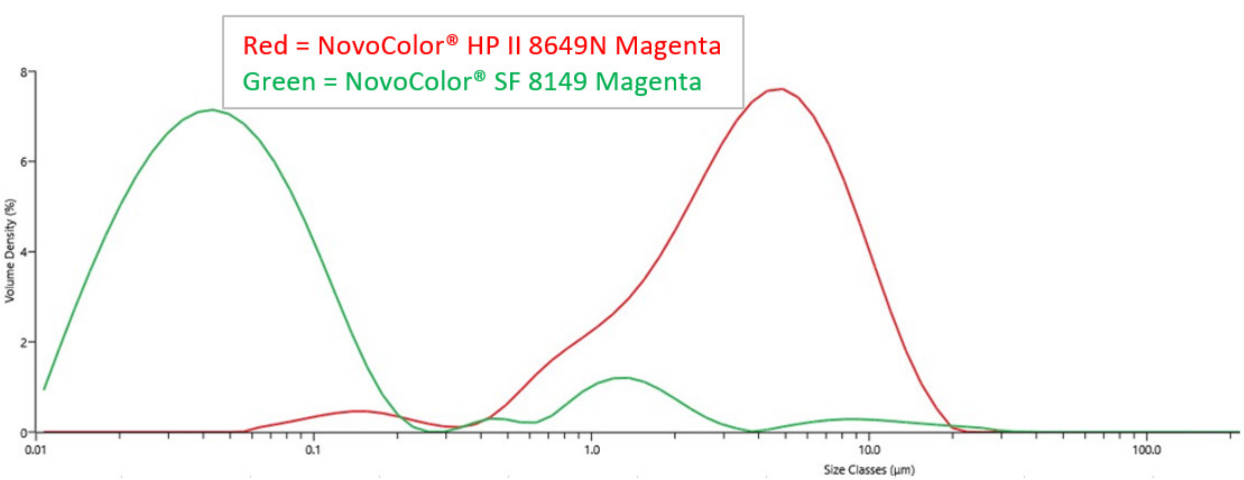

Figure 12: Particle size distribution of magenta colorants

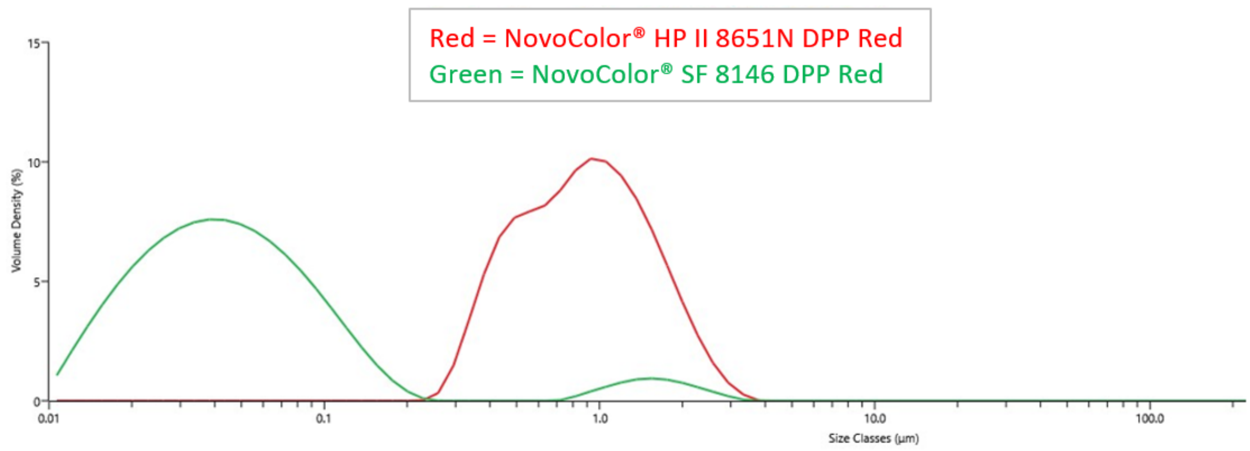

Figure 13: Particle size distribution of red colorants

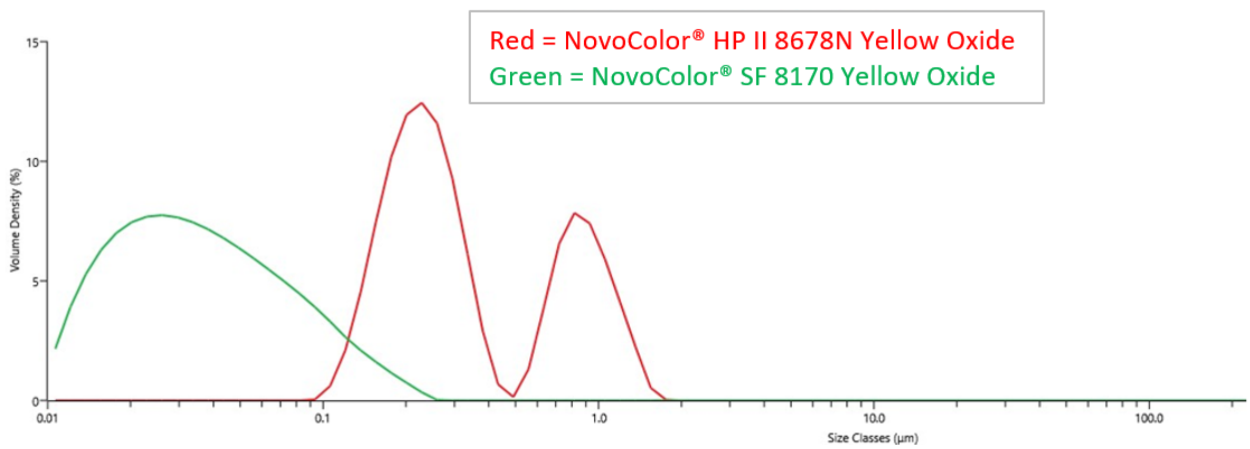

Figure 14: Particle size distribution of yellow iron oxide colorants

The smaller particle size of the NovoColor® SF colorants compared to NovoColor® HP II provides increased transparency for specialty applications.

The lightfastness and durability of CCA NovoColor® SF 8113 Organic Yellow, CCA NovoColor® SF 8114 Medium Yellow, and CCA NovoColor® SF 8115 Golden Yellow were compared and photographs taken following 2000 hours QUV® durability testing as can be observed in Figures 15 to 17. CCA NovoColor® SF 8113 Organic Yellow is based on a pigment yellow 13 diazo complex organic compound. CCA NovoColor® SF 8114 Medium Yellow is based on a pigment yellow 83, also a diazo complex organic compound, but with additional methoxy and halogen groups protecting the chromophore thus providing slightly better durability. CCA NovoColor® SF 8115 Golden Yellow is based on a pigment yellow 110 isoindolinone complex organic compound, with many halogen groups on the molecule protecting the chromophore providing the best durability.

Figure 15: NovoColor® SF 8113 organic yellow unexposed (left) compared to 2000-hour QUV® exposure (right)

Figure 16: NovoColor® SF 8114 medium yellow unexposed (left) compared to 2000-hour QUV® exposure (right)

Figure 17: NovoColor® SF 8115 golden yellow unexposed (left) compared to 2000-hour QUV® exposure (right)

The gloss and color retention of CCA NovoColor® HP 8920 Phthalo Green and CCA NovoColor® SF 8122 Phthalo Green were tested in various test bases. The average measurements of duplicate panels are reported in Figure 18 following 1500 hours QUV® durability testing. Across a range of commercially available test bases, CCA NovoColor® SF maintains similar gloss and color retention compared to the conventional CCA NovoColor® HP platform. No negative impact on performance was observed.

QUV	**NovoColor® HP 8920**				
	Initial		**1500 hrs**		
Base	**20°**	**60°**	**20°**	**60°**	**CIE-dE**
Commercially Available Exterior Satin Pastel	2.6	18.3	1.1	6.3	2.77
Commercially Available Exterior Satin Clear	1.8	13.4	0.5	5.1	0.48
Commercially Available Exterior S/G Tint	33.0	64.5	29.2	64.0	0.47
Commercially Available Exterior S/G Midtone	23.1	57.8	13.7	49.4	1.02
Commercially Available Exterior Gloss Deep	20.3	54.5	8.1	37.9	1.89
Commercially Available Deck Stain	0.9	7.3	0.5	4.1	20.46

QUV	**NovoColor® SF 8122**				
	Initial		**1500 hrs**		
Base	**20°**	**60°**	**20°**	**60°**	**CIE-dE**
Commercially Available Exterior Satin Pastel	2.7	18.5	1.1	6.4	3.12
Commercially Available Exterior Satin Clear	2.3	16.0	0.6	6.4	0.22
Commercially Available Exterior S/G Tint	37.4	67.9	28.1	65.7	0.08
Commercially Available Exterior S/G Midtone	36.1	66.9	22.8	60.7	0.83
Commercially Available Exterior Gloss Deep	27.2	58.2	17.0	49.3	1.78
Commercially Available Deck Stain	1.4	9.9	0.7	5.6	27.23

Figure 18: NovoColor® HP 8920 compared to NovoColor® SF 8122 gloss and color retention.

Following 2000 hours QUV® durability testing, photographs were taken showing the performance of NovoColor® SF brown and black colorants to commercially available colored dyes. The top section of each panel was covered during exposure to simulate an unexposed area. As can be gleaned from Figures 19 and 20 the NovoColor® SF colorants show much better lightfastness and durability, in terms of resistance to UV degradation compared to commercially available colored dyes. This durability improvement using the NovoColor® SF colorants is an important feature that should be kept in mind when formulating water-borne stain technology for exterior applications.

Figure 19: 2000-hour QUV® exposure brown (left) compared to colored dye (right)

Figure 20: 2000-hour QUV® exposure black (left) compared to colored dye (right)

An important takeaway from this evaluation is the benefits the NovoColor® SF colorants have in terms of being highly transparent while also maintaining high lightfastness and durability. NovoColor® SF colorants provide a broad range of color space while offering both interior and exterior grade pigments so formulators can choose the best combination of colorants for their specific application. This research provides direction for paint and coatings professionals who are developing the next generation of water-borne transparent coatings systems for wood stains and other specialty applications like glass and metal.