Improving Manufacture Efficiency through the use of Waterbased UV Curable Polyurethanes in Wood Coatings

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WHAT CHALLENGES DO MANUFACTURERS WHO APPLY COATINGS FACE?

DOES MEETING A PERFORMANCE SPECIFICATION MEET THESE CHALLENGES?

HOW CAN RESIN AND COATINGS SUPPLIERS ADDRESS THE CHALLENGES OF THE END USER?

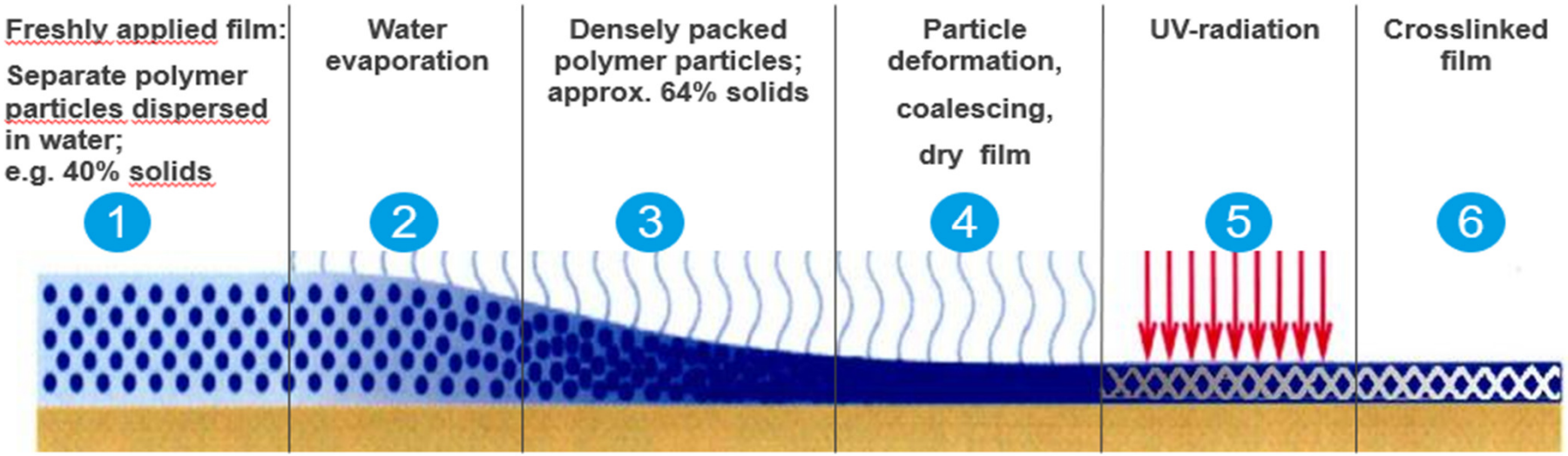
Slow water releasing coatings **impact** manufacturing **efficiency**

"Manufactures of joinery and cabinetry are seeking improvements in factory efficiency."

"Manufacturers want the ability to expand production on shorter production lines with less rework damage due to the coatings with slow water releasing properties. "

Coating attributes	End user benefits
Fast water release	Shorter/faster drying lines
Improved blocking resistance	Faster damage free packing and stacking
Improved coating stability	Simplifies supply chains/prevents waste
Improved coating properties	Better competitive positioning
Lower VOC	Improved carbon footprint /regulatory compliance
Low Viscosity	Better spray properties
Recyclability	Lower coating cost/waste and carbon footprint

For a UV curable waterbased coating, most of the manufacturing line is **dedicated** to **removing water**



- Typically >= 140°F for up to 8 minutes on the line
- Cannot apply > 4-5 wet mils
- Up to 10 minutes off the line to achieve blocking and chemical resistance

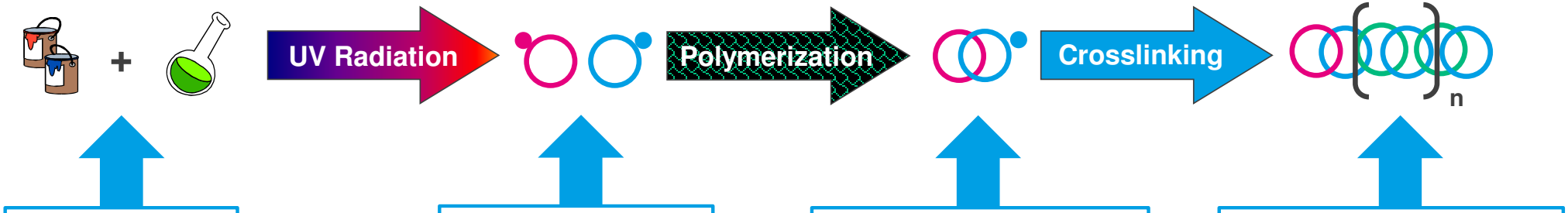
Based on what we heard from these manufacturers, a **new** set of **ideal state performance targets** were developed

Property	WB Current State	Ideal State Performance
Chemical Resistance	Pass KCMA	Pass KCMA
Stability	4 wks. 40°C	**6 wks. 50°C**
Steel Wool Test	<10% gloss red.	<10% gloss red.
Water/Flash Bake (5 mils)	5-10 min	**2 min**
Block Resistance w/ Flash/Bake	8-10 min	**3 min**
VOC	200g/L	**50g/L**

New performance criteria associated with **improved** factory **efficiency**

Waterbased drying **speed** like that **of solvent** based coatings

UV curing is photoinduced free radical polymerization producing a crosslinked coating



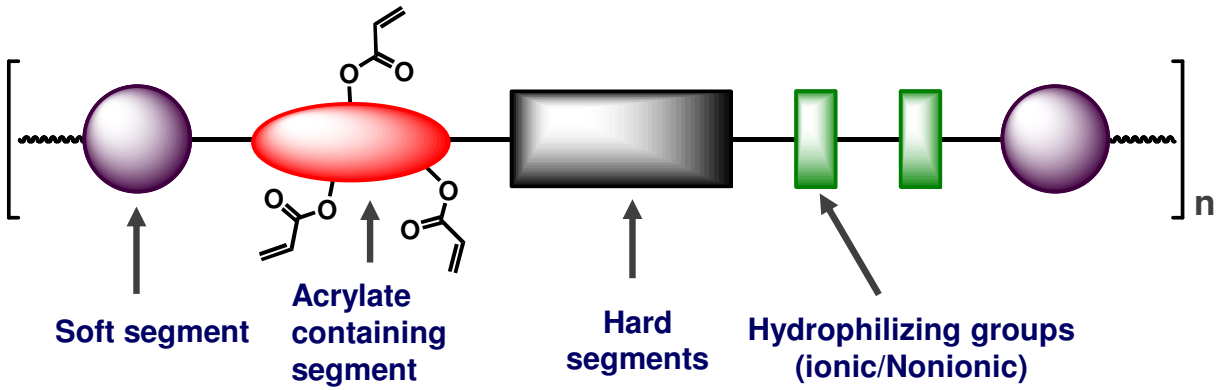
Acrylate polymers and photo initiators are mixed

UV-light activates the photoinitiator, which cleaves and generates free radicals

Radical attacks a double bond and a new bond is formed. On the other end of the attacked double bond, a new radical is formed.

Crosslinking occurs when more than one double bond per molecule is present making a three dimensional network

A similar process can be carried out using a **polyurethane dispersion** containing **photopolymerizable** acrylate groups



Choice of **building blocks** and **architecture** will greatly affect a polyurethane dispersion's physical, coalescing and curing attributes

- Aliphatic isocyanate hard segments
- Amine and diol chain extenders
- Ester based soft segments
- Ionic and nonionic hydrophilization
- Hydroxy functional acrylate monomers, esters, ethers or epoxies

Team set out to create a resin to **minimize drying time** and to **prevent blocking** while maintaining other performance properties

Accelerated Process

PUD properties

Resin Property	Standard #1	Standard #2	PUD# 65215A
pH	7.5	7.5	7.0-8.5
Viscosity@ 25°C	<500 cps	<500cps	<500 cps
% Solids in water	40%	40%	40%

Protocols for study – WB UV PUD's

Formulation

- 3 coating types – High Gloss, Low Gloss and Pigmented
- Photoinitiator for High/Low Gloss Clear/Irgacure 500
- Photoinitiator for pigmented/Irgracure 500/ Darocur 4265
- 3% co-solvent level

Application – Drawdown at 3 thickness levels

Substrate – MDF precoated w/black basecoat

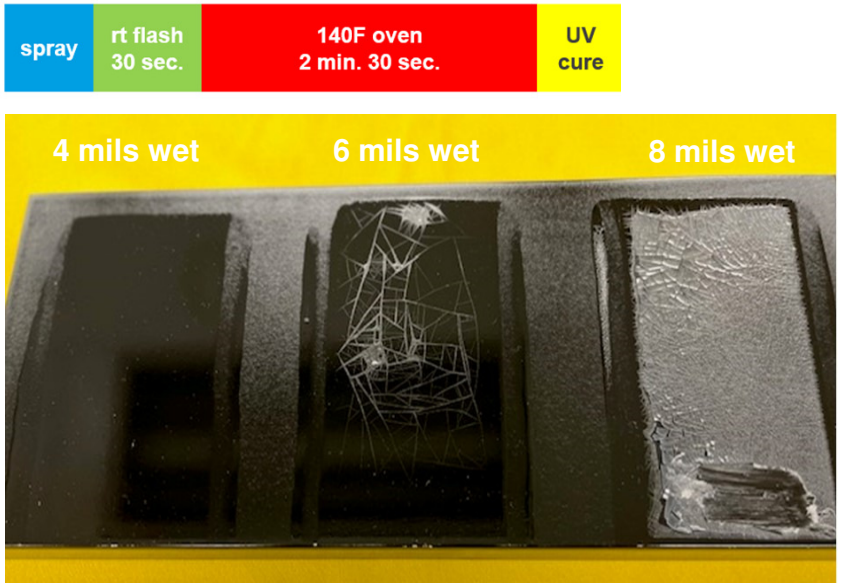
Drying – Lab oven w/ circulating air set to 140°F

- **UV Cure -** UV Cure ≈ 800 millijoules/cm^2
  - Clear coatings used Hg lamp
  - Pigmented coatings used Hg/Ga combination lamp

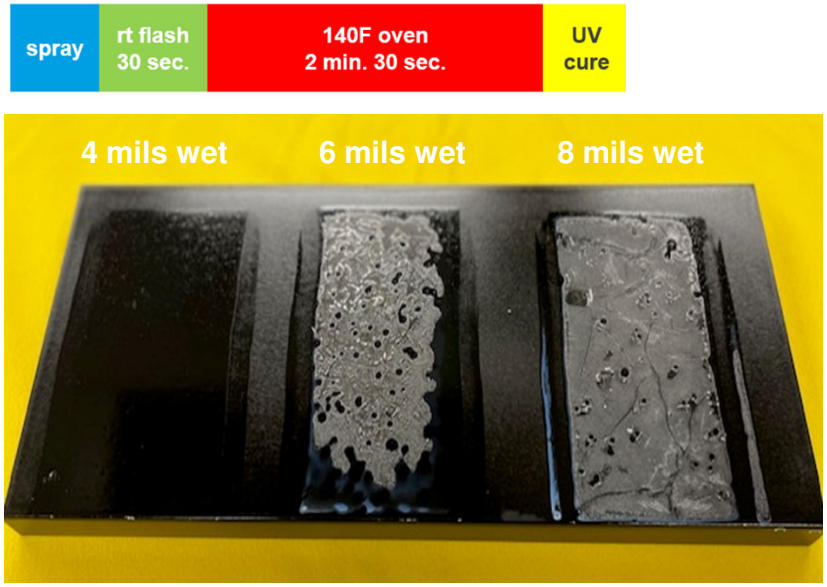
Post Cure – 1 minute cool

High Gloss Clear formulations using **Standard Resins** #1 and #2 **failed at >4 mils** wet film thickness after drying and UV cure

#1

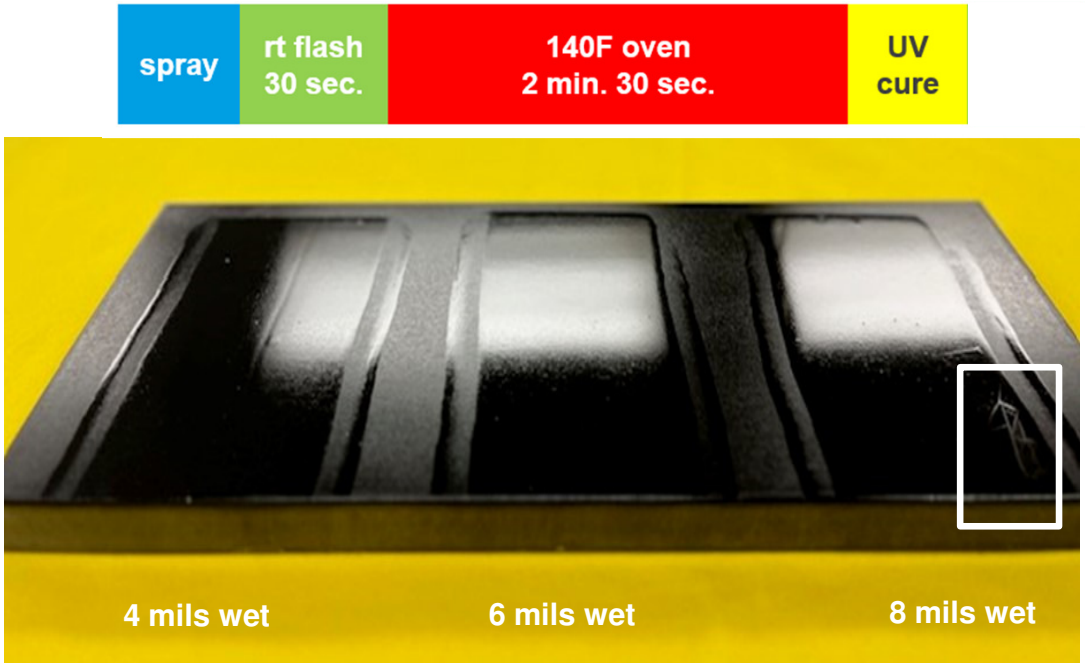


#2



- Standard #1 and #2 both exhibited poor water release at > 4 wet mils
- Trapped water caused cracking at 6 wet mils wet and greater

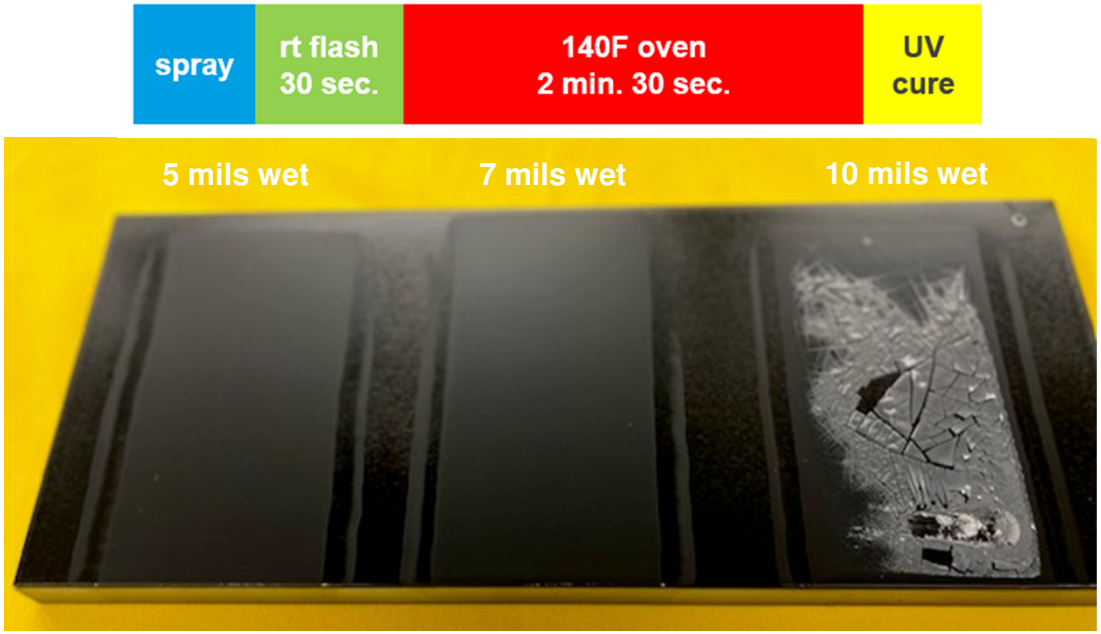
High Gloss Clear formulation using **WB UV PUD #65215A passed at 6-8 mils wet** after drying and UV cure



Minor Cracking

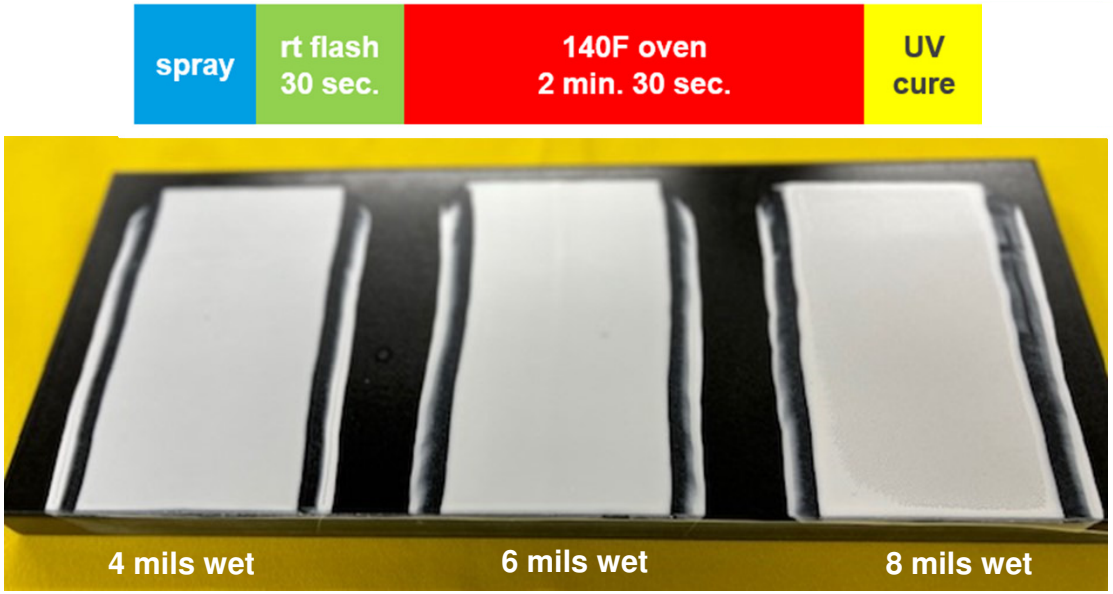
- PUD #65215A exhibited acceptable water release up to 8 mils wet
- No trapped water observed
- Minor cracking observed on the lower edge at 8 mils wet

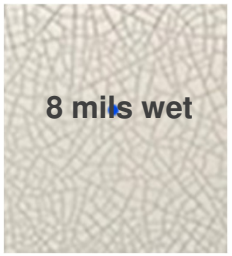
Low Gloss Clear formulation using **WB UV PUD #65215A passed at 7-10 mils wet** after drying and UV cure



- PUD #65215A exhibited acceptable water release observed up to 7 mils wet
- No trapped water observed at 7 mils wet
- Poor water release observed at 10 mils wet

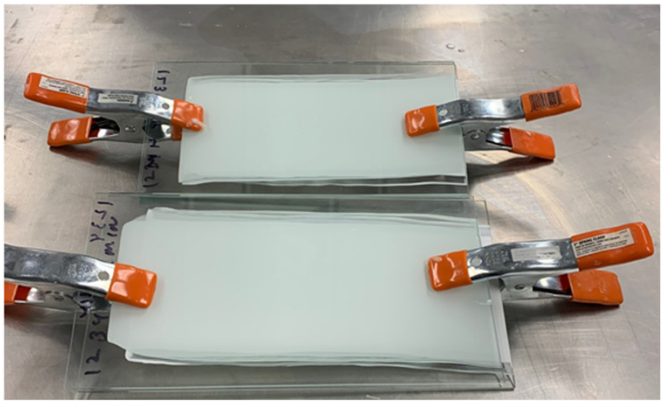
Low Gloss Pigmented formulation using **WB UV PUD #65215A passed at 6 mils wet** after drying and UV cure





- PUD #65215A exhibited acceptable water release observed up to 6 mils wet
- No trapped water observed at 6 mils wet
- Poor water release observed at 8 mils wet

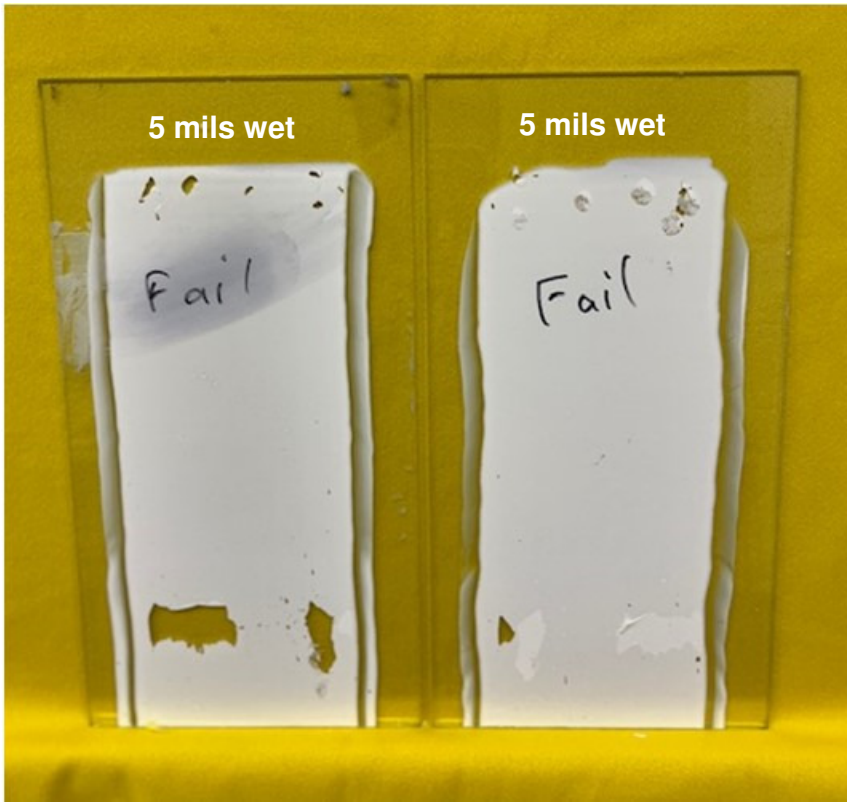
Pigmented low gloss formulation using **Standard #1 failed blocking resistance** test at 5 mils wet



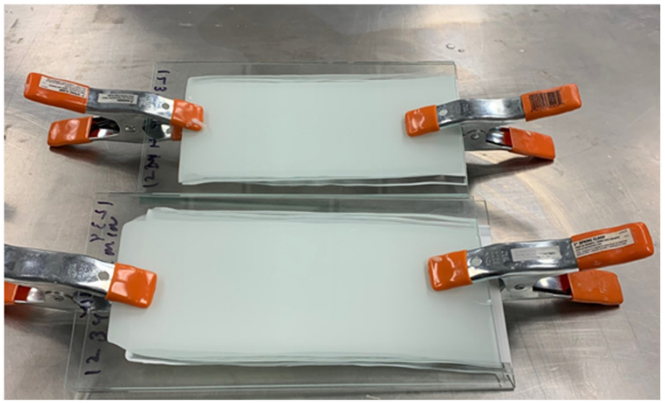
3 minutes water flash/bake + 1 minute cool

Immediately after 1-minute cool step

- Coated sides clamped face to face
- Maintained at room temperature for 24 hrs
- Separated and noted coating damage



Pigmented low gloss formulation using **WB UV PUD #65215A passed blocking resistance** test at 5 mils wet

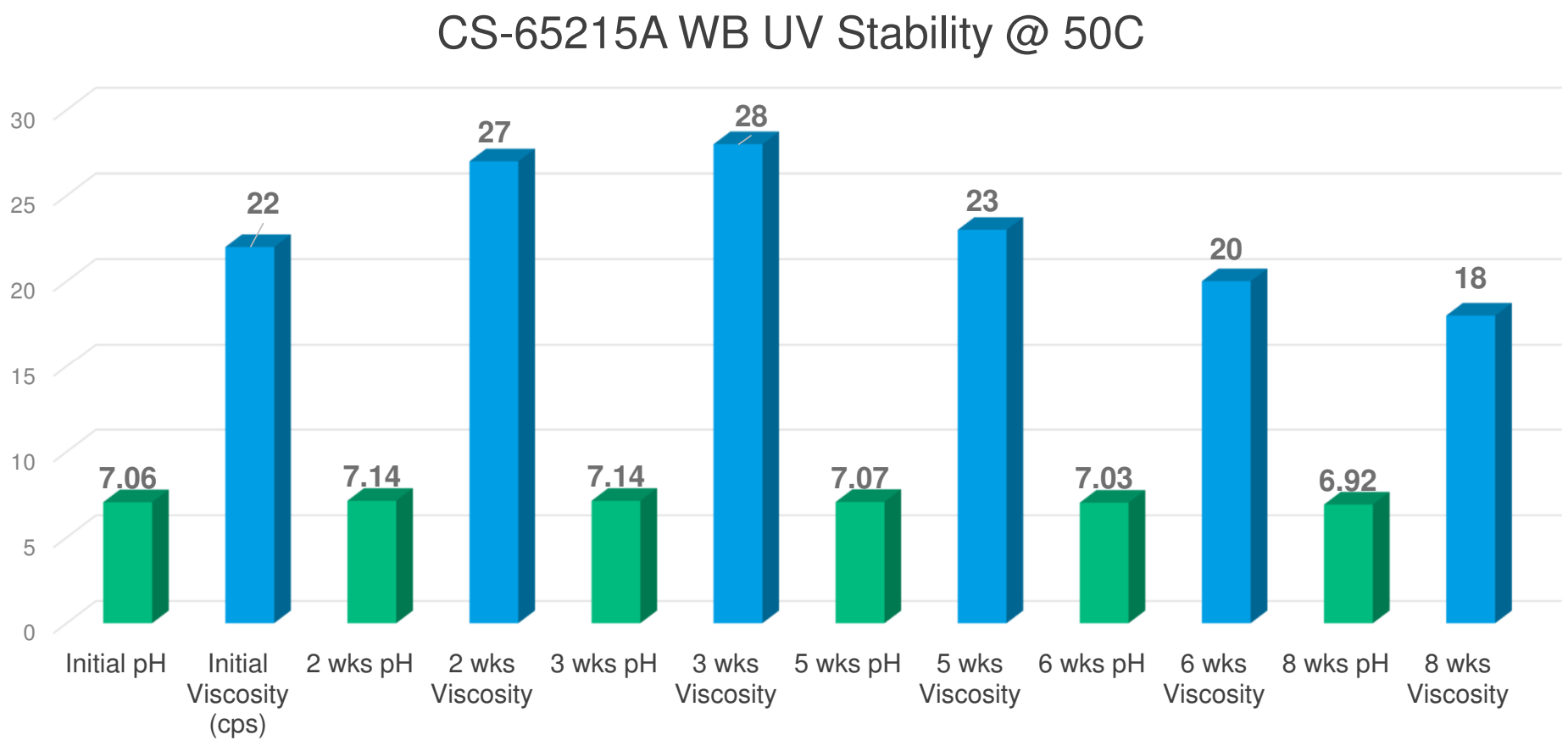


Immediately after 1-minute cool step

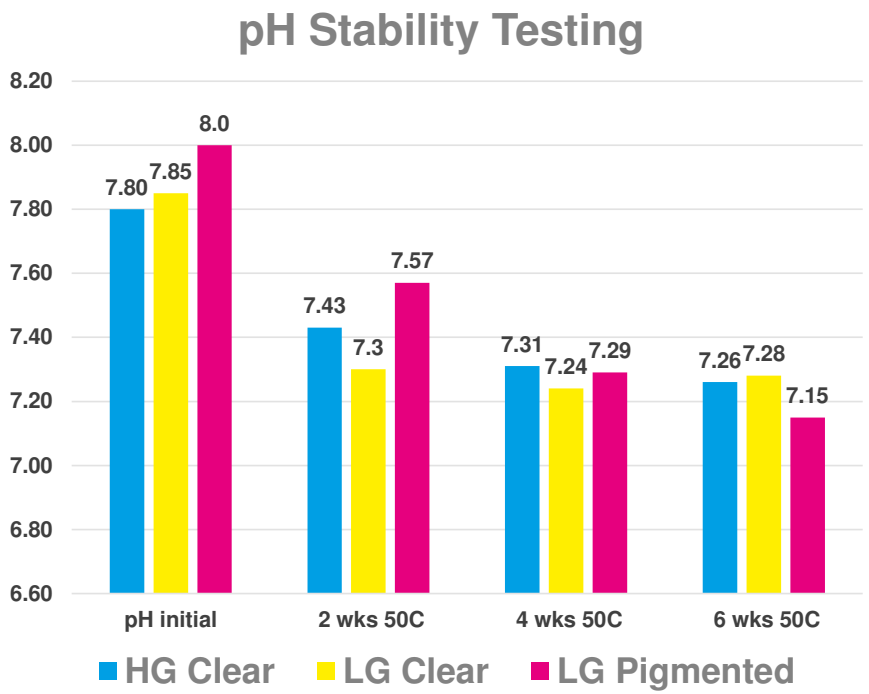
- Coated sides clamped face to face
- Maintained at room temperature for 24 hrs
- Separated and noted coating damage

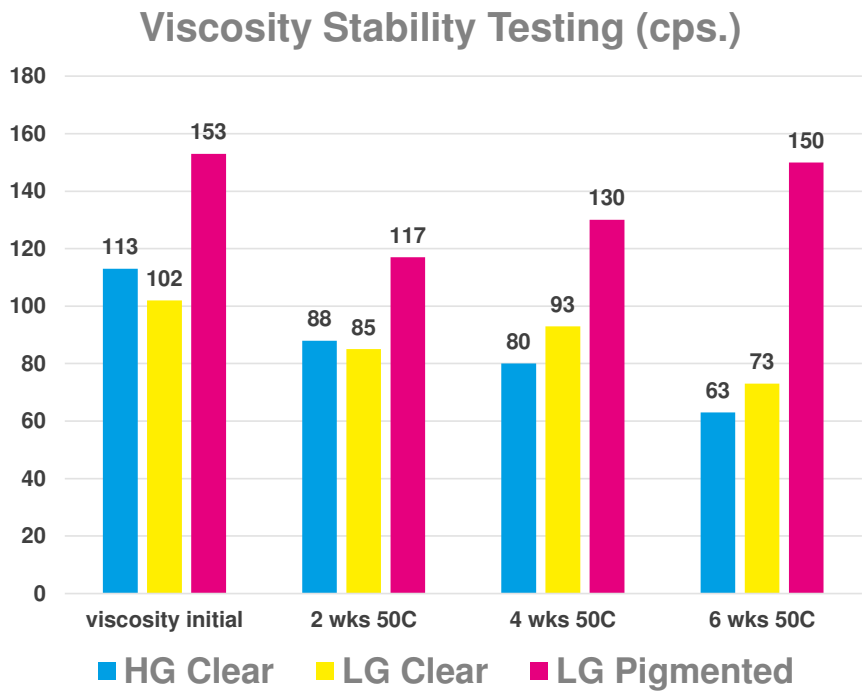
***65215A/Neocryl XK-12 pig. (1/1) also passes 4 min block test**

WB UV PUD #65125A remains **stable after** a more aggressive **8 weeks @ 50°C**



Formulated coatings using WB UV PUD #65125A remains **stable after 6 weeks @ 50°C**





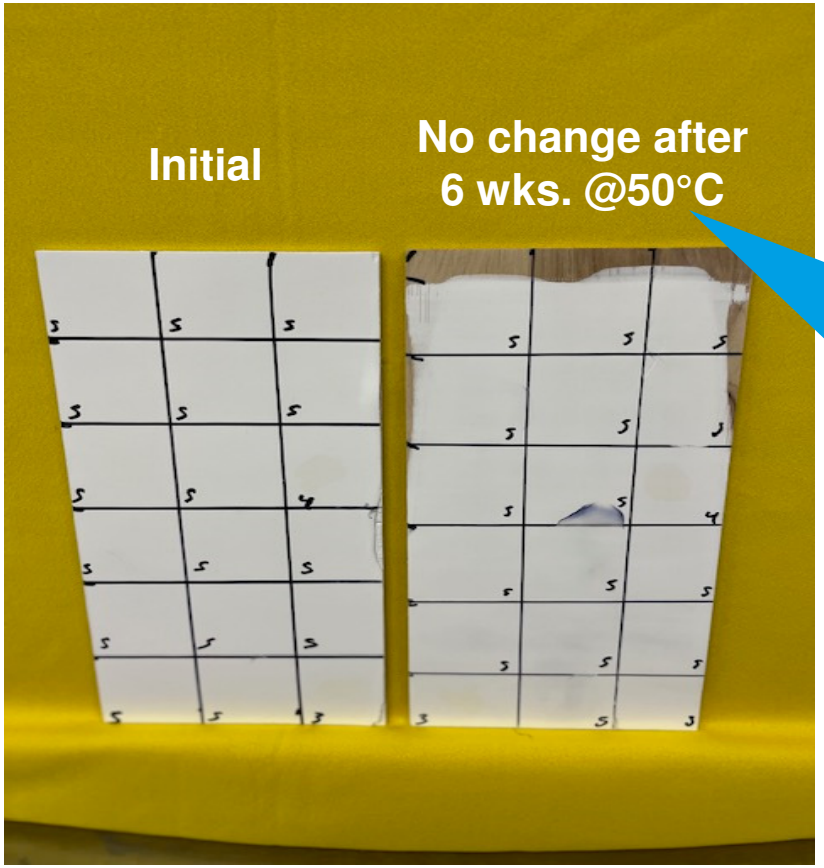
Clear and pigmented formulations	1/1 65215A/acrylic blend Pigmented	65215A Pigmented	65215A Low Gloss Clear	61215A High Gloss Clear
KCMA (rating 5 = no effect) (initial/ 24hrs. Recovery)	**15 gloss**	**42 gloss**	**10 gloss**	**90 gloss**
Detergent Soln. 0.5%, 24 hrs.	5/5	5/5	5/5	5/5
Ethanol/Water, 24 hrs.	5/5	5/5	5/5	5/5
Vinegar, 24 hrs.	5/5	5/5	5/5	5/5
Lemon Juice, 24 hrs.	5/5	5/5	5/5	5/5
Orange, 24 hrs.	5/5	5/5	5/5	5/5
Grape juice, 24 hrs.	5/5	5/5	5/5	5/5
Ketchup, 24 hrs.	5/5	5/5	5/5	5/5
Olive Oil, 24 hrs.	5/5	5/5	5/5	5/5
Coffee, 24 hrs.	4/4	4/4	5/5	5/5
Mustard, 1 hr.	3/4	4/5	4/5	4/5
Other chemicals				
Nail Polisher Remover, 15 min	4/5	5/5	5/5	5/5
IPA, 15 min	4/5	5/5	5/5	5/5
Windex, 15 min	5/5	5/5	5/5	5/5
28% Ammonium hydroxide, 15 min	5/5	5/5	5/5	5/5
77% Sulfuric acid, 15 min	5/5	5/5	5/5	5/5
Gasoline, 15 min	4/5	5/5	5/5	5/5
Acetone, 2 minutes	3/5	5/5	5/5	5/5
Bleach, 24 hrs.	5/5	5/5	5/5	5/5
Mustard, 24 hrs.	2/3	3/4	4/5	4/4
Total	**84/91**	**91/93**	**93/95**	**93/94**

- ✓ WB UV PUD# 65215A passes KCMA chemical testing
- ✓ 1:1 acrylic blend performs very well
- ✓ Mustard and acetone recover to acceptable levels

Pigmented coating using WB UV PUD #65125A remains **stable** and **chemical resistant** when stored at **50°C for 6 weeks**

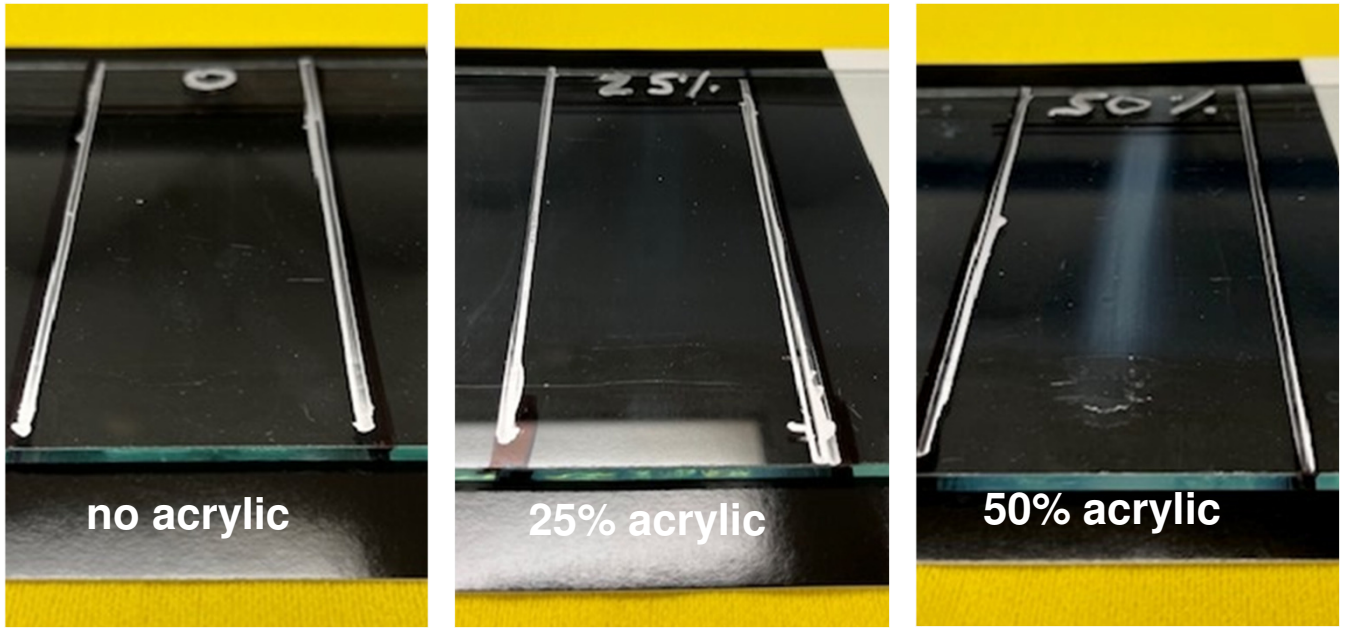
KCMA chemical test panels

Nail Polisher Remover, 15 min IPA, 15 min Windex, 15 min 28% Ammonium hydroxide, 15 min 77% Sulfuric acid, 15 min Gasoline, 15 min Acetone, 2 minutes Bleach, 24 hrs. Mustard, 24 hrs.
Detergent Soln. 0.5%, 24 hrs. Ethanol/Water, 24 hrs. Vinegar, 24 hrs. Lemon Juice, 24 hrs. Orange, 24 hrs. Grape juice, 24 hrs. Ketchup, 24 hrs. Olive Oil, 24 hrs. Coffee, 24 hrs. Mustard, 1 hr.



Chemical test **ratings** remained **unchanged**

WB UV PUD #65125A can be **blended with** 1K WB acrylic to reduce cost with **minimal impact** on properties



- 1 minute after UV cure
- 20 IPA double rubs
- Breakthrough at 50% blend
- **Passed at 25% blend**

Blended with NeoCryl® XK-12 / NeoCryl® is a registered trademark of the Covestro Group

Ideal State performance set out to **accelerate line speed** by about **60-70%** compared to the current state

Property	WB Current State	Ideal State Performance
Chemical Resistance	Pass KCMA	Pass KCMA
Stability	4 wks. 40°C	6 wks. 50°C
Steel Wool Test	<10% gloss red.	<10% gloss red.
Water/Flash Bake (5 mils)	5-10 min	2 min
Block Resistance w/ Flash/Bake	8-10 min	3 min
VOC	200g/L	50g/L

Focus was on drying

WB UV PUD# 65215A accelerates line speed by about **50-60%** while meeting other project targets

Property	WB Current State	Ideal State Performance	PUD# 65215A
Chemical Resistance	Pass KCMA	Pass KCMA	Pass KCMA
Stability	4 wks. 40°C	6 wks. 50°C	**6 wks. 50°C**
Steel Wool Test	<10% gloss red.	<10% gloss red.	6 - 9% gloss red.
Water/Flash Bake (5 mils)	5-10 min	2 min	**3 min**
Block Resistance w/ Flash/Bake	8-10 min	3 min	**4 min**
VOC	200g/L	50g/L	**<100g/L**

- ✓ Bake time reduced
- ✓ Shorter block resistance time
- ✓ Thicker application
- ✓ Lower VOC
- ✓ Lower carbon footprint
- ✓ Improved coating stability

50-60% Improvement!!

Key takeaways for accelerating the line speed of a **waterbased UV curable coating**

For applicators of waterbased UV curable coatings, **WB UV PUD# 65215A** offers a **50-60% improvement in line speed** while maintaining other key performance properties

- Accelerated production
- Increased application thickness reduces need for additional coats
- Shorter drying lines
- Faster damage free stacking and packing
- Increased resin stability reduces waste
- Energy saving due to reduced drying needs
- Allows for production expansion without major capital expenditures

WB UV PUD# 65215A dries as **fast as** current **solvent-based** UV curable coatings with improved blocking resistance

Property	SB Current State	PUD# 65215A
Chemical Resistance	Pass KCMA	Pass KCMA
Stability	**6 wks. 50°C**	**6 wks. 50°C**
Steel Wool Test	<10% gloss red.	6 - 9% gloss red.
Water/Flash Bake (5 mils)	**3-5 min**	**3 min**
Block Resistance w/ Flash/Bake	**4-6 min**	**4 min**
VOC	**300 to 400 g/L**	**<100g/L**

- ✓ Matched solvent-based bake time
- ✓ Shorter block resistance time
- ✓ >3X less VOC
- ✓ Lower carbon footprint

Matched solvent-based drying speed at >3X less VOC

Key takeaways for **replacing solvent-based** UV curable coating

For applicators of solvent based UV curable coatings, **WB UV PUD# 65215A has the potential to fit into your current process**

- Use current coating lines with minimal capital expenditure
- Increase film build per coat to improve efficiency
- Reduce time for stacking and packaging to improve efficiency and speed
- Energy savings, VOC reduction, cost savings, and reduced carbon footprint

THANK YOU

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References

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