Coatings Trends & Technologies SUMMIT

Influence of Novel Multi-Functional Additive on Melt Rheology and Surface Control in Powder Coatings

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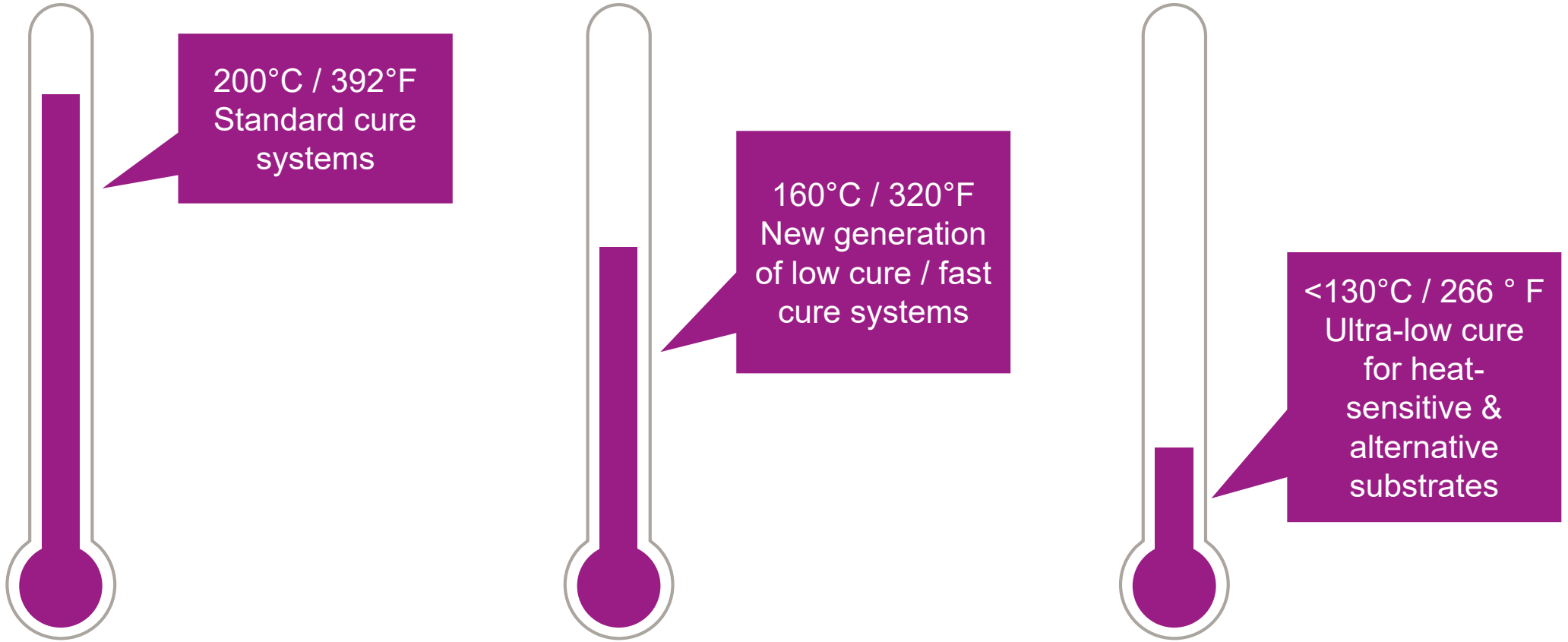
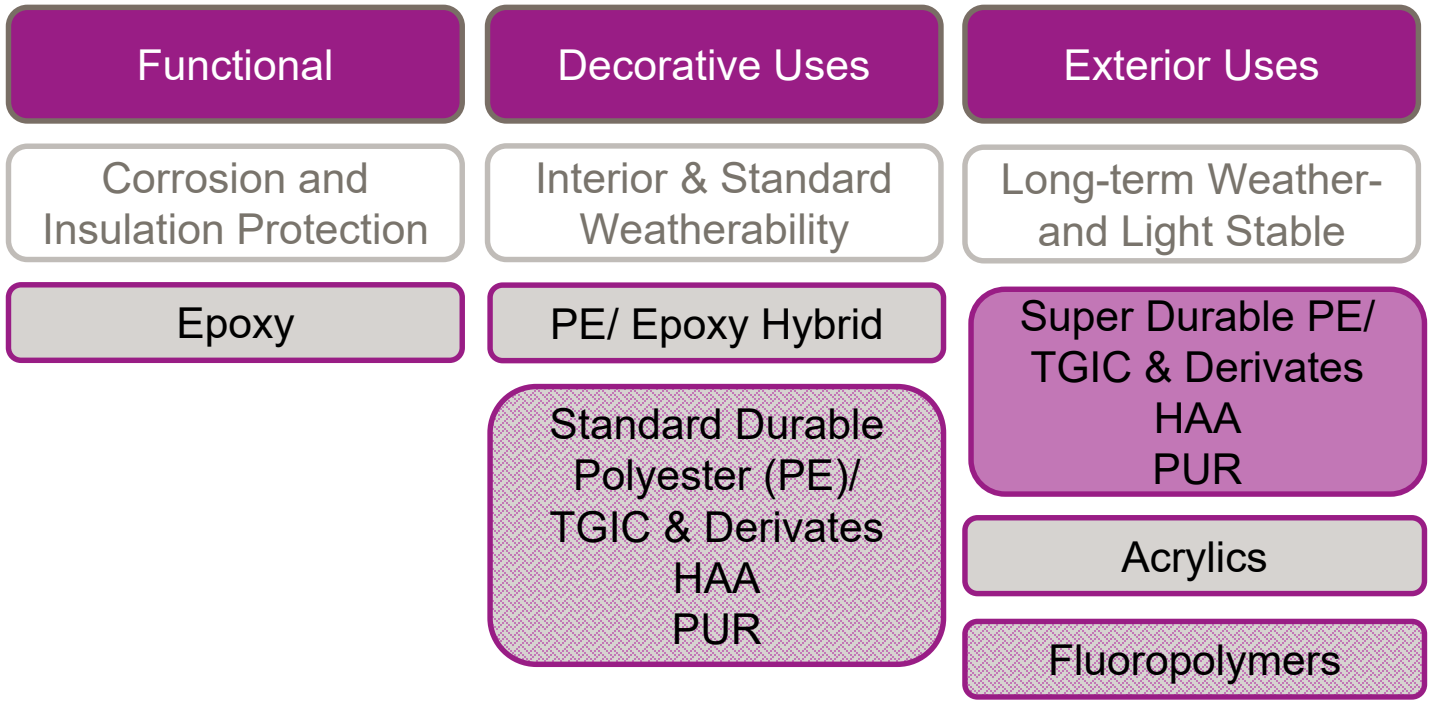
9/5/2024

Industry Trend: Reduction of Curing Temperature and / or Time

A Need for New Additives? Let's have a look…

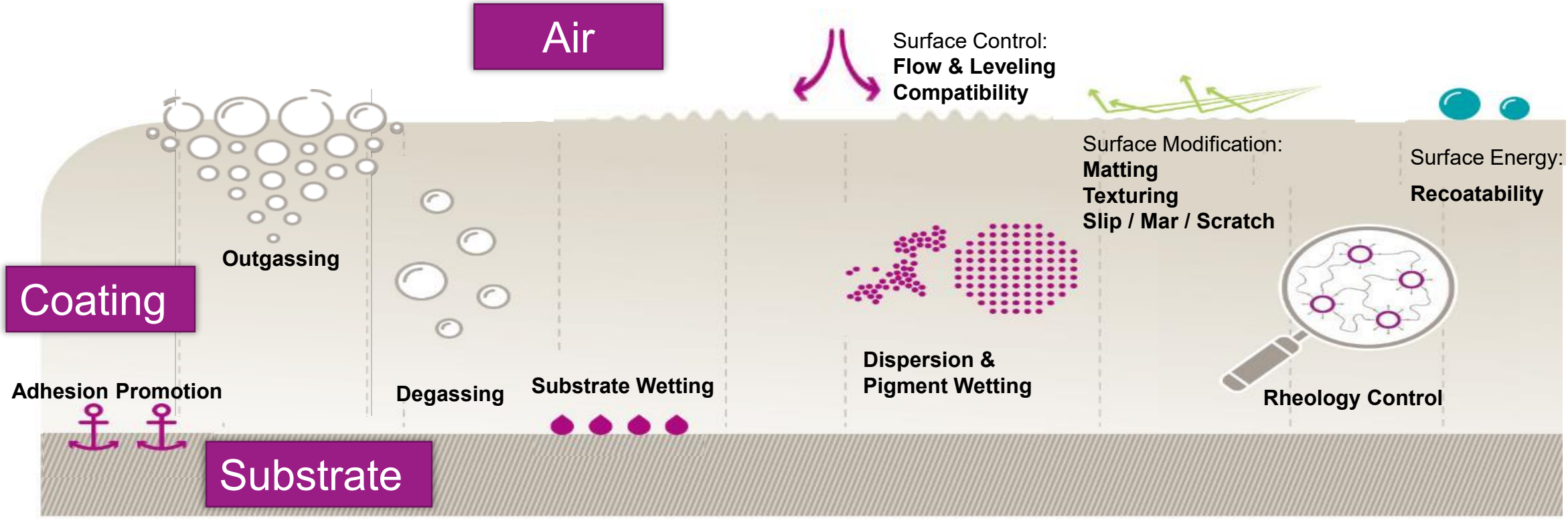


Powder Coating Systems in Comparison



System Name	Crosslinker / Resin
Epoxy	Polyamide or anhydride / bisphenol-A-resin
Hybrid	Blend of bisphenol-A-resin and COOH-polyester
TGIC	Triglycidyl isocyanurate / COOH-polyester
TGIC derivatives	Glycidylester / COOH-polyester
HAA	ß-Hydroxyalkylamide / COOH-polyester
PUR	Polyisocyanate / OH-polyester ⇨ Polyurethane
Acrylics	Di-acid / glycidyl methacrylate ⇨GMA
Fluoropolymers	Polyisocyanate / OH-FEVE

Powder Coating Additives – Key Functional Properties

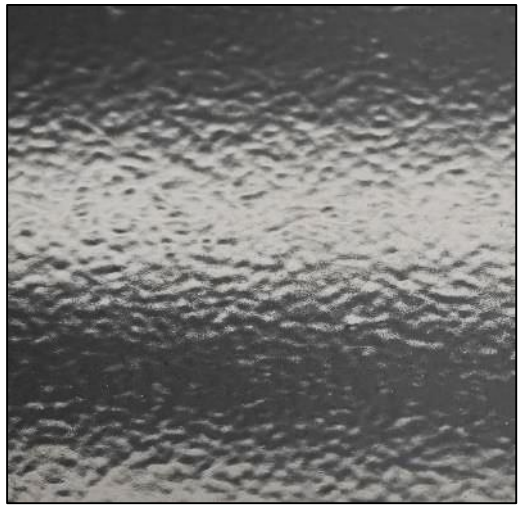


Powder Coating Additive Groups

Additive Group	Effect	Examples
Flow & Leveling Compatibility Surface Energy	Gloss / Orange Peel Defects control Recoatability	Polyacrylates (on silica carrier) Amide / polyether blends
Degassing & Outgassing	Pinholes Popping	Benzoin Modified Polyethylenes, Amide waxes
Mar & Scratch Matting Wax Texturing	Surface slip Gloss reduction Fine / Coarse / Wrinkle	PTFE / Polyethylene / Fischer-Tropsch Polypropylene, Castor wax PTFE & PTFE-free, CAB, reactive additives
Pigment Wetting	Gloss / DOI Melt viscosity	Wax based additives and Copolymers

Standard Cure Tested Formulations – Focus: Pigment Dispersion

Super durable HAA / Polyester systems with different compositions targeting a variety of use cases



Black

High filler and carbon black loading

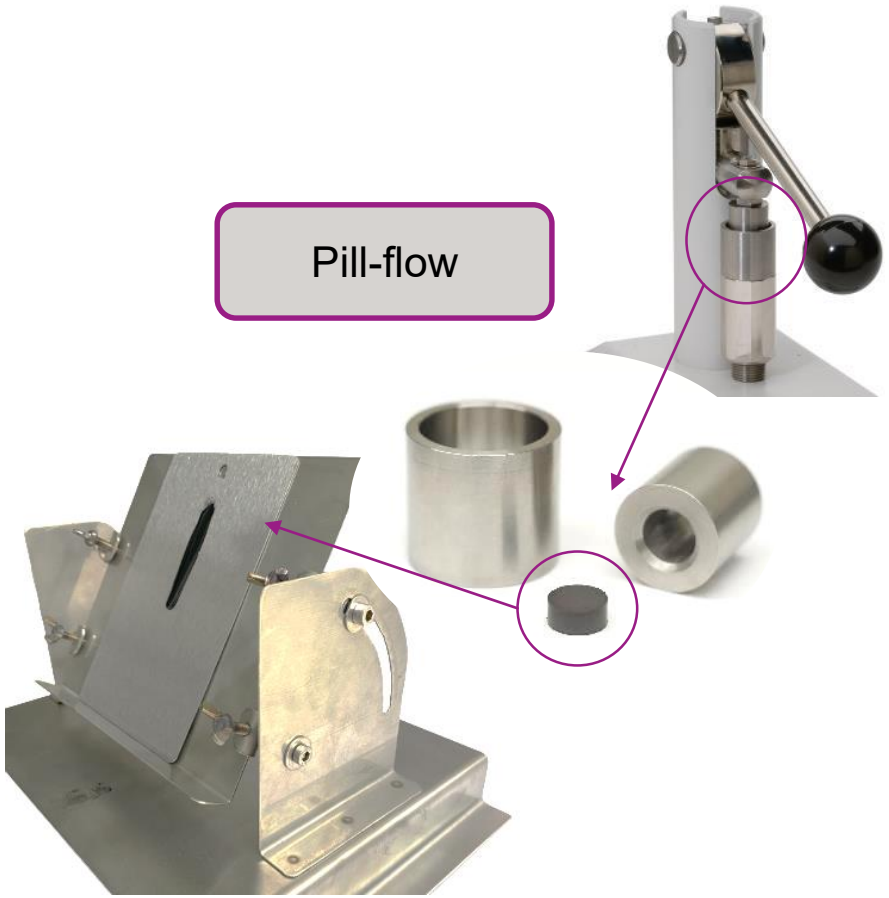
Gray

High loading level inorganic pigments and filler combination

Test Protocol - Surface Free Energy (SFE) & Melt Viscosity

Drop Shape Analyzer* - SFE

Pill-flow

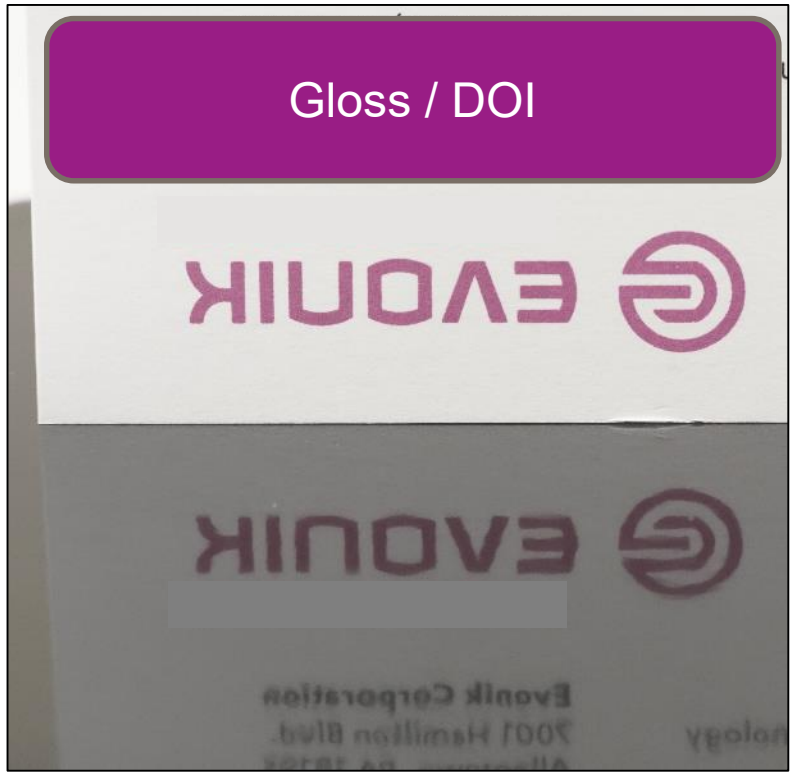


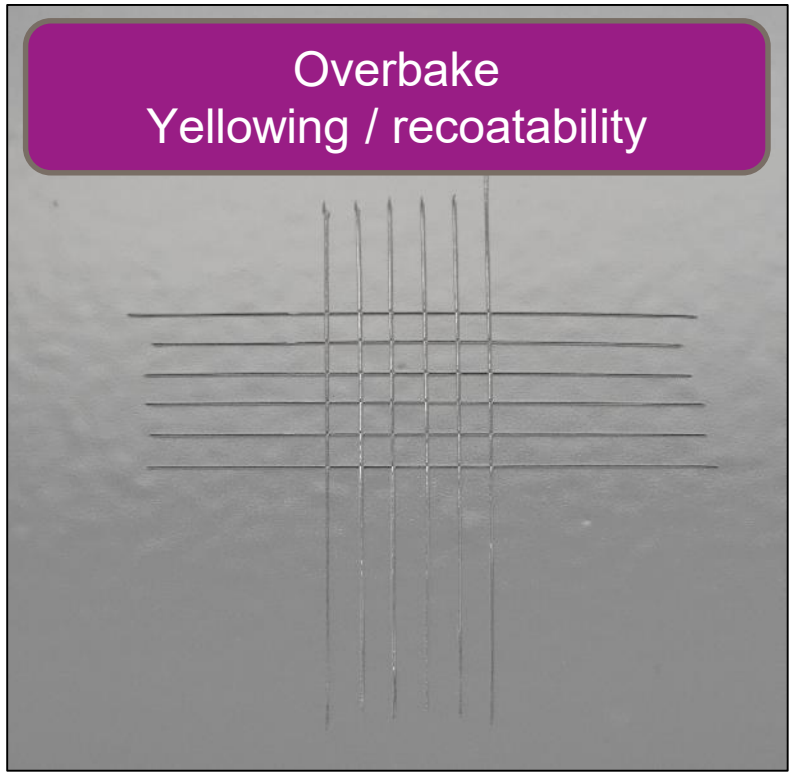
Melt Viscosity

Rheometer - Temperature sweep

* https://images.kruss-scientific.com/files/kruss-bro-dsa100-en.pdf

Test Protocol - Tested Properties





Powder Coating Formulation

Black HAA Super Durable – Carbon Black & Filler

Main Formulation	
Polyester (95/5)	68.4
HAA	3.6
Leveling agent	1.0
Benzoin	0.5
Carbon Black	1.5
Barium Sulfate	25.0
Total	**100.0**
Fumed Aluminium Oxide*	0.3

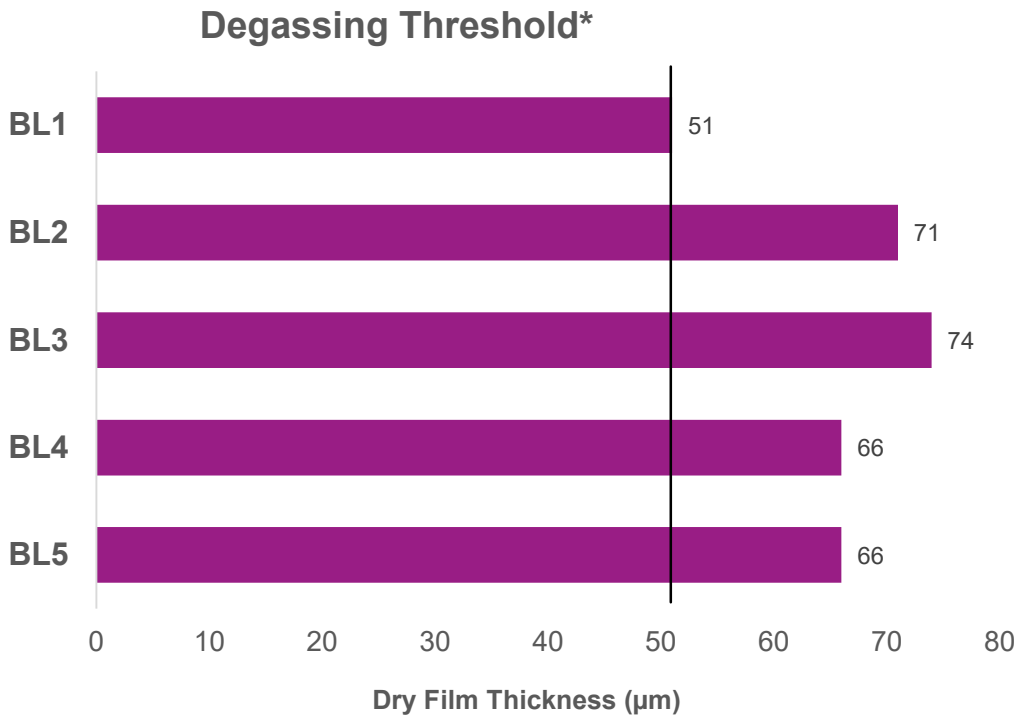
* Free-flow additive post-add at grinding

	Blank	Additive A		Additive B	
Trial # → Composition ↓	**BL1**	**BL2**	**BL3**	**BL4**	**BL5**
Main Formulation**	100%	**99.5%**	**99%**	99.5%	99%
Additive A	**-**	**0.5%**	**1%**	**-**	**-**
Additive B	-	-	-	0.5%	1%

** Coextrusion of additives and main formulation raw mix

Gloss / Degassing

Black HAA Super Durable – Carbon Black & Filler



Curing condition:

204°C / 400°F – 10’

	Blank	Additive A		Additive B	
	BL1	BL2	BL3	BL4	BL5
Gloss Units (20°)	58	63	68	61	60
Gloss Units (60°)	90	92	94	92	94
Degassing threshold (µm)	51	71	74	66	66

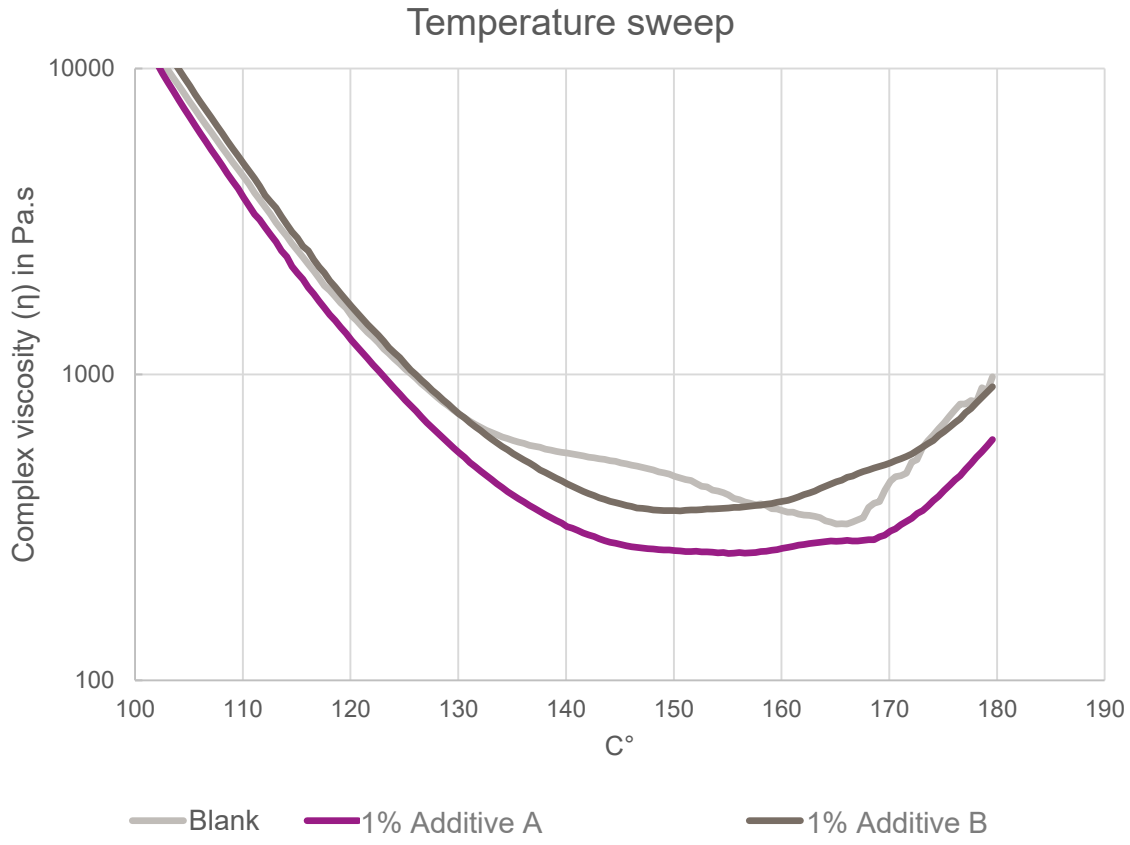
✓ Better gloss development and improved degassing with Additive A

* Thickness depended pinholing effect

25µm = 1 mil

Melt Viscosity – Anton Paar & Pill Flow

Black HAA Super Durable – Carbon Black & Filler



Pill flow: 1g pill

Test conditions: 149°C / 300°F – 15’

	Blank	Additive A		Additive B	
	BL1	**BL2**	**BL3**	**BL4**	**BL5**
Pill Flow (mm)	39	44	46	38	39

✓ Reduced melt viscosity with Additive A

Powder Coating Formulation

HAA Super Durable Light Gray - Highly Filled Inorganic

Main Formulation	
Polyester (95/5)	50.6
HAA	2.7
Leveling agent	1.0
Benzoin	0.5
Carbon Black	0.2
Titanium Dioxide	35.0
Barium Sulfate	10.0
Total	**100.0**
Fumed Aluminium Oxide*	0.3

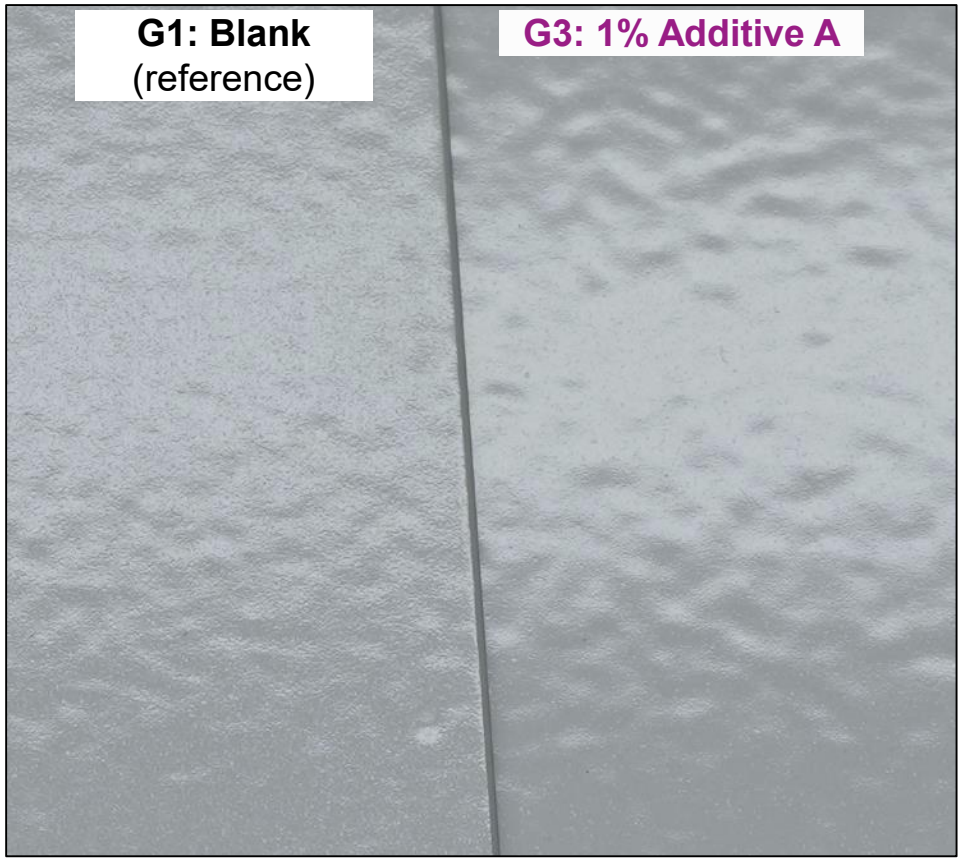
* Free-flow additive post-add at grinding

	Blank	Additive A		Additive C		Additive D	
	G1	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**
Main Formulation**	100%	**99.5%**	**99%**	99.5%	99%	99.5%	99%
Additive A	**-**	**0.5%**	**1%**	**-**	**-**	**-**	**-**
Additive C	-	-	-	0.5%	1%	-	-
Additive D	-	-	-	-	-	0.5%	1%

** Coextrusion of additives and main formulation raw mix

Degassing & Gloss Values

HAA Super Durable Light Gray - Highly Filled Inorganic



Curing condition:

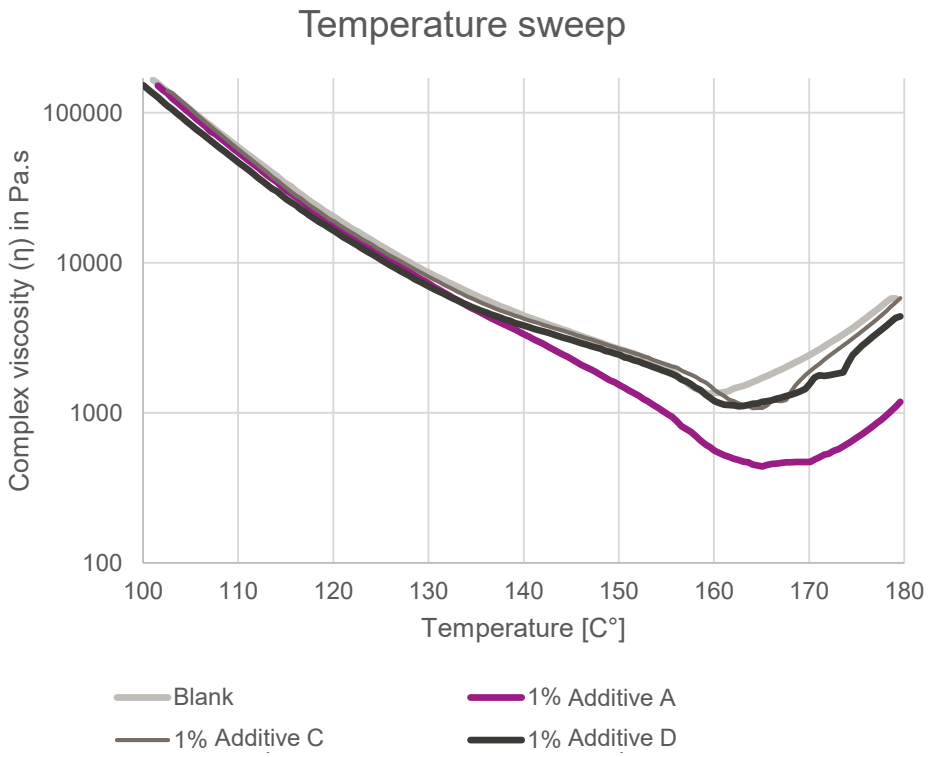
204°C / 400°F – 10’

	Blank	Additive A		Additive C		Additive D	
	G1	G2	G3	G4	G5	G6	G7
Gloss Units (20°)	54	59	64	59	63	49	52
Gloss Units (60°)	87	89	90	89	90	86	86
Degassing threshold (µm)	76	81	86	76	84	84	84

✓ Better gloss development and improved degassing with Additive A

Melt Viscosity – Anton Paar & Pill Flow

HAA Super Durable Light Gray - Highly Filled Inorganic



Pill flow: 1g pill

Test conditions: 149°C / 300°F – 15’

	Blank	Additive A		Additive C		Additive D	
	G1	G2	G3	G4	G5	G6	G7
Pill flow (mm)	40	52	55	39	40	41	42

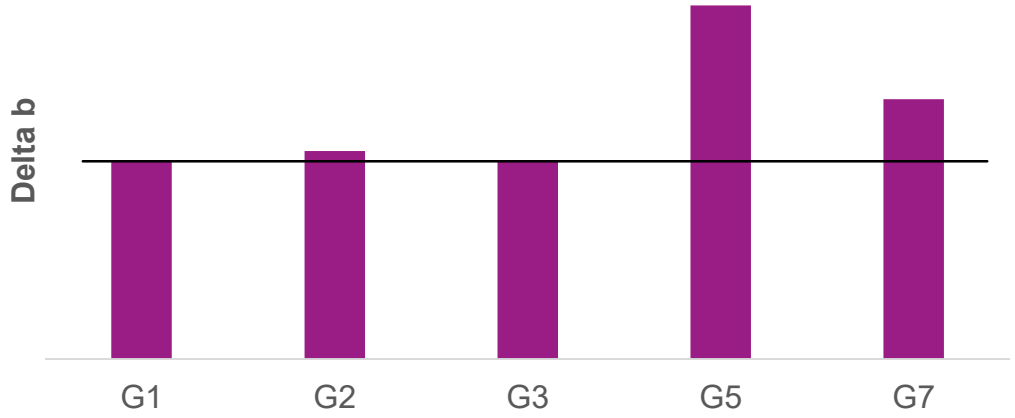
✓ Reduced melt viscosity with Additive A

Overbake Yellowing

HAA Super Durable Light Gray - Highly Filled Inorganic

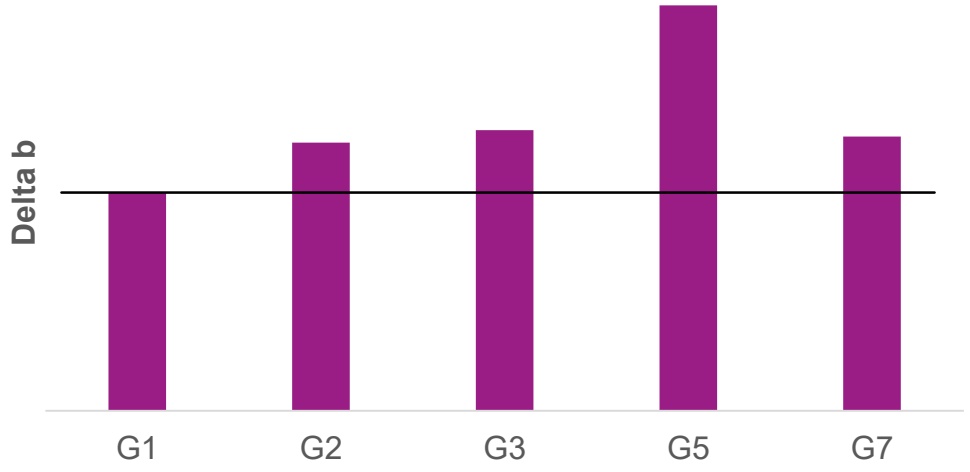
Overbake yellowing at 204 °C / 400 °F – 30 min*

* Electric oven



	Blank	Additive A		Add. C	Add. D
	G1	G2	G3	G5	G7
Δb	0.19	0.20	0.19	0.34	0.25

Overbake yellowing at 230 °C / 450 °F – 10 min*



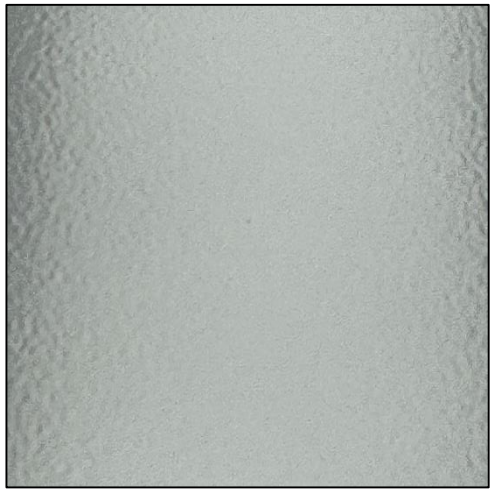
	Blank	Additive A		Add. C	Add. D
	G1	G2	G3	G5	G7
Δb	0.35	0.43	0.45	0.65	0.44

- ✓ Minimal effect on overbake yellowing with Additive A
- ✓ Note: All systems had full recoatability adhesion (Crosshatch 5B / GT0)

Low Cure Tested Formulations – Focus: Melt Viscosity & SFE

Low-cure super durable HAA / Polyester and TGIC / Polyester systems with a variety of additives to evaluate the effect on surface appearance and properties at varying temperatures.

Low / fast cure HAA
Super Durable
Medium Gray



Catalyzed TGIC
Super Durable
Medium Gray

Powder Coating Formulation

Low / Fast Cure Catalyzed TGIC Super Durable Medium Gray

Main Formulation	
Polyester (93/7)	58.5
HAA	4.4
Leveling agent	1.0
Benzoin	0.5
Imidazole Catalyst	0.3
Carbon Black	0.3
Titanium Dioxide	18.0
Barium Sulfate	15.0
Total	**98.0**
Fumed Aluminium Oxide*	0.3

* Free-flow additive post-add at grinding

	Blank	Cat.			
	FCT1	**FCT2**	**FCT3**	**FCT4**	**FCT5**
Main Formulation**	100%***	100%	**98%**	98%	98%
Additive A	-	-	**2%**	-	-
Additive E[1]	-	-	-	3%	-
Additive F[2]	-	-	-	-	2%

** Coextrusion of additives and main formulation raw mix

*** FCT1 – no catalyst added

1. Additive E - 66% active ingredient on silica carrier

2. Additive F - Polyethylene Wax

Coating Properties – Pill Flow, Gloss, Surface Free Energy

Low / Fast Cure Catalyzed TGIC Super Durable Medium Gray

	Blank	Control	Add. A	Add. E	Add. F
	Uncat.	Catalyzed	Polymer	Liq. on Si	PE
Conditions 1 & 2	**FCT1**	**FCT2**	**FCT3**	**FCT4**	**FCT4**
Pill flow 1 (mm)	74	55	**56**	45	62
Gloss Units 1 (60°)	76	65	**67**	56	39
SFE [mN/m] 1	49.8	51.1	**51.0**	51.2	35.5*
Pill flow 2 (mm)	70	42	**41**	38	40
Gloss Units 2 (60°)	79	67	**68**	61	57
SFE [mN/m] 2	49.1	51.6	**51.3**	51.2	35.8*

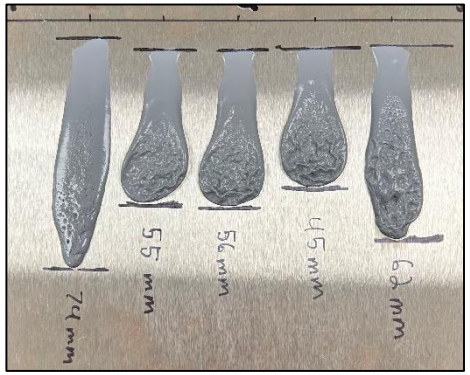
* the coating retained recoatability “5B”

- ❑ Catalyzed TGIC system proofed difficult to enhance

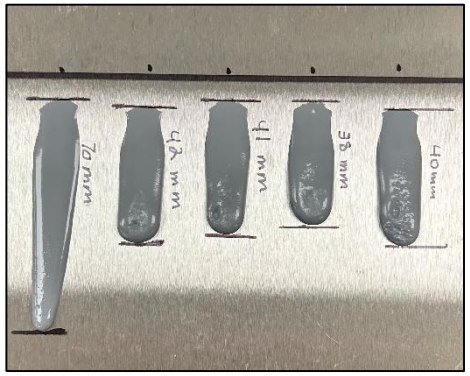
Powder & Pill Flow Cure:

Test conditions 1: 200°C / 392°F – 8’

Test conditions 2: 160°C / 320°F – 20’



1. 200°C / 392°F



2. 160°C / 320°F

Powder Coating Formulation

Low / Fast Cure HAA Super Durable Medium Gray

Main Formulation	
Polyester (93/7)	61.6
HAA	4.6
Leveling agent	1.0
Benzoin	0.5
Carbon Black	0.3
Titanium Dioxide	18.0
Barium Sulfate	12.0
Total	**98.0**
Fumed Aluminium Oxide*	0.3

* Free-flow additive post-add at grinding

Blank						
	LCP1	**LCP2**	**LCP3**	**LCP4**	**LCP5**	**LCP6**
Main Formulation**	100%	**98%**	98%	98%	98%	98%
Additive A	-	**2%**	-	-	-	-
Additive E[1]	-	-	3%	-	-	-
Additive F[2]	-	-	-	2%	-	-
Additive G[3]	-	-	-	-	2%	-
Additive H[4]	-	-	-	-	-	2%

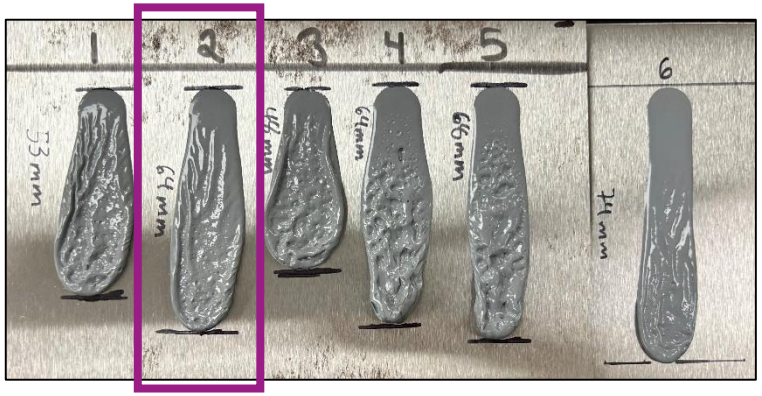
** Coextrusion of additives and main formulation raw mix

1. Additive E - 66% active ingredient on silica carrier
2. Additive F - Polyethylene Wax
3. Additive G - Wax Blend
4. Additive H - EBS Wax

Coating Properties – Pill Flow, Gloss, Surface Free Energy, Flexibility

Low / Fast Cure HAA Super Durable Medium Gray

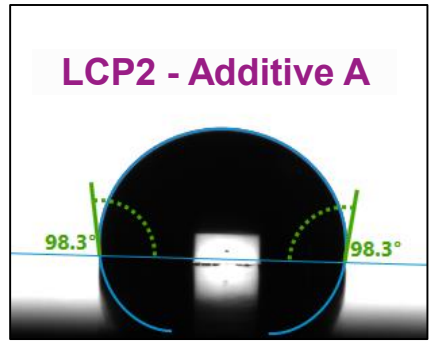
	Blank	Add. A	Add. E	Add. F	Add. G	Add. H
		Polymer	Liq. on Si	PE	Wax Blend	EBS
Curing: 400°F / 8 min	**LCP1**	**LCP2**	**LCP3**	**LCP4**	**LCP5**	**LCP6**
Pill flow (mm)	53	**64**	48	64	68	74
Gloss Units (60°)	68	**75**	55	71	66	68
SFE [mN/m]	51.2	**51.1**	50.6	38.1	38.0	41.6
Reverse Impact (80 in-lb)	Cracks	**Improved**	Cracks	Improved	Improved	Improved

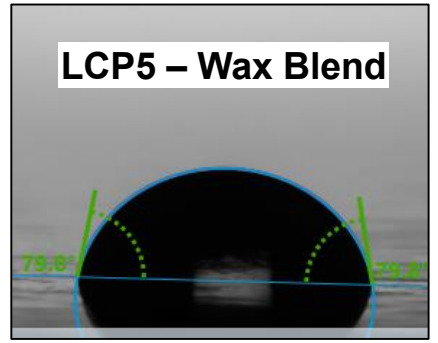


- ✓ Additive A positively influences various coating properties

Pill flow: 1g pill

Test conditions: 160°C / 320°F – 20’





Water Contact Angle

Influence of Additive Selection on Coating Properties

Enhanced flow & leveling

Reduction of melt viscosity

Recoatability

Label adhesion

Screen printing

Degassing &
outgassing properties

Good pigment & filler wetting

Gloss and DOI

Processing conditions

Physical properties