POWDER COATING SUMMIT

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covestro

Sustainable Powder Coating Developments

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Outline

- Introduction
- Sustainability in powder coating
- Explore various sustainable solutions
- Concluding remarks

Covestro – Coating and adhesives

VISION

MISSION

Become the leading sustainable solutions provider

SOLUTIONS AND SPECIALTIES

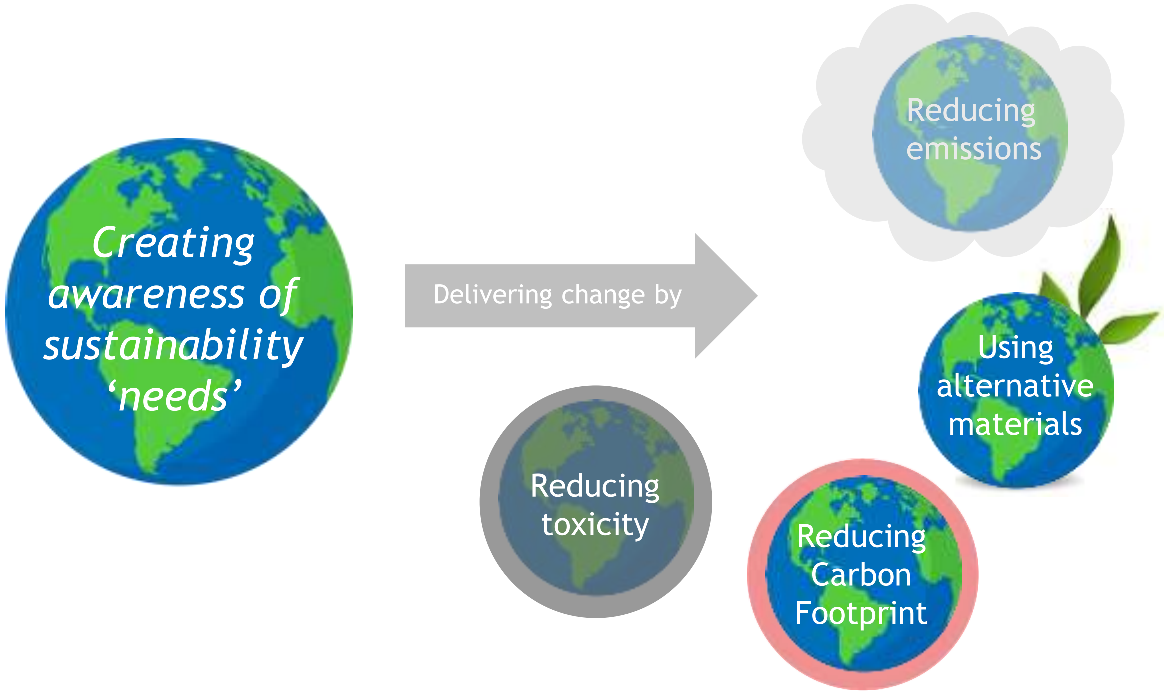
Engineering Plastics	**Coatings and Adhesives**
Thermoplastic Polyurethanes	Tailored Urethanes
Specialty Films	Elastomers

PERFORMANCE MATERIALS

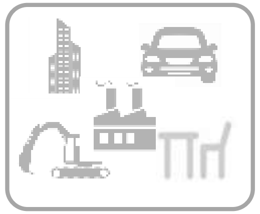
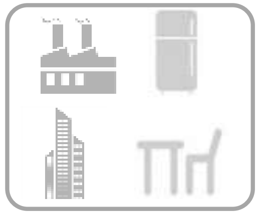
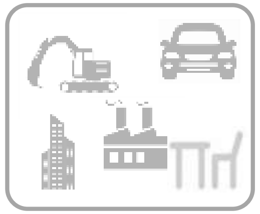
Performance Materials

Sustainability in powder coatings

Innovation is the driver for sustainable coatings solutions
- Move away from solvent-based coating technologies
- Optimize production and application techniques
- Conduct LCA studies to create insights

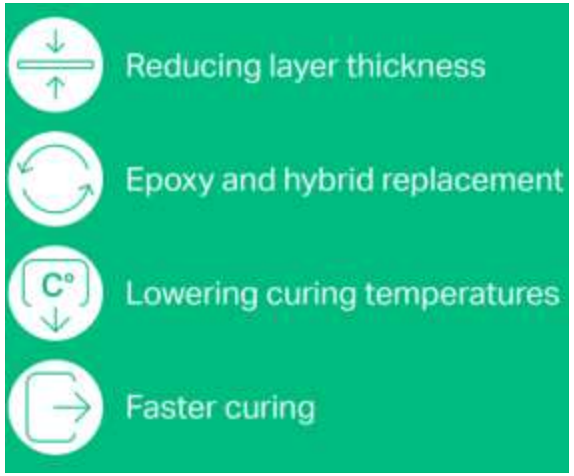


Sustainable solutions

Category	Application	Product and solution areas
New Technologies (Heat Sensitive Substrates)		Low temperature cure; Reduce toxic materials; Fast cure; Fast and low temperature
High Performance Solutions (Metal)		Increase output (faster); Durability (weathering); Corrosion resistance; Energy saving (lower temperature); Non sparkling matte (i/o anodizing); Bio-based and recycled RM
Core Resin Technologies (Metal)		Chemical resistance; Reduce toxic materials; Reducing layer thickness; Replacing epoxy
Crosslinkers		Reduce emissions; Energy saving (lower temperature)

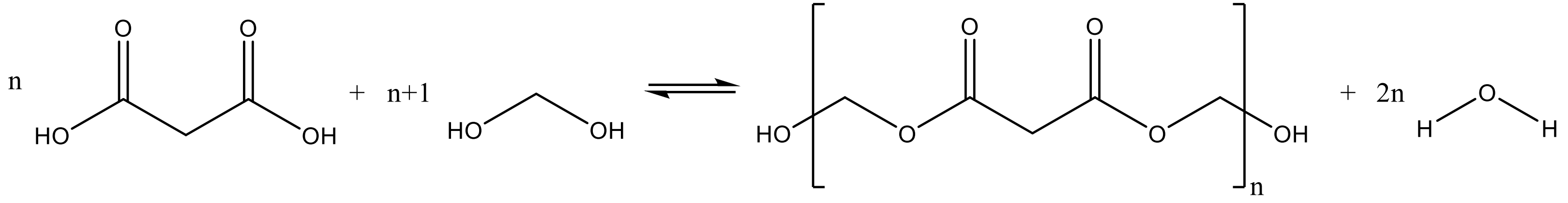
Sustainable solutions

- Increase coating performance
- Reduce raw material use
- Decrease energy usage
- Use of powder coatings on non-standard substrates
- Reduce emissions and (potential) harmful components
- Renewable / recycled raw materials

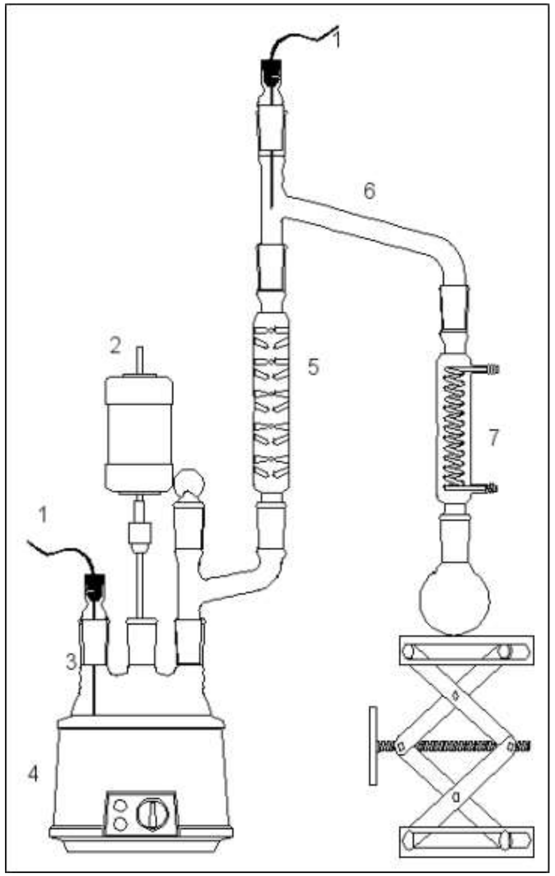


Polyester powder coatings

- General intro on polycondensation

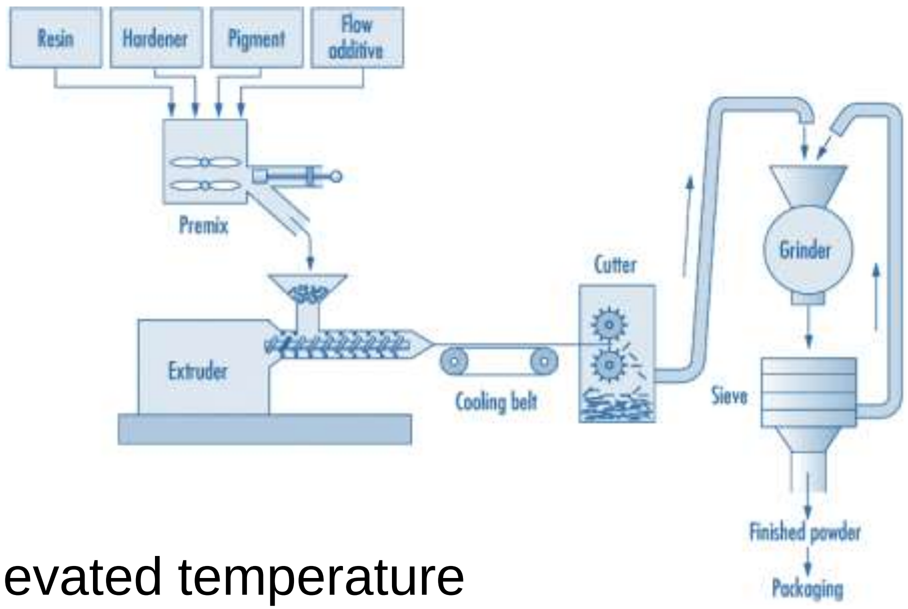


- Polyester powder coating resin synthesis
  - Bulk reaction without solvent
  - Batch process, on the lab, and also in production
  - Monomers charged in one or multiple stages
  - Reaction performed at various temperatures
  - Specifications determined during production process
  - After discharge resin solidifies at RT



Powder coating process

- Making a powder paint
  - Pre-mixing components
  - Melt-extrusion of all components
  - Grinding and classification to obtain a powder



- Applying a powder coating
  - Electrostatically or corona spraying
  - Particles melt, fuse into a film and cure in an oven at elevated temperature
    - During cure optionally network formation due to reaction between resin and crosslinker

- Evaluation of a powder coating (testing)
  - Basis properties like gloss, flow, color, mechanical properties
  - Outdoor durability, corrosion resistance, chemical resistance

Increase coating performance

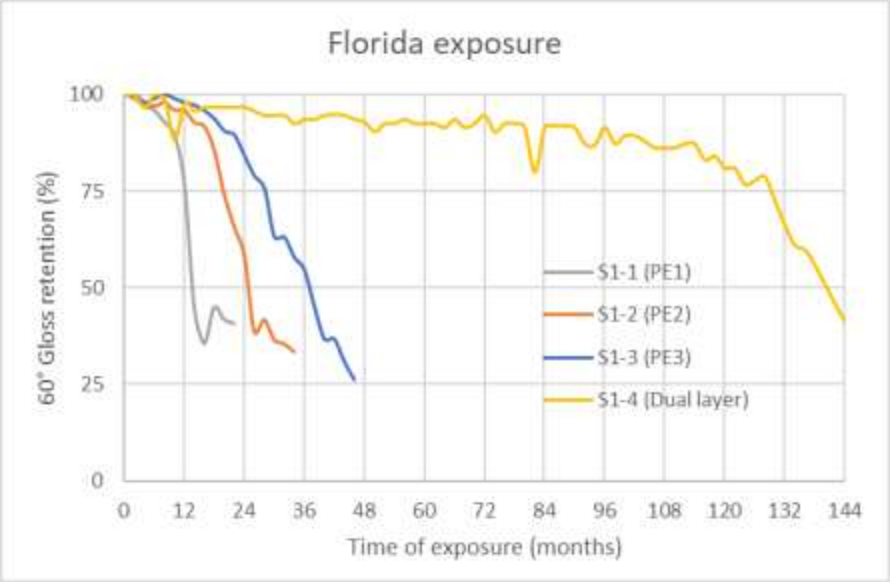
- Outdoor durability

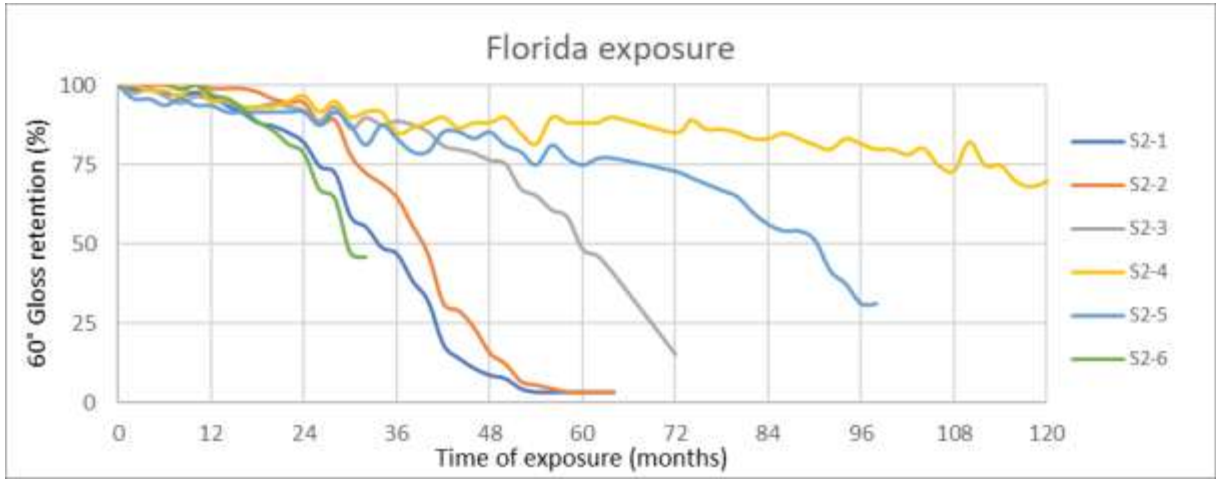
  - Monomer composition of the resin
  - Application method
  - Including other polymers

✓Extend the lifetime of your product
✓No need to recoat before end of live

Standard white powder coating formulations with HAA crosslinker
PE1 = Polyester resin 1
PE2 = Polyester resin 2
PE3 = Polyester resin 3
Dual layer = Polyester resin 3 with clear polyester topcoat

Standard white powder coating formulations with NCO crosslinker
PE4 = Polyester resin 4
FMP = Fluor modified polymer
S2-1 = 100% PE4
S2-2 = 90% PE4 and 10% FMP
S2-3 = 75% PE4 and 25% FMP
S2-4 = 50% PE4 and 50% FMP
S2-5 = 25% PE4 and 75% FMP
S2-6 = 100% FMP

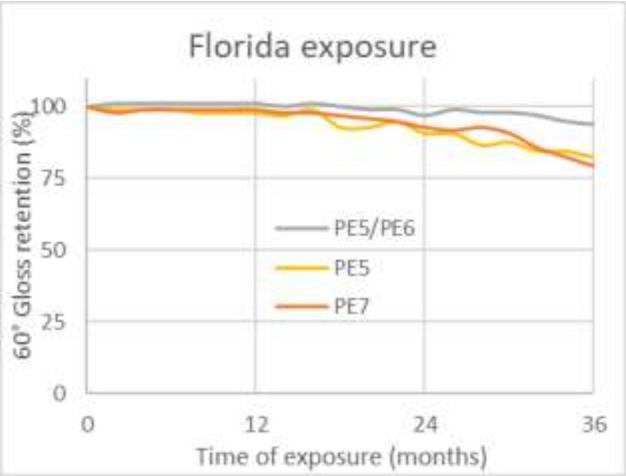




Increase coating performance

- Extend application space
  - Enhance flexibility, while maintaining durability, of a super durable powder coating formulation

  - PE5 = optimized amorphous super durable resin
  - PE6 = novel crystalline resin
  - PE7 = standard amorphous super durable resin



Test panel cured 15' @ 350 °F	85% PE5 15% PE6	reference 100% PE5
Reverse impact 20 i.p. @ 70 µm on AQT46 (ISO 6272-1)	Pass	Microcracks
Reverse impact 60 i.p. @ 70 µm on AQT46 (ISO 6272-1)	Pass	Fail
T-bend @ 60 µm on AQT46 (ISO 3270)	T0	>T3
Wedge bend Electrolytic tin plate (ETP) @ 30 µm (bend and impact test model 471)	Pass (0 mm)	>5 mm
Erichson cupping test 1+2 Electrolytic tin plate (ETP) @ 30 µm (ISO 11531)	Pass	Fail

Increase coating performance

- Extend lifetime of the object
  - ✓Corrosion resistance combined with super durability, in a single coat
  - ✓Reduced carbon footprint and lower system costs

PE8	Superdurable corrosion resistant resin
PE9	Architectural corrosion resistant resin
PE10	Superdurable reference resin
COM1	Commercial reference powder coating
COM2	Commercial reference powder coating

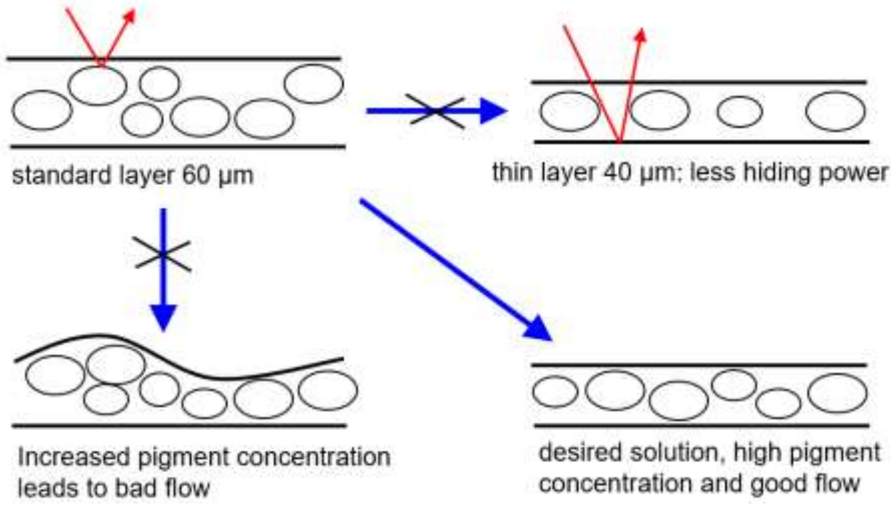
	White formulation		
	PE8	PE9	PE10
NSS 500 h (mm from Scribe)	1,4	1,4	2,0
Cyclic corrosion 20 cycles (mm from scribe)	2,8	2,4	4,3
SAE J2334 40 cycles (mm from scribe)	5,1	5,5	6,9
Florida exposure (yrs)	3	1	3

	Green formulation			Yellow formulation		
	PE8	COM1	COM2	PE8	COM1	COM2
NSS 500 h (mm from Scribe)	1,5	1,6	1,7	1,3	1,7	1,6
Cyclic corrosion 20 cycles (mm from scribe)	2,5	2,5	2,8	2,4	3,2	2,9
SAE J2334 40 cycles (mm from scribe)	4,7	4,6	5,7	5,1	5,6	5,1
QUV-B exposure (hrs)	597	272	263	878	299	342

NSS = natural salt spray
NSS and Cyclic corrosion test are on Iron phosphate steel

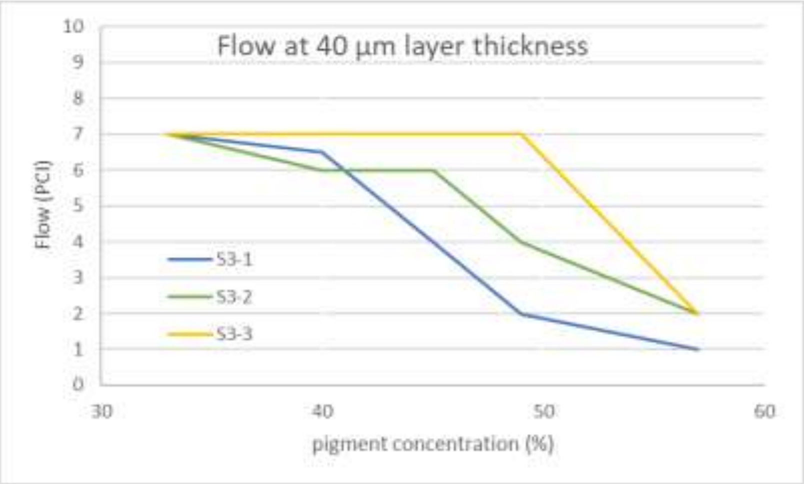
Reduce layer thickness

Reducing layer thickness



S3-1	Reference formulation
S3-2	Reference + pigment dispersant
S3-3	Formulation with improved resin

• Same properties; less raw materials



Formulation Pigment	S3-1 33 wt%	S3-2 33 wt%	S3-3 33 wt%	S3-1 50 wt%	S3-2 50 wt%	S3-3 50 wt%
Flow (PCI)	7	7	7	2	3	7
Haze	23	22	22	204	178	25
Gloss 20°	94	96	99	74	82	95
L*	95	96	95	96	96	96
b*	-0.3	1.3	-0.1	-0.6	1.3	-0.4
Hiding Power*	1	1	1	4	5	5
Chemical resistance*	5	5	5	5	5	5
Heat stability*	5	3	5	5	3	5
Reverse impact (160ip)	Pass	Pass	Pass	Pass	Pass	Pass

* 0 = bad / 5 = good   all formulations applied at 40 µm

Decrease energy use

- Lower curing temperature to 320 °F or lower
  - Same properties as at 350/400 °F in 10-12 minutes

Formulations for e.g. heavy mass application (50/50 hybrid)	S4-1	S4-2	S4-3
Cure time (min)	10	30	30
Cure temperature (°F)	260	270	270
PCI flow (60 µm)	2	3	3+
Impact @ 60 in.-lbs.	pass	pass	pass

- Outdoor durable
- Gloss and matt appearance

Formulations for low temperature cure (white pigmented)	S5-1	S5-2	S5-3	S5-4	S5-5	S5-6
Cure time (min)	10	10	10	10	10	10
Cure temperature (°F)	350	320	350	320	320	320
PCI flow (60 µm)	6	6	6	6	6	4
Gloss	96	96	94	94	96	37
Impact @ 60 in.-lbs.	pass	pass	pass	pass	cracks	cracks
Outdoor (yrs Florida)	n.a.	n.a.	1	1	3	3
Pencil hardness	2B	2B	n.d.	n.d.	n.d.	n.d.
QUV-B (hrs)	n.d.	n.d.	400	403	n.d.	n.d.

S5-1	Standard HAA formulation (General Industrial)
S5-2	Low temp HAA formulation (General Industrial)
S5-3	Standard HAA formulation (Architectural)
S5-4	Low temp HAA formulation (Architectural)
S5-5	Low temp HAA formulation (Super durable)
S5-6	50/50 dry blend of 97/3 and 92/8 HAA formulations

C°

Lowering curing temperatures

Faster curing

Decrease energy use

- Decrease cure time up to 50%
  - Same properties as at 350/375 °F in 10/12 minutes

- Gloss and matt appearance

Formulation	S6-1	S6-2	S6-2
Cure time (min)	10	5	2
Cure temperature (°F)	350	350	480
Appearance	OK	OK	OK
PCI flow (60 µm)	5	5	5
Gloss	94	94	94
Impact @ 60 in.-lbs.	pass	pass	pass
ADR	>100	>100	>100
Adhesion	5B	5B	5B

S6-1	Reference formulation
S6-2	Fast bake formulation

Formulation	S7-1	S7-2
Cure time (min)	12	5
Cure temperature (°F)	375	375
Appearance	OK	OK
Gloss	39	36
Colour L*	96	97
Colour a*	-1,2	-1,0
Colour b*	1,2	0,8
Impact @ 60 in.-lbs.	pass	pass
ADR	>100	>100

S7-1	Reference DBM formulation
S7-2	Fast bake DBM formulation

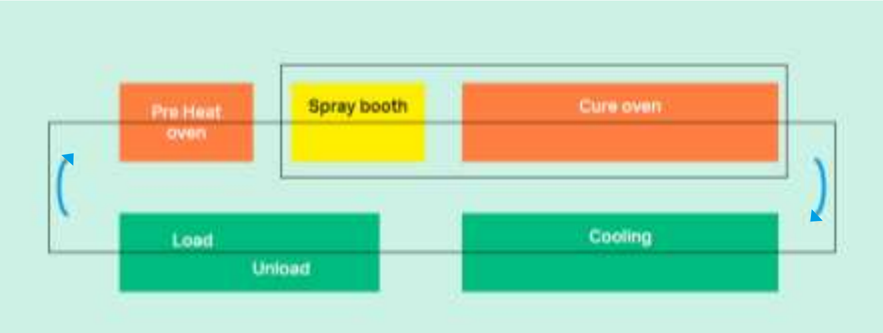
C°
Lowering curing temperatures

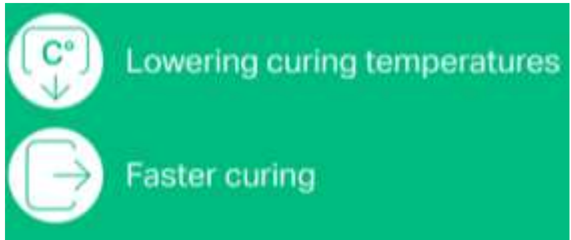
Faster curing

Enable use of powder coatings on non-standard substrates

- Use more sustainable coating technologies (with lower CFP) to coat non-standard substrates for powder coatings

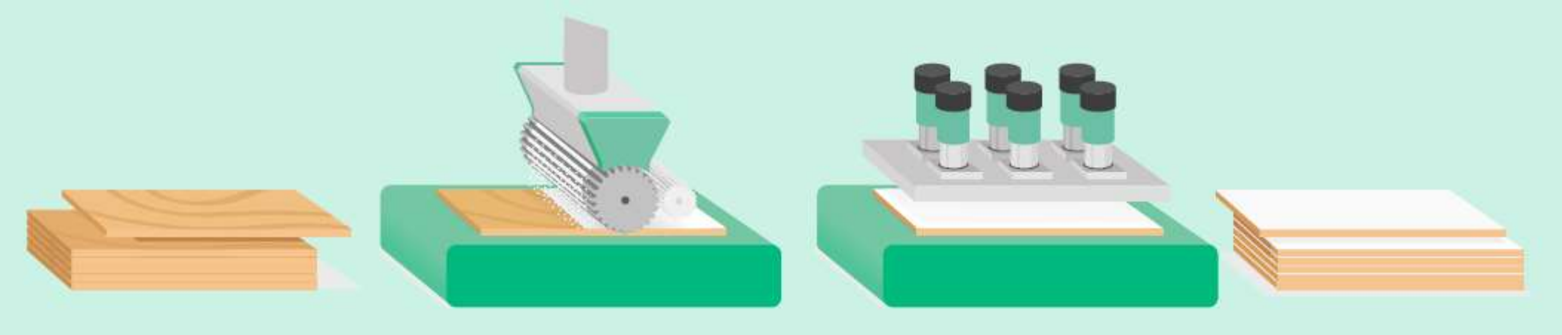
	2K waterborne acrylic	Solventborne	Waterborne UV	ultra low cure powder coating	2-layer hybrid powder coating
Appearance	Smooth or texture	Smooth or texture	Smooth or texture	Smooth or texture	Texture
Chemical resistance	+/-	++	++	++	++
Nail scratch resistance	--	-	-	+/-	+/-
Humidity/ moisture resistance	-+	-+	-+	++	++
Process efficency	-	--	+/-	++	+
Carbon footprint kg eq/m² coated substrate	3,1	4,7	1,7	1,0	1,5

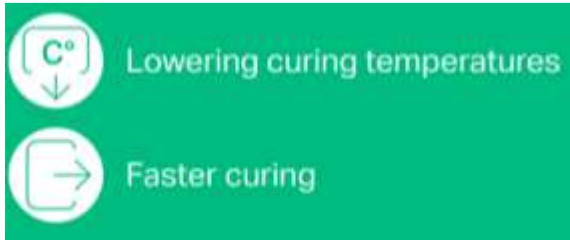




Enable use of powder coatings on non-standard substrates

- Apply other application technique to decrease overall CFP and provide sustainable coating solution
- Decrease powder coating cure time (3-5 times faster)





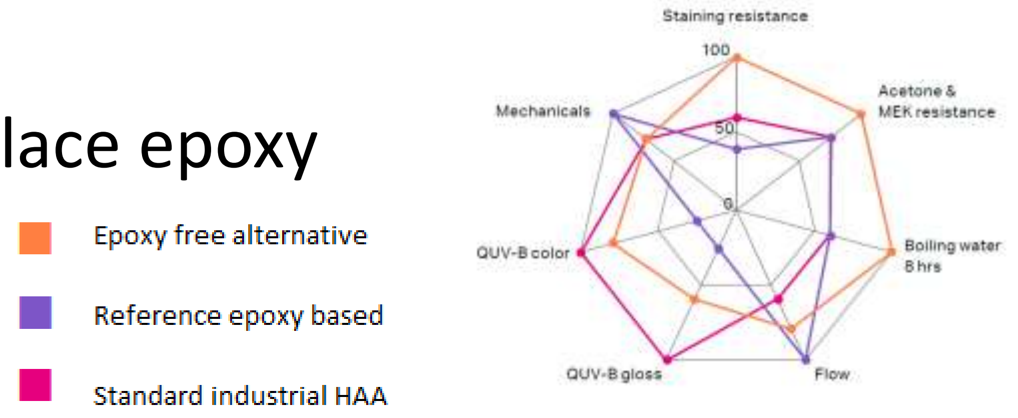
Reduce emissions and (potential) harmful components

- Develop powder based solutions for current non powder based application (e.g. coil, heavy mass, wood)

- Replace TMA containing resins/formulations for less harmful and/or biobased alternatives

- Sn free or organo Sn free catalysis for polyester resins

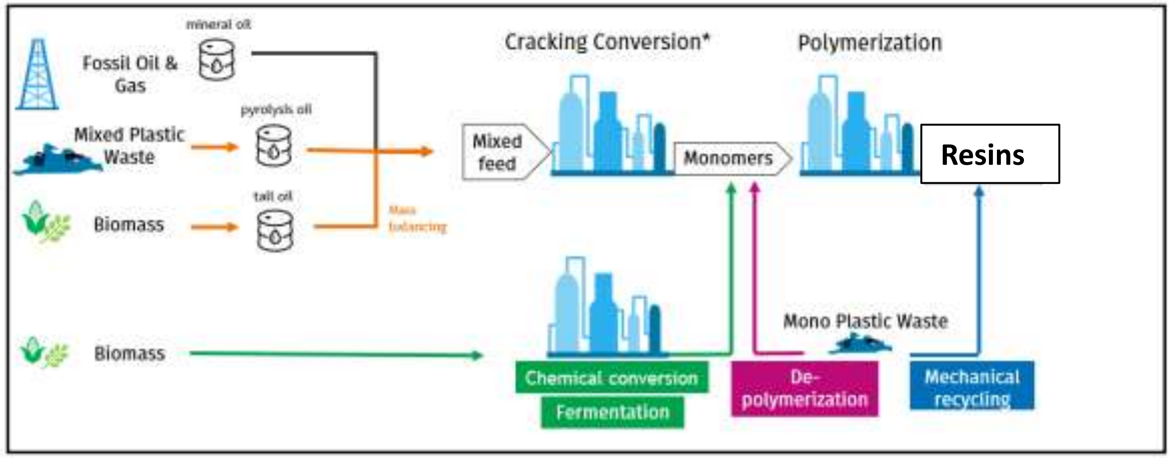
- Introduce resins and formulations to replace epoxy based/functional crosslinkers

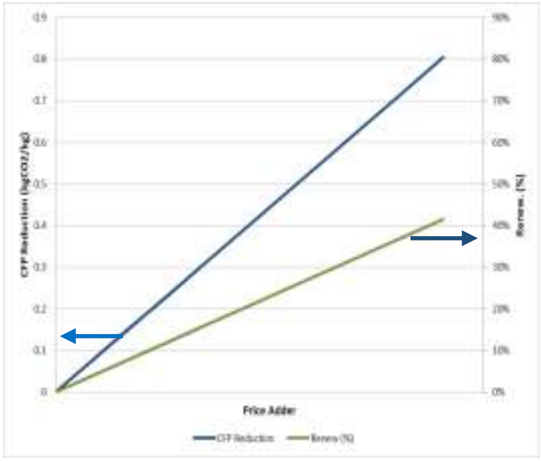


Renewable / recycled raw materials

- Reduce carbon footprint of polyester resins
  1. Use recycled feedstock (e.g. rPET)
  2. Use mass balanced raw materials
  3. Use biobased raw materials

- Mass balanced raw materials
  - CFP reduction with <u>no</u> impact on coating properties





Renewable / recycled raw materials

- Example of using bio-based raw materials
  - Gloss and matte appearance

- Reduce CFP (with 0.12 kgCO_2e/kg) @ 32% bio-based content (C14)
  - up to 46% attainable

✓Biobased raw materials

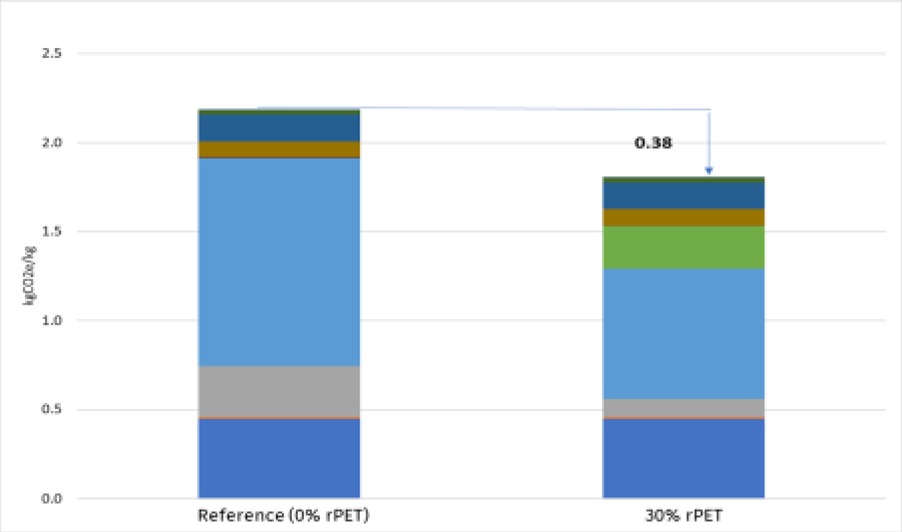
✓Reduce harmful components

✓Good coating properties

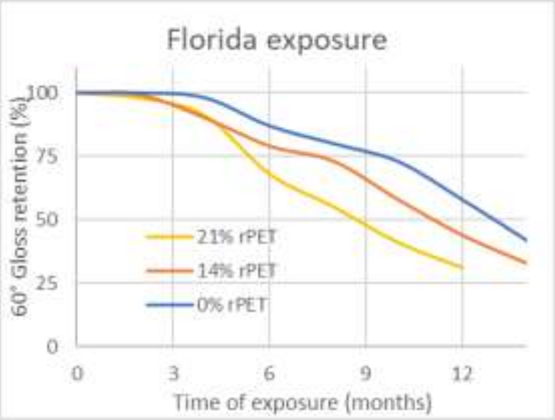
White pigmented 50/50 hybrid powder coating formulations				
	Glossy		Matt	
Refence resin	X		X	
(partly) bio-based resin		X		X
Formulations cured for 10' @ 350 °F				
Appearance (60 µm)	ok	ok	ok	ok
PCI flow (60 µm)	5	6	smooth	smooth
Gloss 20°	93	92	7	4
Gloss 60°	99	98	33	24
Color b*	0.5	0,6	0.4	0,6
Impact @ 160 in.-lbs.	pass	pass	cracks	cracks
Boiling water resistance 2 hrs.	good	good	n.d.	n.d.
Boiling water resistance 8 hrs.	good	good	n.d.	n.d.
Adhesion	5B	5B	5B	5B
Staining resistance	good	good	good	good
Salt spray 480 hrs. (NSS)	1.4 mm	1.4 mm	n.d.	n.d.
Powder stability (4wks/40°C)	8	6	6	6

Renewable / recycled raw materials

- Use of recycled feedstock



- Basic properties do not change for hybrid and HAA formulations
  - ➢Some effect on color/yellowing
- Outdoor durability decrease for non EG containing resins
  - ➢rPET cannot be used for all resins



Concluding remarks

- Sustainable powder coating solutions is not only about introducing bio-based raw materials
- Providing extended or improved protection of the coated object has a significant impact
  - Considering not only the CFP of the coating, but also of replace/(re-)create the coated object (perform LCA for full object)
- No one size fits all solution for a sustainable coating

- Start taking first steps for a sustainable coating future together

Thank you for your attention

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