FAST CURING 2K SYSTEMS WITH NO POPPING LIMIT MICHAEL ADDITION GOES WATERBORNE – **ACURE™ AQ**

Oliver Truchses & Gottfried Fuerpass

01 December 2022

SPEAKERS OF TODAY

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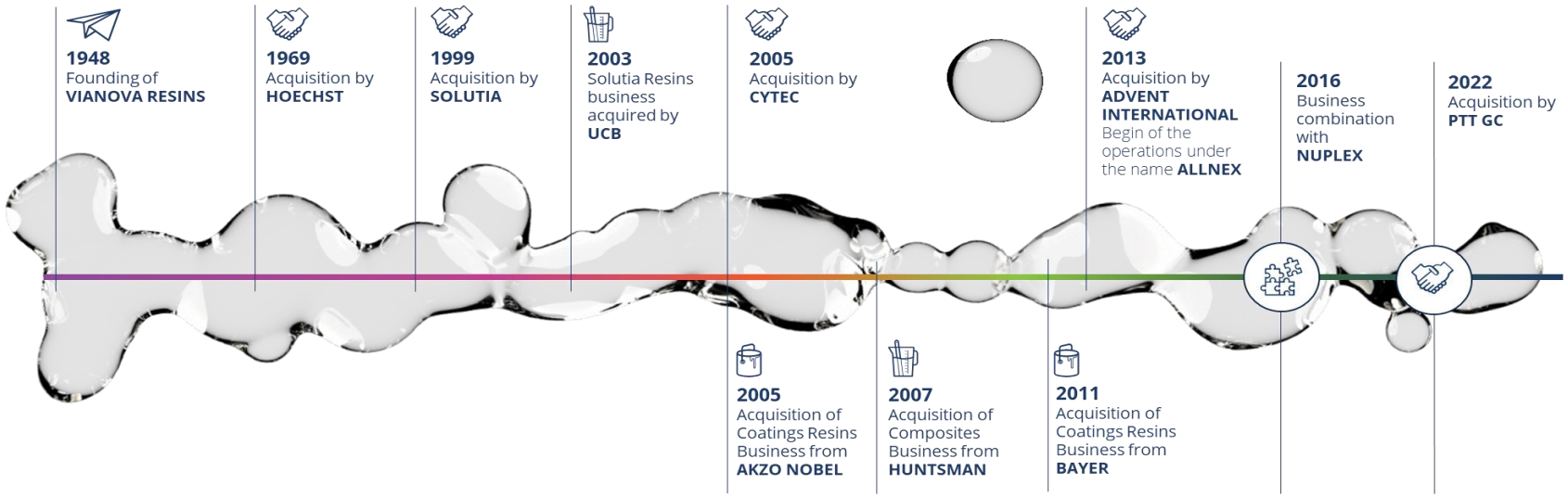
ALLNEX AT A GLANCE



TOTAL REVENUES
EUR 2.4 billion in 2021

4 BUSINESS AREAS

3,865 TOTAL STAFF
2021 (FTE)

33 MANUFACTURING SITES
worldwide

SALES
PER REGION

30 November 2022
www.allnex.com

allnex
The Coating Resins Company

OUR SUSTAINABILITY PILLARS

These pillars form the basis of allnex's ambitious Sustainability Program, covers all aspects from

- product development,
- raw material sourcing
- manufacturing supply chain management
- customer service.

13 CLIMATE ACTION

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

7 AFFORDABLE AND CLEAN ENERGY

PLATINUM Top 1% 2022 ecovadis Sustainability Rating

EMISSIONS REDUCTION

Reduce VOC across PLC

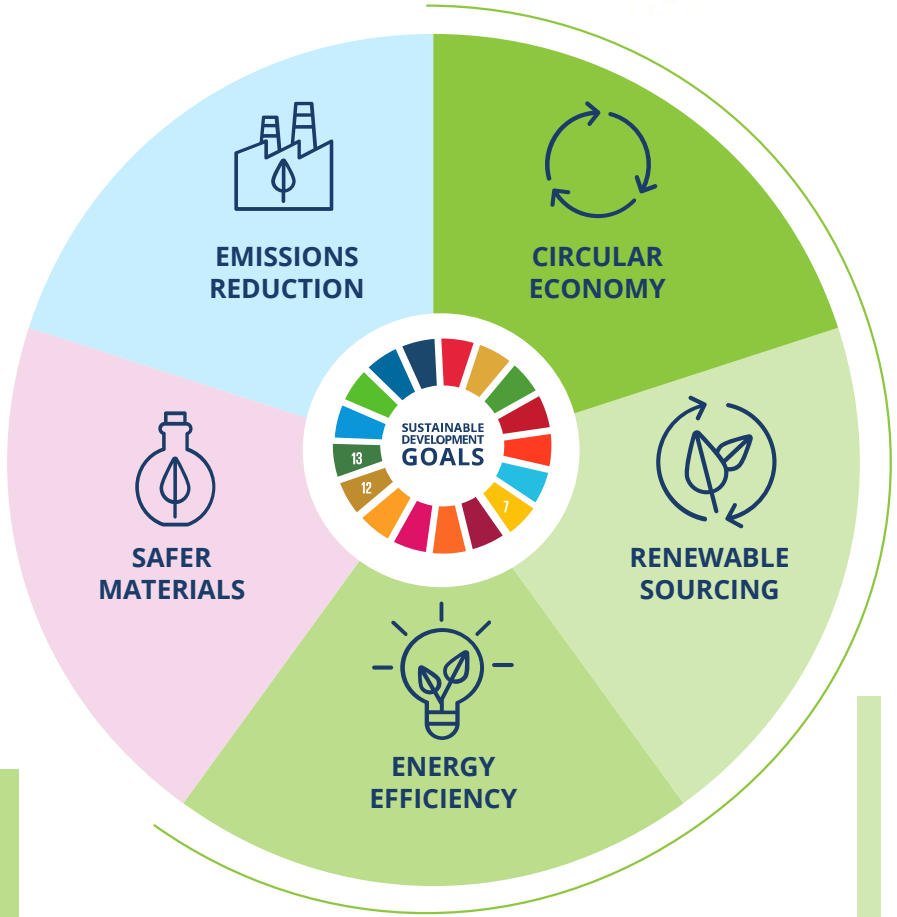
Protect people and enviroment

SAFER MATERIALS

Strong comittment of substitution of potentially harmful chemicals.

ENERGY EFFICIENCY

Maximum energy efficiency in energy utilizazion across PLC



CIRCULAR ECONOMY

Limit consumption of resources

Use them as long as possible

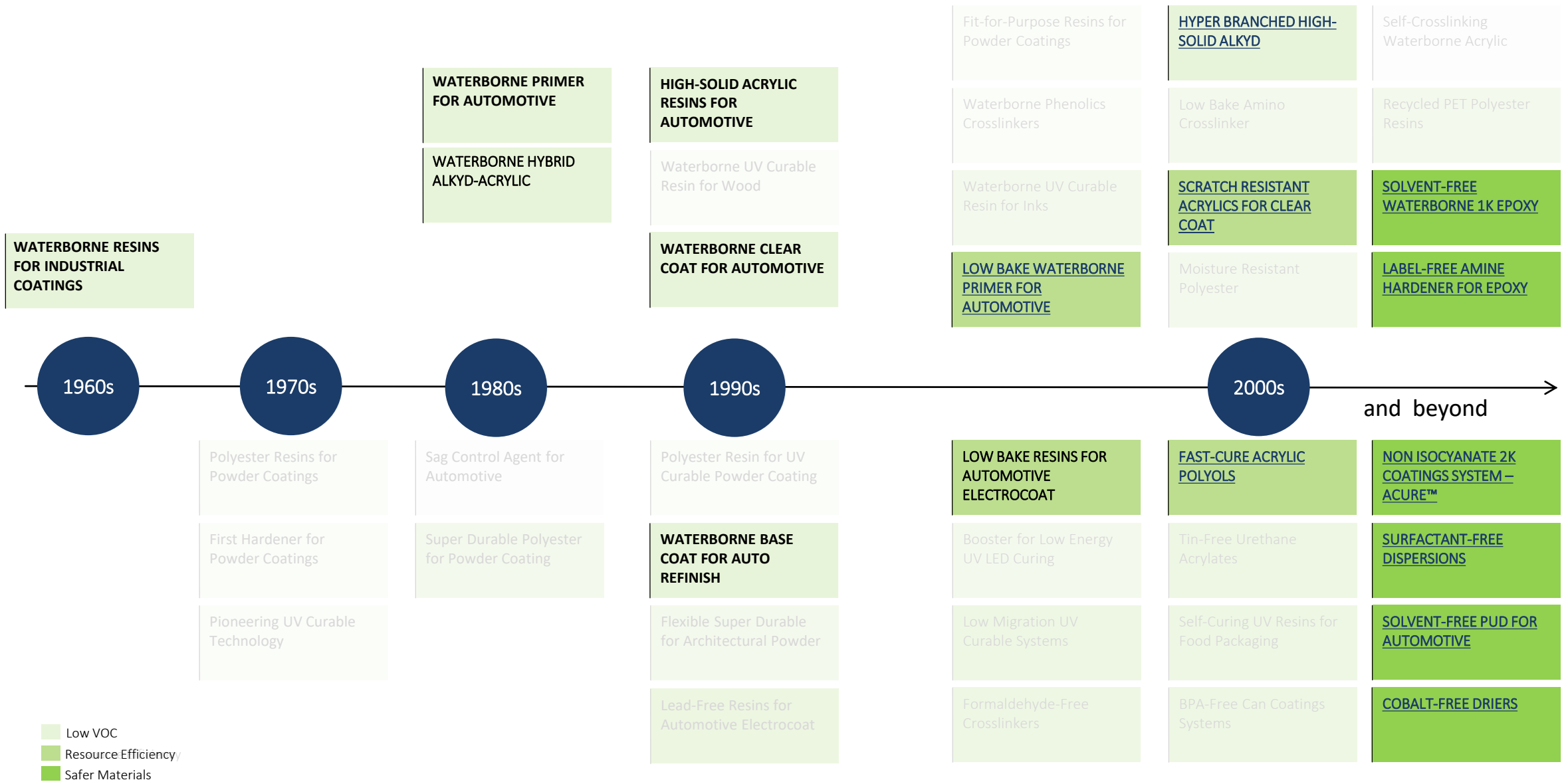
Eventually revcover & recycle

RENEWABLE SOURCING

Minimal use of finite resources

Reduce climate impact by renewable alternatives

PIONEERING SUSTAINABLE CHANGE



OUTLINE

- NISO Overview
- ACURE™ AQ – Introduction
- ACURE™ AQ – Do´s & Don’ts
- ACURE™ AQ – Future developments & value proposition

SUSTAINABLE IMPROVEMENT VERSUS ISOCYANATE CURING

Why allnex?

- Working on NISO technologies since many years
- Main driver, any new NISO system should be a sustainable improvement in product safety
- No toxic, harmful or allergy causing substances

Why NISO?

- Even 2K Isocyanate system are established for centuries, they have intrinsic issues which might be a challenge in future
- Most all global paint companies have active alternative programs
- Seeking for similar performance & preparing for tighter regulations

be ECOWISE™

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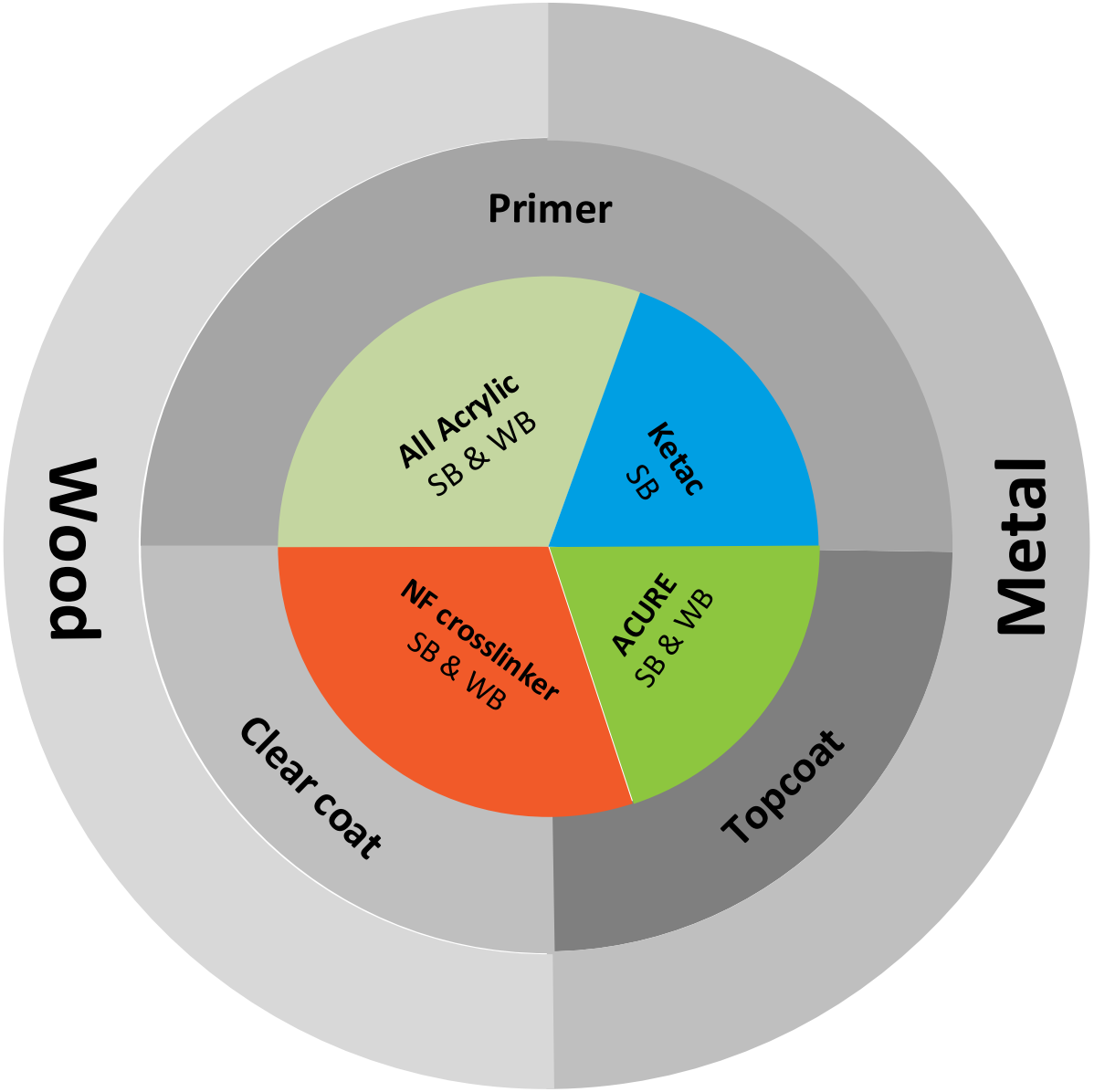
NISO OVERVIEW

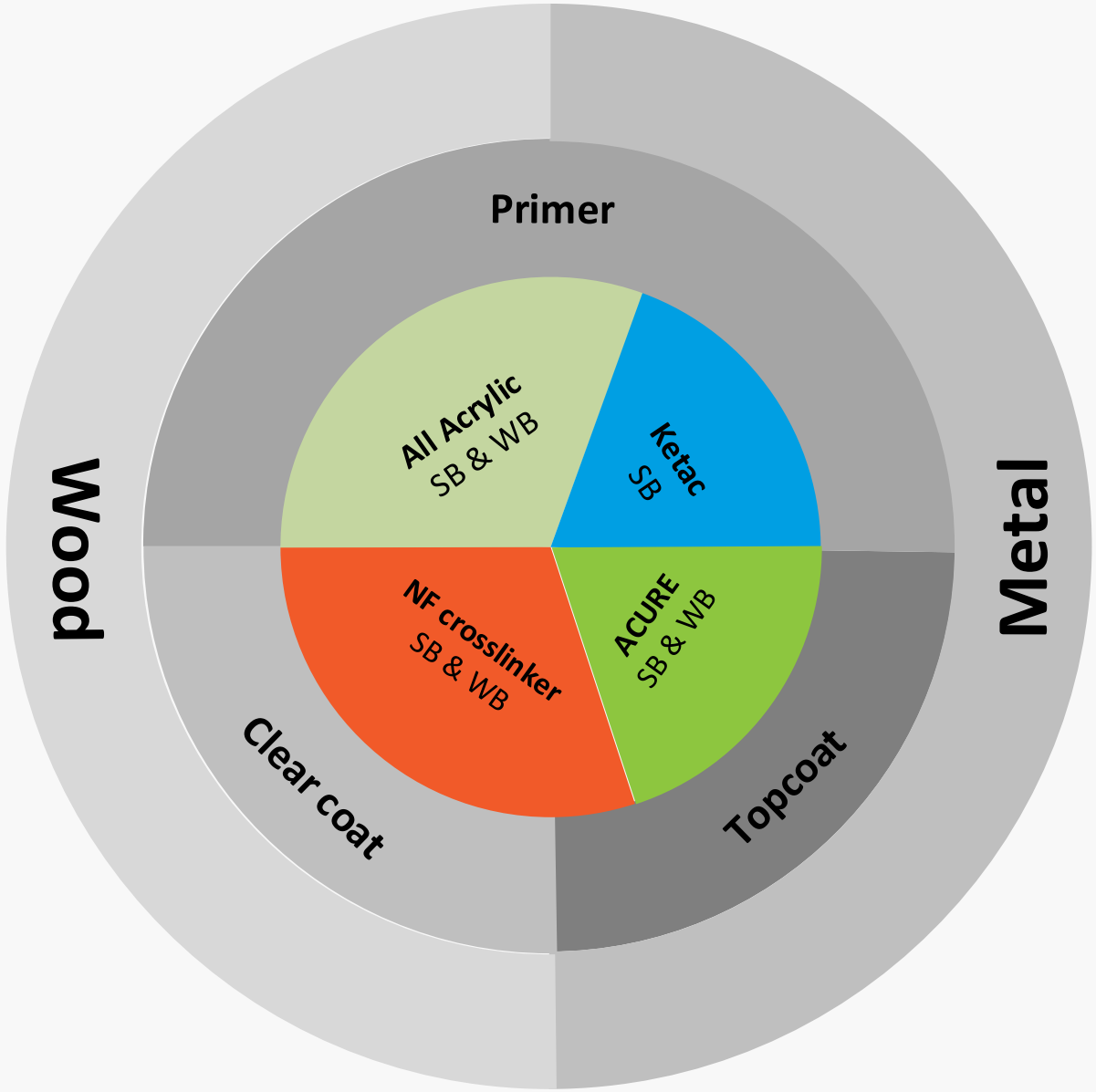


NISO OVERVIEW

ALL ACRYLIC
SETALUX® 8403 SS-55
SETALUX® 8503 SS-60

SETAQUA® 8455
SETAQUA® 8556

NON FORMALDEHYDE CROSSLINKER
CYMEL® NF 2000A
CYMEL™ NF 3030
CYMEL™ NF 3041

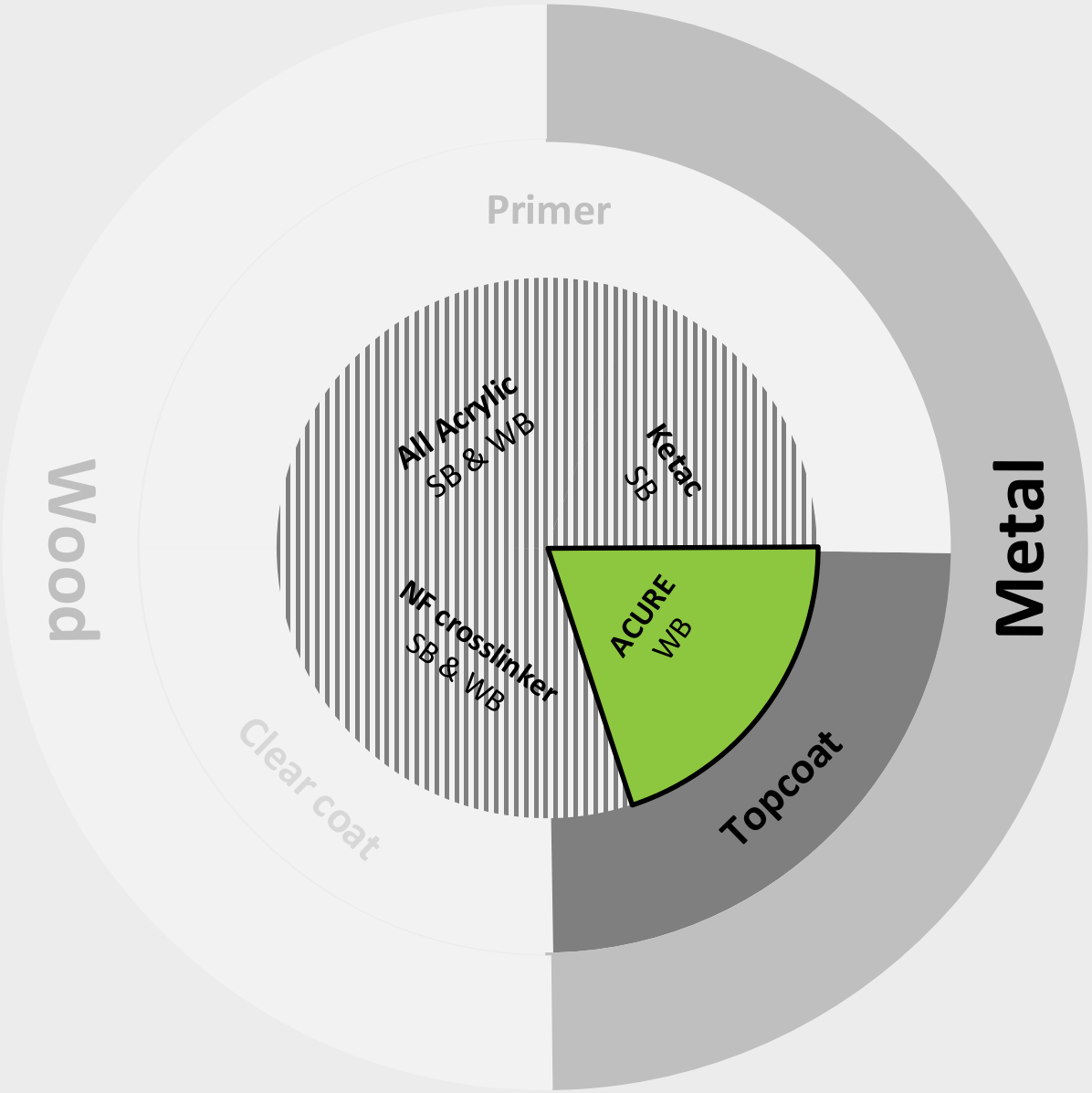


KETAC
SETALUX® 7006 SS-65
SETAL® 7205 BA-86

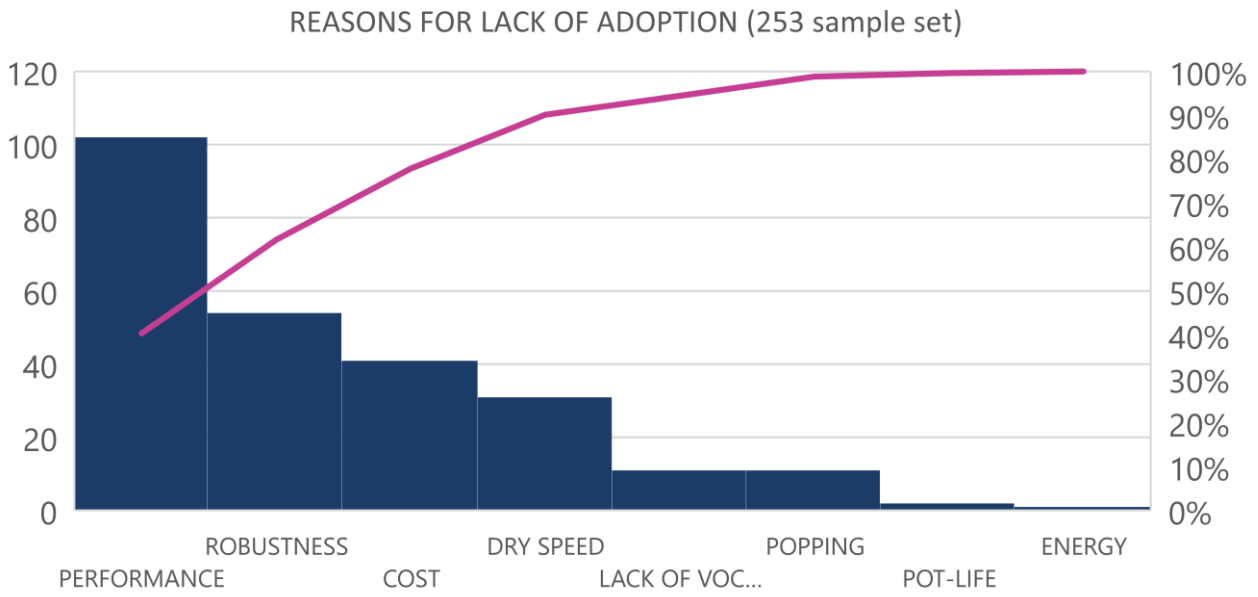
ACURE
ACURE™ 510-200
ACURE™ 510-270
ACURE™ 500

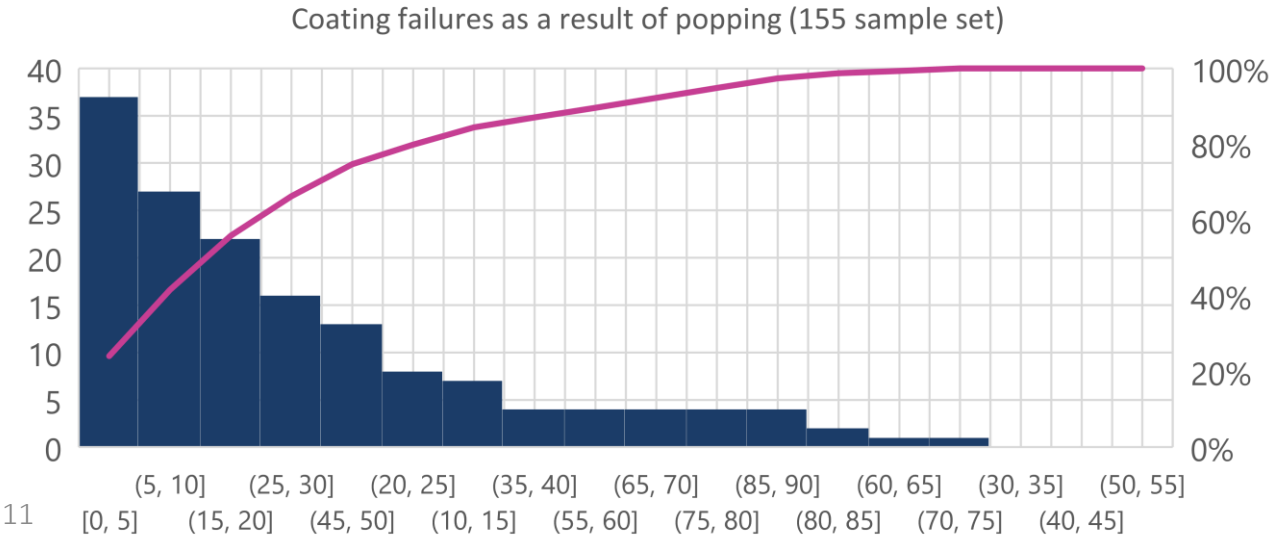
- WEBINAR: ACURE™ – Application-Specific Performance (ulprospector.com)
- WEBINAR: New ACURE™ Topcoat Based Non-Isocyanate Layer Systems (ulprospector.com)

TODAY´S FOCUS



REPLIES TO QUESTIONNAIRE





- The cost/performance balance for WB 2K systems seems to be too low in comparison to a SB alternative
- About 25% of respondents commenting about performance or other issues, flagged that there is a perception issue at the end user rather than an actual problem
- Robustness issues mostly pointed at application conditions related to temperature, humidity. Other issues related to paint formulation and surface preparation.
- 23% of respondents reported very low amounts of failures due to popping, about 36% reported failures in between 5-20% failures. Important to not that there is a big spread in the numbers.

2

ACURE AQ™ Introduction

Chemistry & Performance profile

ACURE™ AQ – THE NEW WATERBORNE NON-ISOCYANATE 2K SYSTEM

Why a Waterborne NISO system?

- Isocyanates are used as crosslinkers in 2K PU coatings, these products are labeled as **harmful & allergenic**.
- A key issue identified in working with 2K waterborne systems is the so-called **popping effect**, which results from the reaction of isocyanate with water. This results in bad appearance in higher layer-thickness and negative effects on corrosion performance amongst others.
- Another drawback of these systems is the **limited pot-life** after mixing the two components, as this causes **paint waste** and **inconsistent quality** at different points in time.

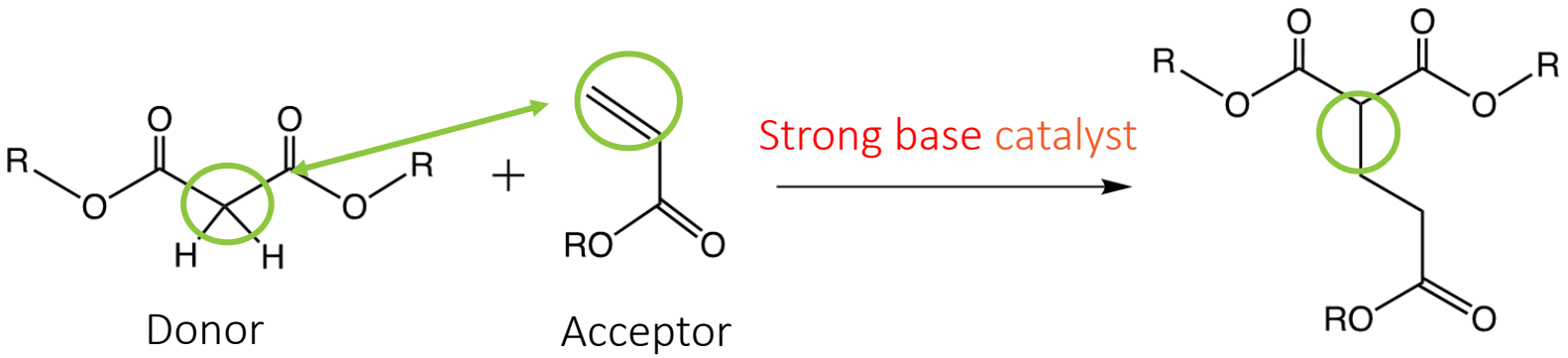
Potential solution?

ACURE™ AQ

- addressing some of these key issues by bringing our ACURE™ technology to the waterborne coatings domain

ACURE™ AQ - THE CURING MECHANISM (MICHAEL ADDITION)

Strong base catalyst deprotonates the donor-site, which enables reaction with the acceptor double bond. Resulting in carbon-carbon crosslinking.

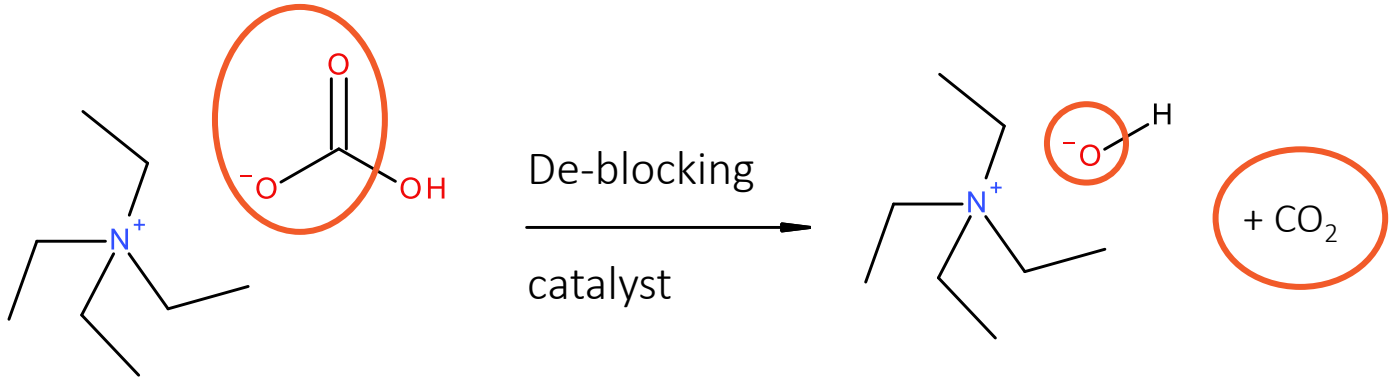


Donor

Acceptor

ACURE™ AQ - THE CURING MECHANISM (MICHAEL ADDITION)

Catalyst becomes deblocked by the release of CO2 creating the strong base needed in the **Michael addition reaction**



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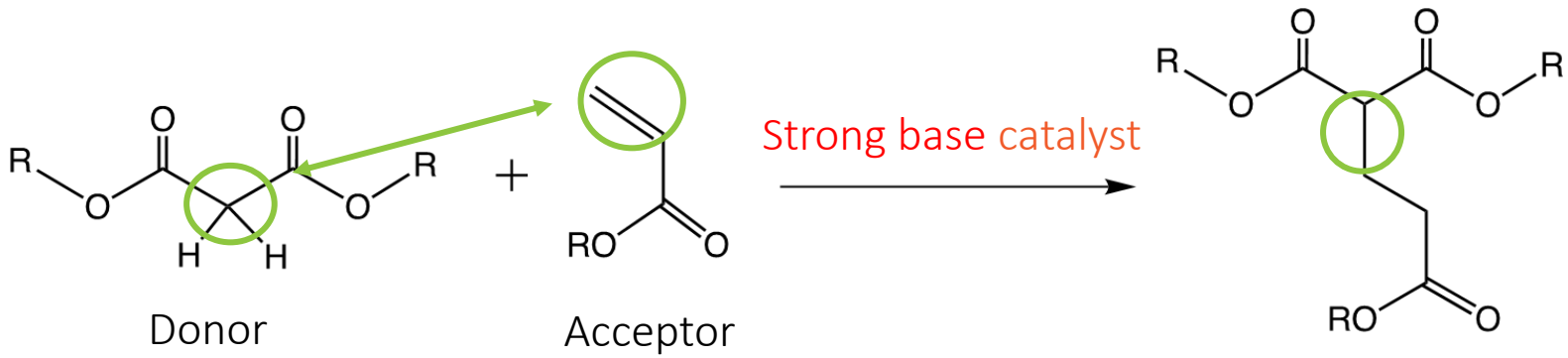
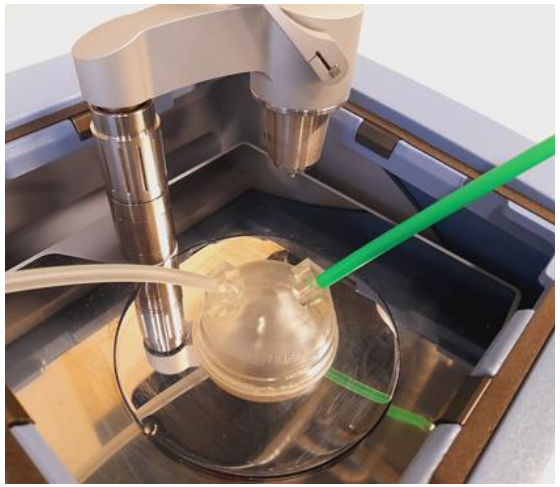
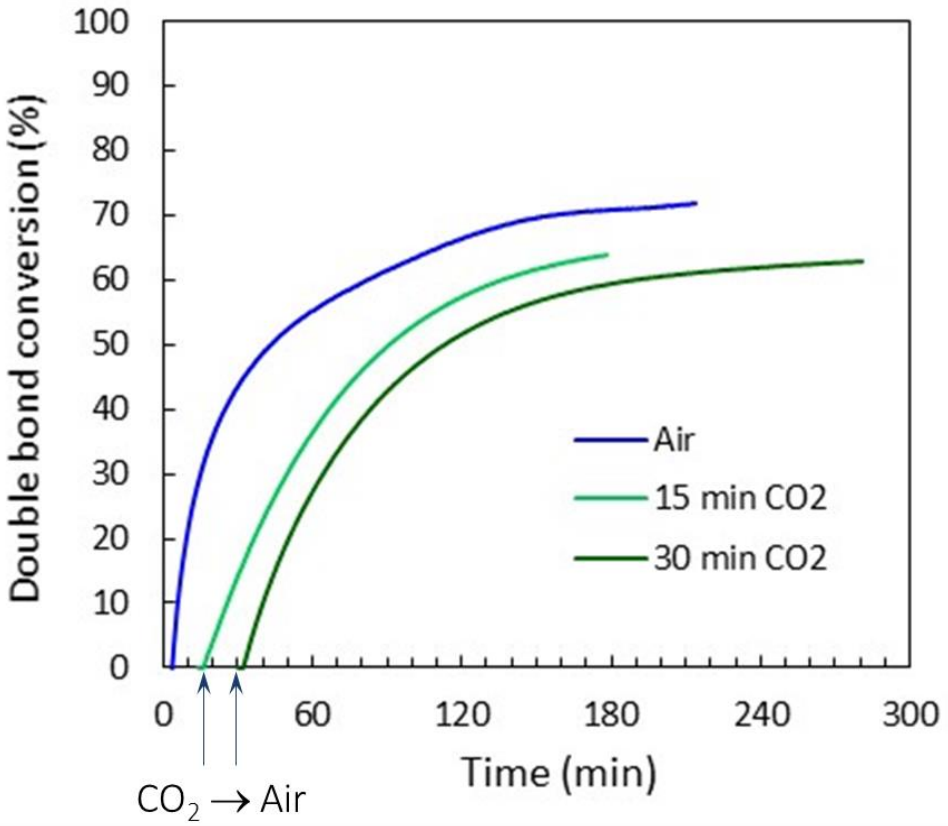


Extremely fast cure/conversion once catalyst is de-blocked
No side reactions with water, no toxic metal catalyst

ACURE™ AQ - THE CURING MECHANISM (MICHAEL ADDITION)

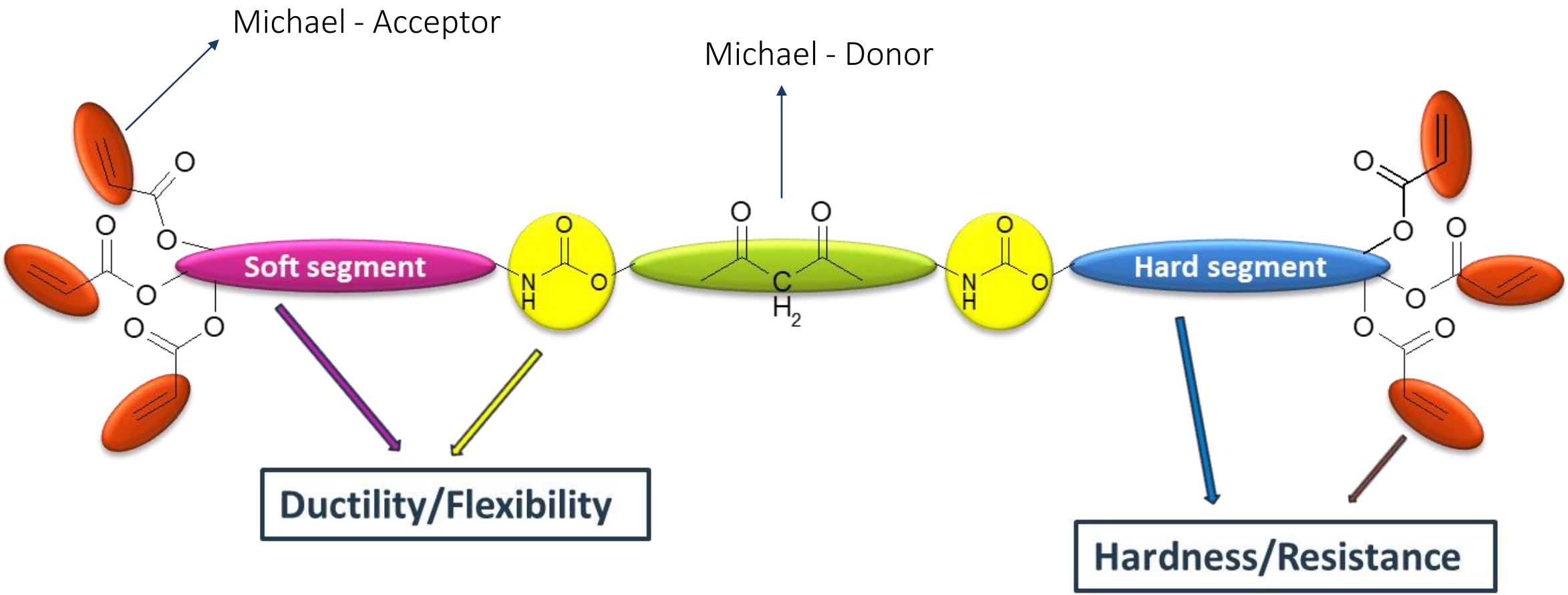


DLP printed environmental chamber for FTIR spectroscopy. The chamber is flushed with CO_2 gas.



- No curing upon CO_2 saturation
- Curing starts immediately after switch to air

ACURE™ AQ – THE BINDER CONCEPT



Options for bio-based content!

ACURE™ AQ – RESIN PROPERTIES

RESIN (COMP A) ± 95 % mixing ratio	ACURE™ AQ 620-100
Technology: Non-ionic PUD containing both Michael donor and acceptor sites	
Solids content, DIN 55671	41.0 – 43.0 %
Dyn. Viscosity, ISO 3219	< 4000 mPa.s
Acid number, ISO 2114	<= 2 mg KOH/g
pH-value, DIN 976	6.0 – 8.0
Flashpoint, DIN 1523	> 94 °C
VOC content	< 3 % (methoxy propanol)

+

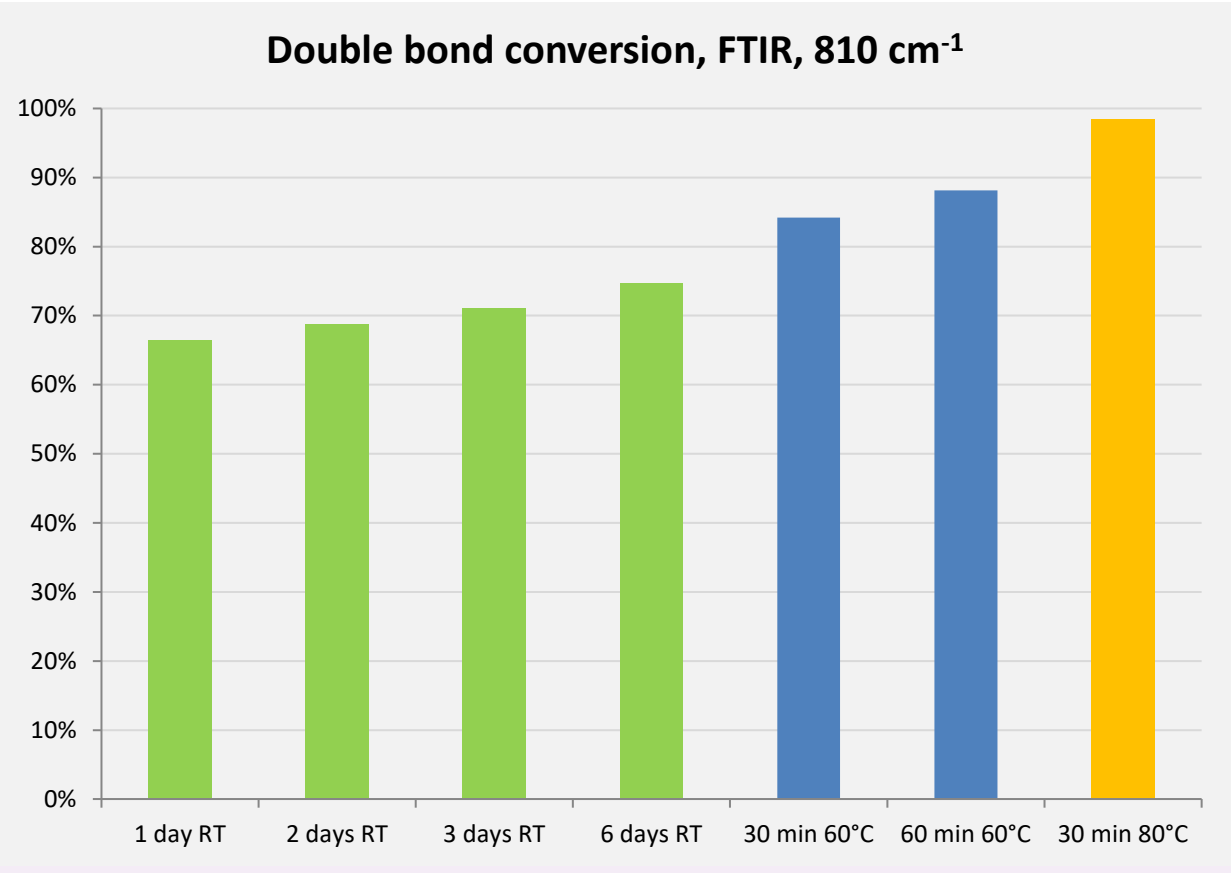
CATALYST (COMP B) ± 5 % mixing ratio	ACURE™ 600
Technology: Blocked base	
Color (HAZEN), DIN 6271-1	< 100
Amine value, DIN 53176	43.5 – 46.5 mg KOH/g
pH-value, DIN 976	8.0 – 11.0
Flashpoint, DIN 1523	> 44 °C
VOC content	< 10 % (ethanol)

Low viscosity catalyst is easily blended into component A

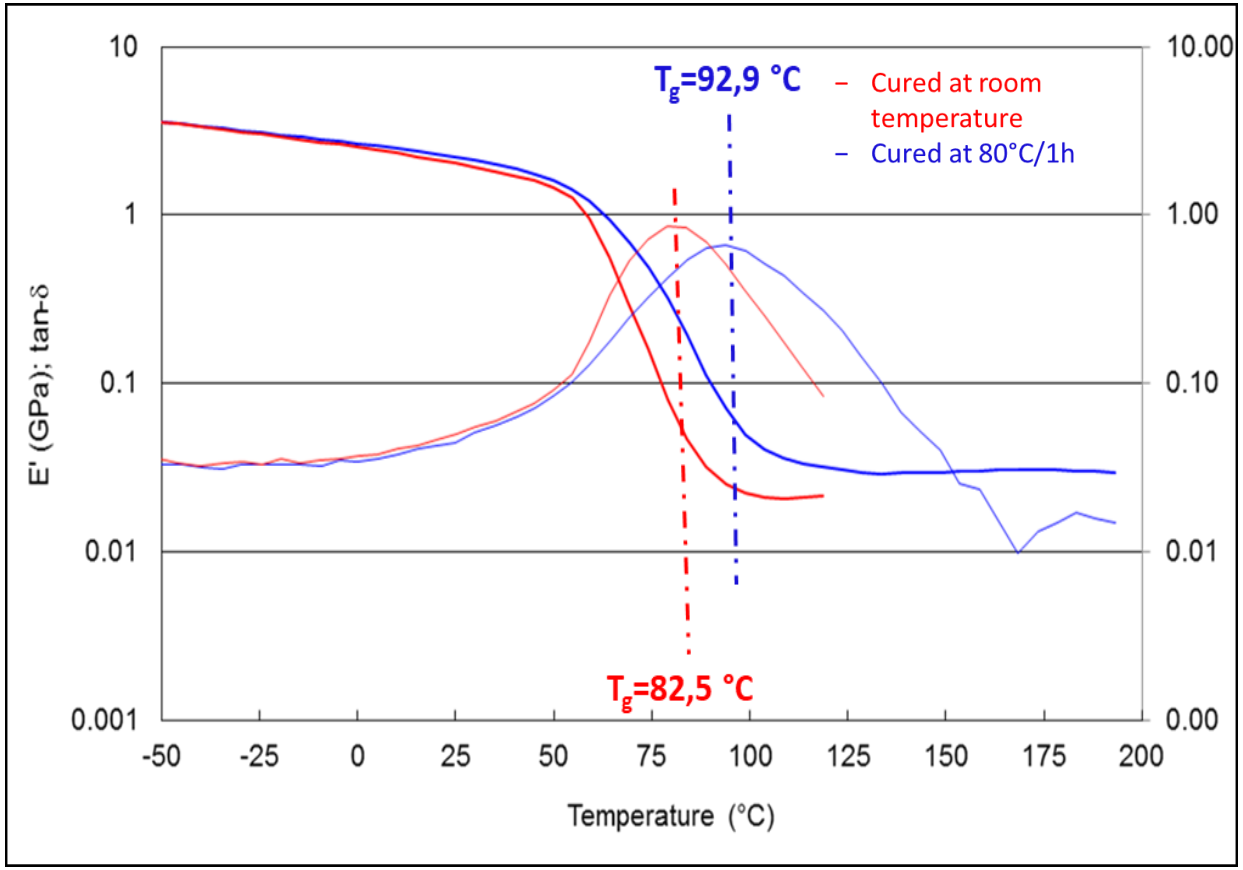
ACURE™ AQ – LESS HAZARDOUS MATERIALS

Typical hydrophilic Polyisocyanate	ACURE™ AQ 620-100	ACURE™ 600
 **Signal Word** Warning	 **Signal Word** Warning	 **Signal Word** Warning
H317 - May cause an allergic skin reaction. H332 - Harmful if inhaled. H335 - May cause respiratory irritation. H412 - Harmful to aquatic life with long lasting effects.	H315 - Causes skin irritation. H319 - Causes serious eye irritation. H412 - Harmful to aquatic life with long lasting effects.	H226 - Flammable liquid and vapour. H312 - Harmful in contact with skin. H336 - May cause drowsiness or dizziness. H319 - Causes serious eye irritation. H412 - Harmful to aquatic life with long lasting effects.
	Not considered to be a skin allergenic (H317) or a respiratory irritant (H332, 335). Suspected skin and eye irritation Cat 2 (H315 and H319).	Mixture of ACURE™ AQ 620-100 + ACURE™ 600 is no longer flammable.

ACURE™ AQ – HIGH CROSSLINK DENSITY EVEN AT AMBIENT CURE

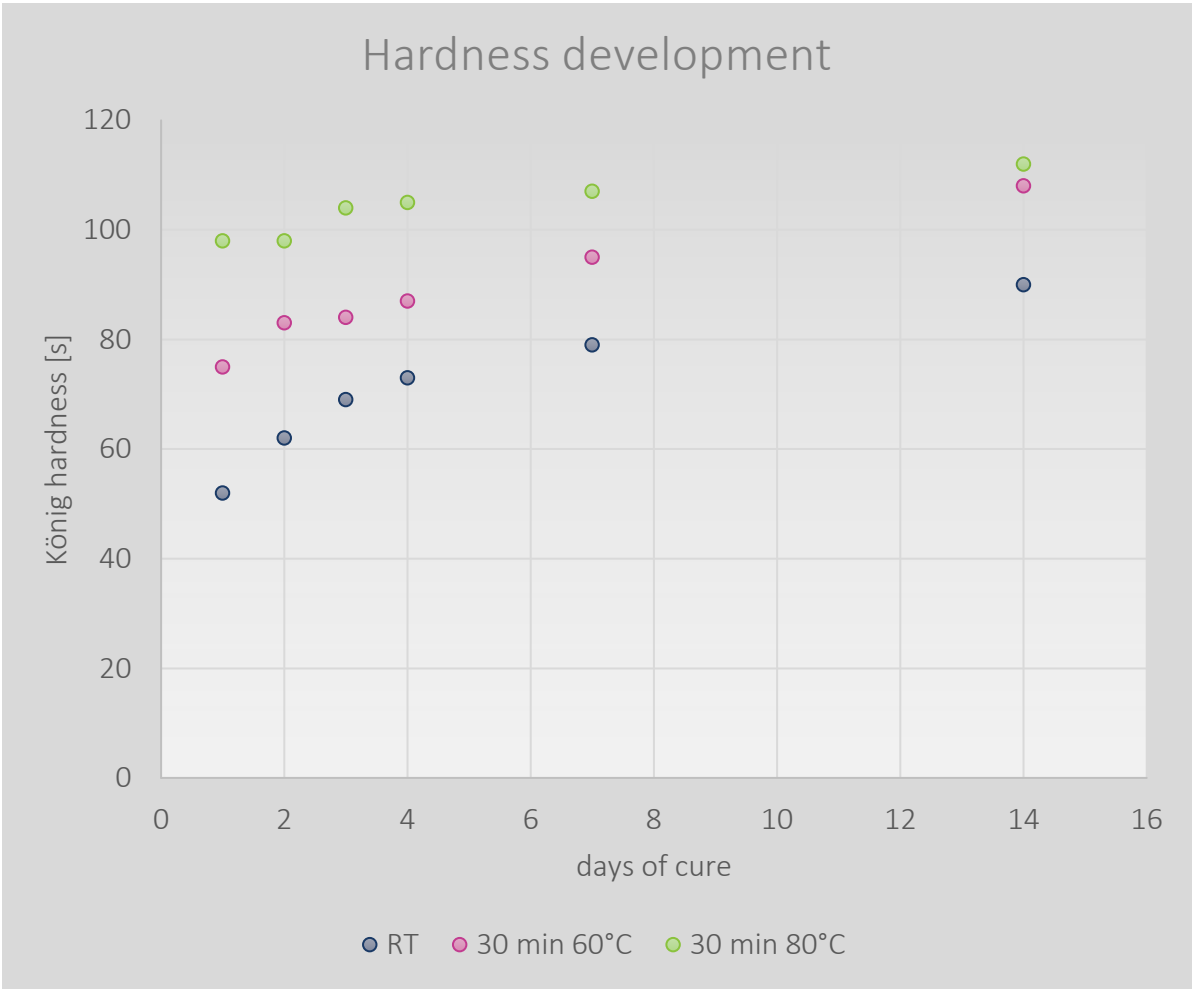


A high x-linking density is already feasible with pure room temperature cure. Full conversion is achieved by forced cure.



		RT	1h/80°C
XLD	v_e, mmol/cm³	2,089	2,883
	M_c, g/mol	530	380

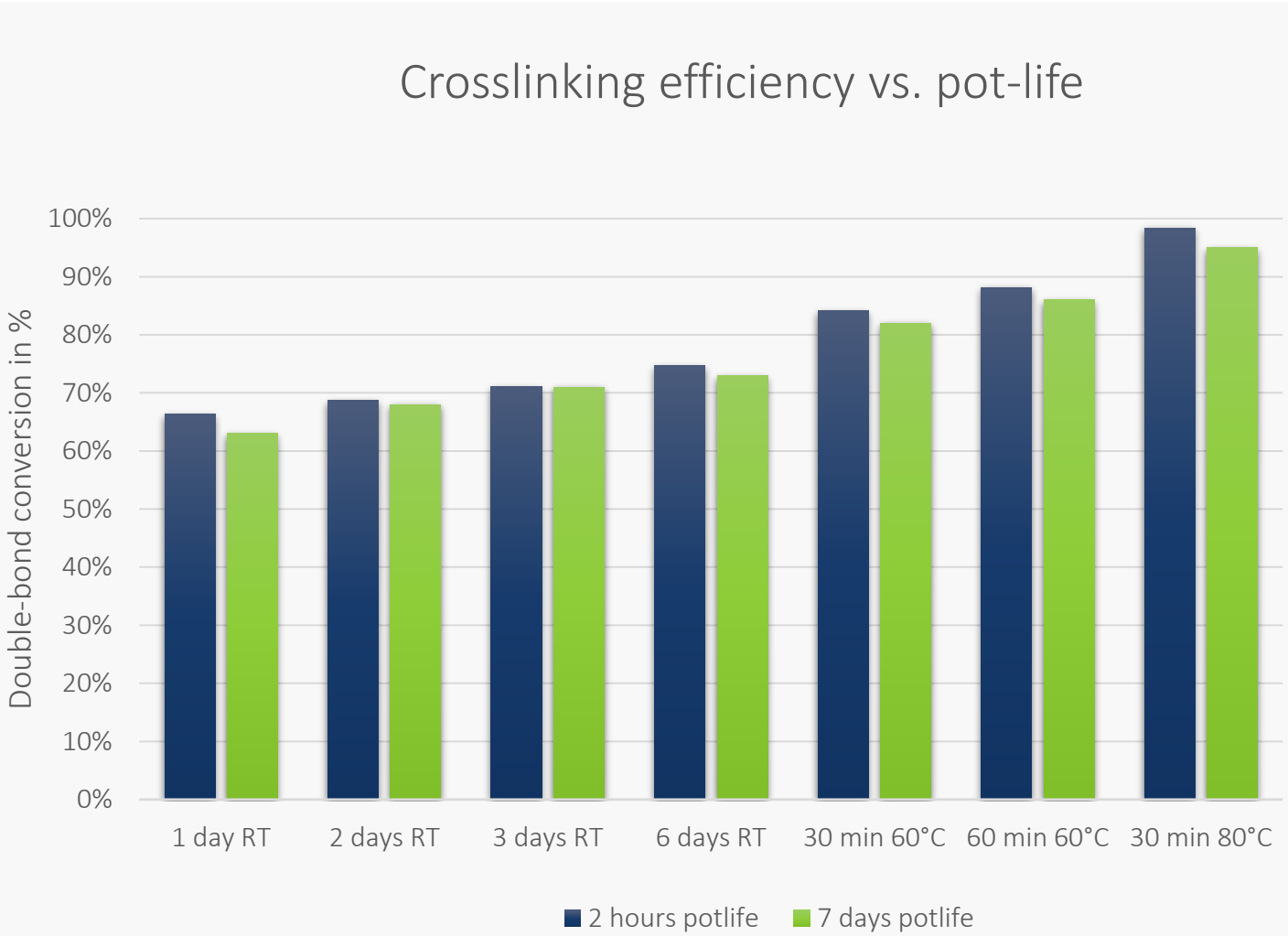
ACURE™ AQ – PAINT PERFORMANCE AS A FUNCTION OF CURE TEMPERATURE



Performance data of white pigmented topcoat (P/B=0,8)

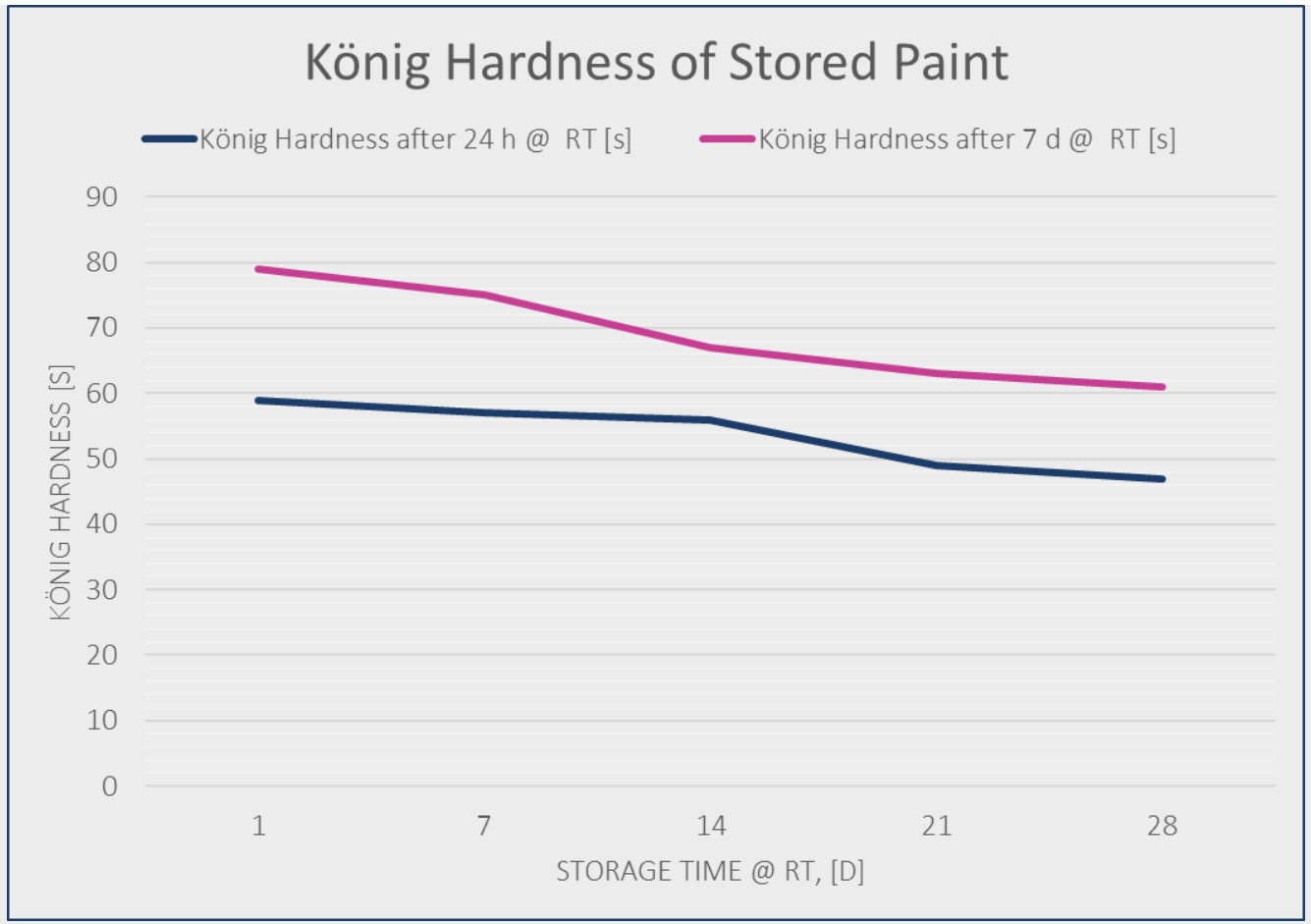
	23°C	30 min / 60°C	30 min / 80°C
Tack free time	< 60 min	-	-
Erichsen cupping	9,5 mm	9 mm	9 mm
Impact, front	> 50 iP	> 50 iP	> 50 iP
Impact, back	> 50 iP	> 50 iP	> 50 iP
MEK-double rubs	> 200	> 200	> 200
EtOH resistance	10 min	15 min	20 min
Acetone resistance	4 min	5 min	6 min

ACURE™ AQ – AN OUTSTANDING POTLIFE



Almost same x-linking kinetics seven days after mixing of components

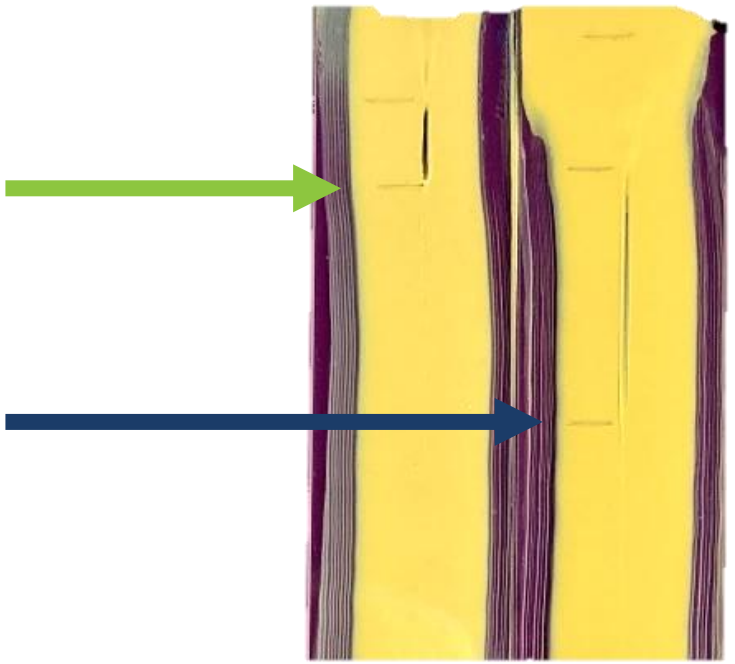
ACURE™ AQ – AN OUTSTANDING POT-LIFE



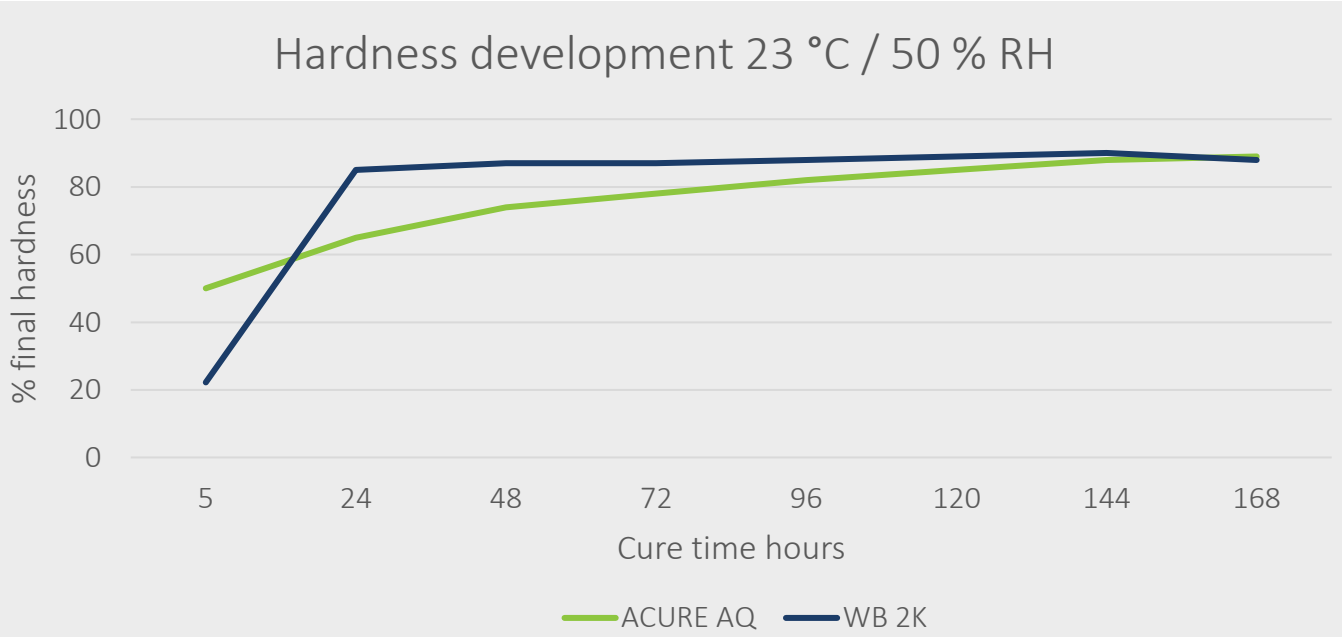
- Still 80 % of initial hardness after 28 days of pot-life
- 200 MEK DR throughout 28 days of pot-life
- No loss of gloss performance

ACURE™ AQ - EARLY PROPERTY DEVELOPMENT (HARDNESS)

	ACURE™ AQ	WB 2K PU
End of reflow	1hr	2hr



Tack-free	1.5 hr	4.5 hr
Early hardness 5 hr	33 s	20 s
Hardness 1 wk	66 s	90 s
Final Hardness 3 wk	74 s	102 s



ACURE™ AQ has a clear advantage during the initial stages of cure, which enables faster cycle times at end-users

Final properties take a bit longer to develop with ACURE™ AQ. Typical WB 2K PU formulations have NCO reacting with H_2O in the formulation, leading to faster hardness build up. This causes formation of CO_2 and may lead to bad appearance and film properties.

ACURE™ AQ - EARLY PROPERTY DEVELOPMENT (RESISTANCE TO WATER)

ACURE™ AQ:
swells with water but fully regenerates

wb 2K PU:
suffers from irreversible damage

Water spot test, 2 hours after coating is applied
23 °C / 55 %RH

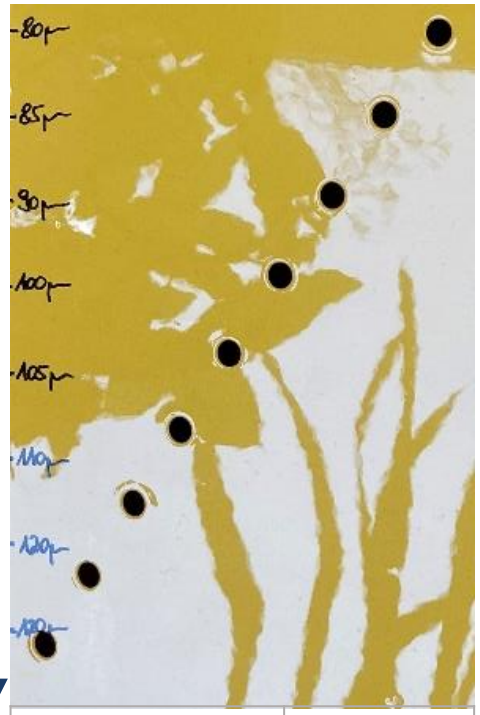
Exposure time	ACURE™ AQ Topcoat	wb 2k PU Topcoat
1 h	ok	soft/sticky
3 h	small blisters/regen.	whitish/flat
5 h	small blisters/regen.	whitish/flat
7 h	small blisters/regen.	whitish/flat
24 h	small blisters/regen.	whitish/flat

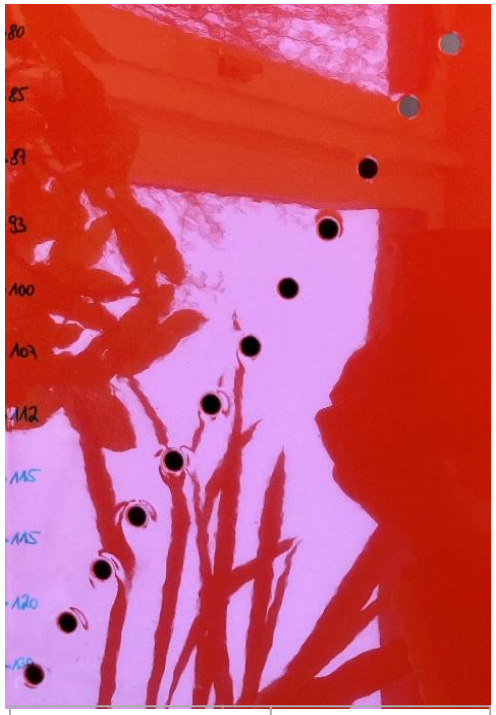
A key issue with 2K waterborne polyurethane coatings is their sensitivity to water in the early hours after the coating is applied.

ACURE™ AQ - GREAT APPEARANCE REGARDLESS OF COATING THICKNESS

ACURE AQ based topcoats

80 µm DFT 120 µm





P:B ratio	0.48:1
VOC (excl. water)	135 g/L
Gloss (20°/60°)	80 / 90

P:B ratio	0.54:1
VOC (excl. water)	130 g/L
Gloss (20°/60°)	80 / 90

No side reactions happen during the curing of ACURE™ AQ as there is no NCO present to form CO_2

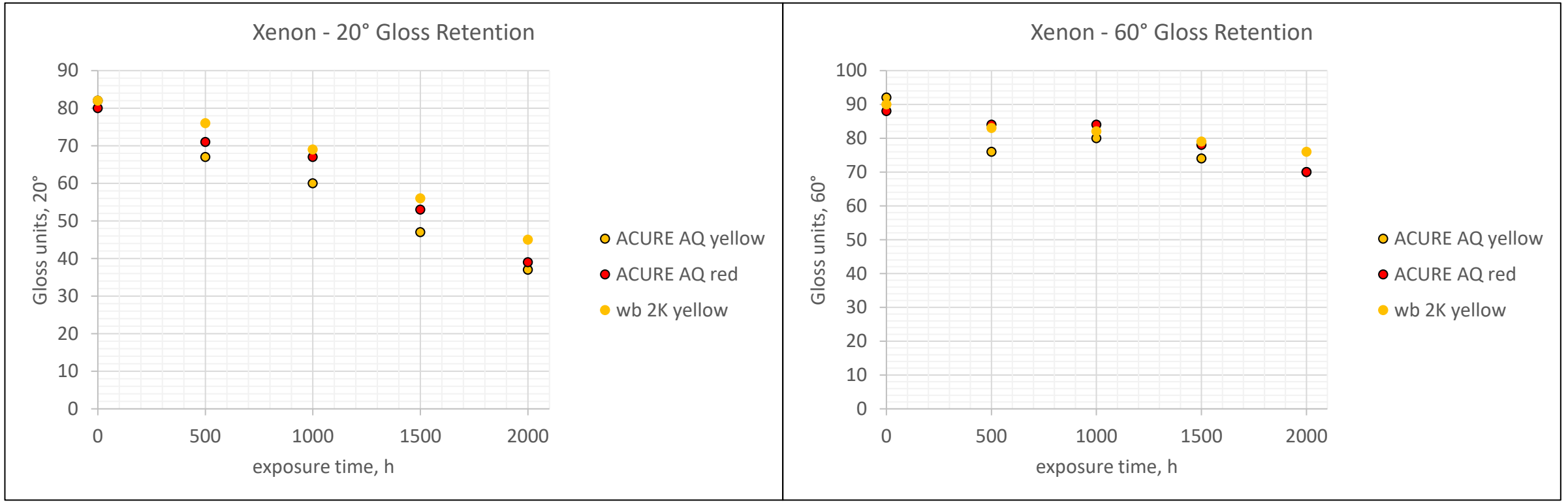
Maximum coating thickness is determined by sagging performance of the coating

Short flash-off time before forced cure, might cause catalyst to trigger before H_2O has evolved from the film. (min 40 mins)

Typical popping issues with WB 2K PU

80 µm DFT 120 µm

ACURE™ AQ - XENON WEATHERING



German Railway Standard = Initial gloss >80 GU at 20°; 1500 h Xenon >50 GU at 20° & delta E = 1,5

ACURE™ AQ - SYSTEM FLEXIBILITY DETERMINED BY PRIMER NOT BY TOPCOAT

DFT 60 µm (Primer), 50 µm (TC), 7 days 23°C/50%RH, Cold rolled steel

	Impact (ASTM D-2794), inch-pounds		Erichsen indentation (DIN 53156), mm	Conical Mandrel (DIN 6860), mm	Adhesion (DIN 53151), Gt
	face	reverse			
Primer (EP 2387/EH 2100)	60	10	7.7	0	n.a.
Primer + ACURE AQ Topcoat red	70	30	9.6	0	0-1
Primer + ACURE AQ Topcoat yellow	80	50	> 10	0	0-1
Primer + wb 2k Topcoat yellow	70	30	> 10	0	0-1

DFT 70 µm (Primer), 50 µm (TC), 7 days 23°C/50%RH, Cold rolled steel

	Impact (ASTM D-2794), inch-pounds		Erichsen indentation (DIN 53156), mm	Conical Mandrel (DIN 6860), mm	Adhesion (DIN 53151), Gt
	face	reverse			
Primer (EP 2384/EH 2261)	**20**	**<5**	1.0	11 cm	n.a.
Primer + ACURE AQ Topcoat red	20	<5	5.9	0	0-1
Primer + ACURE AQ Topcoat yellow	20	<5	8.7	0	0-1
Primer + wb 2k Topcoat yellow	20	<5	9.9	0	0-1

> 200 MEK double rubs!

ACURE™ AQ - ADHESION TO EPOXY PRIMERS

FLEXIBLE ULTRA LOW VOC PRIMER (REC 20026)

BECKOPOX™ EP 2387w/53WA BECKOCURE® EH 2100w/44WA	Cross cut adhesion after 14 days			
Dry time Primer	2 hours	6 hours	24 hours	24 h RT + 24 h 80 °C
ACURE AQ yellow	0-1	0-1	0-1	0
wb 2K PU yellow	0	0	0-1	0

FAST CURING LOW VOC PRIMER (REC 19012)

BECKOPOX EP 2384w/57WA BECKOCURE EH 2261w/41WA	Cross cut adhesion after 14 days				
Dry time Primer	2 hours	6 hours	24 hours	24 h RT + 24 h 80 °C	24 h RT + 24 h 80 °C + sanding
ACURE AQ yellow	1-2	1	1	5	0-1
wb 2K PU yellow	1	1	1	1	1

It is advisable to sand force cured/baked epoxy primer, if compatibility has not been tested upfront.
With our newly developed ultra-low VOC flexible primer system, sanding can be avoided while also keeping total VOC emissions at the lowest possible level.
Fast primers based on EP 2384 and EH 2261 can be overcoated after short ambient cure.

ACURE™ AQ - SHORT RECOAT WINDOW FOR HIGHER THROUGHPUT

VDA Test: 2-layer system
ACURE™ AQ Red Topcoat (REC20042)
Primer based on BECKOPOX™ EP 2384w/57WA - BECKOCURE® EH 2261w/41WA

2 H*	6 H	24 H

* Time indication: drying of the primer layer @ 23 °C / 50 %RH

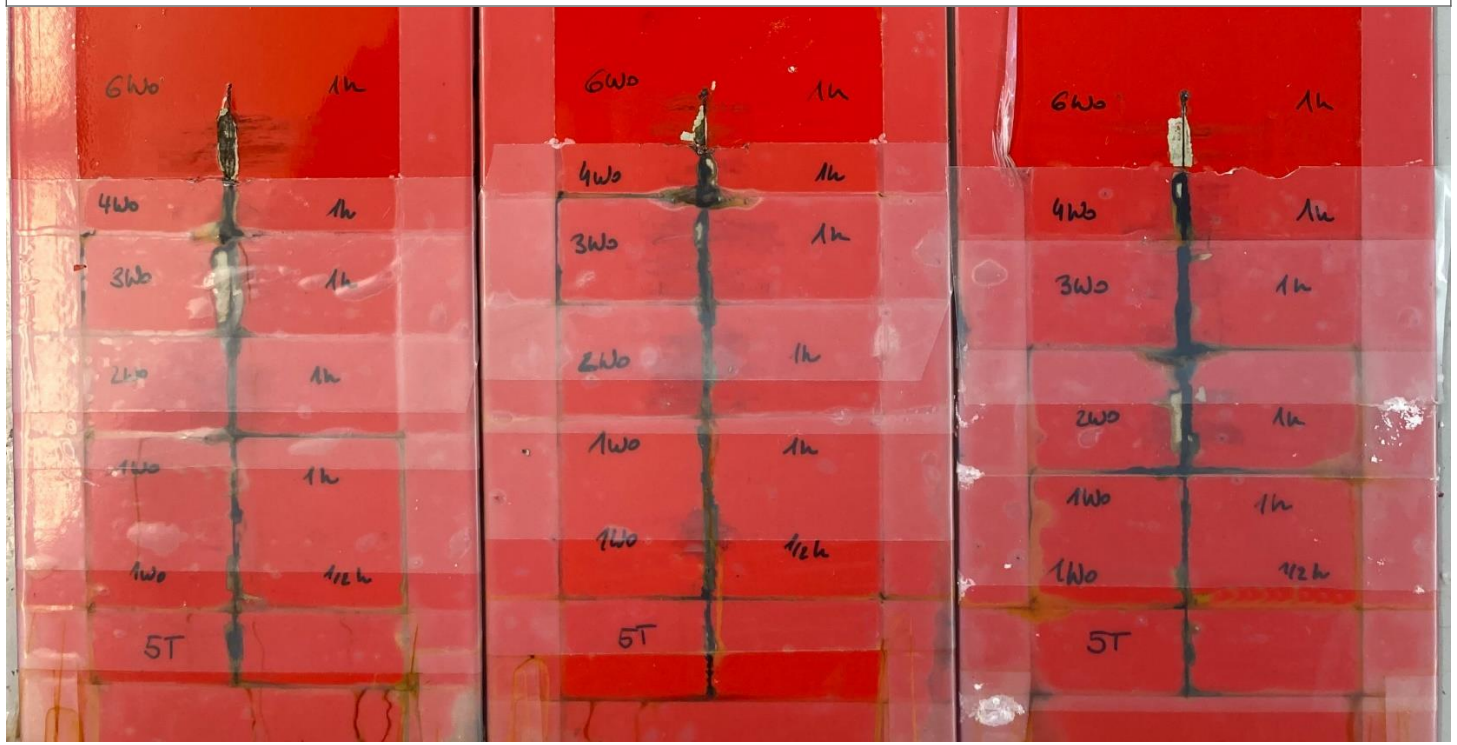
DIN 11997-1	6 cycles
Blisters	none
Blisters at scribe	2(S2)
Adhesion (DIN 2409)	GT 2
Rust (DIN 4628-3)	Ri 0
Delamination from scribe	0 – 1 mm

Substrate: Sandblasted steel (Sa 2½)
VDA Test: DIN EN ISO 11997-1 / Cycle B
Primer: 90 µm DFT
Topcoat: 55 µm DFT
Drying: 7 days 23 °C / 50 %RH

ACURE™ AQ - SHORT RECOAT WINDOW FOR HIGHER THROUGHPUT

Neutral Salt Spray Test: 2-layer system
ACURE™ AQ Red Topcoat (REC20042)
Primer based on BECKOPOX™ EP 2384w/57WA - BECKOCURE® EH 2261w/41WA

2 H*	6 H	24 H



	672 h	1008 h
Salt Spray Test: DIN 9227		
Delamination from scribe	0-2 mm	1-3 mm
Blisters	1(S1)	1-2(S1-2)
Humidity Chamber: DIN 6270-2		
Gloss (20°/60°)	76/90	72/88
Blisters	ok	1(S2)

Substrate: Sandblasted steel (Sa 2½)
Primer: 90 µm DFT
Topcoat: 55 µm DFT
Drying: 7 days 23°C/50% RH

* Time indication: drying of the primer layer @ 23 °C / 50 %RH

3

ACURE AQ™

Do´s & Don’ts

CONSIDERATIONS IN FORMULATING AND APPLYING ACURE™ AQ

Avoiding acids in the formulation or substrates:

The topcoat cures by strongly basic catalysis. Any acidic components (dispersants, thickeners, fillers, etc.) will consume the catalyst and lead to cure inhibition. The primer layer should not contain accessible acidic groups. If anionic primers are used it should be readily cured before the topcoat is applied.

Light Stabilizers:

HALS stabilizer (e.g. Tinuvin 292) and UV-absorber (e.g. Tinuvin 1130) can be used in darker pigmented systems. For better incorporation it is recommended to dissolve the light stabilizers in a proper solvent, (e.g. 1:1 in butyl glycol acetate). For clearcoats over brighter basecoats paint discoloration (yellowing) with certain UV-absorbers may be an issue. Tinuvin 292 alone works well, if additional UV-absorber is desired we recommend to use Tinuvin 479-DW.

Pot-life:

The resin does not show a pot-life indication (no increase of viscosity, no loss of gloss). Application of premixed resin + catalyst during 24 hours can be achieved without loss of properties. Formulations are useable for even longer periods, but this has to be evaluated depending on formulation and performance requirements.

Shear stability:

Direct grinding is possible

Paint storage:

Formulated component A should not be stored under oxygen free atmosphere as it contains acryloyl functionality. Storage temperatures exceeding 40°C are not recommended.

Catalyst dosing:

ACURE 600 shows good miscibility with water and component A. It can be diluted with water to ensure easy dosing and mixing ratios of both components.

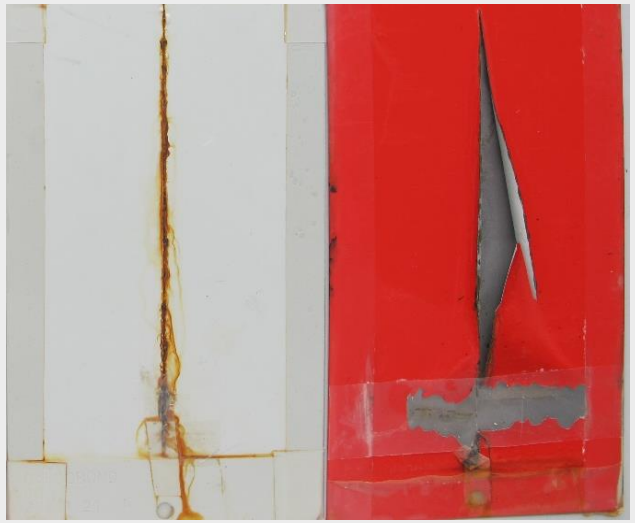
CONSIDERATIONS IN PRIMER FORMULATION

Primer formulation

Part	Components
	Deion. Water
I	ADDITOL VXW 6208
	ADDITOL VXW 6393
	Talcum
	Kronos 2190
II	Bayferrox 3920
	Bayferrox 306
	EWO
III	ADDITOL VXW 6393
	Texanol
IV	ADDITOL VXW 6388
	Methoxypropanol
	Slurry
V	BECKOPOX EP 2384w/57WA
VI	BECKOPOX EH 2261w/41WA

Primer alone

Primer ACURE AQ



Salt spray test after 168 hours

Untreated steel panels (Gardobond OC)
Drying primer 24 h before topcoat application
DFT: 50-60 µm / 40-50 µm (Primer / Topcoat)

Primer formulation

Part	Components
	Deion. Water
I	ADDITOL VXW 6208
	ADDITOL VXW 6393
	Silitin Z 89 or Aktisil AM
	Kronos 2190
II	Bayferrox 3920
	Bayferrox 306
	EWO
III	ADDITOL VXW 6393
	Texanol
IV	ADDITOL VXW 6388
	Methoxypropanol
	Slurry
V	BECKOPOX EP 2384w/57WA
VI	BECKOPOX EH 2261w/41WA

Primer alone

Primer ACURE AQ

Salt spray test after 168 hours

Untreated steel panels (Gardobond OC)
Drying primer 24 h before topcoat application
DFT: 50-60 µm / 40-50 µm (Primer / Topcoat)

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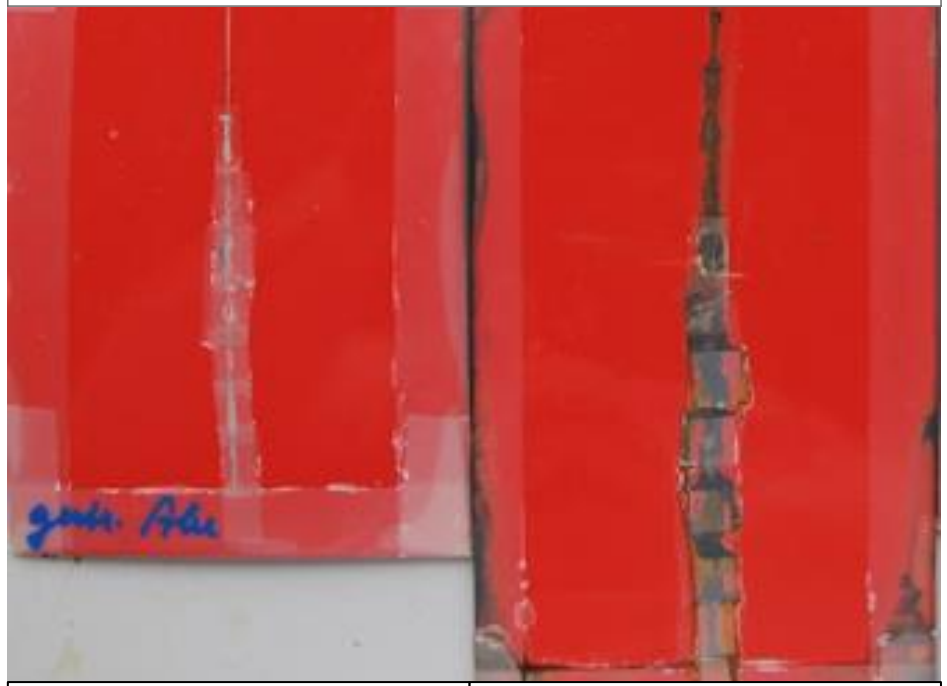
ACURE AQ™

Future developments & value proposition

COMING SOON: A HIGH PERFORMANCE PRIMER FOR ALUMINIUM AND STEEL

Neutral Salt Spray Test: 2-layer system
ACURE™ AQ Red Topcoat (REC20042)
Primer based on **NEW wb 2K epoxy/amine system**

24 hours drying of the primer layer @ 23 °C / 50 %RH

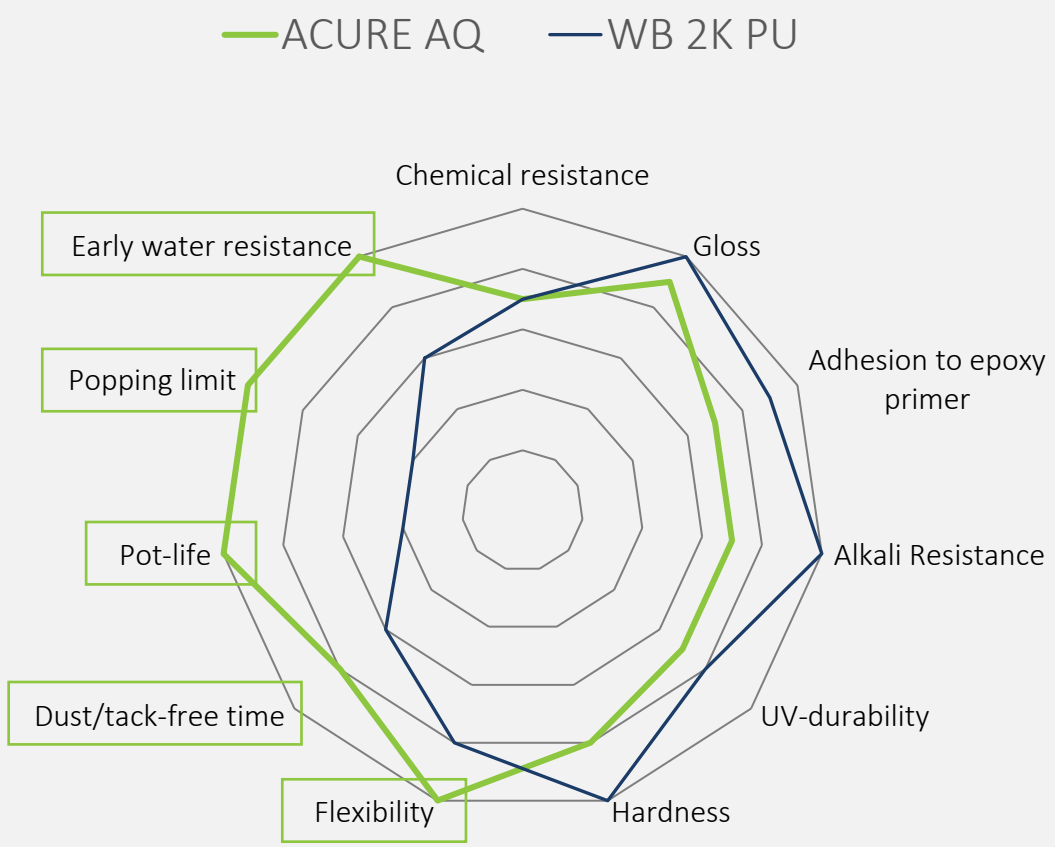


sandblasted aluminium (AA5049)	sandblasted steel (Sa 2½)

Key features of new primer system

- Excellent corrosion performance on sandblasted steel and sandblasted aluminium
- Fast drying properties

ACURE™ AQ – VALUE PROPOSITION



While the system offers unique benefits in terms of early property development, popping limit and pot-life, there are some parameters which have to be taken into consideration to identify the most suited application.

With ACURE AQ we will enable the coatings industry to overcome some of the key shortcomings of 2K WB PU systems enabling a broader penetration in markets like ACE, RAIL, TRANSPORT and lowering overall VOC emissions in the coatings industry, which is one of the key commitments in the allnex sustainability strategy.

GREENER BY NATURE

ACURE™ hits all five of allnex's sustainability pillars

ENERGY EFFICIENCY
Reduction in curing energy due to the speed of Michael addition chemistry and our unique blocked catalyst

CIRCULAR ECONOMY
Reduced paint waste from longer pot lives, enabled by ACURE™'s unique blocked catalyst

AIR EMISSIONS
VOC levels lower than incumbent systems

SAFER MATERIALS
ACURE™ AQ don't require isocyanate, tin, formaldehyde or other materials of concern for curing

RENEWABLE SOURCING
BIO CONTENT POTENTIAL

be ECOWISE™

THANK YOU FOR JOINING OUR WEBINAR!

Questions?

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https://acure-coating-resins.com/allnex-fast-curing-waterborne-2k/

LEGAL NOTICES