Science Simplified

Furniture Coatings - Challenges and Limits in Formulating a Chemically Resistant 1K White Pigmented Acrylic Topcoat

Massimo Longoni - Technical service. EPS B.V. – H.I.Ambacht, The Netherlands

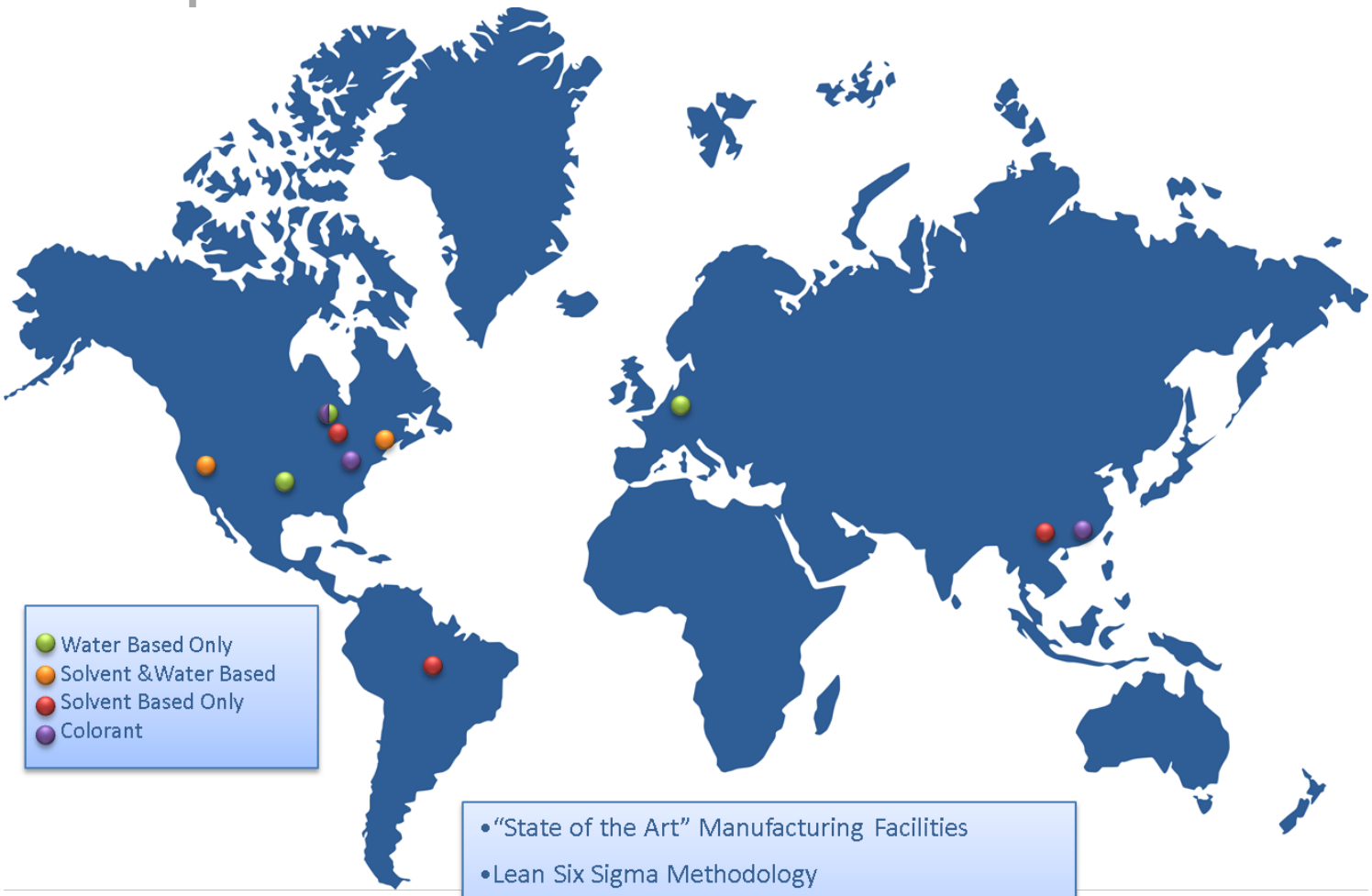
Summary

- **Company profile**
- Furniture coating: general overview
- Formulation: key parameters
- Broader approach: the whole system performs
- Conclusions

EPS – polymer capability

- Latex emulsions: specialty acrylic
- Polyurethane resins and PUDs
- Polyester resins
- Decades of exterior exposure data; test fences
- Fully equipped labs in USA and Netherlands
- Global regulatory knowledge

Global operational excellence



- "State of the Art" Manufacturing Facilities
- Lean Six Sigma Methodology
  - -Statistical Process Control
- High Efficiency with Automated Manufacturing

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Furniture, a global approach …

- Production of furniture and relevant coating is global → general standard quality level
- Performance of coatings defined by international norms and standards (e.g. DIN 68861, IOS MATT 0066 …)

One example: IKEA

- Direct operations in 43 countries between Europe, Americas, Asia*.
- 1000ca. suppliers in 50 countries*.

(*) - IKEA GROUP AT A GLANCE FY15

An additional challenge: substrates

- No more massive wood
- Veneered chip board or particleboard
- Melamine foil
- MDF (different qualities)

Engineered wood introduce multiple additional challenges: fiber swelling, adhesion, substances migration.

Basic facts …

- Waterbase (WB) acrylics (AC) are widely used in industrial wood coating – easy to apply – cost effective.
- 1K AC transparent products performing high level in chemical resistances (B1 – DIN 61681 or IKEA R2 – IOS MATT 0066) are common.
- 1K WB AC in pigmented coatings are used for low-end products – don't meet high demand in chemical resistances (e.g. Kitchen …).
- Main limit in pigmented products: alcohol and coffee resistances.

Focus on 1K AC pigmented chemical resistant

- Why IKEA R2? - Industrial standard
  - Aim is alcohol and coffee resistance
- Not one single component (e.g. binder) can achieve the results (IKEA R2 spec)
- The whole system has to perform

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Formulation: factors investigated

- Binder
- Dispersing agent → Mill base
- Solvent
- Matting agent

Formula			Short name	Ingredient
Binder	60		Solvent BG	Butyl Glycol
Solvent BG, BDG, DPM, DPnB	5.5		Solvent BDG	Butyl Diglycol
Water	5.7		Solvent DPM	Dipropylene Glycol Methyl Ether
Matt 1, Matt 2, Matt 3	1		Solvent DPnB	Dipropylene Glycol n-Butyl Ether
Wax dispersion	2.5		Matt 1	Inorganic un-treated silica (TS 100)
Defoamer	0.5		Matt 2	Organic matting agent (PMH C)
Deareator	0.8		Matt 3	Inorganic post treated silica (ED 30)
Mill-base A, B, C, D	21		Mill-base A	Dispersant - high MW acrylic copolymer - DB190
Substrate wetting agent	0.5		Mill-base B	Dispersant - high MW acrylic block copolymer - GR100
Surface agent	0.3		Mill-base C	Dispersant - hydrophobic acrylic copolymer - O681
Ammonia	0.1		Mill-base D	Dispersant - low MW anionic polymer - Z3600
Preservative	0.1			
Thickener	2			
	100			

Binder: acrylic dispersion

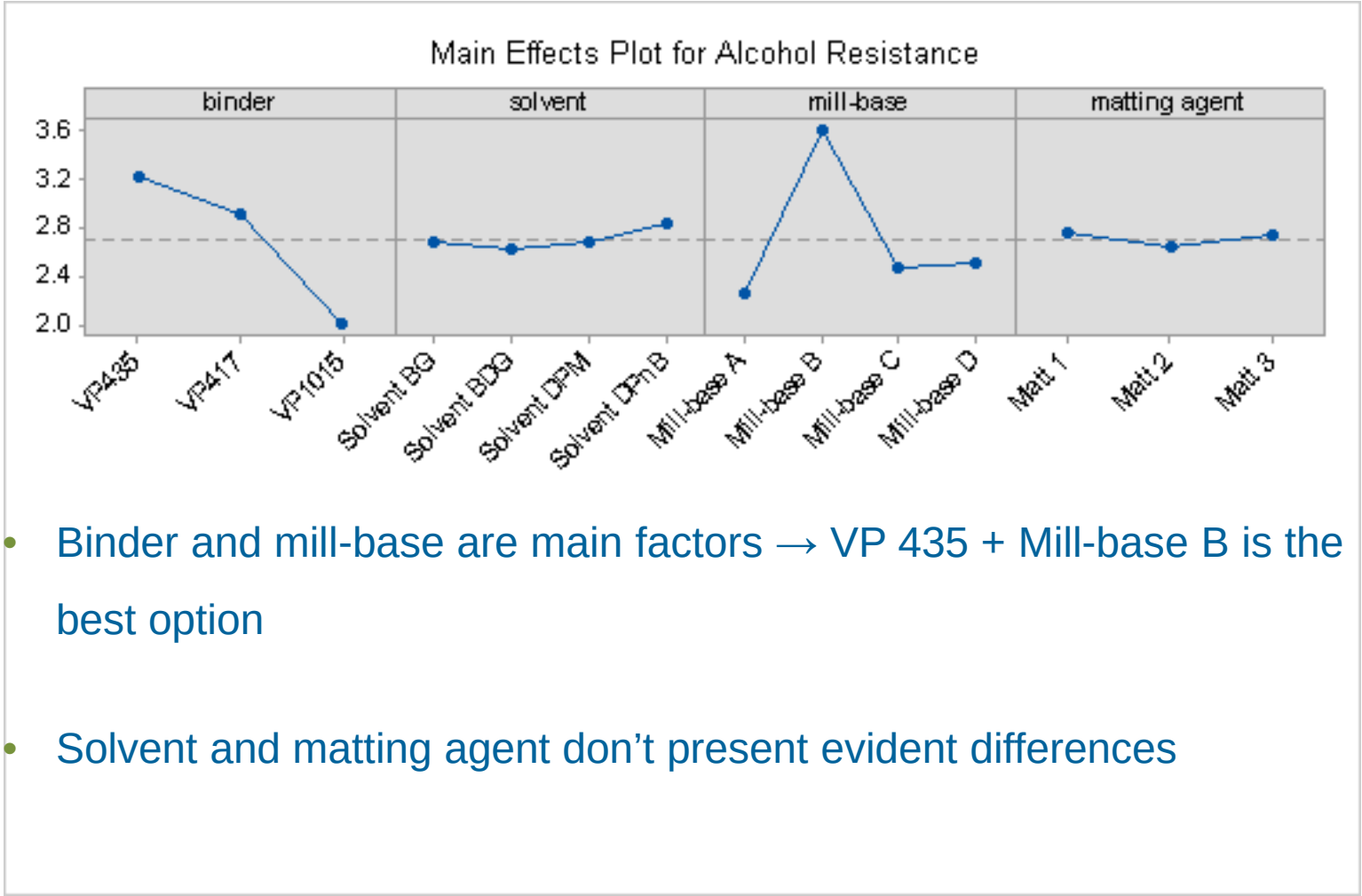
	Stabilization	MW	Solid content (%)	pH	Tg (°C)	Particle size (nm)
VP1015	Acid Oligomer	Low/High	41	8.0	37	40
VP417	Acid oligomer & Surfactant	Low/High	40	8.0	37	50
VP435	Surfactant	High/High	45	8.0	30	85

- Three representative products
- Fixed monomer composition
- Different cross-linking mechanism (Schiff Base …)

Chemical resistances study

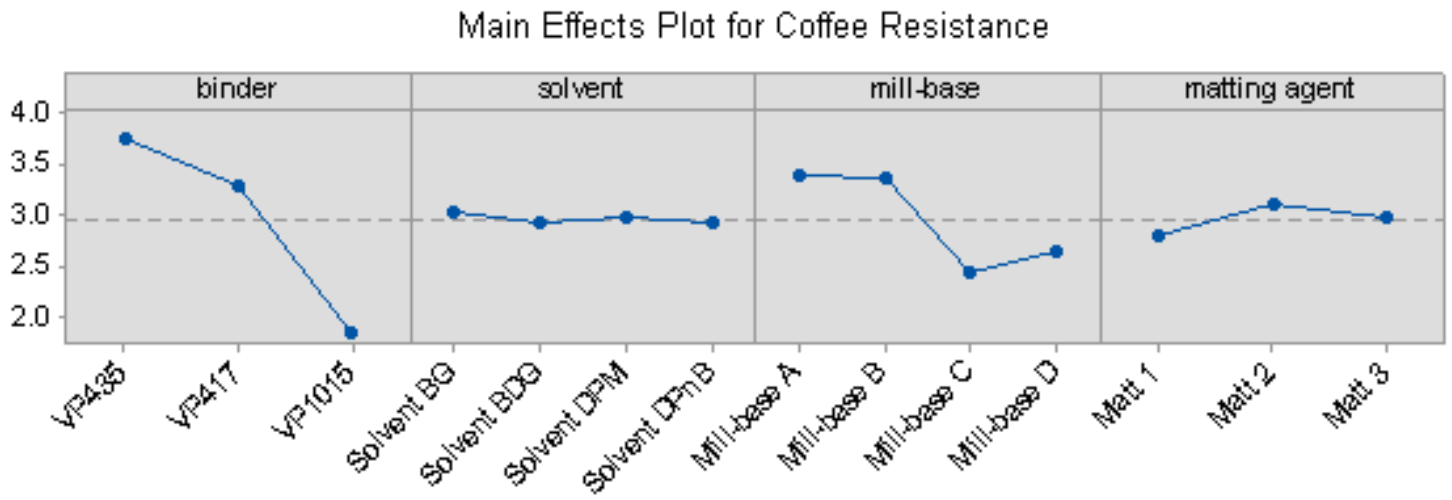
- Full factorial DOE – 4 factors, multiple levels. (144 combinations)
- Products applied on melamine foil and tested after 3 weeks conditioning at RT
- Reference norm: EN 12720 → Target IKEA R2 level
- Water and paraffin oil resistance (24h) easy to achieve
- Alcohol and coffee resistance (1h) is the challenge

Focus on alcohol resistance



- Binder and mill-base are main factors → VP 435 + Mill-base B is the best option
- Solvent and matting agent don't present evident differences

Focus on coffee resistance

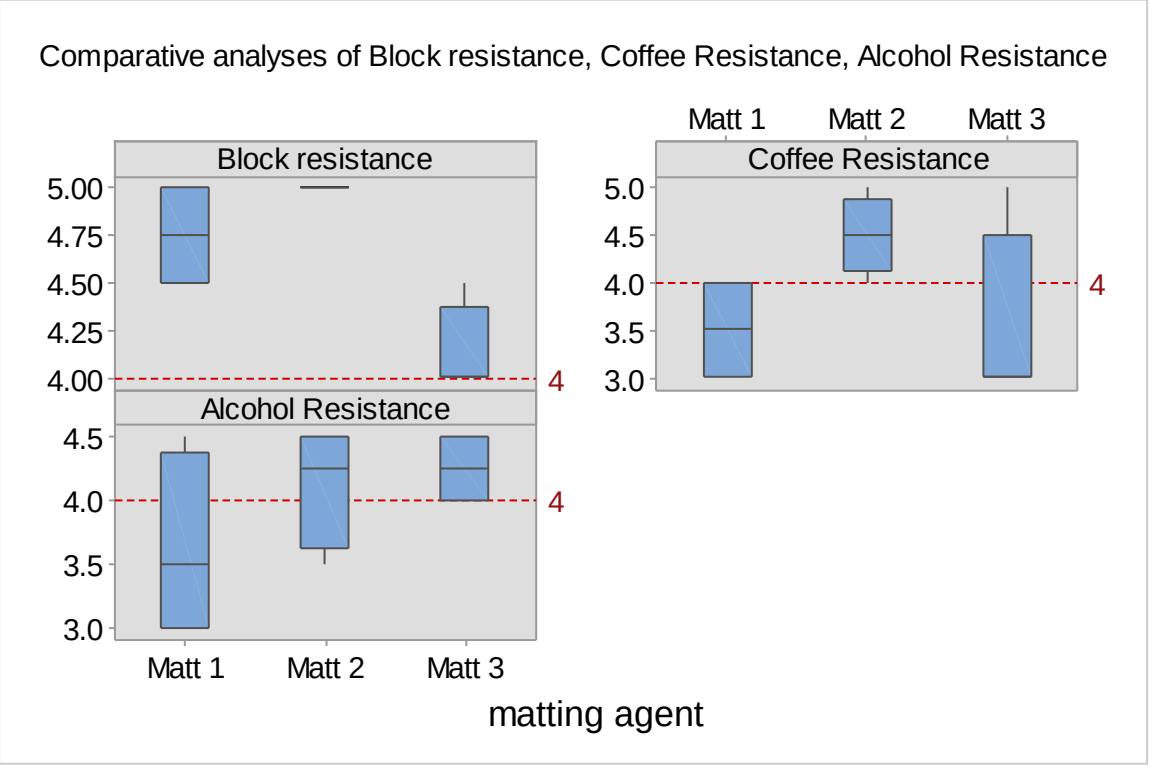


- Binder and mill-base are main factors → VP 435 + Mill-base B is the best option
- No clear differences between Solvent and Matting agent (Matt 2 slightly better)

Different weight of key factors

- Correct combination of Binder and Mill-base is mandatory to get good coffee and alcohol resistance
- Combination VP 435 and Mill-base B comply IKEA R2 spec. for resistances to cold liquids in 42% of the combinations, 13% out of all the samples (based on VP435) tested
- Matting agent and Solvent influence on chemical resistances is strongly dependent on the combination Binder/Mill-base

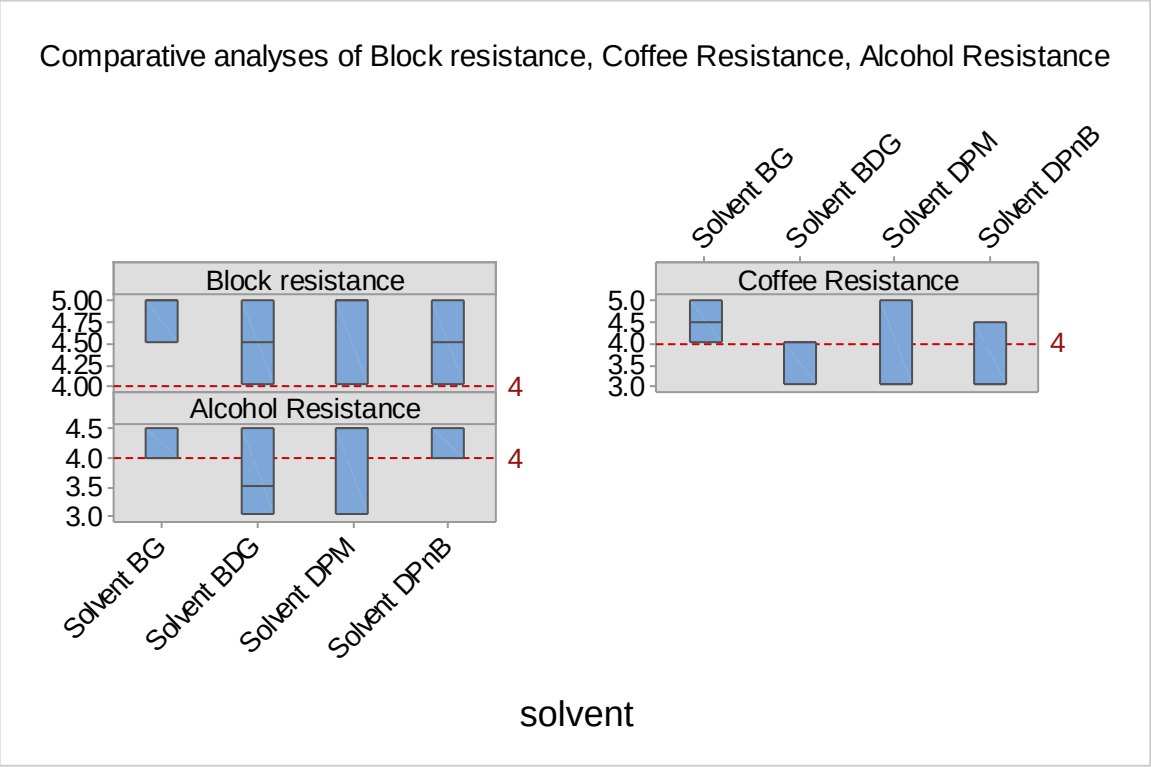
Does the matting agent play a role?



- Matting agent must fit Binder/Mill-base combination to minimize loss in performance. Matt 2 is the best fit.

- Gloss level required has a dramatic impact on performances

What about the solvents?



- Solvents influence chemical resistances but play a minor role
- Solvents selection driven by application and curing conditions (Blend Solvent BG and Solvent BDG)

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The coating system is key to success

- MDF is a widely used material for pigmented furniture, different problems than melamine foil
- Topcoat alone doesn't perform at acceptable level (coverage, substance migration)
- A basecoat is necessary to support the topcoat
- To complete the puzzle any piece must be correct and in place

Basecoat overview - characteristics

Formula (ML-06)	
Water	14.0
Dispersing agent DB 190	0.8
Talc (15 micron)	10.0
Calcium Carbonate (5 micron)	15.0
Sodium potassium alumina silicate	15.0
Titanium Dioxide	10.0
Binder (9624, 503, 700)	30.0
Solvent BG + DPnB	3.0
Defoamer	1.3
Anti-setteling agent	0.1
Ammonia	0.1
In-can preservative	0.1
PU thickener	0.6
	100.0

- Medium PVC – 55%
- Quick sandability
- Good coverage
- Minimal fiber swelling

Coating package study

Cycle		A	B	C	D	E	A1	B1	C1	D1	E1
Basecoat	ML-06 (9264)	2*					2*				
	ML-06 (700)		2*					2*			
	ML-06 (503)			2*					2*		
	Reference 1				2*					2*	
	Reference 2					2*					2*
Topcoat	ML-09	1*	1*	1*	1*	1*	2**	2**	2**	2**	2**
Chemical resistance (according to EN 12720)	Alcohol (48%) - 1 hour	5	5	4	4	4	5	5	4	4	4
	Coffee (4% sol.) - 1 hour	4/5	3	3	4/5	3	4/5	3/4	3/4	4/5	4/5
	Alcohol spot Gloss change 60 angle(gloss-meter)	4%	19%	3%	3%	6%	3%	1%	4%	4%	3%
	Coffee spot ΔE (spectrophotometer)	0.52	1.17	1.07	0.54	1.25	0.60	0.97	0.91	0.57	0.71

1* - conventional spray application, 1 layer, 100 g/m2

2* - conventional spray application, 2 layers, 120 g/m2

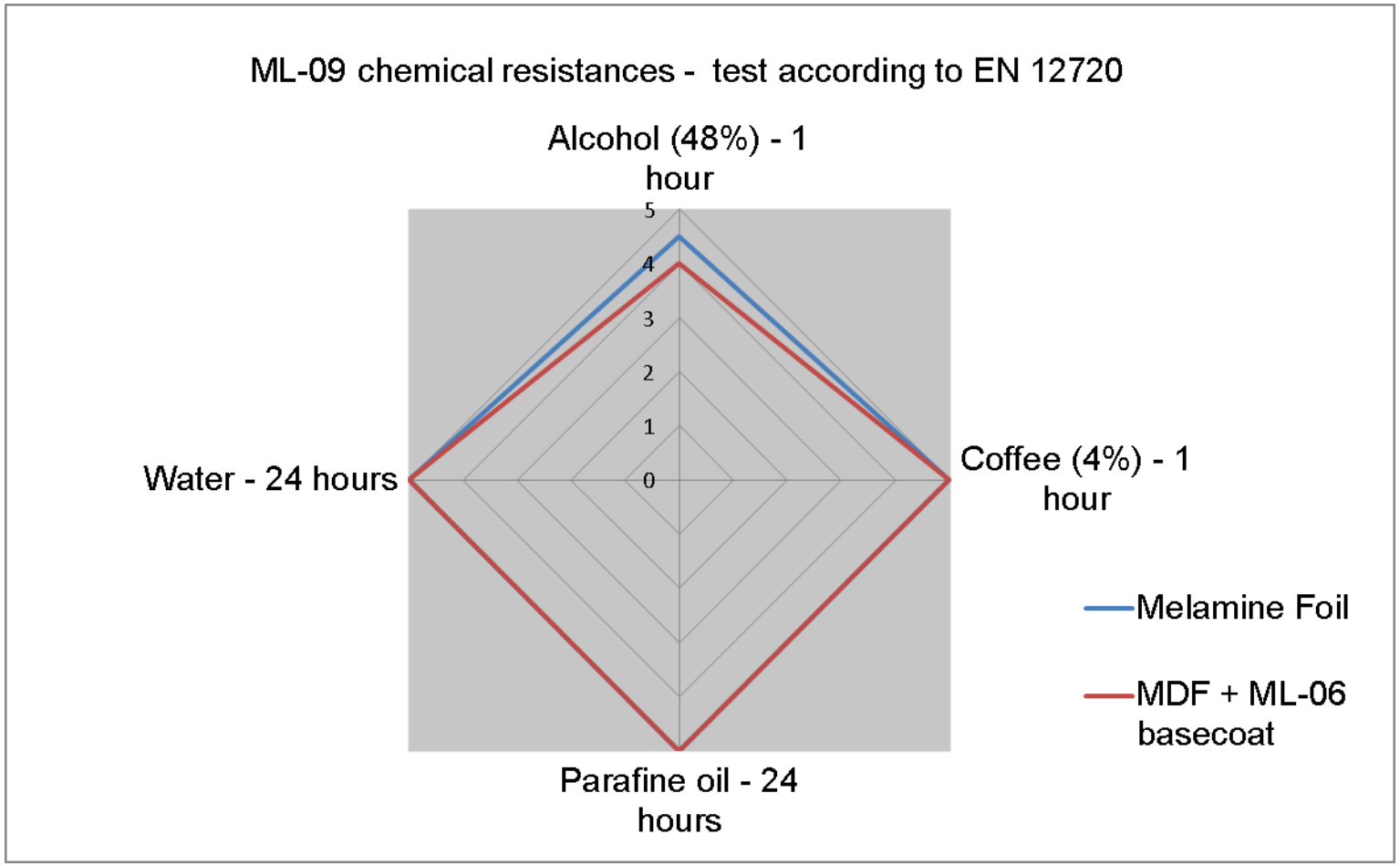
2** - conventional spray application, 2 layers, 100 g/m2

Why is the basecoat important?

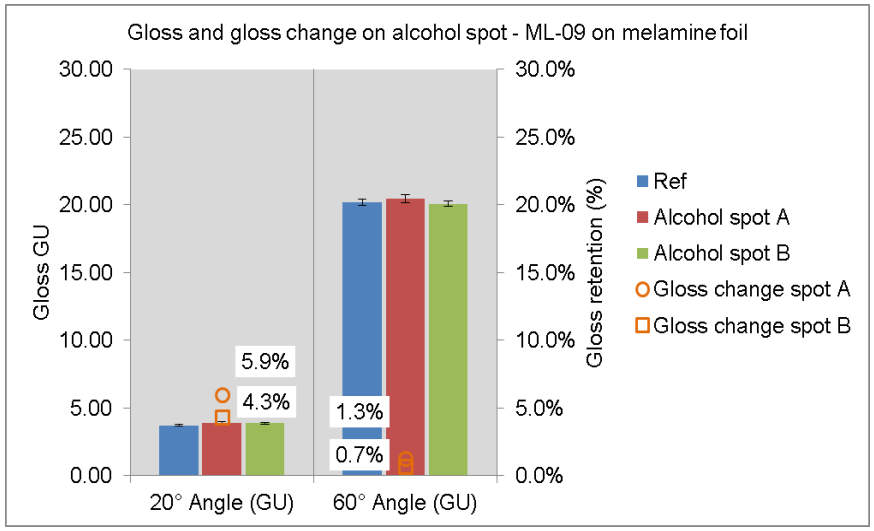
Water resistance (1h) of basecoat, spray applied - 120 g/m2, 1 week at RT

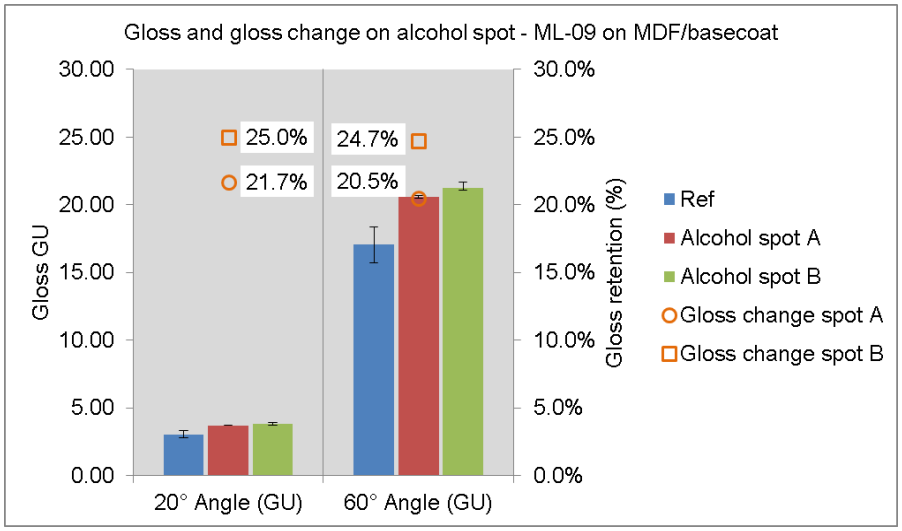
- Industrial process is generally quick, early water resistance of the basecoat is important
- Hypothesis: water sensibility of the basecoat changes the performance of the topcoat (in study)

Results on melamine foil and MDF/basecoat



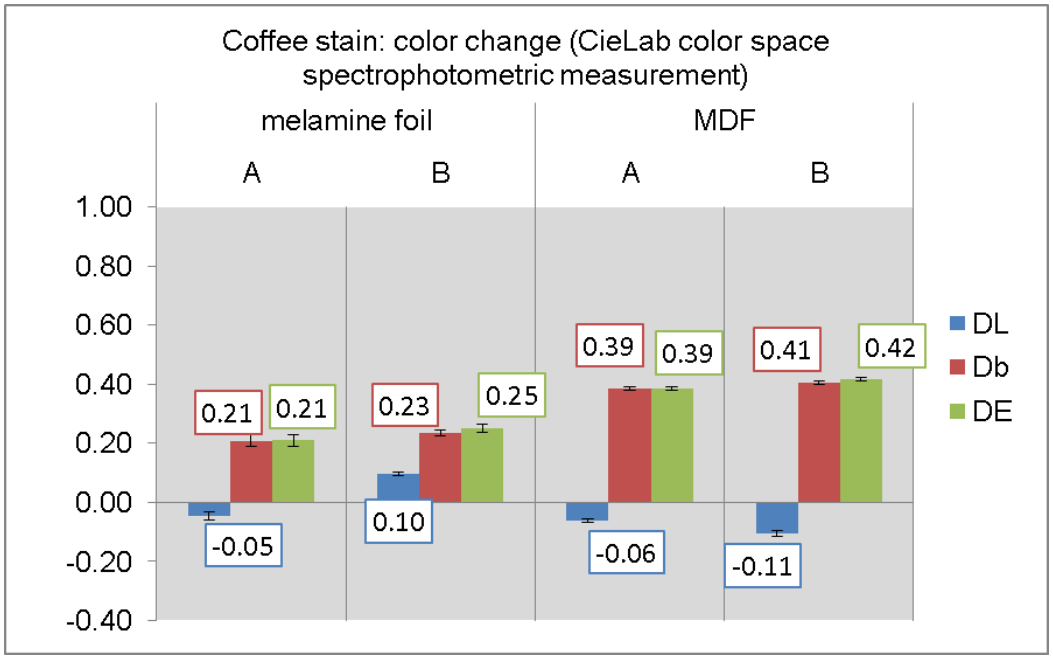
Alcohol spot not easy to evaluate





- No direct correlation with instrumental measurement
- It is not only the gloss variation but also the view angle

Coffee spot: one step forward



- Color discoloration of coffee spot can be measured with spectrophotometer → if Δb is below 0.8 it is highly probable to rate a 4 according to EN 12720 (confidence level approx. 95%).

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- It is possible to formulate a 1K WB AC pigmented IKEA R2 compliant (coffee and alcohol 1 hour resistant)
- Optimal combination of Binder, Mill-base (dispersing agent) and Matting Agent is a must, Solvents play a secondary role
- Where a Basecoat is required (e.g. MDF) the complete cycle delivers the performance.
  - *Bad basecoats spoil good Topcoats as well as bad dispersing agents spoil good binders.*
- There is direct correlation between Δb and coffee rate according EN 12720

Thank you for your attention!

Questions?