High Performance Environmentally Compliant Two-component Waterborne Urethane Dispersions

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Lubrizol Advanced Materials

Coatings Trends and Technologies Conference 2023

Lubrizol | Performance Coatings

Agenda

- **Enabling a Sustainable Future with Lubrizol: KEY INNOVATION PROGRAMS**
- **Polyurethane Dispersion: Responsible Design, Sourcing and Use**
- **Performance: Wood Coatings**
- **Summary**

Resins to Formulate Coatings with Reduced Environmental Impact

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Lubrizol Innovation Drivers

Driver	New Urethane Dispersion
Sustainability	• Water based • Enable high quality indoor air • FREE of materials of concern • Bio Carbon Renewable Content • Reduce CO_2 emissions
Performance	• 2-Component Formulations • Extended durability • Chemical resistance • Mechanical properties
Productivity	• Simplifying the paint process • Reducing the total applied cost • Faster return to service

HIGH END WOOD COATINGS

MINIMIZING OUR FOOTPRINT

MAXIMIZING OUR HANDPRINT

Enabling a Sustainable Future with Lubrizol: Putting Sustainability into our Chemistry

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Enabling a Sustainable Future with Lubrizol

Putting sustainability into our chemistry

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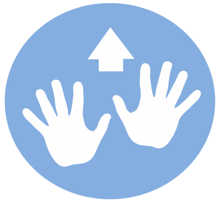
Key Innovation Sustainable Programs

Lubrizol Performance Coatings is committed to **maximizing our handprint** by offering innovative **solutions with reduced environmental impact** that enable our customers to achieve their sustainability goals.



MAXIMIZING OUR HANDPRINT

MINIMIZING OUR FOOTPRINT

Reduce emissions (**VOCs**)
Eliminate chemicals of concern (**ADH, APEO…**)

Building capability in biobased **raw materials**

Enabling water, waste & energy reduction through **high solids resins.**

Improved Productivity:
Simplify the paint process

- **VOC (Volatile Organic Component)**
- **ADH (Adipic Acid Dihydrazide)**
- **APEO (Alkylphenol ethoxylates)**

Polyurethane dispersion:
Responsible design, sourcing & use

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Responsible design: Synthesis of waterborne polyurethane

	Technical Requirements
Sustainability	• Water based • Enable high quality indoor air • FREE of materials of concern • Bio Carbon Renewable Content • Reduce CO_2 emissions
Performance	• 2–Component Formulations • Extended durability • Chemical resistance • Mechanical properties
Productivity	• Simplifying the paint process • Reducing the total applied cost • Faster return to service

Technical Profile

- **Low MFFT: Low VOC**
- **Plant based raw materials**
- **NMP, ADH, TEA…free**
- **NCO free crosslinkers**
- **Optimized reactivity**
- **High solids**

- **MFFT (Minimum Film Forming Temperature)**
- **NMP (N-Methylpyrrolidone)**

Develop a urethane dispersion for a sustainable, user-friendly, wood coating.

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Structure Property Design: Compositional Drivers

1 Identify **COMPOSITIONAL DRIVERS**, which affect critical **PERFORMANCE PROPERTIES**.

DRIVER

HO-[ ]-OH	OCN-[ ]-NCO	HO-[ ]-OH	Diluent
Polyol (Soft segment)	Poly-Isocyanates (Hard segment)	Acid (Water dispersing)	Process Aid (viscosity control)

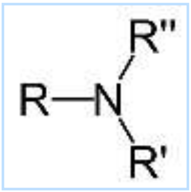
IMPACTS

Polyol:
- Mechanical property
- Chemical resistance
- Water resistance
- Bio-renewability

Poly-Isocyanates:
- Mechanical prop
- Chemical resistance.

Acid:
- PUD functionality.
- Dispersion stability
- Film formation

\+

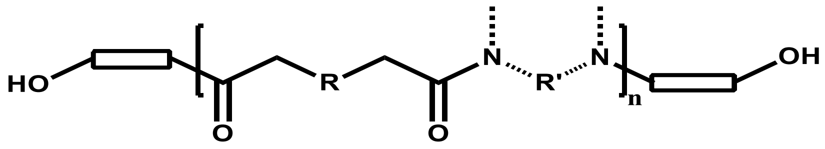


Tertiary amine

Neutralizer

- Chemical resistance
- Black Heel Mark
- Potential Hazardous air pollutant

- ❑ **POLYAMIDE was chosen as the main polyol**
- ❑ **Most polyamide polyols developed have high (>80%) renewable carbon content**
- ❑ **The source of renewable carbon in the monomers is plant-based, that cannot be used as food source.**



Structure Property Design: Urethane Morphology

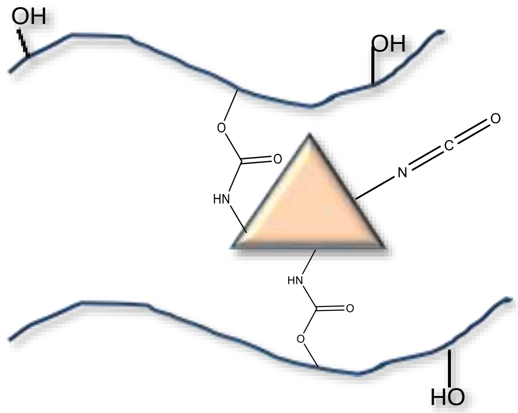
2 Optimize urethane **MORPHOLOGY**

- ✓ Reduction/elimination of hazardous components: Crosslinkers
- ✓ Performance: Crosslinking efficiency
- ✓ Film formation at low temperatures

DRIVER **URETHANE FUNCTIONALITY**

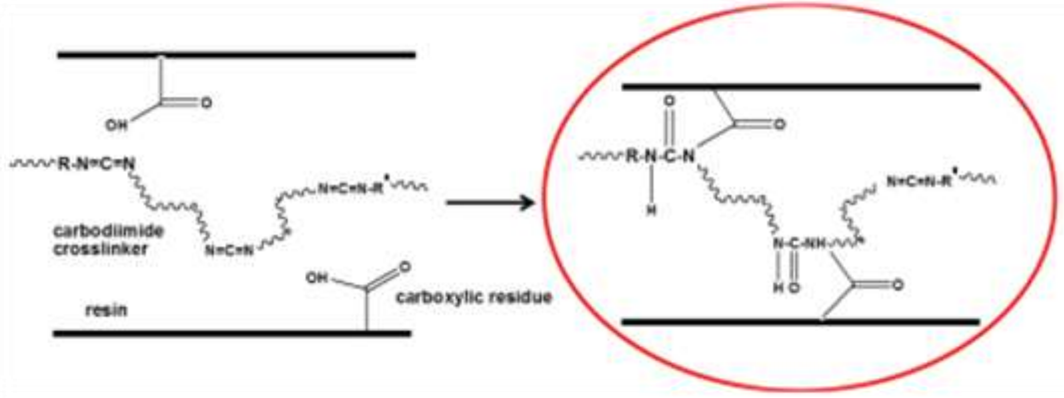
ISOCYANATE CROSS-LINKING

- Reacts with hydroxyl groups
- High reactivity/performance
- Hazardous identification



CARBODIIMIDE CROSS-LINKING

- Reacts with carboxyl groups
- Environmentally friendly: Low Toxicity
- Moderate performance improvement: Poor reactivity - Long Pot life



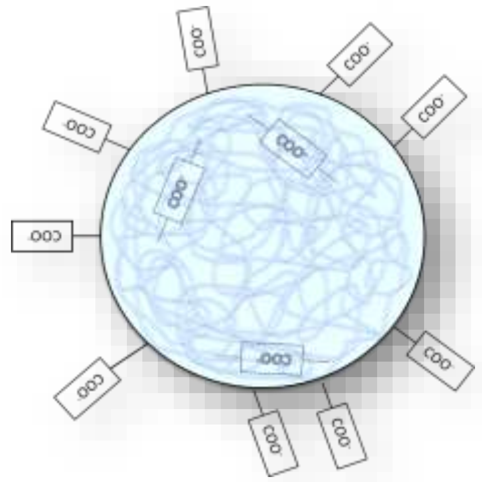
Structure Property Design: PUD Morphology

2 Optimize urethane **MORPHOLOGY**

DRIVER **URETHANE FUNCTIONALITY – CROSSLINKER REACTIVITY**

TRADITIONAL DISPERSION

- ❑ Uniform composition
- ❑ Carboxylic functionalities inside particles
  - Internal carboxylic groups less reactive
  - Lower effective acid number for crosslinking



NEW TECHNOLOGY DISPERSION

- ❑ Transfer the carboxylic groups to the surface:
  - More available to react
- ❑ Higher effective acid number:
  - More effective crosslinking
- ❑ Decreases MFFT

Carbodiimide reactivity issue was addressed by improving the reactivity of the functional groups on the resin. Better efficiency with environmentally friendly polymeric carbodiimide crosslinkers.

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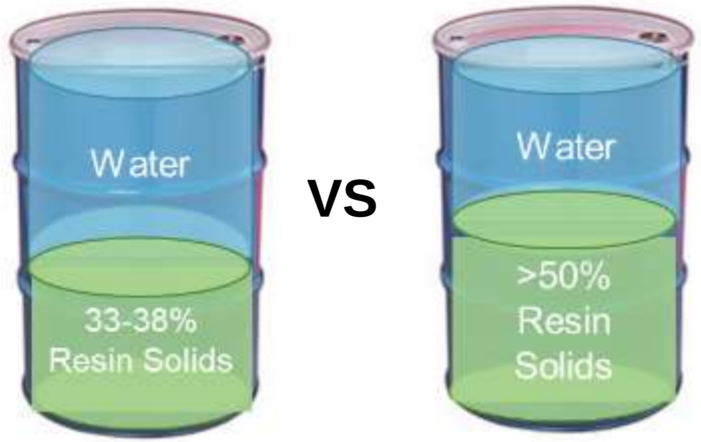
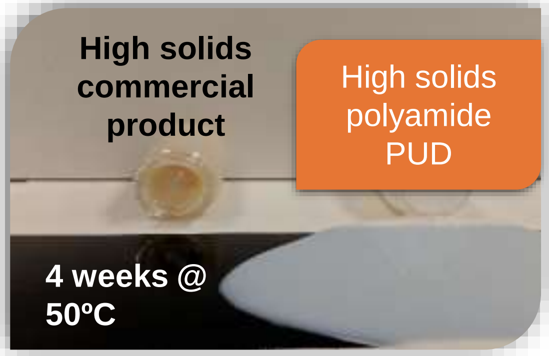
Structure Property Design: High Solids PUD

3 Develop a viable urethane **PRODUCTION PROCESS**:

✓ Define compositional and process boundaries of new technology dispersion and… **HIGH SOLIDS PUD**

Traditional PUD | **High Solids PUD**





Key Benefits

- Freight and packaging cost savings. Transport >35% more resin and less water.
- Improved productivity and better application efficiency
- CO_2 emission reduction- freight and manufacturing
- Enables higher film build
- Quicker drying saving labor times

Improve productivity and application efficiency

New Polyurethane Dispersion: Responsible design, sourcing & use

- Renewable Content in Polyamide-based PUDs
- Reduction / Elimination of Regulated Components: VOC
- Elimination of Regulated Components: TEA (Triethylamine)
- Elimination of Regulated Components: Crosslinker Isocyanate & ADH
- Manufacturing Methods: Use of Resources, Energy, and Waste in Production / Application

PERFORMANCE COMPARISON

Performance: Experimental HS BIO Polyamide PUD

1 EFFECT OF NEUTRALIZER

Polymer #	Components	Crosslinker	✓ Resin Solid% (wt%)	✓ Bio Content (wt%)	✓ VOC (g/l) EPA Method 24	✓ VOC (g/l) ISO 11890-2	✓ Number of Coats
APT-1	2K	**Carbodiimide**	45	34	100	40	**2**
APT-2	2K	**Carbodiimide**	45	34	100	40	**2**
APT-3	2K	**Carbodiimide**	45	34	100	40	**2**
Benchmark-1	1K	ADH	35	0	140	46	3*
Benchmark-2	2K	ISOCYANATE	41	0	288	130	3*
Benchmark-3	2K	ISOCYANATE	32	0	230	85	3**

*Three coat.
**Two coats over a sealer.

Experimental PUDs and Commercial Benchmarks

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Performance: Experimental HS BIO Polyamide PUD

1 EFFECT OF NEUTRALIZER

Samples	Gloss (60˚)	Konig Hardness (Oscilations)	COF	Hot Pan Test		Taber Abrasion Weight loss (mg) after 1000 cycles	Black Heel Mark (10 best)	Black Heel Mark after cleaning by 70% IPA (10 best)
				Whitening (5 best)	Printing (5 best)			
APT-1	**77**	**50**	**0.58**	**5**	**5**	**73**	**7**	**8**
APT-2	**82**	**50**	**0.56**	**5**	**4**	**60**	**2.5**	**6**
APT-3	**66**	**51**	**0.61**	**5**	**5**	**67**	**2.5**	**6**
Benchmark-1	89	39	0.54	3	3	50	3	7
Benchmark-2	85	54	0.46	5	5	35	2	5
Benchmark-3	56	53	0.50	5	5	60	7.5	9

Mechanical properties, thermal resistance and gloss of polyamide-based polyurethane

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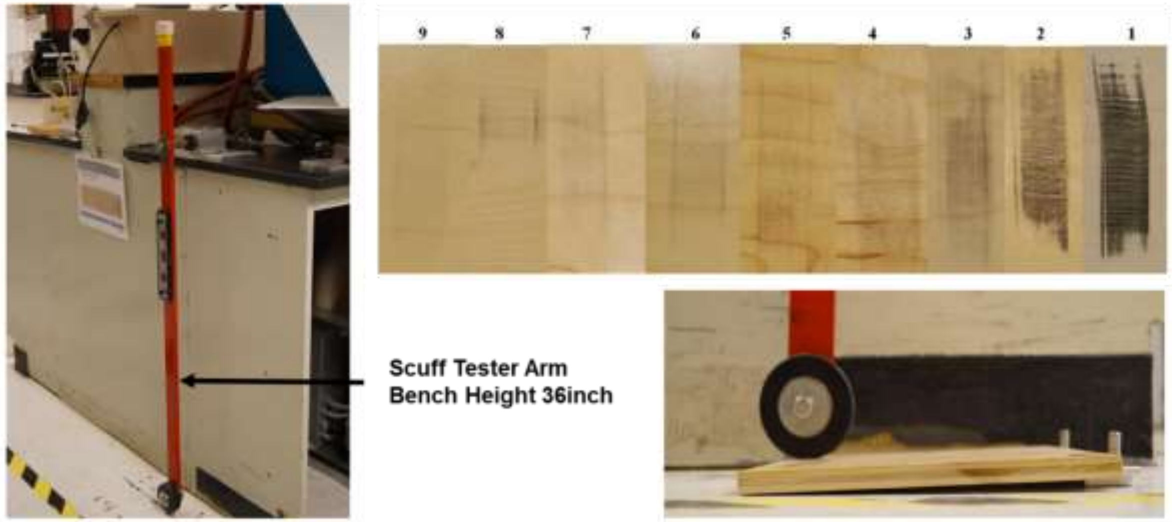
Performance: Experimental HS BIO Polyamide PUD

1 EFFECT OF NEUTRALIZER

Black Heel Mark Score (10 best)



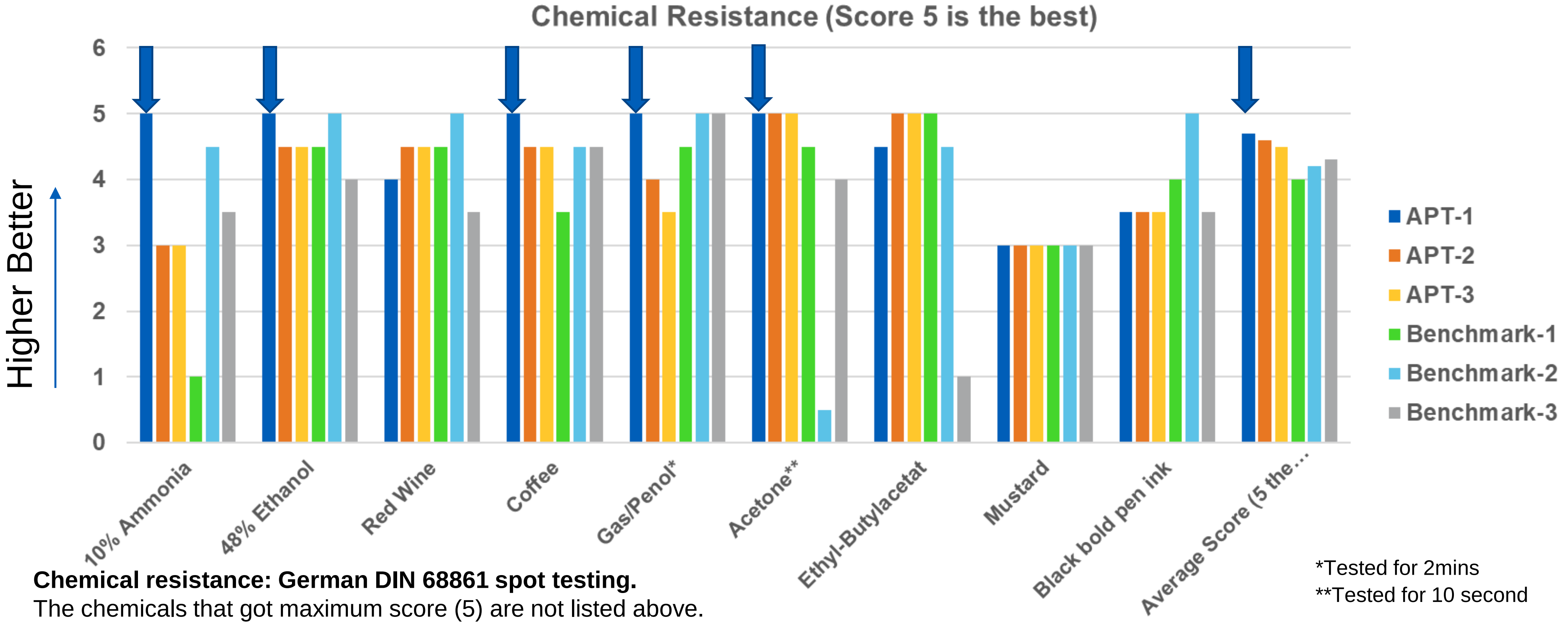
APT-1

APT-2

APT-1 neutralized by amine alternative A provides good black heel mark resistance.

Performance: Experimental HS BIO Polyamide PUD

1 **EFFECT OF NEUTRALIZER**



Chemical resistance: German DIN 68861 spot testing.
The chemicals that got maximum score (5) are not listed above.

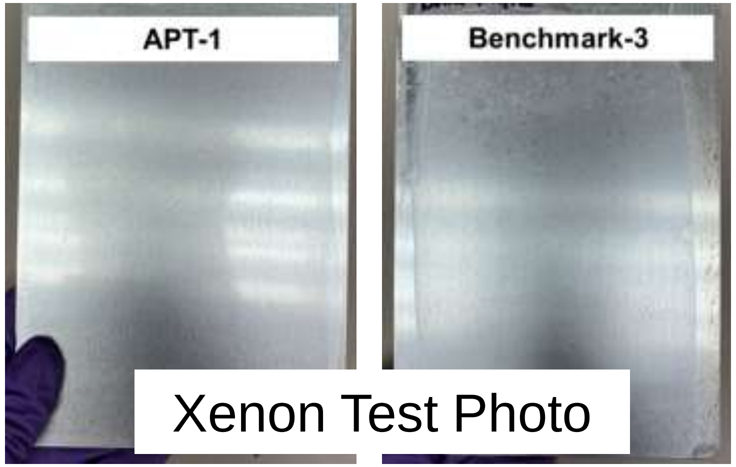
*Tested for 2mins
**Tested for 10 second

Excellent chemical resistance for gloss, matte and pigmented formulations

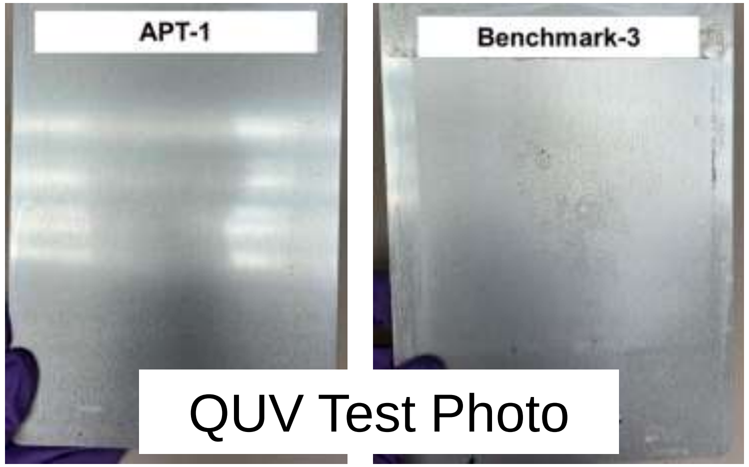
Performance: Experimental HS BIO Polyamide PUD

2 WEATHERING PERFORMANCE

System	Weatherometer Xenon					QUV		
	Initial	500 hours	**% Gloss Retention**	1000 hours	**% Gloss Retention**	Initial	750 hours	**% Gloss Retention**
APT-1	116	111	**96%**	113.7	**98%**	116	108.7	**94%**
Benchmark-3	106	105	**99%**	85.8	**81%**	106.1	60.8	**57%**



Xenon Test Photo

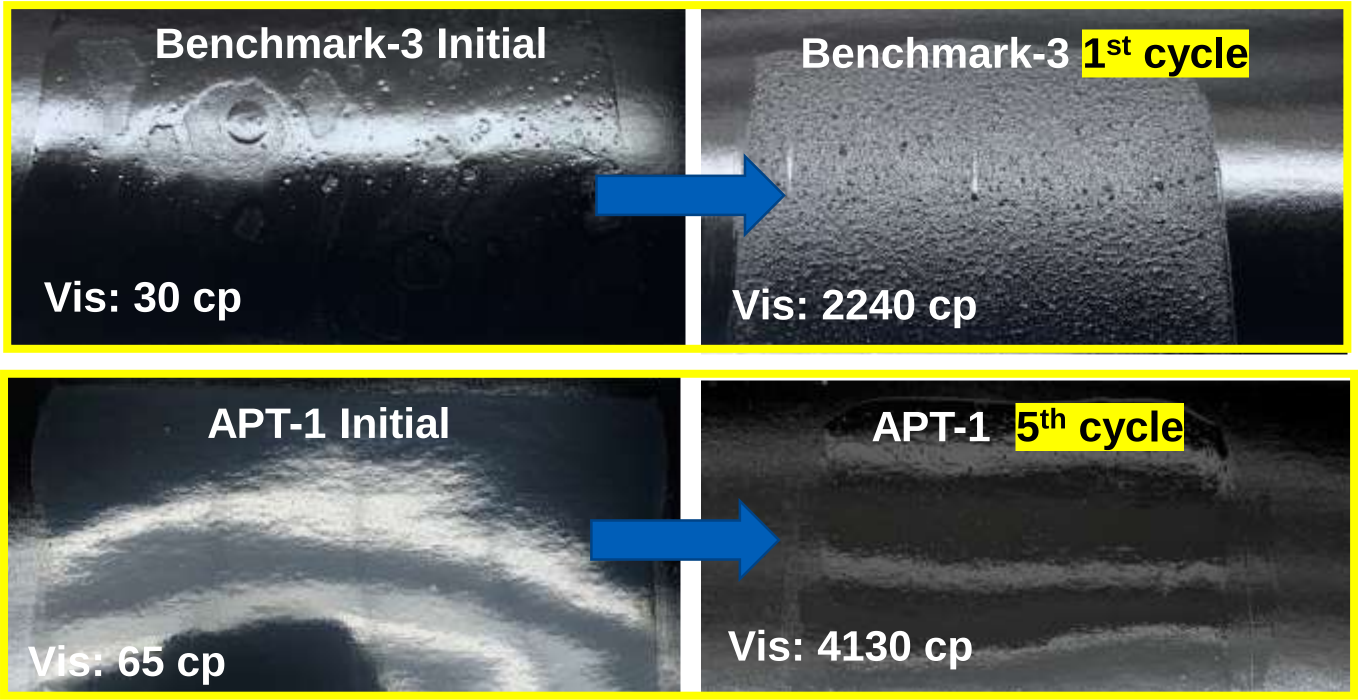


QUV Test Photo

Polyamide PUD provides excellent weathering resistance and gloss retention.

Performance: Experimental HS BIO Polyamide PUD

3 FREEZE-THAW RESISTANCE OF THE CLEAR PAINT



ASTM D2243-95 was followed: Put the paints in the chamber at −18°C (0°F). For one cycle, keep in the chamber for 17 h and then remove and allow to stand for 7 h at room temperature, for a complete freeze-thaw cycle of 24 h. Viscosity and film formation were checked for each cycle.

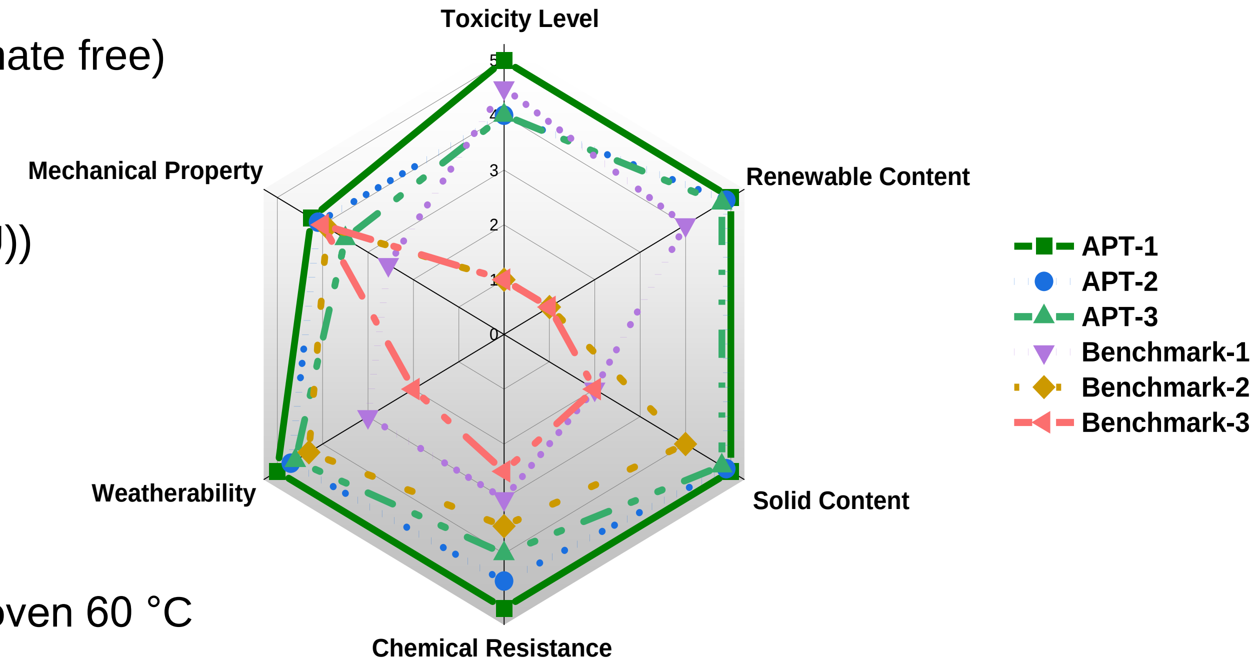
Polyamide PUD has good freeze-thaw resistance.

Summary

Conclusions

A New Urethane for Wood Coatings has been developed

- Crosslinking with Carbodiimide (isocyanate free)
- Triethylamine (TEA) free
- Low VOC –Can formulate to (40 g/l (EU))
- Bio-renewability ~34%
- High solids ~45 wt.%
- Simplifying the paint process
- Polymer and paint stability: > 8 weeks oven 60 °C



HIGH END PERFORMANCE

Balance of properties in the novel high-performance BIO PUD for sustainable coating solutions

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Thanks

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Appendix

Appendix 1: Test Methods

Taber abrasion: According to ASTM D4060. CS-17 resilient Calibrase wheels was used to provide abrasion while rotating on tested sample for 1000 cycles. The wheels were resurfaced, and weight loss was recorded per each 250 cycles.

Coefficient of friction (COF): ASTM D2047-17 was followed to check the static coefficient of friction of painted maple board measured by James Machine Coefficient of Friction Tester.

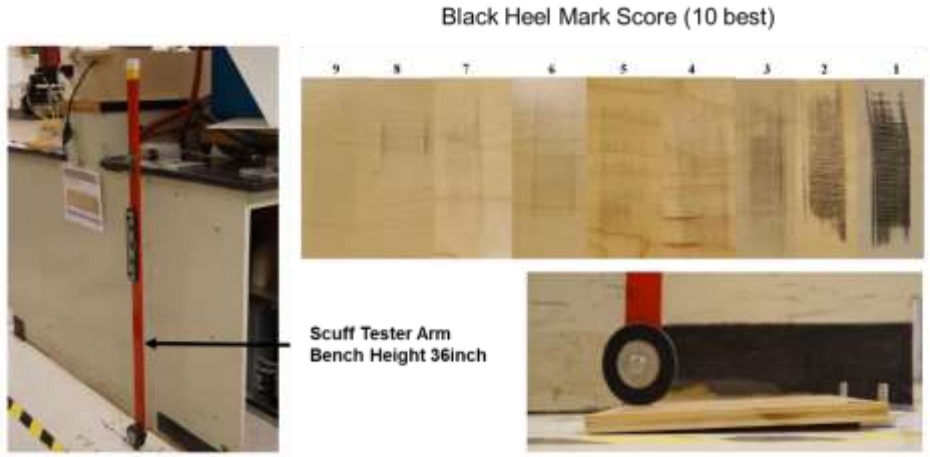
Konig hardness: Apply the prepared paints on aluminum panels and cure the panels at ambient temperature for a week. Following ASTM D4366, hardness was measured using a Pendulum Tester.

Gloss: ASTM Standard D 523 was followed to measure gloss by using a glossmeter.

Hot-Pan water resistance test: A wet cheese cloth is placed on a painted wood surface and a 250 ml stainless-steel cup with boiling water is placed on top of the cheese cloth for 1 hour. The cheese cloth and cup are then removed and the area on which they were resting is given a rating from 0-5, five being the best, corresponding to the level of whitening and printing that occurs.

Chemical resistance: German DIN 68861-1:2011-01 standard was used, a spot test, with 16h exposure time in category 1A. Exposure time was shorter for chemicals that completely failed before 16 hours (category 1B or 1C).

Black heel mark: This scratch resistance test method was developed in the lab, as shown in Figure 1. An ice hockey puck, made of solid vulcanized rubber, is used to simulate black heel. In the test a coating sample board is placed on the floor at 15° angle below the scuff tester which is oriented horizontally then allowed to drop and hit the sample. The mark left behind is rated from 0 to 10, the higher score the better performance the coating provides.



Appendix 2: Formulation

Material	% Weight
Part A	
Polyamide Polyurethane (45% T.S.)	82.91
D.I. Water	8.36
Defoamer	0.01
DPnB glycol ether	3.72
Total	95.00
Part B	
Carbodiimide	5.00
Total	100.00

Coating formulation for new urethane dispersions