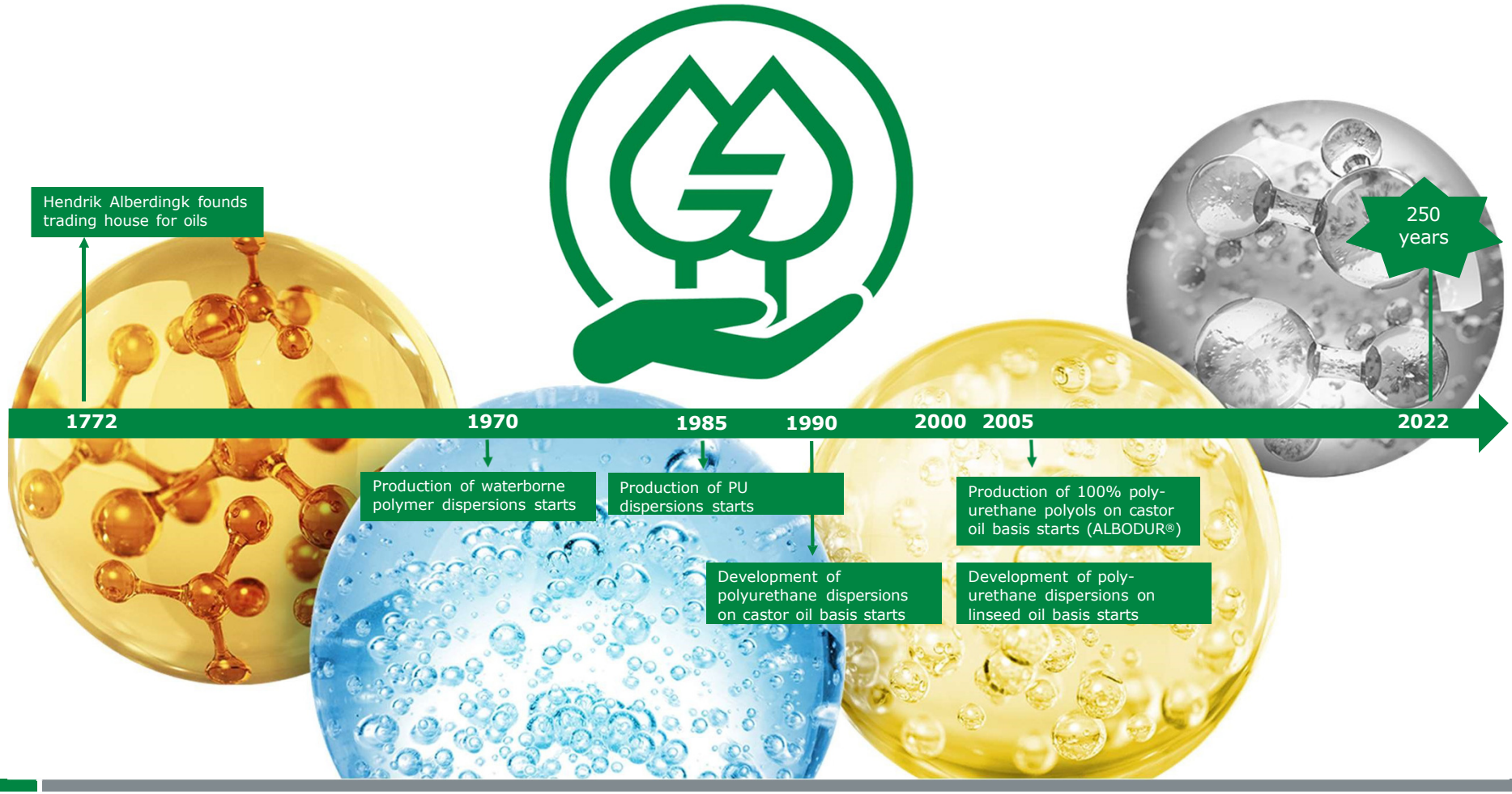
ALBERDINGK BOLEY

The Protection of Wood Surfaces by Inventive Polymer Design

George Wang

Alberdingk Boley, Inc.

ALBERDINGK BOLEY - Green for 250 years



Agenda

3 renewable PUDs:

- Market perspective
- Introduction to plant oil based PUDs
- Properties & Applications
- Comparative testing
- Summary and Outlook

Why the trend towards renewable?

- Global sustainability
- Less dependence on petroleum based raw materials
- Increasing regulations and specifications worldwide
  - Volatile Organic Compounds (VOCs)
    - EPA, SCAQMD (California), OTC etc.
  - Hazardous Air Pollutants (HAPs)
  - Interior air quality
    - LEED, Greenguard etc.
- Initiative programs (USDA BioPreferred)

Major components of PUDs

Isocyanates + Polyols + Solvents Amines = Polyurethane dispersion

Aromatic Isocyanates MDI & TDI

Aliphatic Isocyanates HDI, H_{12}MDI, IPDI

Ar-aliphatic Isocyanates TMXDI, XDI

Polyether Polyols

Polyester Polyols

Polyacrylate Polyols

Polycarbonate Polyols

NMP

MEK

Acetone

TEA

DMEA

Appearance
- High Gloss
- Wet look

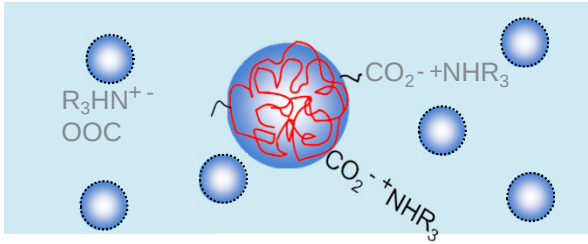
Weatherability
- Environmental etch
- Hydrolytic stability

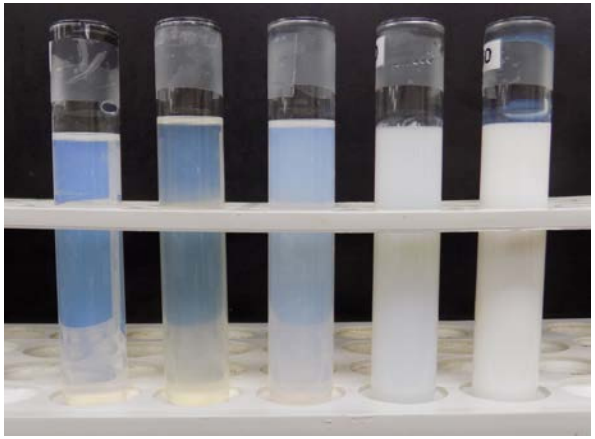
Resistance
- Abrasion
- Chemical
- Solvent

Mechanical
- Toughness
- Flexibility

Temperature
- Low and High Tg

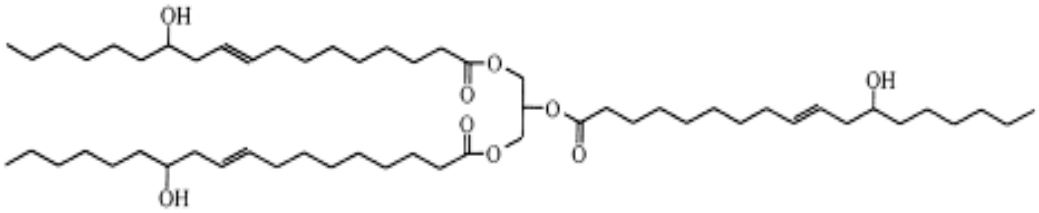
Crosslinkable





Castor oil based PUDs

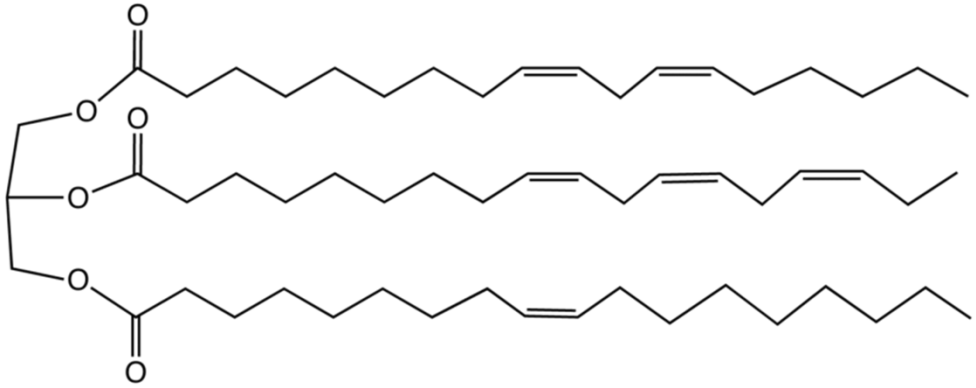
- Extracted from seeds of *Ricinus communis*
- Excellent gloss
- Outstanding wood warming properties
- Hydrophobic
- Physical drying



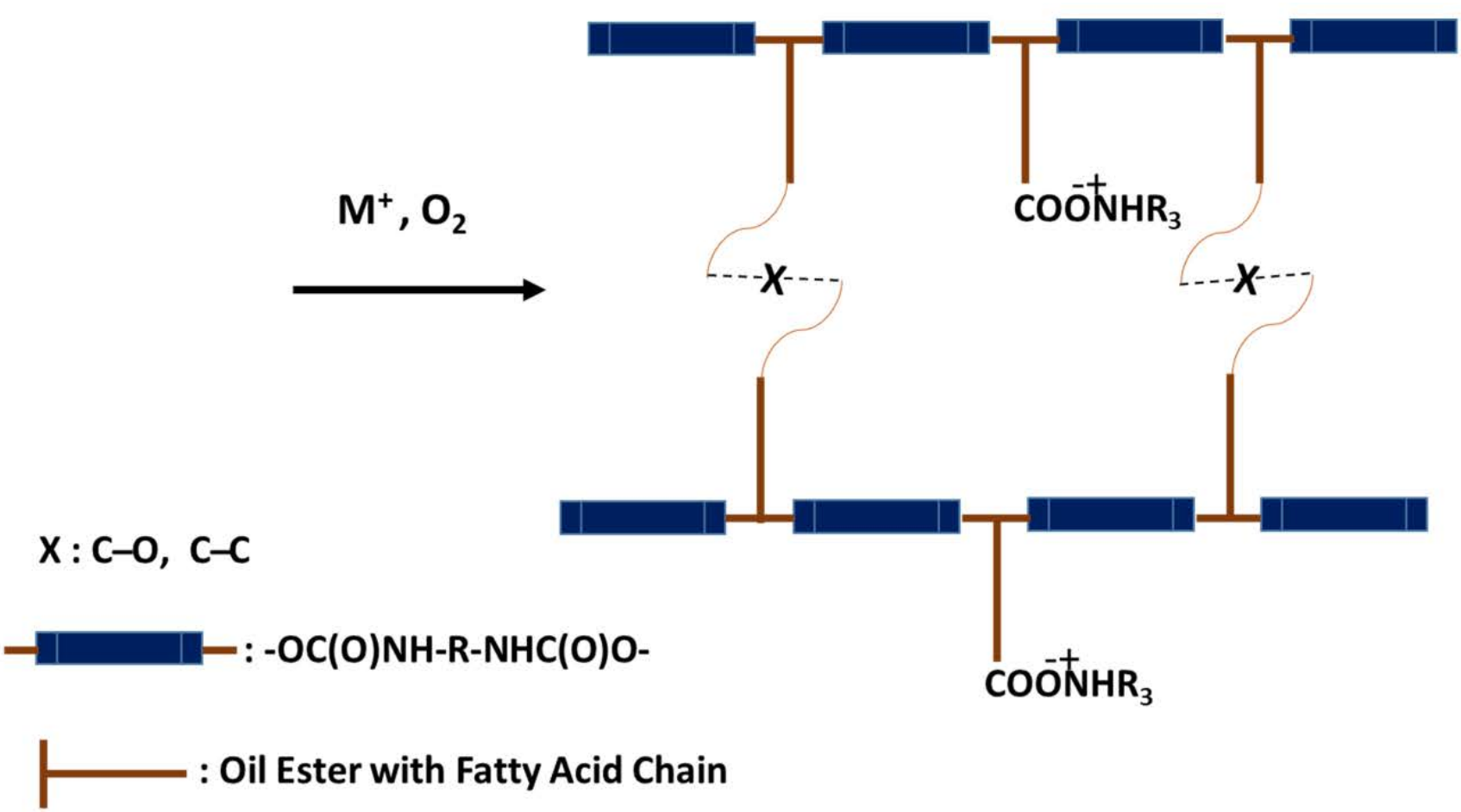
Ricinoleic acid triglyceride

Linseed oil based PUDs

- Derived from seeds of the flax plant
- Fast drying with good hardness
- Outstanding wood warming properties
- Exterior durability
- Alkyd-like flow



Oxidative cure of linseed oil based PUDs



Renewable PUDs

		Solids [%]	Viscosity [mPas]	MFFT [°C]	Renewable content [% on solids]
1K	**LO–2**	34 - 36	20 - 200	approx. 21	approx. 32
2K	**U-1**	34 - 36	20 – 200	approx. 0	approx. 21
WB UV	**UV-1**	30 - 32	20 - 200	approx. 0	approx. 30

Wood Flooring using Renewable PUDs

- Polyurethanes are the dominant choice for wood floors due to their flexibility, toughness and chemical resistance.
- Solvent (1K oil modified) and water-based (1 & 2K) materials are available in the market.
- Renewable PUDs have been evaluated according to the testing protocol of the Maple Flooring Manufactures Association (MFMA). Competitor commercial controls were benchmarked for comparison.

  Performance Criteria:

  - Black Heel Mark Resistance
  - Chemical Resistance
  - Taber Abrasion
  - Coefficient of Friction (CoF)

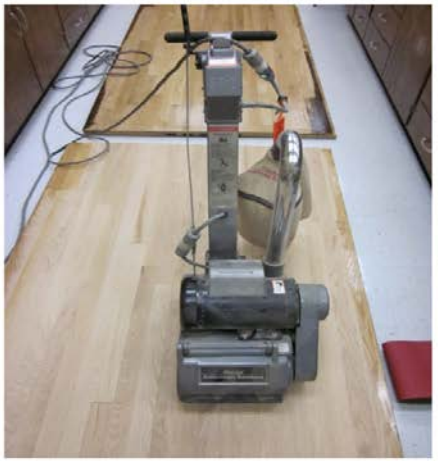
M F M A
Maple Flooring Manufacturers Association, Inc.
The Sports Flooring Authority

Starting point formula based on 1K LO-2

Raw material	Weight
1 LO-2	**80.08**
2 Defoamer	0.10
3 Water	9.32
4 Solvent	5.00
5 Substrate wetting agent	0.50
6 Wax dispersion	5.00
Total	**100.00**

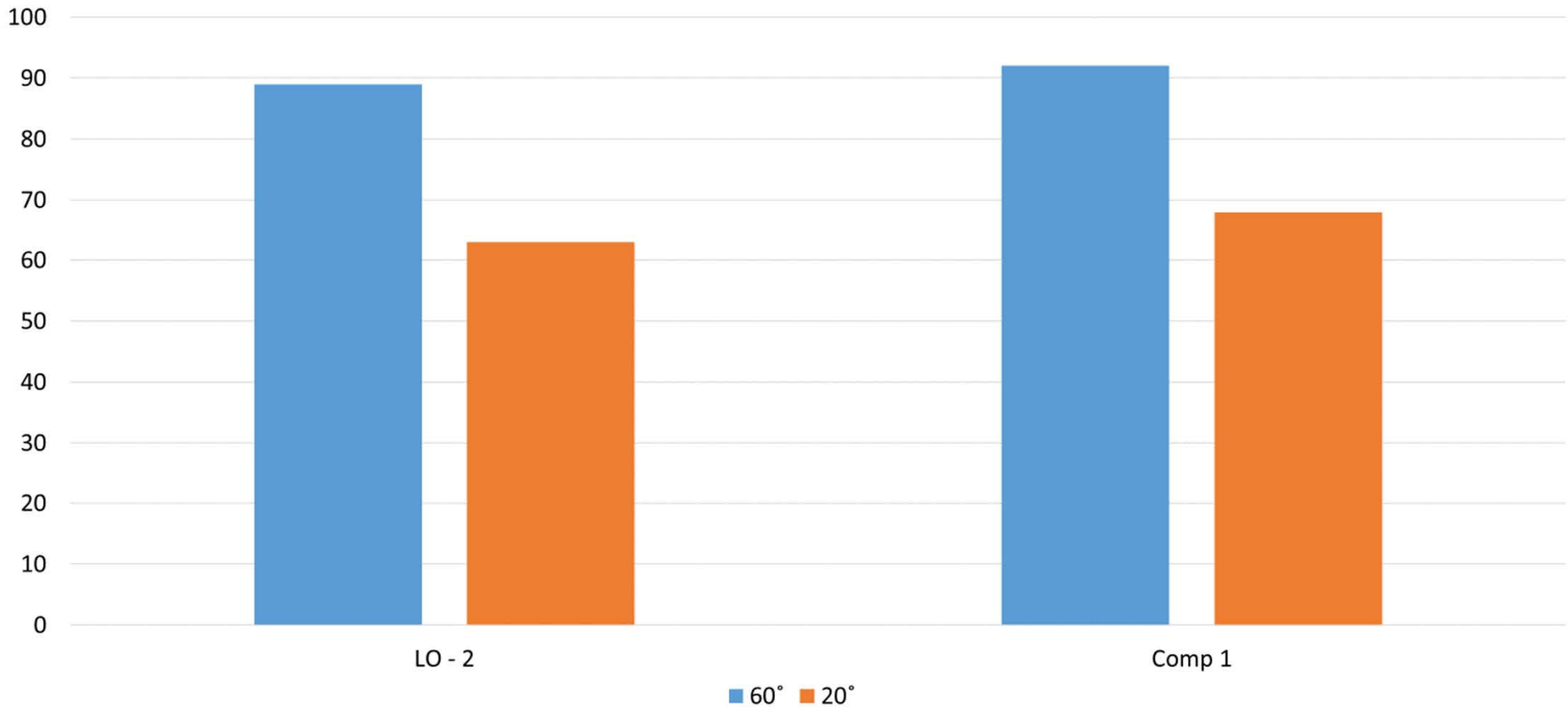
Wt/Gal (lb/gal):	8.64
VOC (lb/gal)	1.38
VOC (g/L)	165.00
Weight solids (%)	30.00
Volume solids (%)	27.00

Appearance & Sanding performance

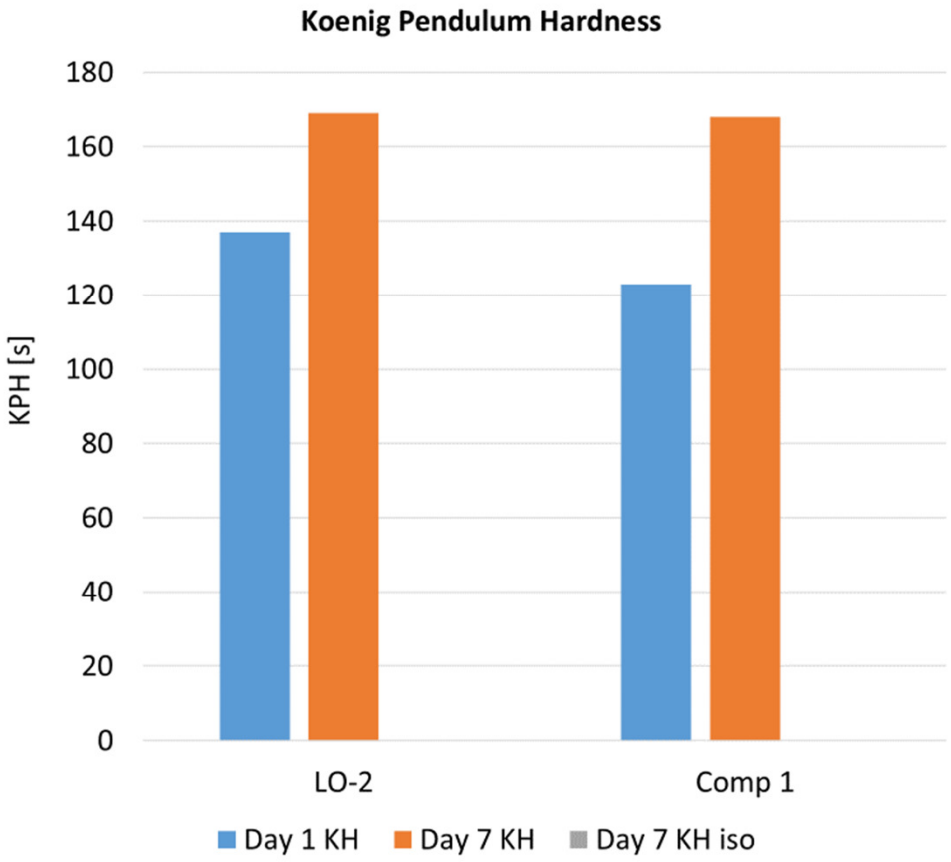


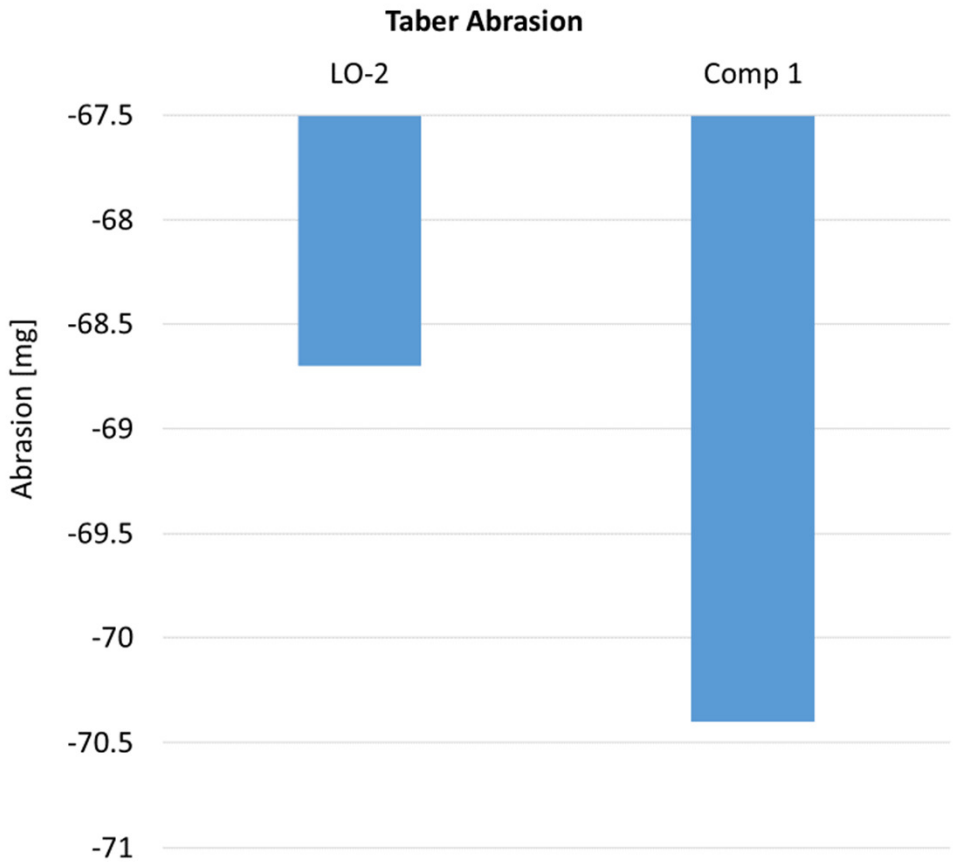
LO-2 has excellent sanding performance

Gloss comparison



Hardness and Taber abrasion





Additional testing

Test Procedures	LO-2	Commercial Control 1
Coefficient of Friction	0.54	0.51
Stain Resistance	Pass	Pass
Scrape Adhesion (5kg)	Pass	Pass
Scratch Resistance (% Gloss loss)	29.8	22.1

Summary of LO-2 for 1K application

- Unique linseed oil PUDs offer excellent performance on wood substrates, including flooring and decorative applications.
- These products are easy to formulate and perform similarly to competitor product in the market.
- Linseed oil PUDs are more environmentally friendly compared to traditional solvent based OMUs, have less reliance on petroleum feedstock and offer versatile performance for a broad range of markets.
- Further development continues expanding application to other substrates (masonry) using exterior grade linseed oil PUDs.

Features of U-1 for 2K application

- Solvent Free
- Very easy mixing with crosslinkers
- Very good chemical and stain resistance
- High gloss
- Biobased content 21%

Properties of U-1

Solids content [%]	34 – 36
Viscosity [mPas]	20 – 200
pH-value	7.5 – 8.5
MFFT [°C]	approx. 0
Koenig Hardness (s)	125
Polymer type	Polyester
VOC capability	< 50 g/L

Competitor – 2K waterborne finish

PHYSICAL CHARACTERISTICS:

Ingredients - Water, polymeric resins, and amorphous silica.

Color – Milky white (wet)

pH – 7.9

Solids – 32% (with hardener)

Density – 8.70 lbs./gallon (1.04 S.G.)

US Regulatory VOC Compliant – 150 g/L (with hardener), 155 g/L Gloss (with hardener)

Coefficient of Friction - ≥ 0.5

Gloss Level – (60°): 7-10 for Commercial Extra Matte, 15-20 for Commercial Satin,

40-45 for Commercial Semi-Gloss, 65-70 for Commercial Gloss

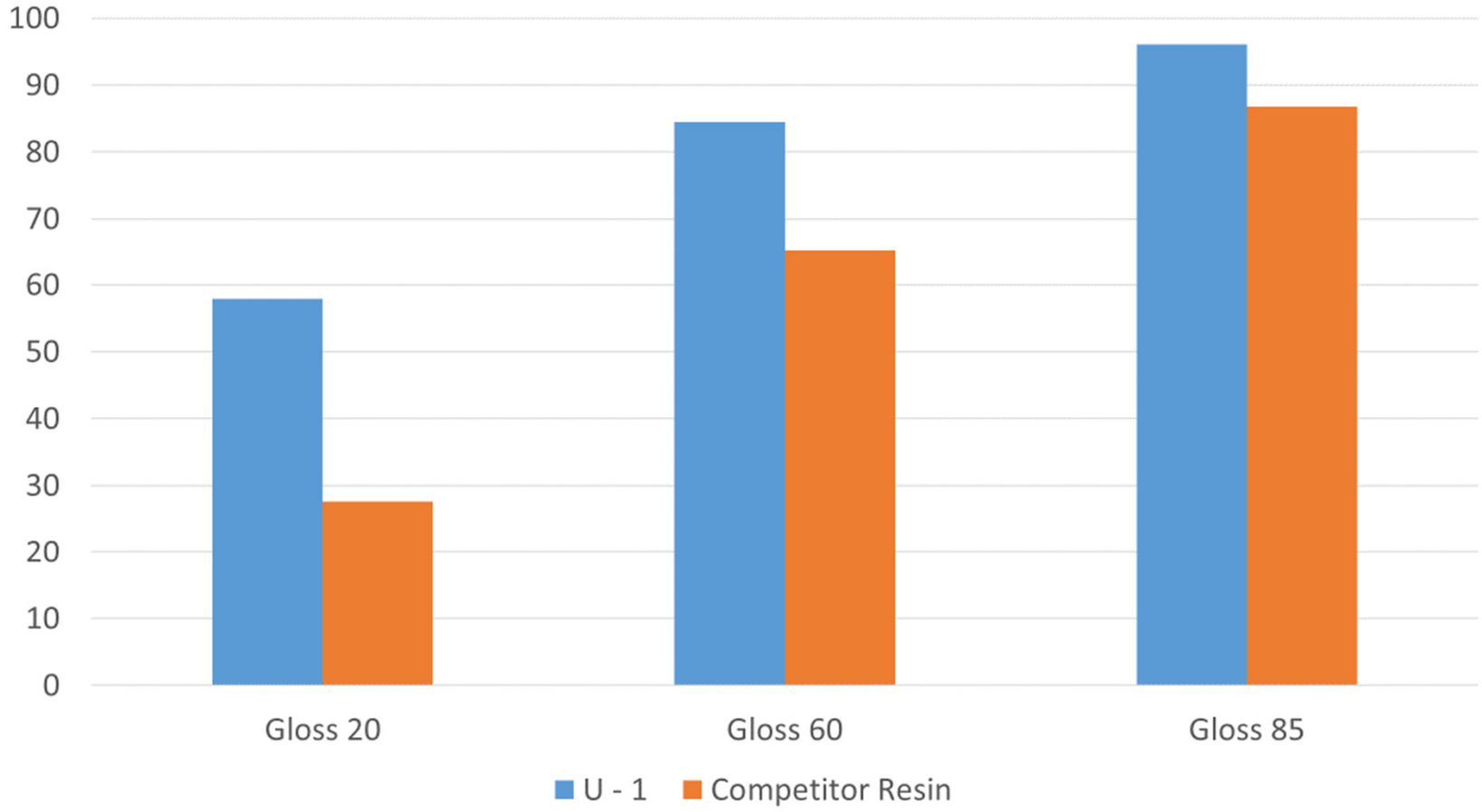
Odor – Very slight non-offensive odor

Formulas

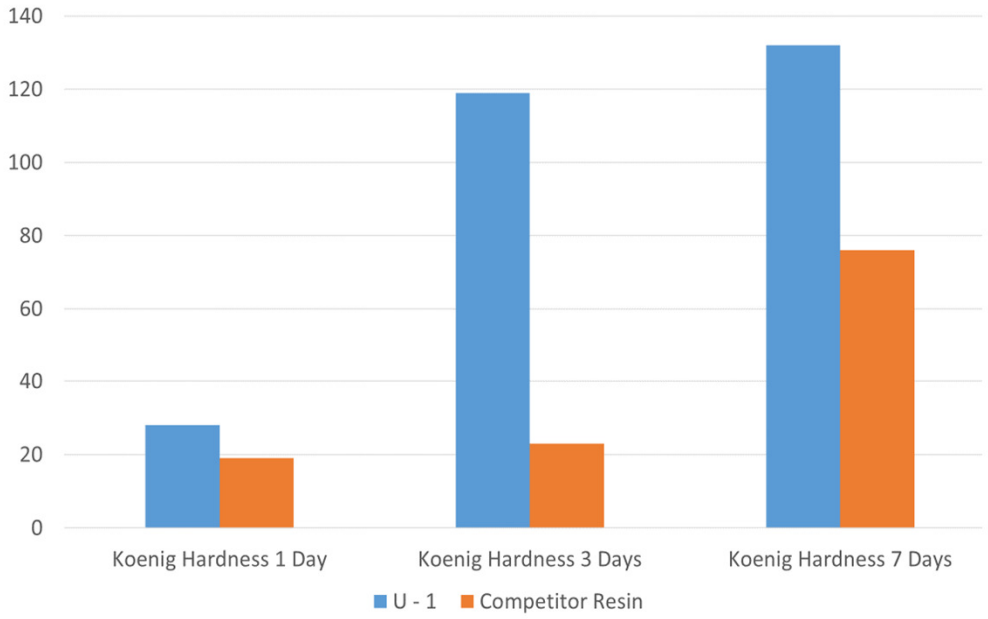
Ingredients	Competitor Resin	ABI resin
U -1		**78.80**
Defoamer		1.20
Flow Additive		0.80
Water		18.90
Rheology Modifier		0.30
Water Dispersible NCO		10.00
Competitor Resin	100	
Competitor crosslinker	10	
Total	**110**	**110**

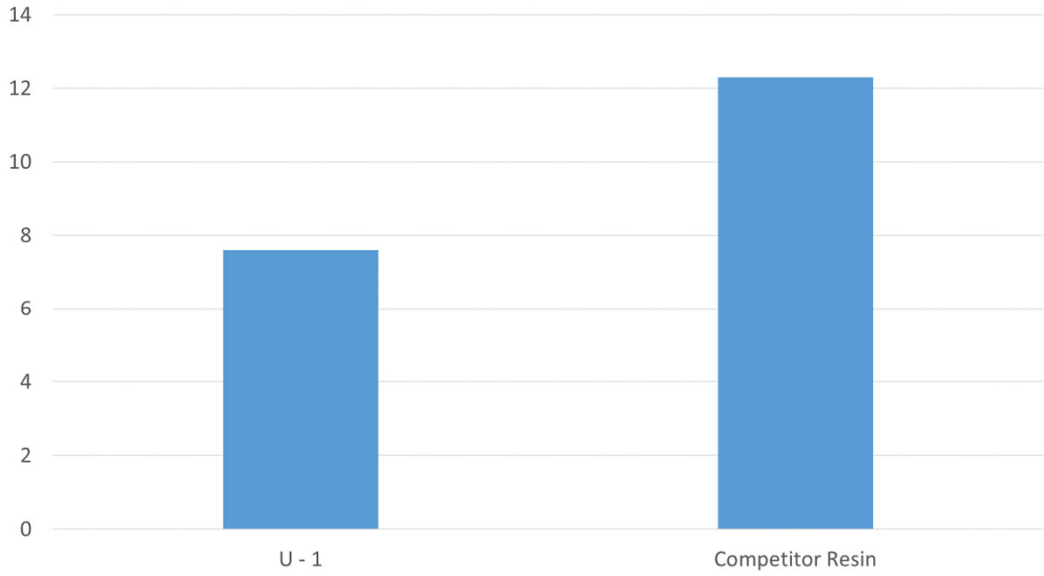
	% solids (mixed)	VOC (g/L)
U 8500	34.87	37.3
Competitor resin	32	155

Gloss


100
90
80
70
60
50
40
30
20
10
0
Gloss 20
Gloss 60
Gloss 85
U - 1
Competitor Resin

Hardness and Taber loss





Other properties

- Chemical resistance - DI water, 100 proof ethanol, cleaning solution, olive oil, VM&P Naptha, beer, Cola

  – Both excellent

- Black heel mark resistance – Both excellent
- Fingernail mar resistance – Both excellent
- Coefficient of friction

U-1	0.50
Competitor resin	0.42

Blending U-1 with self-matting PUD

When U-1 is combined with an inherently dull PUD, they offer a finish with:

- Ultra low gloss (20°/60°/85°): 0.3/3.5/18.0
- Can be used with any sealer or self-sealing
- Suitable for residential and high traffic

Conclusion

U-1 offers a “BEST” 2K wood floor finish:

- Higher gloss
- Higher hardness
- Improved Taber wear resistance
- Excellent chemical resistance

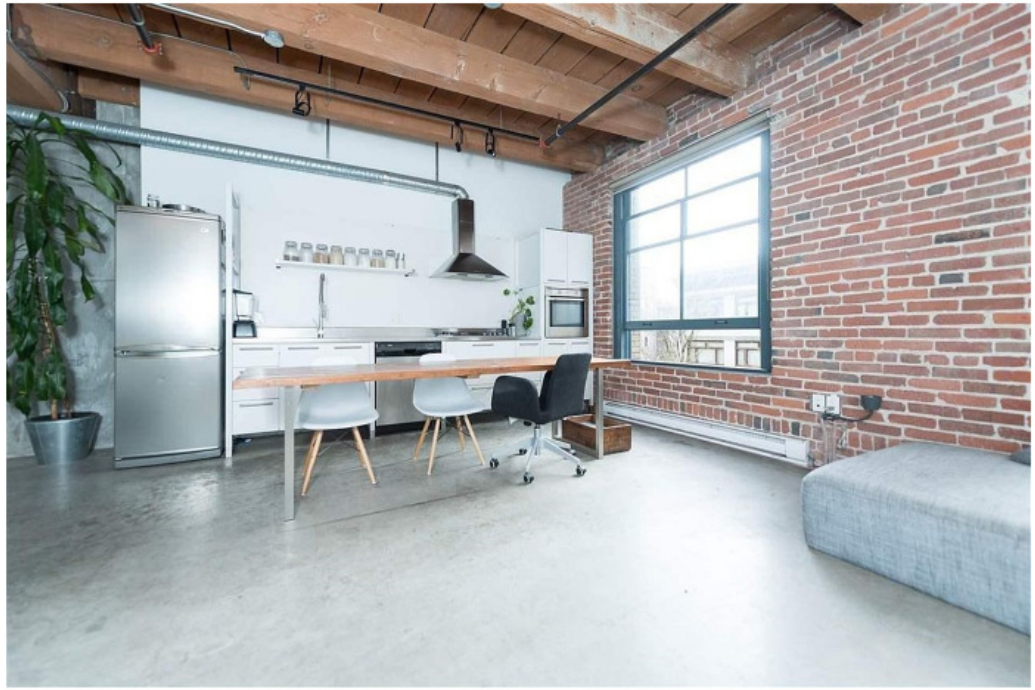
2K U-1 for concrete application

Project scope:

- U-1 was evaluated against hydroxy functional acrylic, AC-2, and a commercial 2K product used on concrete floors.

Properties evaluated:

- Gloss
- Surface hardness
- Chemical resistance
- Wear resistance



	U - 1	AC - 2	Competitor Resin
U - 1	78.8		
AC - 1			
AC – 2		70.01	
Defoamer	1.2	0.5	
Flow Additive	0.8	0.3	
Water	18.9	28.89	
Rheology Modifier	0.3	0.3	
Water Dispersible NCO	10	25.5	
Competitive Resin			100
Competitive NCO			10
Total	110	125.5	110
% Solids	34.87	41.82	32
VOC g/l	37.3	5.25	155

	U – 1	AC - 2	Competitor Resin
VOC g/l	37.3	5.25	155
Gloss 20/60/85	57.9/84.5/96.1	64.3/83.5/96.2	27.6/65.3/86.8
Gloss Loss %	30.4	18.9	20.4
Hardness Koenig 1/3/7 Days	28/119/132	20/48/176	19/23/76
Taber Loss mg	7.6	24.1	12.3
CoF	0.5	0.48	0.42
MEK 2X Rubs	200	200	50
Fingernail Mar	5	5	5
BHMR	5	5	5
Early Water Resistance	5	5	5

Chemical	U - 1	AC - 2	Competitor Resin
10% Acidic Acid	5	5	5
50% NaOH	5	5	5
Betadine	2	2	2
Brake Fluid	5	5	5
ECO-Lab Wash N Walk	5	5	5
Stainless Steel Cleaner	5	5	5
15% Paracetic Acid	5	4	5
95% Ethanol	5	0	5
10% Glycolic Acid	5	5	5
20% HCL	5	5	5
35% H2O2	4	5	4
IPA	5	5	5
10% Lactic Acid	5	5	5
Red Wine	5	5	5
Skydrol	3	5	4
Spor Klenz RTU	5	5	5
DI Water	5	5	5
Mustard	3	3	3
Olive Oil	5	5	5
Pickle Juice	5	5	5
Ketchup	5	5	5
Hand Fat	5	5	5
Chlorox Pro	5	5	5
Total	112	104	113

Conclusion

U-1 offers:

- Lower NCO demand compared to the OH functional acrylic (possible lower total formula cost)
- Very good physical properties especially incredibly high Taber wear resistance (7.6 mg)
- Best overall chemical resistance
- Can be blended with renewable acrylics for higher renewable content

Features of UV-1

- Solvent Free
- Good scratch resistance
- Very good chemical and stain resistance
- High hardness
- Excellent wood warmth

Properties of UV-1

Solids content [%]	30 – 32
Viscosity [mPas]	20 – 200
pH-value	7.5 – 8.5
MFFT [°C]	approx. 0
Polymer type	Castor/Polyester
Biobased content	30%

Formula

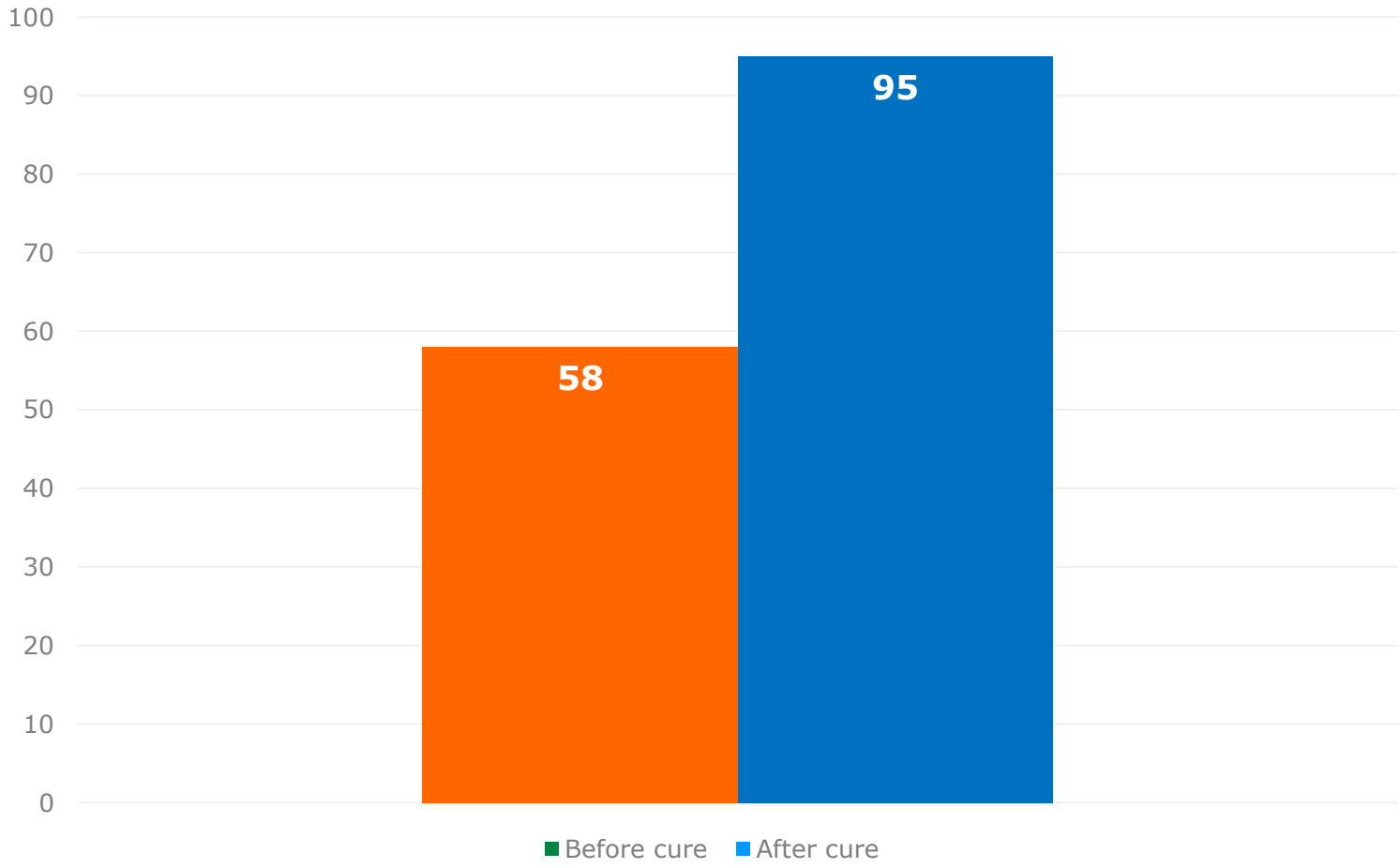
Ingredients		
WB UV-1 PUD	96.45	Resin
Tego Dynol 800	0.7	Wetting agent
Tego Foamex 822	0.21	Defoamer
BYK Ceraflour 1000	1.96	Matting agent
IGM Omnirad 500	0.5	Photo initiator
Arkema Coapur XS 83	0.18	Thickener
Total:	100	

Properties	
Weight/Gallon	8.73
Weight solids:	33.54%
Volume solids:	30.38%
VOC (g/L):	39.76
Renewable content (on solids):	29%

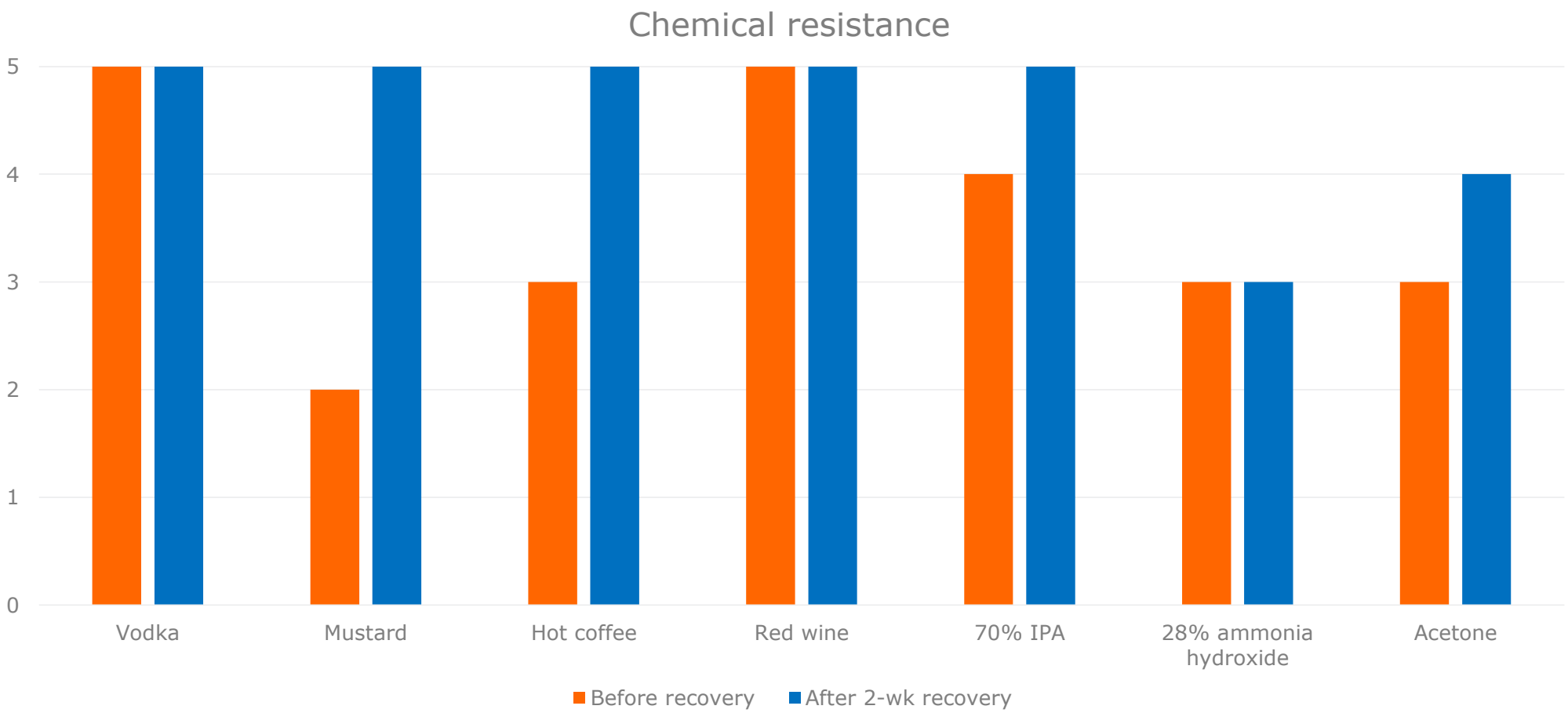
Application on red oak veneer

- Spray and force dry
- UV cure
- Sand
- Repeat for 2nd coat (spray, dry and cure)
- Age at room temp for 1 week to test

Koenig Hardness (s)



Chemical Resistance

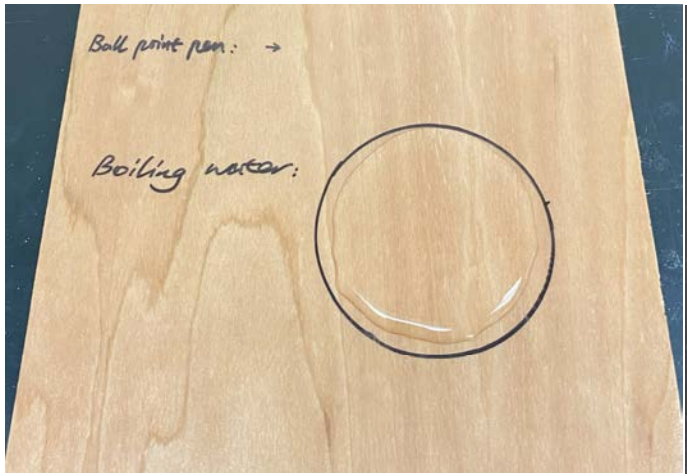


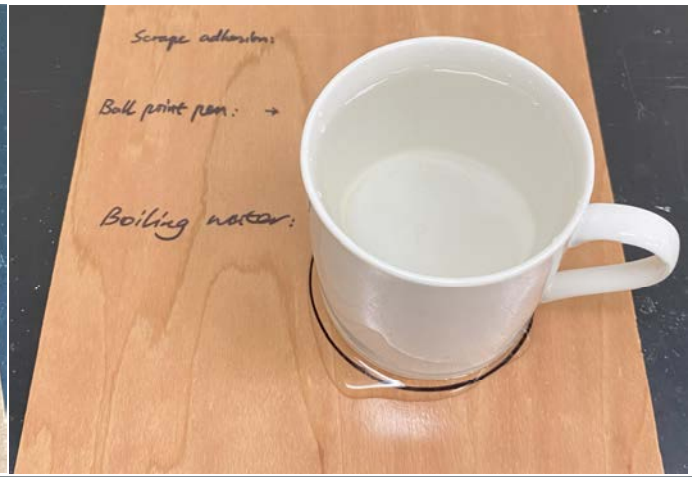
Boiling water resistance

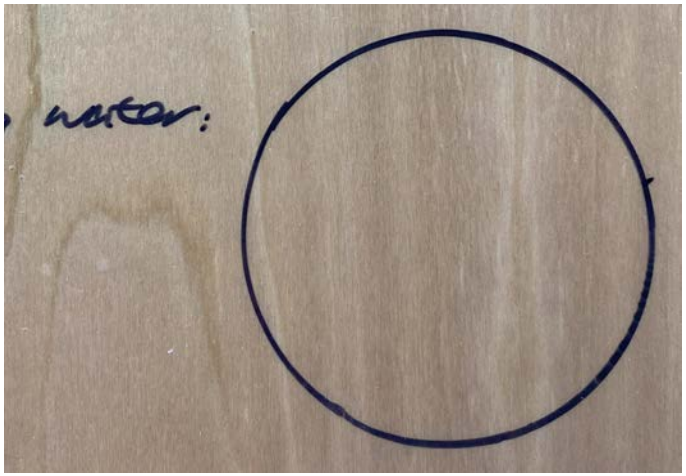
- Hot water drop on surface

- Hot water cup on top for 1 hour

- Result: ***PASS*** with extremely minor mark

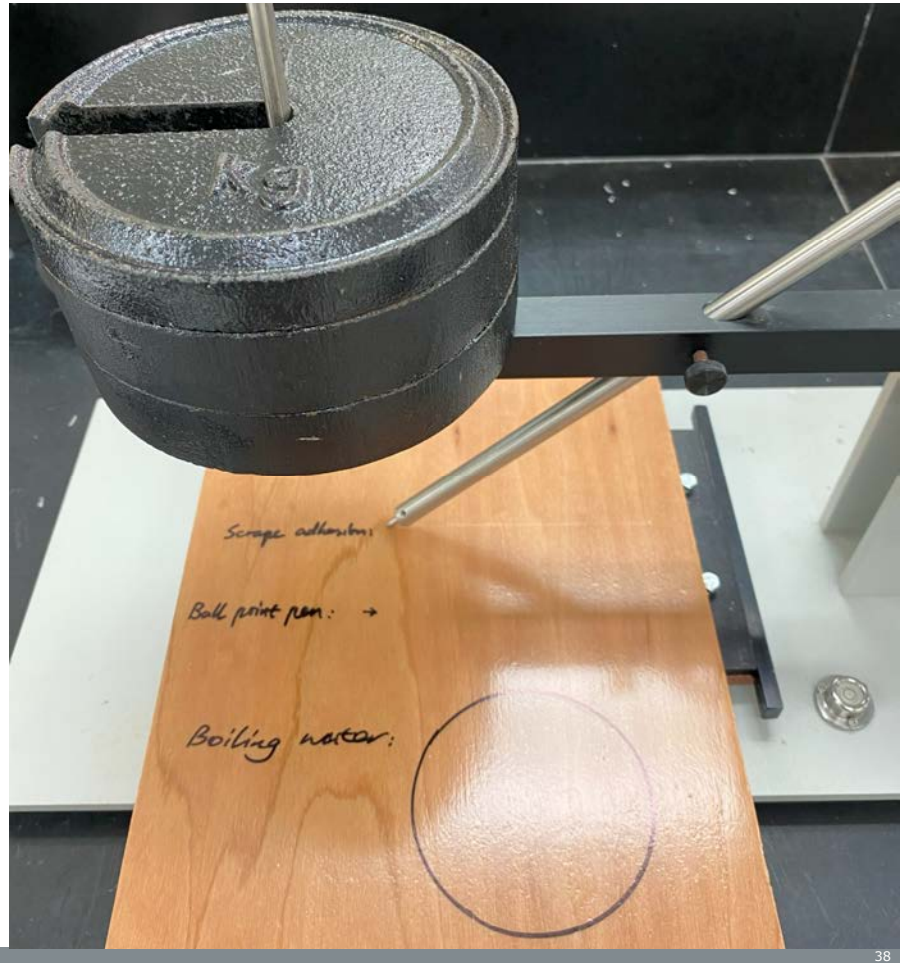






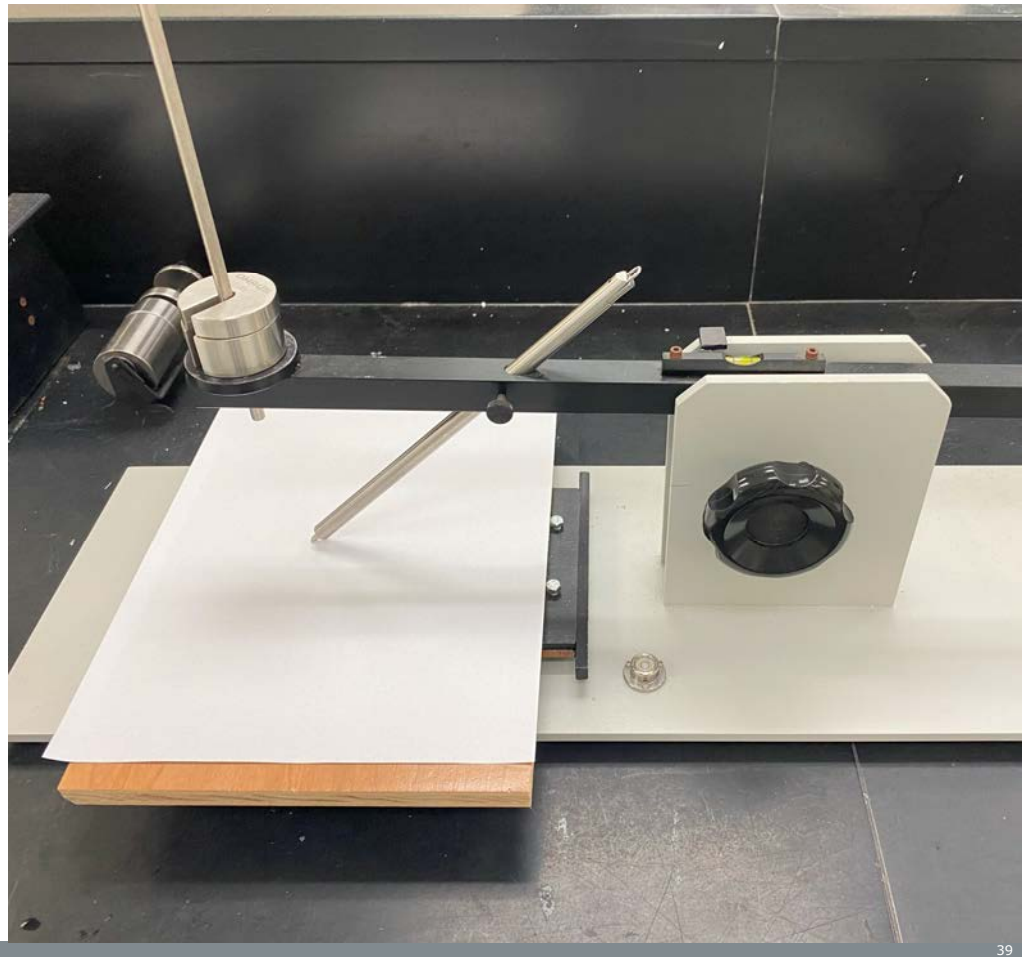
Scrape adhesion

- 5 kg weight applied across board
- Result: ***PASS***, no whitening or cracks.



Ball Point Pen Indentation

- 300 g applied across paper on top
- Result: ***PASS***, no whitening or cracks.



Conclusions

The WB UV-1 PUD resin has great performance as a renewable resin:

- High hardness
- Short dry time (20 min)
- High resistance to scrape and ball point pen

Summary and outlook

- 3 different waterborne renewable PUDs with various biobased contents

PUD	Application	Bio content	Features
LO-2	1K	32%	Wood warming, Incredible sanding, Abrasion resistant
U-1	2K	21%	Higher gloss\hardness\abrasion resistance; Lower NCO demand
UV-1	UV	30%	High hardness, Short dry time, High resistance to scrape and ball point pen

Questions

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