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Polycaprolactone Polyols Designed for Polyurethane Dispersions

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Market Segment Manger – Coatings

AGENDA

1. Polycaprolactone (PCL) Polyols
2. Polyurethane Dispersions using PCL
3. Recently Developed PCL Technologies
4. Results from Application Testing
5. Summary of Findings

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AT A GLANCE

2023 NET SALES BY GEOGRAPHY

NORTH AMERICA 63%

EUROPE, MIDDLE EAST AND AFRICA 13%

ASIA-PACIFIC 22%

SOUTH AMERICA 2%

OUR BUSINESS IN 2023

NET REVENUE
$1.692 BILLION

ADJ. EBITDA MARGIN [1]
23.5%

$3.94
DILUTED ADJUSTED EPS [1]

PERFORMANCE MATERIALS REVENUE
$586.0 MILLION

ADVANCED POLYMER TECHNOLOGIES REVENUE
$204.0 MILLION

PERFORMANCE CHEMICALS REVENUE
$902.1 MILLION

OUR COMPANY

EMPLOYEES GLOBALLY [2]
1,700

MANUFACTURING SITES [2] **13**

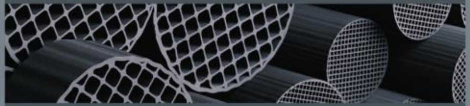
LOCATIONS
30

6
TECHNICAL CENTERS

WE DO BUSINESS IN **75** COUNTRIES

PERFORMANCE MATERIALS

Carbon Technologies



MARKETS
- Automotive
- Food and beverage purification
- Water Treatment

ADVANCED POLYMER TECHNOLOGIES

Caprolactone Technologies

MARKETS
- Automotive and transportation
- Consumer packaging
- Footwear and apparel
- Industrial equipment
- Medical and health

PERFORMANCE CHEMICALS

Industrial Specialties [3]

MARKETS
- Agricultural chemicals
- Industrial intermediates
- Paper chemicals
- Rubber

Limited:
- Adhesives
- Lubricants
- Oil and mining

Road Technologies

MARKETS
- Pavement construction
- Pavement marking
- Pavement preservation
- Pavement reconstruction and recycling

1: See page 115 of our 2023 Annual Report and 10-K for definitions and reconciliations of these non-GAAP financial measures.
2. Manufacturing site count and employee count excludes employees at our CTO-based manufacturing facility in DeRidder, Louisiana, which will be closed in 2024.
3. In November of 2023, we announced an initiative to reposition our Performance Chemicals segment to enhance profitability and earnings stability, which will result in the reduction, and in some cases exit, of historical end-use markets of our Industrial Specialties product line such as adhesives, publication inks, and oilfield. See page 5 of our 2023 Annual Report and 10-K for more information.

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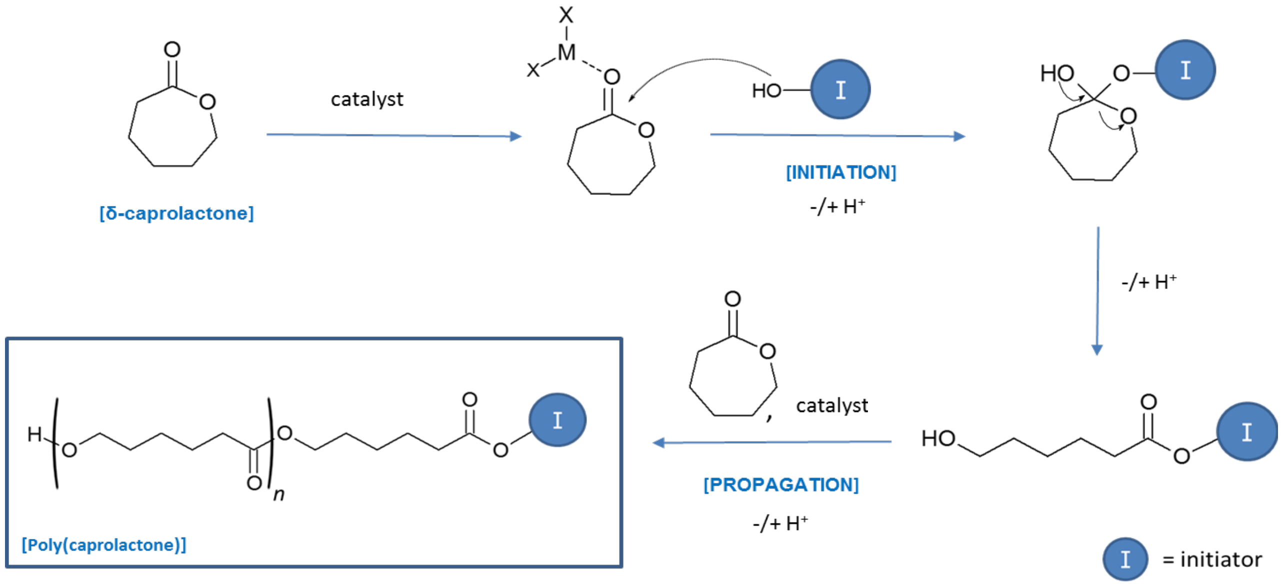
Polycaprolactone (PCL) Polyols



- PCL polyols made *via* **ring opening polymerization**
- **No by-products**
- Acid value and water content can be kept very low
- Fully **aliphatic** backbones
- **All hydroxyls are primary**
- Very **narrow polydispersity**

Polycaprolactone (PCL) Polyol Uses in Coatings

Coating Enhancer

- 2K SB
- 100% Solids
- 2K WB

Building UV Oligomers

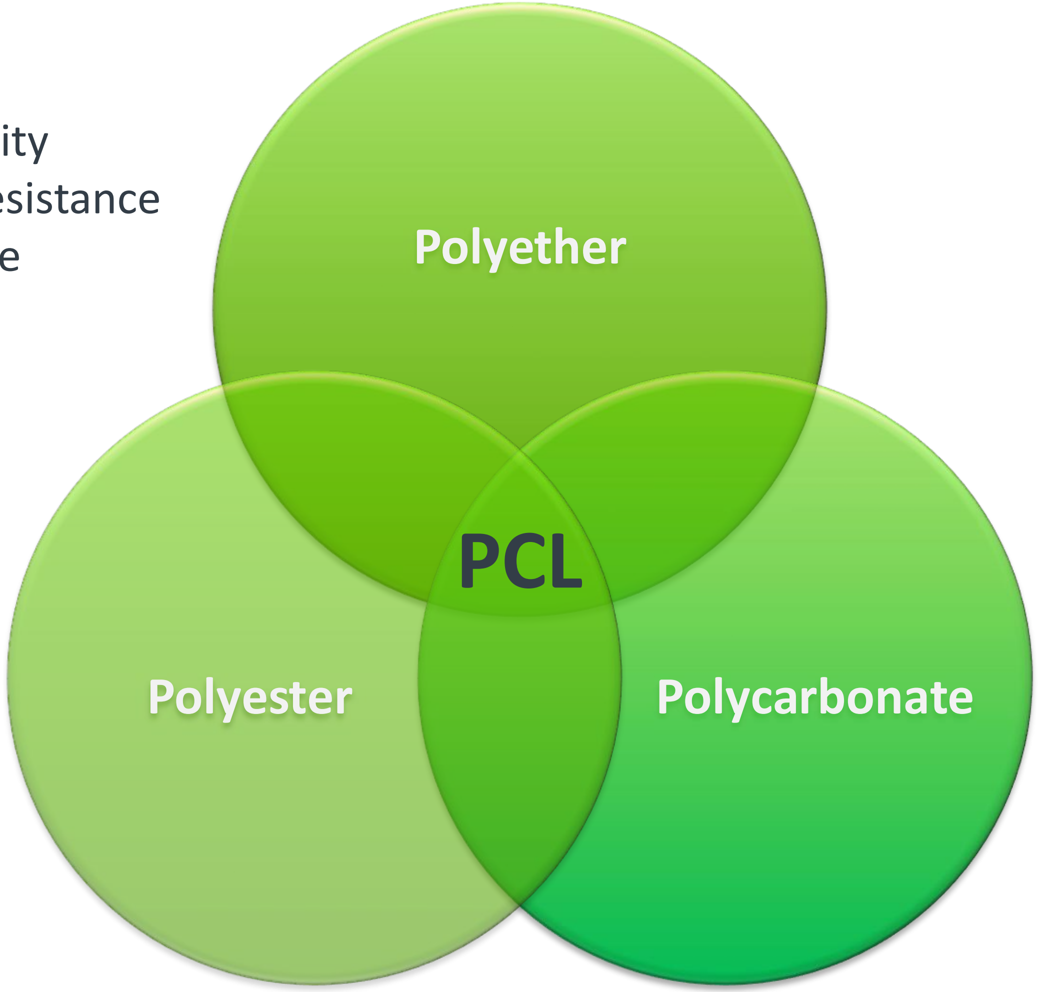
- Radical Cure
- Cationic Cure

Building PUDs

- 1K PUD
- 2K PUD

Comparison of PUD Polyol Technologies

+ Good Flexibility
+ Hydrolysis Resistance
– UV Resistance



+ UV Resistance
+ Application Versatility
– Hydrolysis Resistance

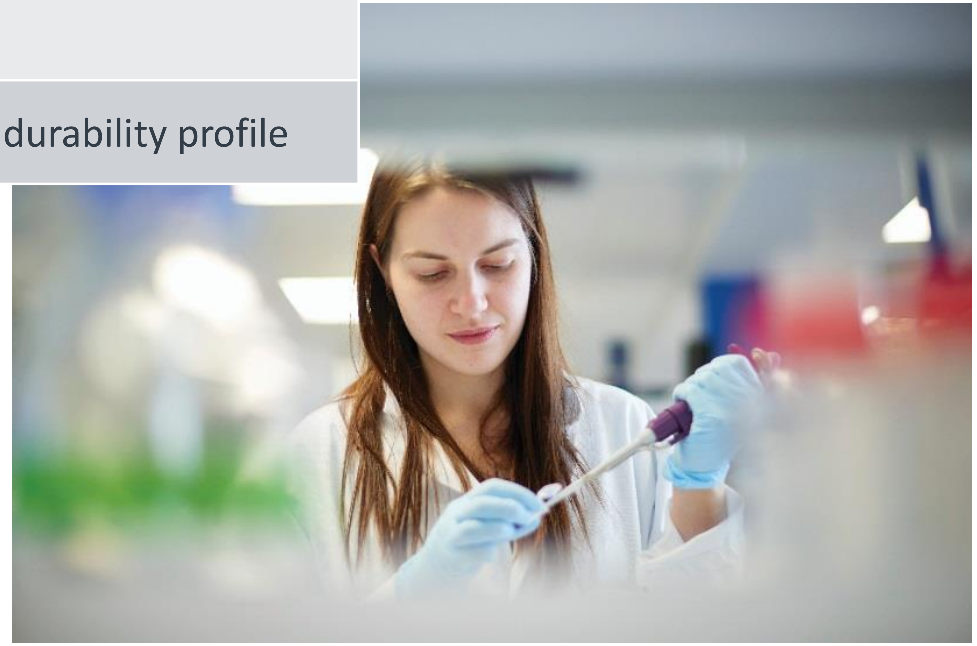
+ Hydrolysis Resistance
+ UV Resistance
– Processing Viscosities

PCL polyols – no compromise on **processing**, **performance** or **durability**

Polyurethane Dispersions (PUDs) With PCL

PCL Polyols for Polyurethane Dispersions

PCL Polyol Feature	Benefit in final PUD
Low glass transition temperature	Excellent low temperature flexibility
Narrow polydispersity	Good reproducibility of coating properties
Low viscosity	Low/Zero VOC and ease of processing
UV & hydrolytic stability	Weather stable
Aliphatic polyester backbone	Excellent mechanical and durability profile



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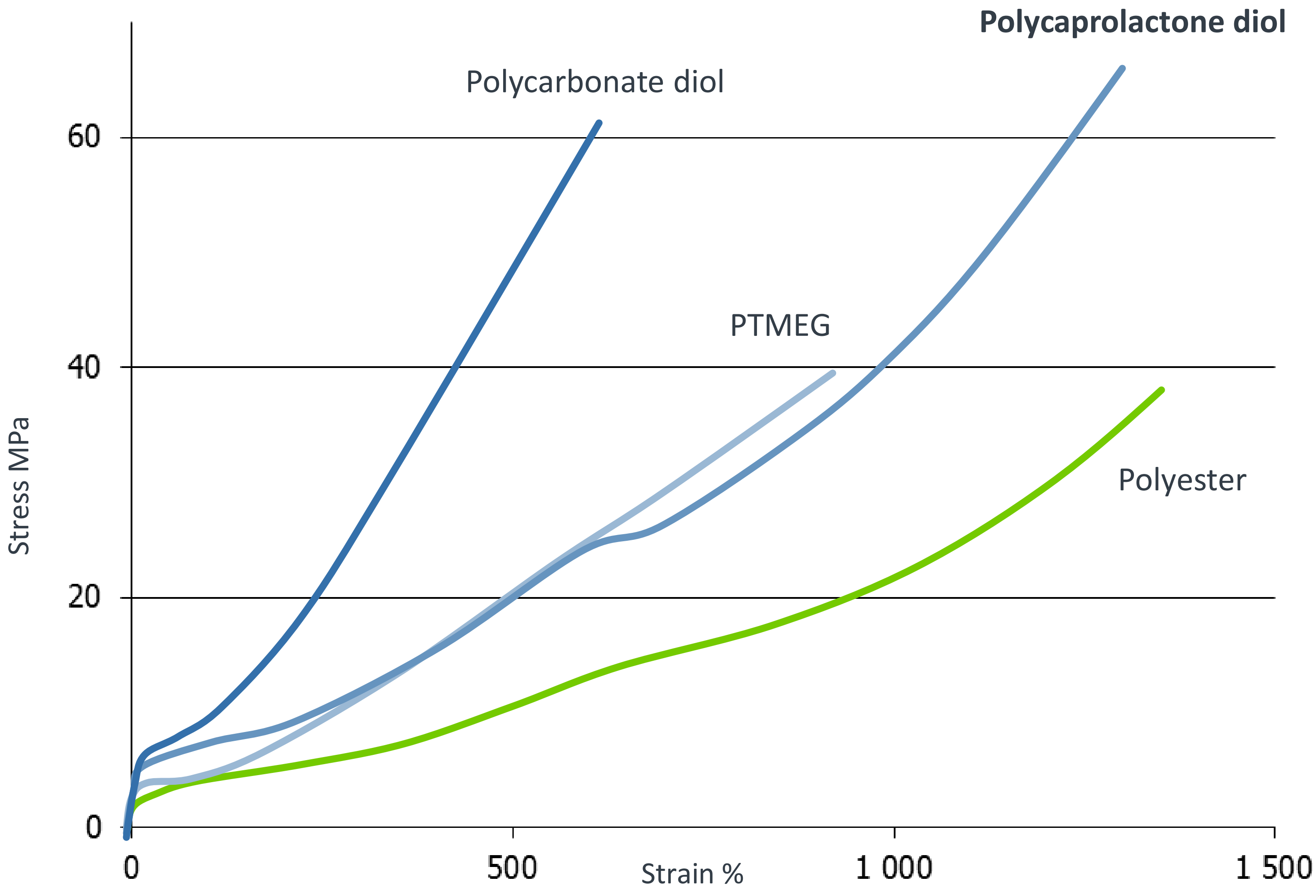
Tensile Testing – 2000 MW



Excellent strength at break with great flexibility

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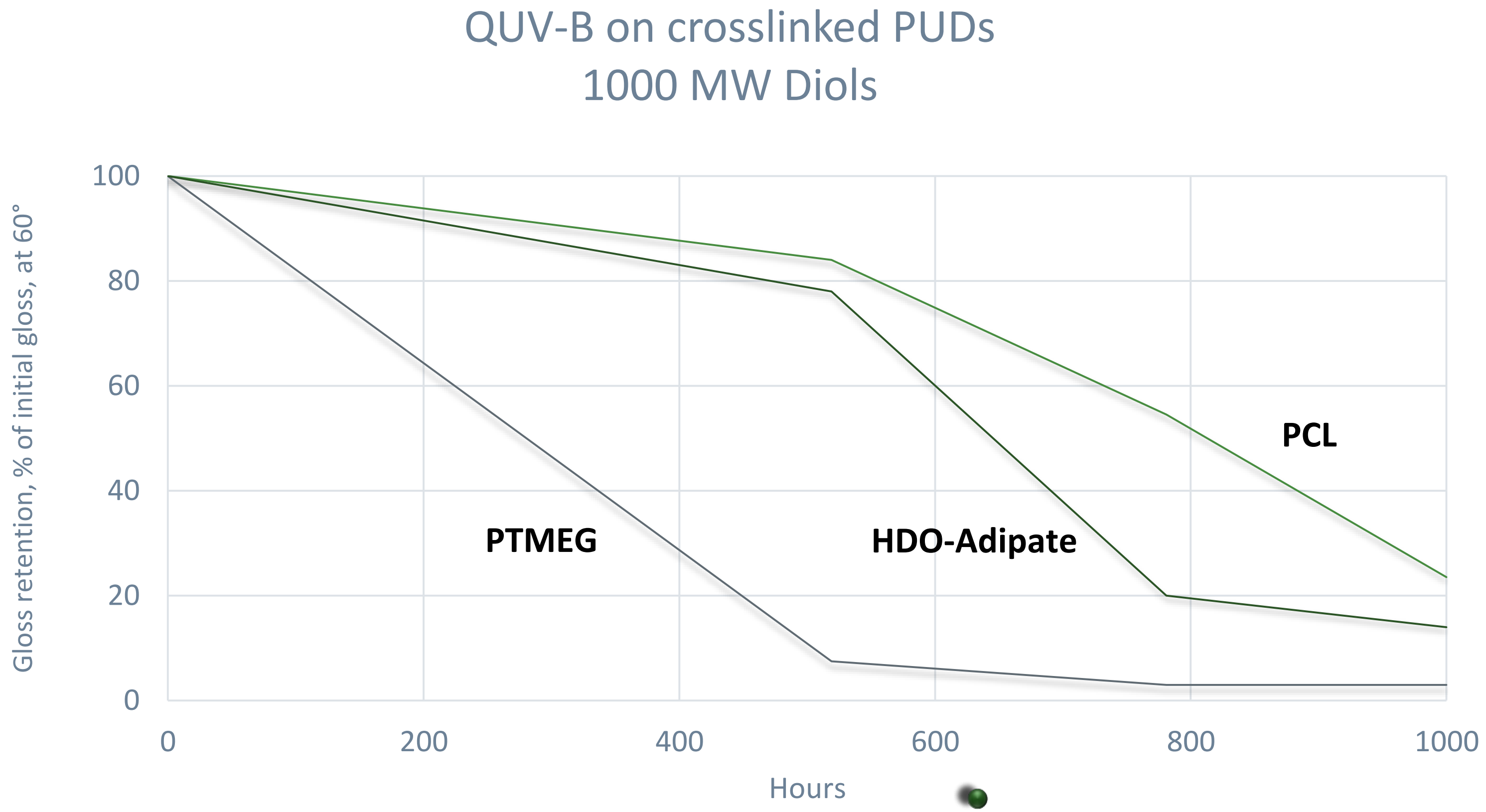
Accelerated Weathering



Cycles of 4 hours of UV-B exposure at 60°C each followed by 4 hours of condensation at 40°C

PCL outperforms PTMEG for UV and Adipate for Hydrolysis

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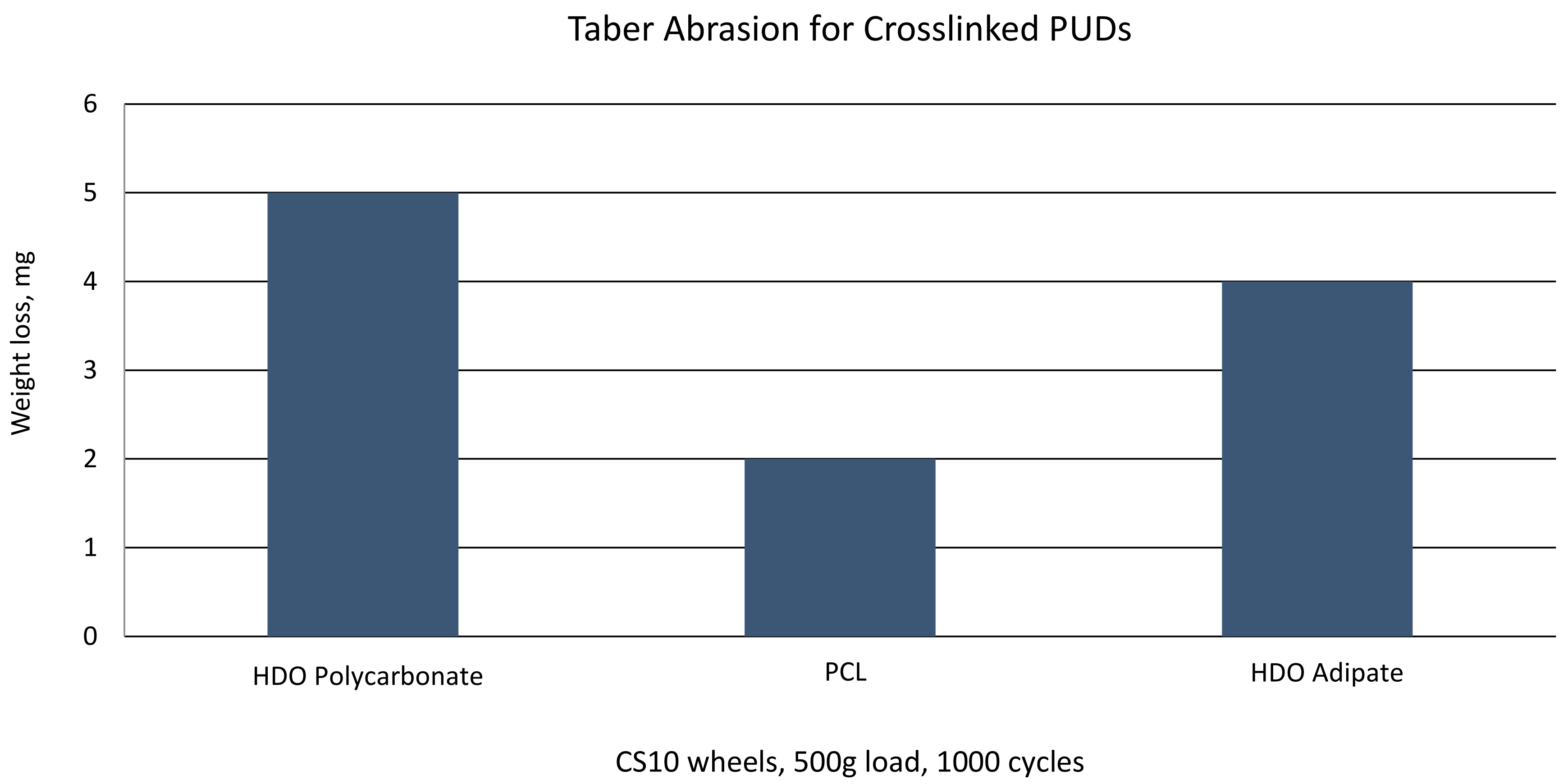
Resistance to Abrasion – 1000 MW Diols



Recently Developed Diols for PUDs

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Newly Developed PCL Diols

- **Harder** than other PCL diols
- Better **Chemical Resistance**
- Faster **Processing** than PCD diols
- Stronger **Flexibility** than PCD diols

Experimental 2000 MW Diol PUD Formulations

Raw Material	Developed PCL PUD	PCD PUD	PCL PUD
Developed PCL Diol	23.6		
Polycarbonate Diol		22.8	
PCL Diol			22.0
DMPA	2.3	2.3	2.2
Hydrazine	0.8	0.8	0.8
Catalyst	8 ppm	8 ppm	8 ppm
Butyl Pyrrolidone	4.5 (to 90% Solids)	7.1 (to 85% Solids)	4.3 (to 90% Solids)
DMEA	1.6	1.6	1.5
Water	68.0	63.9	64.0
Defoamer	20 ppm	20 ppm	20 ppm
Cycloaliphatic Diisocyanate	14.9	14.9	14.3
Total Parts by Weight	100	100	100

Anionic PUDs with Ratios of 2.00/0.40/0.60 $H_{12}MDI$/Polyol/DMPA

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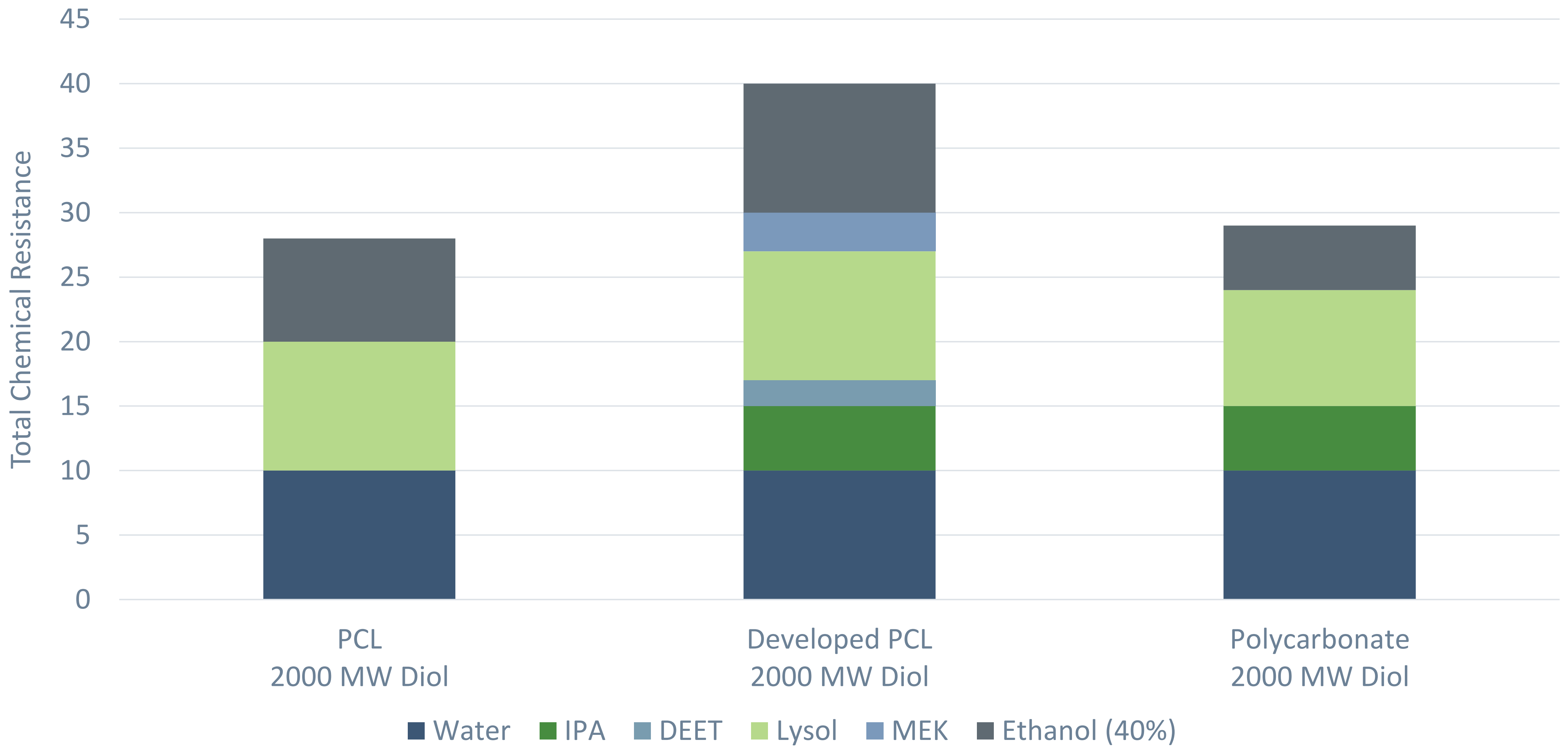
Experimental 2000 MW PUD Properties

Property	Developed PCL PUD	PCD PUD	PCL PUD
Total Solids Calculated (%)	36.00	36.00	36.00
pH	8.46	8.66	8.60
Prepolymer Viscosity at 90°C	3,000	13,500 at 90% 11,500 at 85%	3,000
PUD Viscosity (cps)	300	160	150
Appearance	Semi-Trans	Semi-Trans	Semi-Trans
Density (lb/gal)	8.76	8.66	8.60
VOC (%)	5.30	7.63	5.32
VOC (g/L)	145.27	198.59	144.69

2000 MW PUD Chemical Resistance



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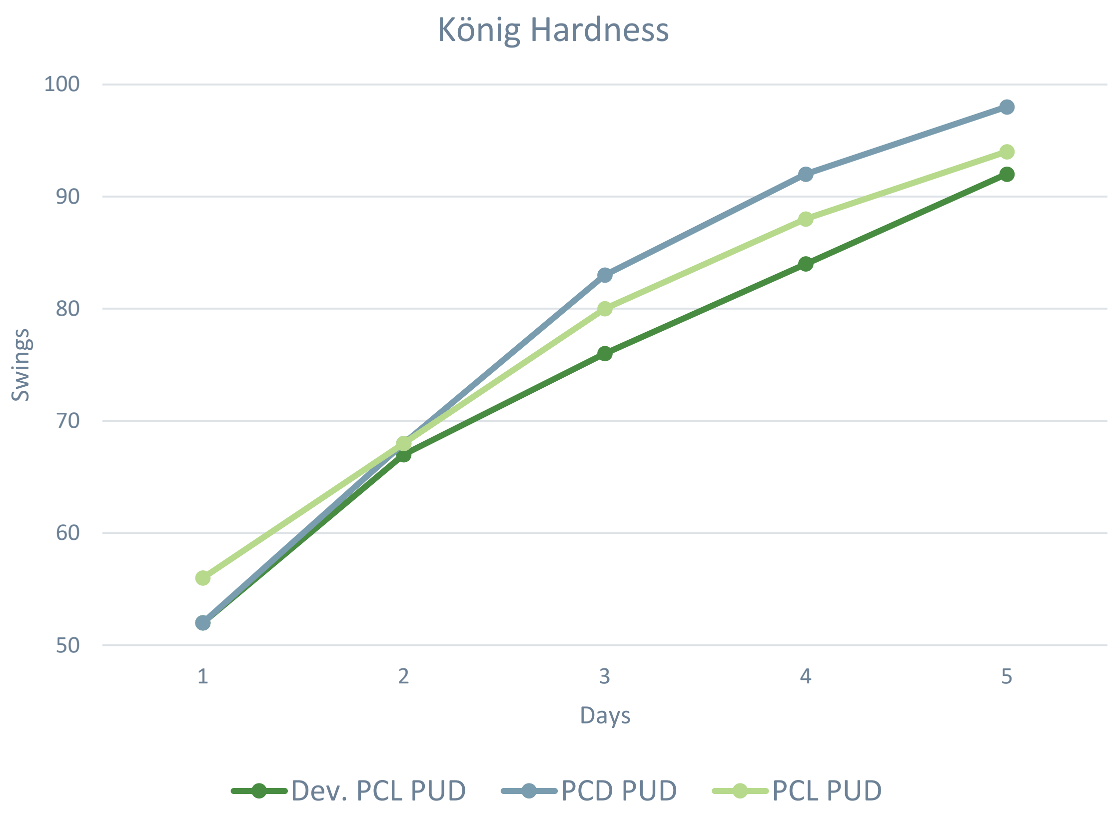
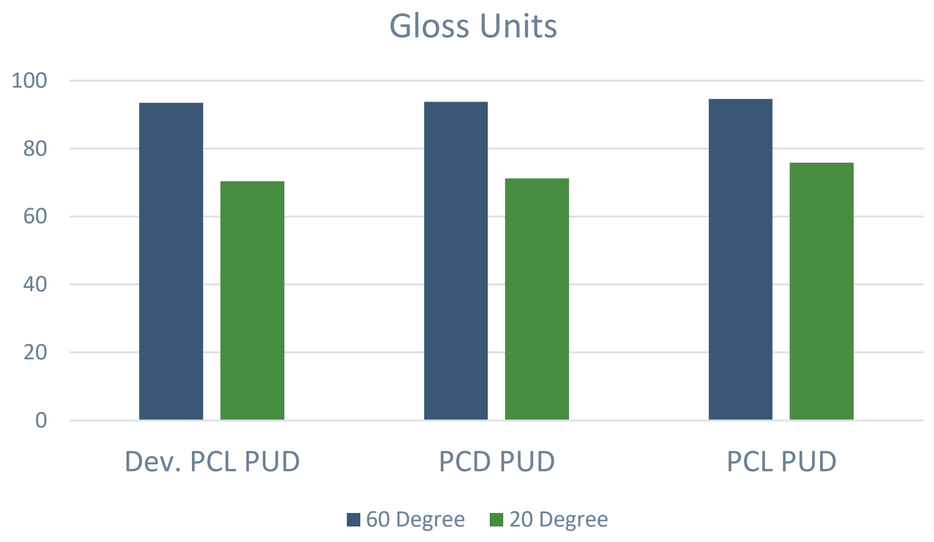
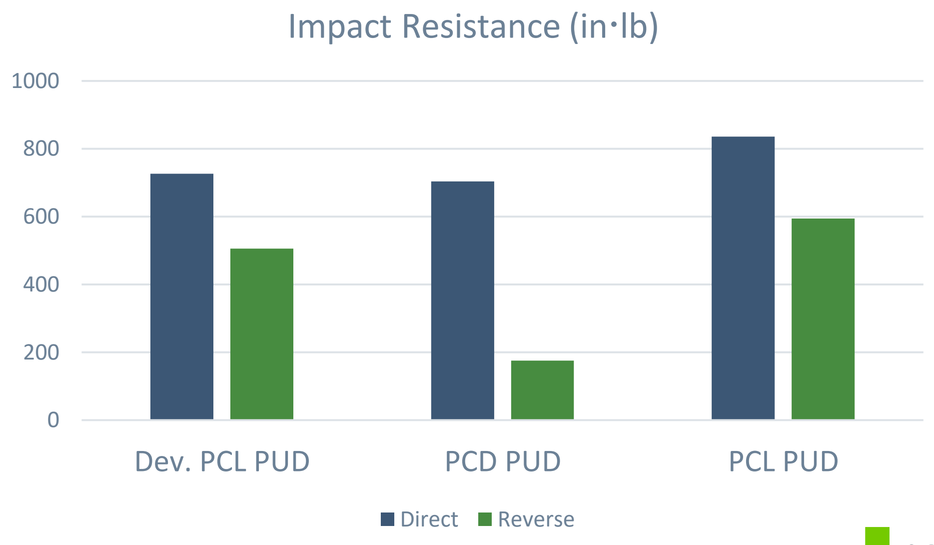
2000 MW PUD Film Properties







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Experimental 1000 MW PUD Formulations

Raw Material	Developed PCL PUD	PCL PUD
Developed PCL Diol	14.5	
PCL Diol		14.2
TMP	0.26	0.18
DMPA	1.6	1.7
Ethylene Diamine	0.6	0.6
Aminoethylethanol amine	0.7	0.7
Adipic Dihydrazide	0.6	0.6
37% Formalin	0.3	0.3
Catalyst	6 ppm	6 ppm
Dipropylene Glycol Dimethyl ether	4.9 (to 85% Solids)	4.9 (to 85% Solids)
Triethylamine Neutralizer (1.0 equiv. on DMPA)	1.2	1.2
Water (to 30% Dispersion Solids)	64	64
Defoamer	20 ppm	20 ppm
IPDI	11.6	11.8
Total Parts by Weight	100	100

Anionic PUDs with Ratios of 1.80/0.48/0.42 IPDI/Polyol/DMPA

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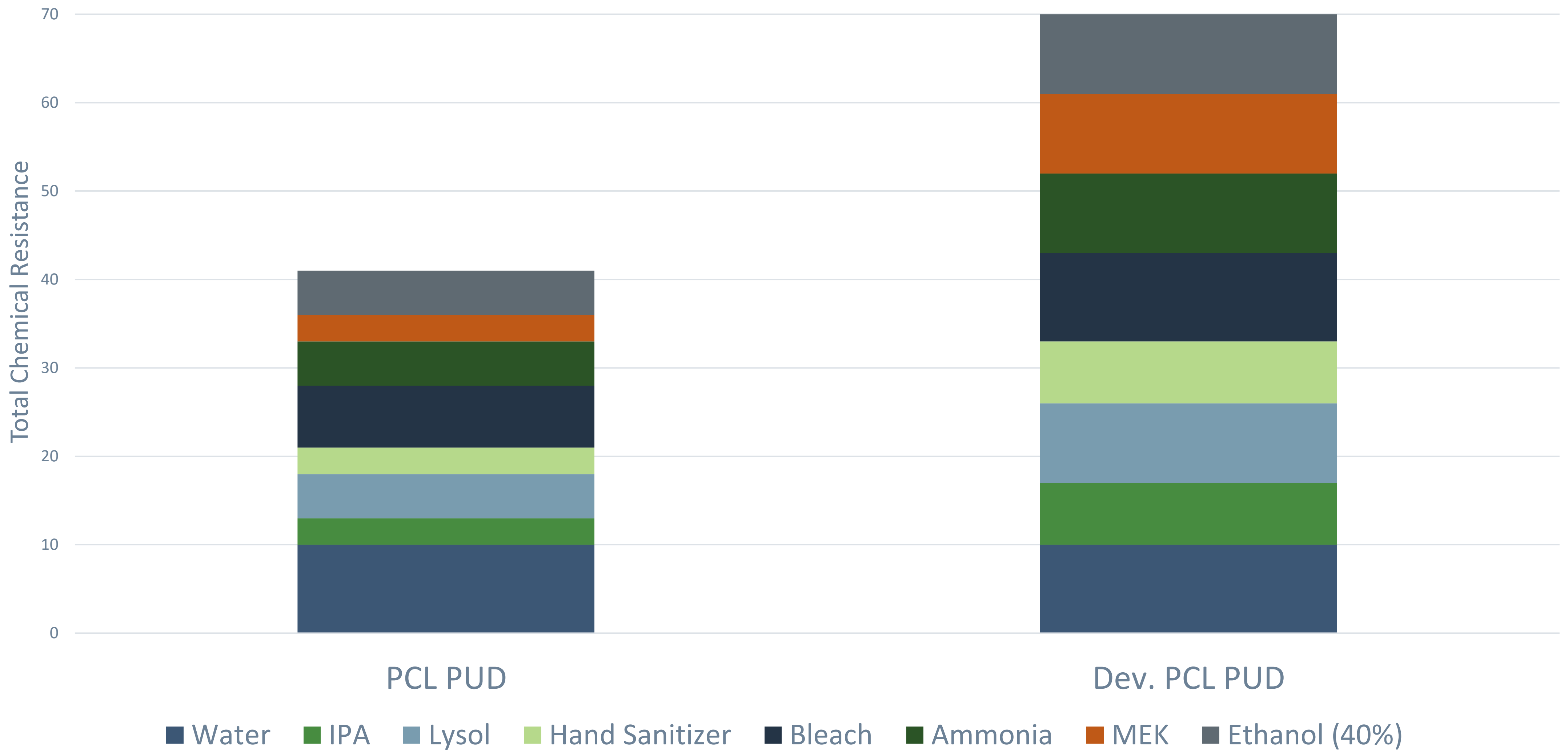
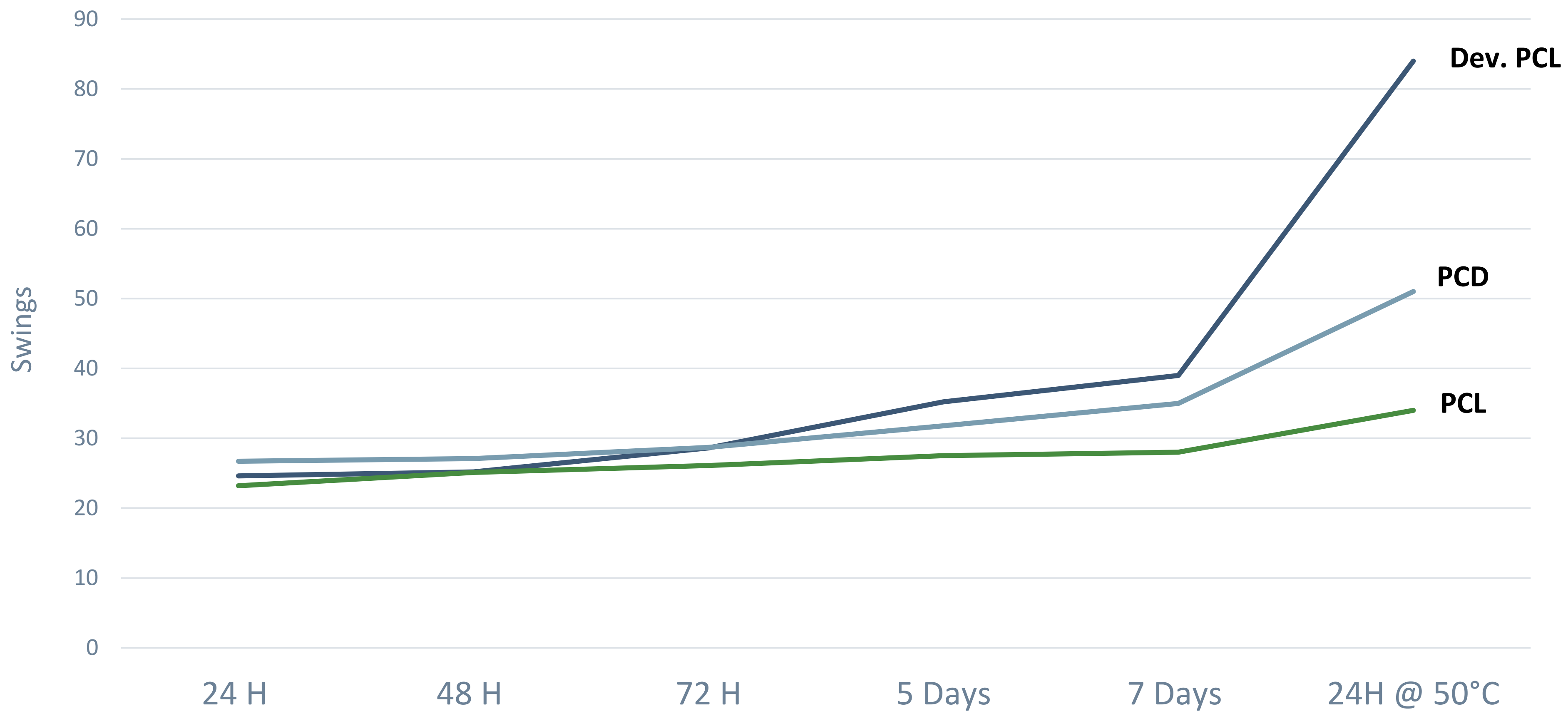
Experimental 1000 MW PUD Properties

Property	Developed PCL PUD	PCL PUD
Total Solids Calculated (%)	31.67	31.46
pH	7.82	8.28
Prepolymer Viscosity at 83°C (cps)	10,000	8,000
PUD Viscosity at 25°C (cps)	20	20
Density at 25°C (lb/gal)	8.720	8.706
Appearance	Clear/Semi-Trans	Clear/Semi-Trans

1000 MW PUD Chemical Resistance



1000 MW PUD Hardness Development



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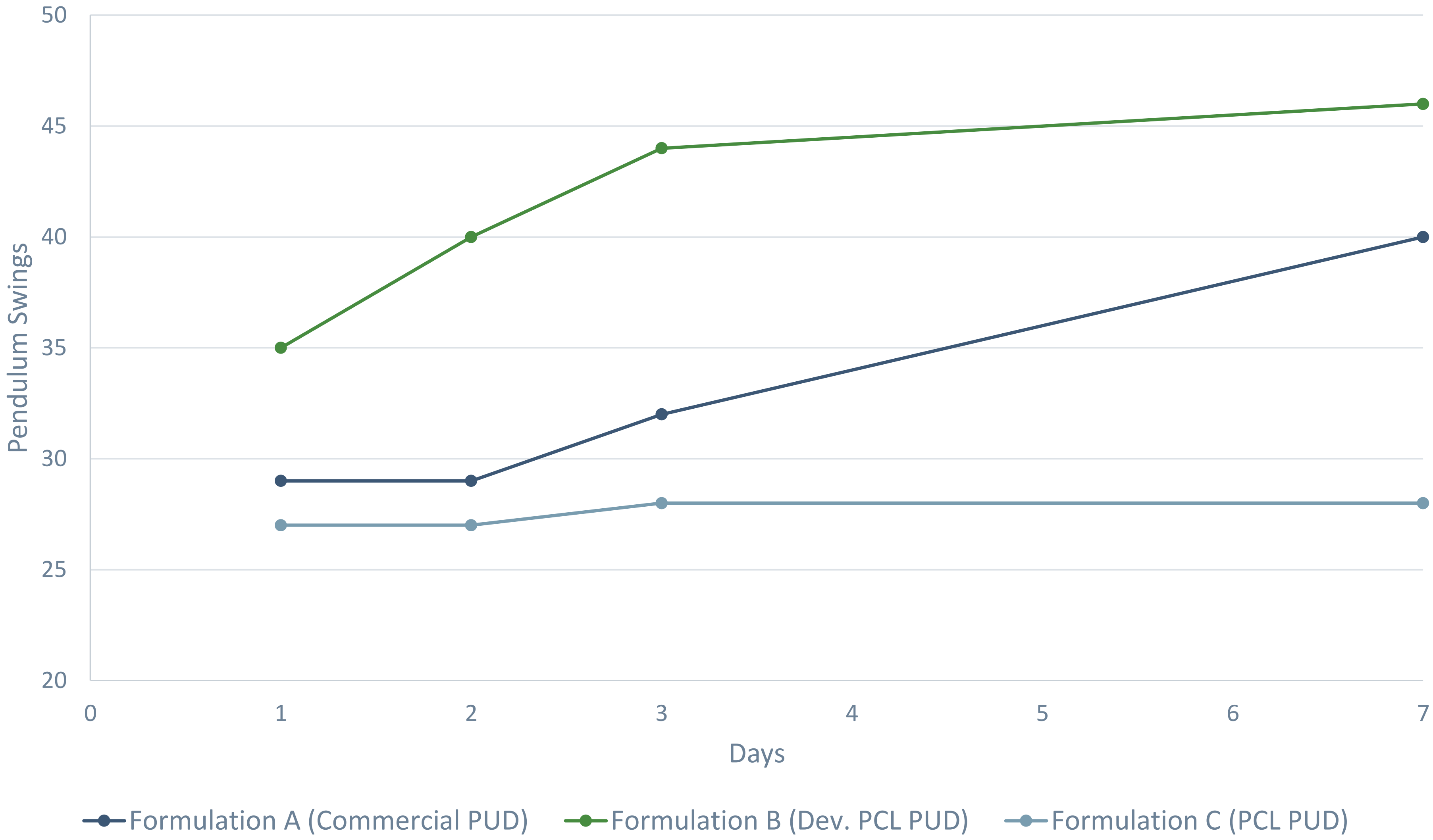
Coatings Application Testing

Formulations for Coatings Studies

Raw Material	Formulation A	Formulation B	Formulation C
Commercial PUD (40% NV)	93.1		
1000 MW Developed PCL PUD (31% NV)		96.1	
1000 MW PCL PUD (31% NV)			96.1
Wetting Agent	0.3	0.3	0.3
Defoamer	0.3	0.3	0.3
Rheology Modifier	0.3	0.3	0.3
Butyl Glycol	6.0	2.0	2.0
Deionized Water	4.0	1.0	1.0
Total Parts by Weight	100	100	100

Hardness Development



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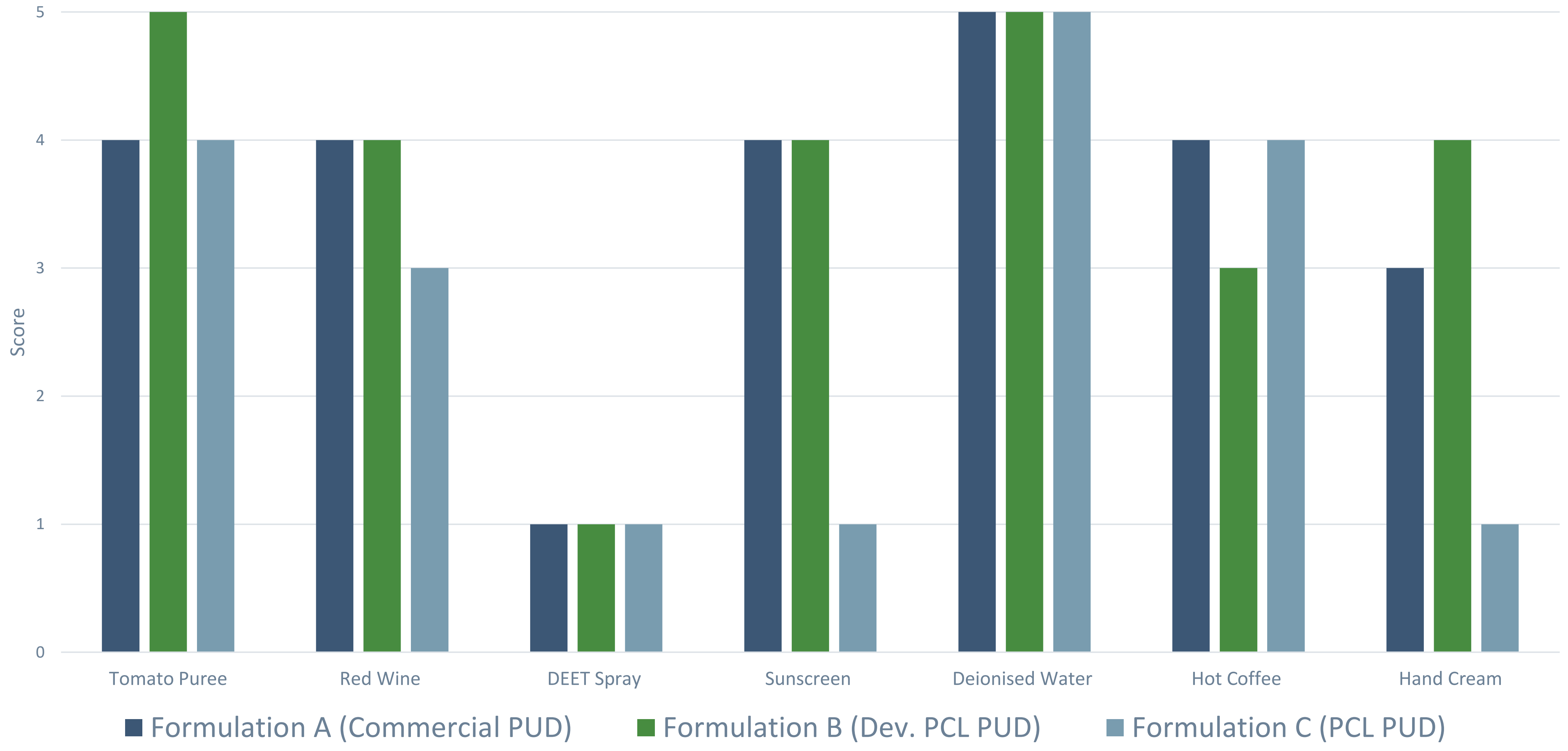
Stain Resistance of Coatings

Stains were graded using the following method:

1. Softening and delamination (worst)
2. Severe softening and damage to coating
3. Severe staining
4. Slight stain
5. No change (best)



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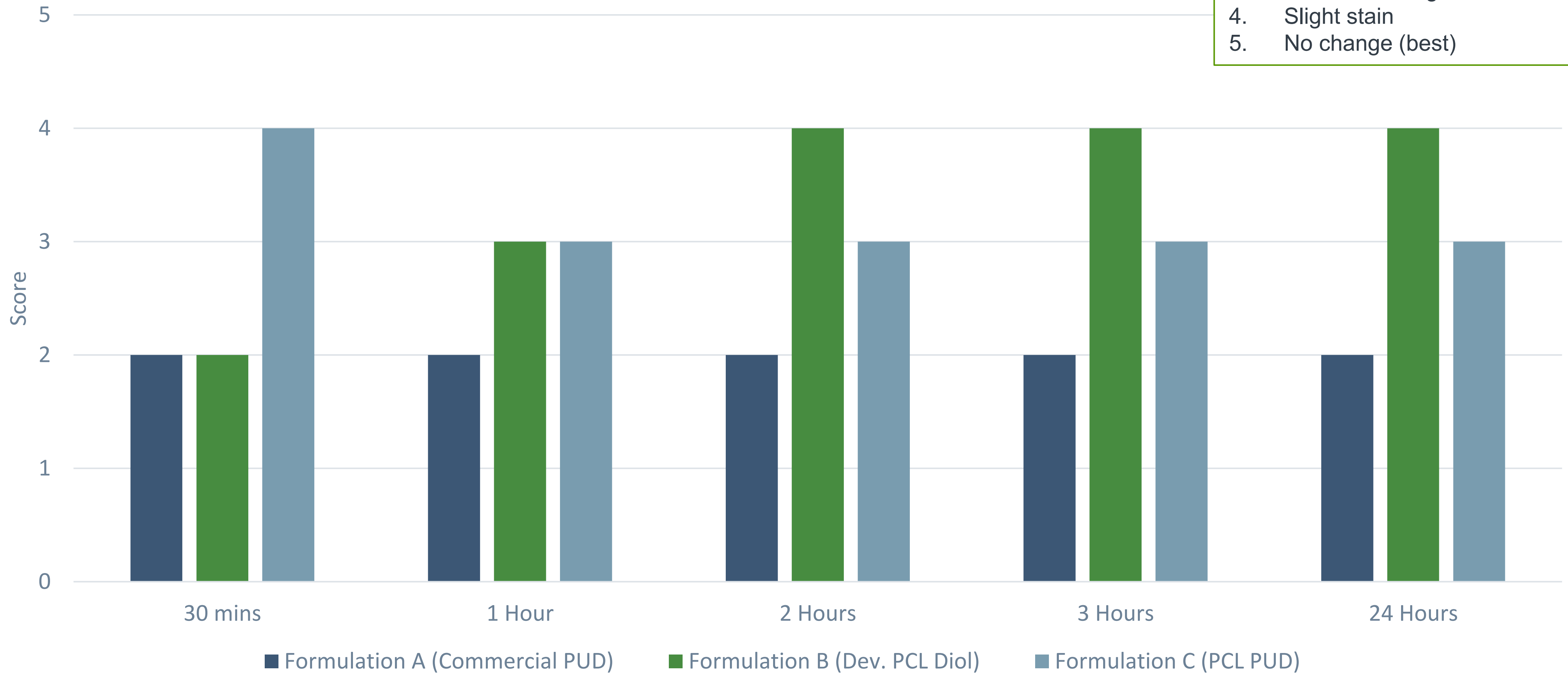
Early Water Resistance

Stains were graded using the following method:

1. Softening and delamination (worst)
2. Severe softening and damage to coating
3. Severe staining
4. Slight stain
5. No change (best)



1. Each coating was applied onto a Laneta card, and left to air dry for specified time

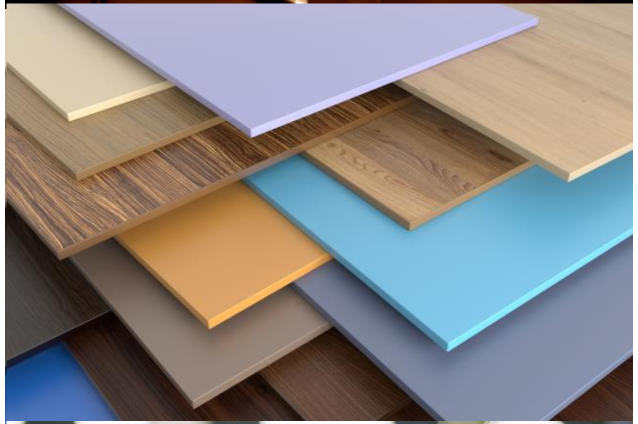
2. A drop of deionized water was applied to each coating, left for 30 minutes, and then removed using a soft cloth before evaluation

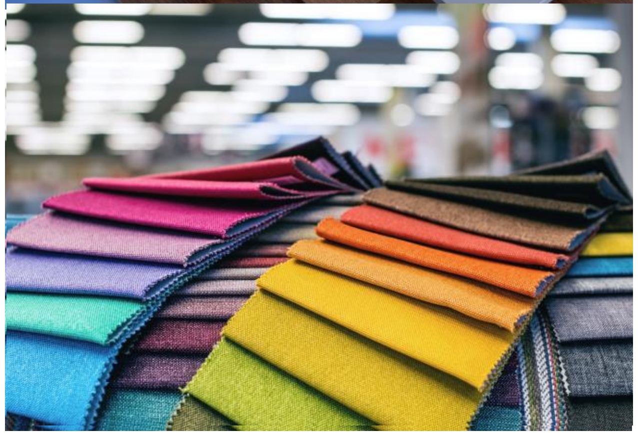
Summary

Summary of Findings

PUDs from the Developed PCL Polyols

- **Harder** Films that Maintain Flexibility
- **Better** Chemical/Stain Resistance
- **Faster** Processing, Capable of Low/Zero VOC
- **Stronger** Impact from 1000 MW Diol





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