# New Polyester Dispersion for VOC-Compliant 2-Component Waterborne Coatings:

## A Comparison of High-Performance Near-Zero-VOC Light-Stable Polyurethane/Polyurea Floor Coating Technologies

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# AGENDA

- Coim Overview
- Sustainability At Coim
- The Need for Sustainable Coatings
- Innovating toward Zero-VOC Floor Coatings
- New Sustainable, Easy-to-Use, Cost-Effective, Water-Based Polyester
- Competing PU Technologies
- Summary of Comparisons
- Conclusions, Future Work

# COIM CORE TECHNOLOGY


COIM is a polyurethane focused company.

Polyester is our core technology with polyols being sold directly to the market or used in downstream polyurethane derivatives and systems.

# COIM USA OVERVIEW

COIM USA IS A
**SPECIALTY CHEMICAL MANUFACTURER**

2006 — **FIRST US PLANT** WEST DEPTFORD, NJ

 — **NORTH AMERICAN** ARM OF GLOBAL COIM GROUP

150 — **US EMPLOYEES** WITH REPRESENTATION FROM MORE THAN 20 NATIONALITIES

500+ — **UNIQUE PRODUCTS** IN ITS PORTFOLIO

4 — **MAIN BUSINESS AREAS**
POLYOLS FOR POLYURETHANES
POLYURETHANE C.A.S.E. AND SYSTEMS
POLYESTERS AND SPECIALTIES FOR COATING
POLYESTERS AND SPECIALTIES FOR COMPOSITE

# COIM SUSTAINABILITY MISSION

## SUSTAINABILITY MISSION

Coim USA is committed to ensuring a sustainable future and to improving the social, economic, and environmental well being of its stakeholders through sustainability driven product development, operational initiatives, and responsible governance.

# SUSTAINABLE OPERATIONS

## PROCESS WATER DISTILLATION & SEPARATION COLUMN

- Online Summer 2022
- Results in:
  - 10% recovered and reused material
  - 83% clean water
  - 7% disposable material
- Reduction of over 1.8 million gallons of disposable material per year

Process water distillation & separation column

## RAILWAY DISTRIBUTION

- Produces approx. 1/5$^{th}$ as much C02 as trucking
- Coim expanded rail capacity in 2015, 2018, and will expand in 2023
- 2030 goals
  - Receive over 80% of raw materials by rail
  - Ship over 80% of finished goods with rail prioritized route

Rail siding at New Jersey production site

# FUTURE SUSTAINABLE OPERATIONS

## PROCESS WATER DISTILLATION & SEPARATION COLUMN

- 2023 updates will increase yield of reusable material and further decrease waste

## SOLAR POWER

- Will be added as part of the 2023-24 new warehouse construction at our West Deptford, NJ site


2023-24 Warehouse Rendering

## COMBINED HEAT & POWER UNIT (CHP)

- Cogeneration of steam and electricity for a single power source
- Unit to be implemented 2024-25
- Solar power & CHP unit will reduce Scope 2 emissions and diversify energy sources to lower reliance on grid power

Cogeneration of Steam and Electricity

# COIM'S SUSTAINABLE PRODUCTS

## POLYESTER POLYOLS

- Bio-based content
- Recycled content
- Zero VOC

## URETHANE PREPOLYMERS

- Bio-based content
- Low-free isocyanate monomer

## LAMINATING ADHESIVES

- Compostable
- Recyclable

# THE NEED FOR SUSTAINABLE COATINGS

## TODAY'S COATINGS INDUSTRY

**Positive**

- Beautifies
- Protects
- Economics
- Job creation

**Negative**

- Occupational health hazards
- Contributes to air pollution and climate change

***VOC emissions are the coating industry's leading threat to environmental and human health***

# VOC REDUCTION DRIVES SUSTAINABILITY

- VOC reduction is a challenge that all raw material suppliers and paint formulators are facing
- Federal, state and regional agencies are setting increasingly lower VOC limits
- The Coatings industry must meet the challenge by developing new technologies that push towards zero-VOC while continuing to improve performance

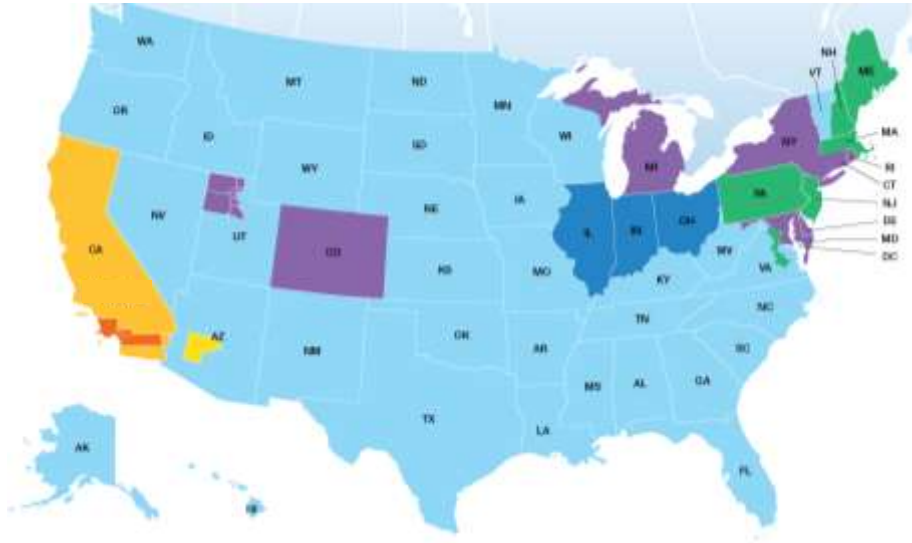
# FLOOR COATING FORMULATORS LEADING

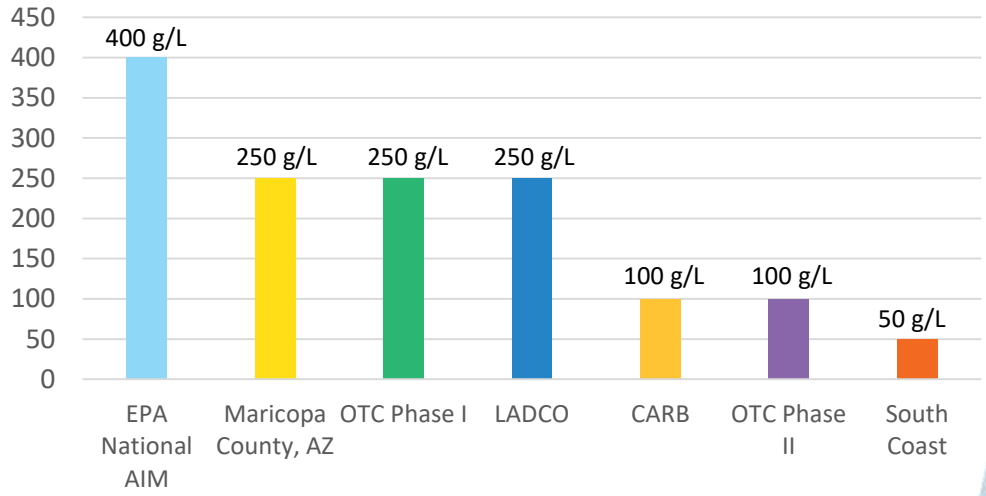
Manufacturers of Architectural & Industrial Maintenance Coatings (AIM), especially floor coatings, must lead the charge to a more sustainable future

## FLOOR COATING CHALLENGES

- Most restrictive VOC limits
  - <50 g/L in some regions
- Exempt solvents phasing out
- Demand for higher performance
  - better light stability, chemical resistance, weathering resistance, and wear resistance

**Floor Coating VOC Limits**





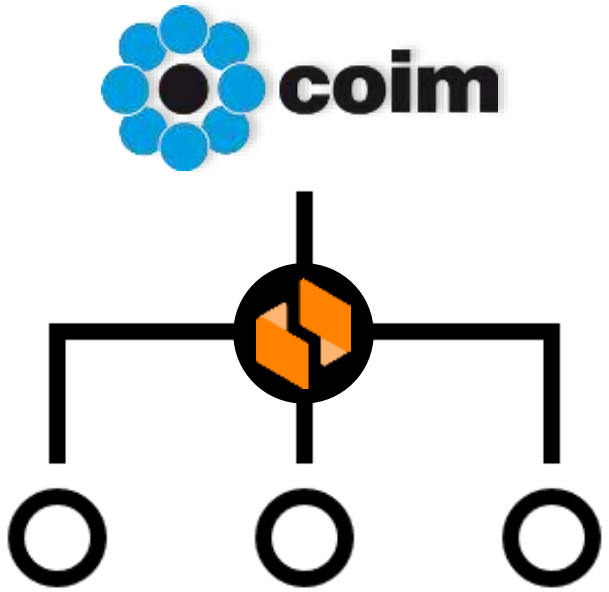
# HELPING SMALLER PAINT COMPANIES

**Small to mid-size floor coating manufacturers are especially challenged**

- Limited R&D and $ resources
- Supply chain disruptions further strain resources
- Evolving regulations and performance requirements

**This is where COIM can have the biggest impact**

- Develop new easy-to-use, cost-effective resins designed for VOC-compliant high-performance ambient-cure floor coatings
- Team up with Univar Solutions to reach target customers




**Small – Medium Manufacturers**

# WATERBORNE POLYESTER SOLUTION

## POLYESTER IS COIM's CORE TECHNOLOGY

### History

- COIM has historically supplied 100% solids and solventborne polyester polyols with limited utility for VOC-compliant floor coatings


### Why Is COIM Entering Coatings Now?

- COIM has had unique water-reducible polyester polyol technology for many years, but no prior experience developing or making water-based polyol dispersions
- COIM overcame these obstacles and successfully developed a solventless water-based polyester polyol dispersions for ultra low-VOC 2K PU

# DEVELOPMENT PARAMETERS

## MAXIMIZE SUSTAINABILITY

- High solids (>60% in water), no co-solvent (including no exempt solvents), surfactant-free, HAPs-free, reactive-amine neutralized
- Able to formulate to VOC <50 g/L

## HIGH-PERFORMANCE

- Thermoset (crosslink reaction)
  - Polyurethane/Polyurea (isocyanate crosslinked)
  - Light-stable (aliphatic isocyanate)
  - Ambient cure within 24 hours

*This study does not include Epoxy, MMA, MA, nor Silicone mainly because they are not PU*

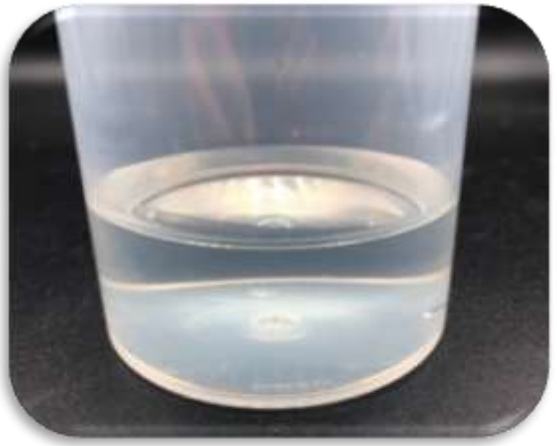
*PUD and MCPU will be included in future work, but not this study because they are more for 1K, while this study focuses on true 2K PU systems*

# NEW POLYESTER POLYOL DISPERSION

## WB PES – WATERBORNE POLYESTER POLYOL DISPERSION

A clear, water dispersed **liquid polyol designed for water-based (WB) coatings.**

It is especially suitable for formulating **near zero-VOC** WB 2-component urethanes using standard hydrophobic isocyanates.



### KEY FEATURES

- High solids (>60% in water)
- No co-solvent
- Surfactant-free
- HAPs-free
- Reactive-amine neutralized

### APPLICATIONS

- Floor coatings
- Corrosion protective
- Automotive/aerospace
- General industrial/maintenance
- Protective and marine

# COMPETING PU TECHNOLOGIES

## Technologies Compared In This Study

| Binder Type | Volatile Component | Cross-Linker | Components | System |
|---|---|---|---|---|
| Polyester Polyol Dispersion | WB | Aliphatic NCO | 2 | **WB 2K PU-PES** |
| Acrylic Polyol Dispersion | WB | Aliphatic NCO* | 2 | **WB 2K PU-PAC** |
| Polyamine | HS | Aliphatic NCO | 2 | **HS 2K PU-PAS** |

**** Typically, a water-dispersible (hydrophilic-modified) isocyanate***

## Terms & Abbreviations

- Polyester = PES
- Polyacrylic = PAC
- Polyaspartic = PAS
- Polyurethane = PU
- Waterborne = WB
- Water reducible = WR
- High-Solids = HS
- Moisture Cure = MC
- Components = K

# COMPETING PU TECHNOLOGIES

General comparison of typical representatives of each resin type for floor coatings

| | WB 2K PU-PES | WB 2K PU-PAC | HS 2K PU-PAS |
|---|---|---|---|
| VOC <50 g/L | Yes | Yes | Yes |
| Hi-Solids >50% | Yes | No | Yes |
| Light Stable | Yes | Yes | Yes |
| Adhesion | +++ | ++ | ++ |
| Abrasion Resistance | +++ | ++ | ++ |
| Hardness | + / ++ | +++ | +++ |
| Flexibility | +++ | + | + |
| Chemical Resistance | +++ | +++ | ++ |
| Weatherability | ++ | ++ | ++ |
| Pot Life [hr.] | 1 to 3 | 4 to 6 | <1 |
| Walk on [hr.] | 12 to 24 | 24 to 36 | 4 to 8 |
| Low Temp Cure | ++ | ++ | +++ |
| Sensitivity to Humidity | ++ | +++ | + |
| Dry Film Thickness | 1 to 5 | 1 to 3 | 4 to 12 |

+++ Best performing

++ Medium

+ Lowest performing

# FORMULATION FOR NEW WB 2K PU-PES

## Polyester

### Ultra-low VOC WB 2K Formulation

- The **WB 2K PU- PES1** system is 2:1 by weight (polyol : iso) using ***standard hydrophobic HDI-trimer***.
- In **WB 2K PU- PES1**, the ratio was adjusted towards 1:1 by weight (polyol : iso) to increase hardness and chemical resistance.
- Typical DFT is 1 to 3 mil.
- The coating dried in 4 to 5 hours without additional catalyst.

| Description | Weight, % | Weight, % |
|---|---|---|
| **Part A** | **WB 2K PU PES1** | **WB 2K PU PES2** |
| WB 2K PU-PES | 41.7 | 31.25 |
| Water | 21.3 | 16.00 |
| Defoamer | 0.3 | 0.25 |
| Wetting agent | 0.9 | 0.63 |
| Rheology modifier | 2.5 | 1.88 |
| **Isocyanate – Part B** | | |
| Standard hydrophobic HDI trimer | 33.3 | 50.00 |

| Formulation Characteristics | | |
|---|---|---|
| Total Formulation Solids (A+B) | 62% | 72% |
| Part A Viscosity | 500 cP | 504 cP |
| Total Formulation Viscosity (A+B) | 2,500 cP | 7800 cp |
| Calculated Material VOC | 6.1 g/L | 4.6 g/L |
| Calculated Coating VOC | 9.4 g/L | 6.1 g/L |

# FORMULATIONS FOR WB 2K PU-PAC

## Acrylic

| Description | Weight, % | | |
|---|---|---|---|
| **Part A** | **WB 2K PU-PAC1** | **WB 2K PU-PAC2** | **Acrylic-3** |
| WB Acrylic Polyol Dispersion | 54.0 | 54.0 | TBD |
| Water | 9.0 | 9.0 | TBD |
| Defoamer | 0.3 | 0.3 | TBD |
| Wetting agent | 0.9 | 0.9 | TBD |
| Rheology modifier | 2.5 | 2.5 | TBD |
| **Isocyanate – Part B** | | | |
| Std. Hydrophobic HDI trimer | 33.3 | - | - |
| Water dispersible HDI trimer | - | 33.3 | TBD |
| **Formulation Characteristics** | | | |
| Total Formulation Solids | 62% | 62% | 40% |
| Part A Viscosity | 4,600 cP | 4,600 cP | TBD |
| Total Formulation Viscosity | 25,000 cP | 27,000 cP | TBD |

# FORMULATIONS FOR WB 2K PU-PAS

## Aspartic

| Description | Weight, % | | |
|---|---|---|---|
| **Part A** | **2K PU-PAS1** | **2K PU-PAS2** | **2K PU-PAS3** |
| Polyaspartic amine | 29.7 | 52.9 | 31.40 |
| Amine diluent * | 17.2* | - | 18.20 |
| Bubble release agent | 0.5 | 0.4 | 0.5 |
| **Isocyanate – Part B (NCO:OH ratio = 1.09 : 1)** | | | |
| Std. Hydrophobic HDI trimer | - | - | 49.90 |
| Proprietary HDI trimer | 52.6 | 46.7 | - |

| Formulation Characteristics | | | |
|---|---|---|---|
| Total Formulation Solids | ~100% | ~100% | ~100% |
| Part A Viscosity | 200 cP | 350 cP | 205 |
| Total Formulation Viscosity | 750 cP | 1,200 cP | 2100 |

* ***Chemical name - Isophoronediamine-isobutyraldimine***

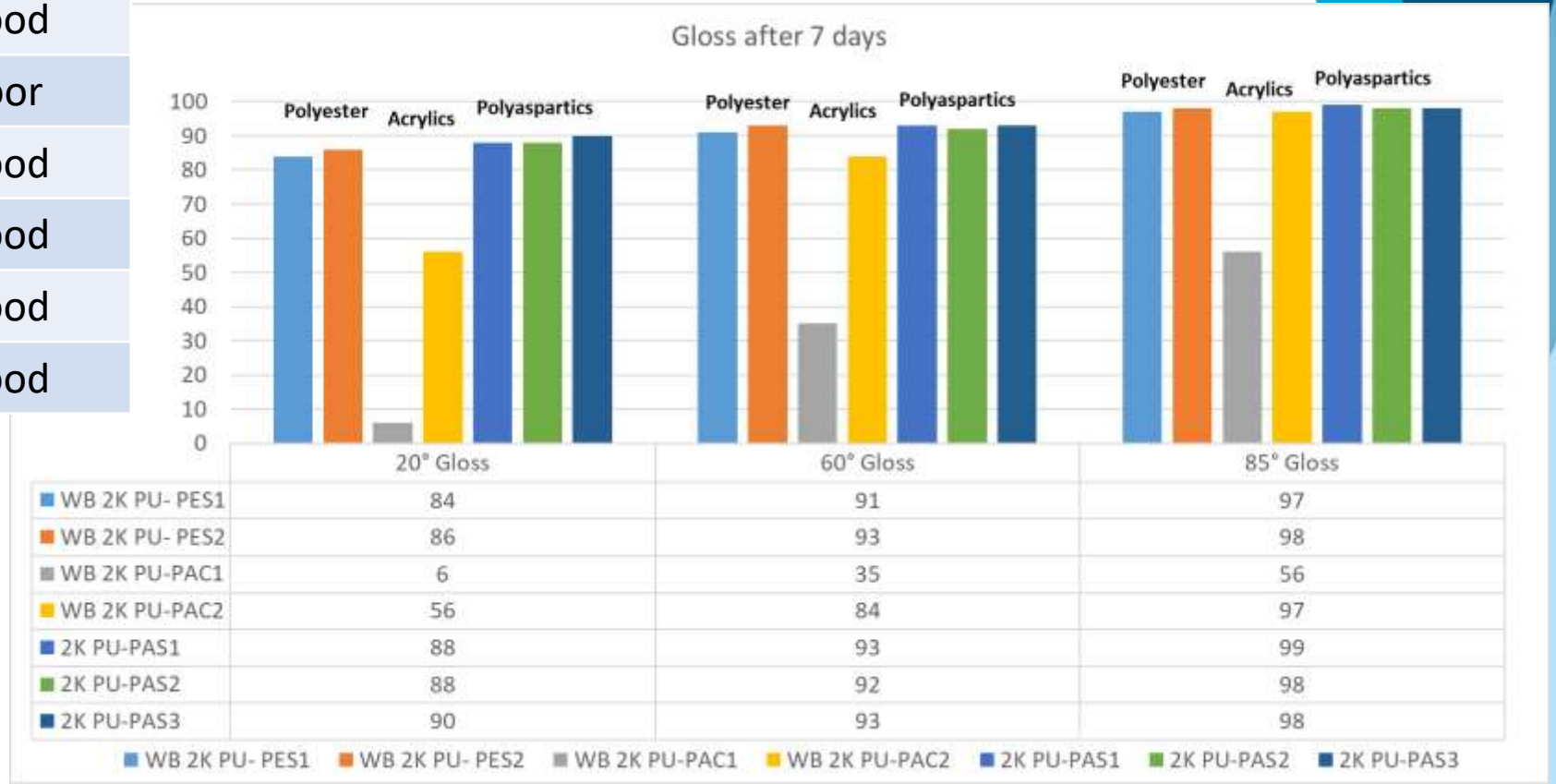
# RESULTS – Appearance and Gloss

Measurements after 7 days cure on Leneta paper

| System | WFT [1] | DFT [2] | Appearance |
|---|---|---|---|
| **WB 2K PU- PES1** | 6 | 3.7 | Good |
| **WB 2K PU- PES2** | 6 | 4.3 | Good |
| **WB 2K PU-PAC1** | 6 | 3.7 | Poor |
| **WB 2K PU-PAC2** | 6 | 3.7 | Good |
| **2K PU-PAS1** | 6 | 6 | Good |
| **2K PU-PAS2** | 6 | 6 | Good |
| **2K PU-PAS3** | 6 | 6 | Good |

[1] ***WFT stands for Wet Film Thickness.***
[2] ***DFT stands for Dry Film Thickness. DFT values are calculated***

- Water Reducible Acrylic Polyol crosslinked with hydrophobic HDI trimer (**WB 2K PU-PAC1**) show poor appearance (clarity) and low gloss due incompatibility between polyol and crosslinker.

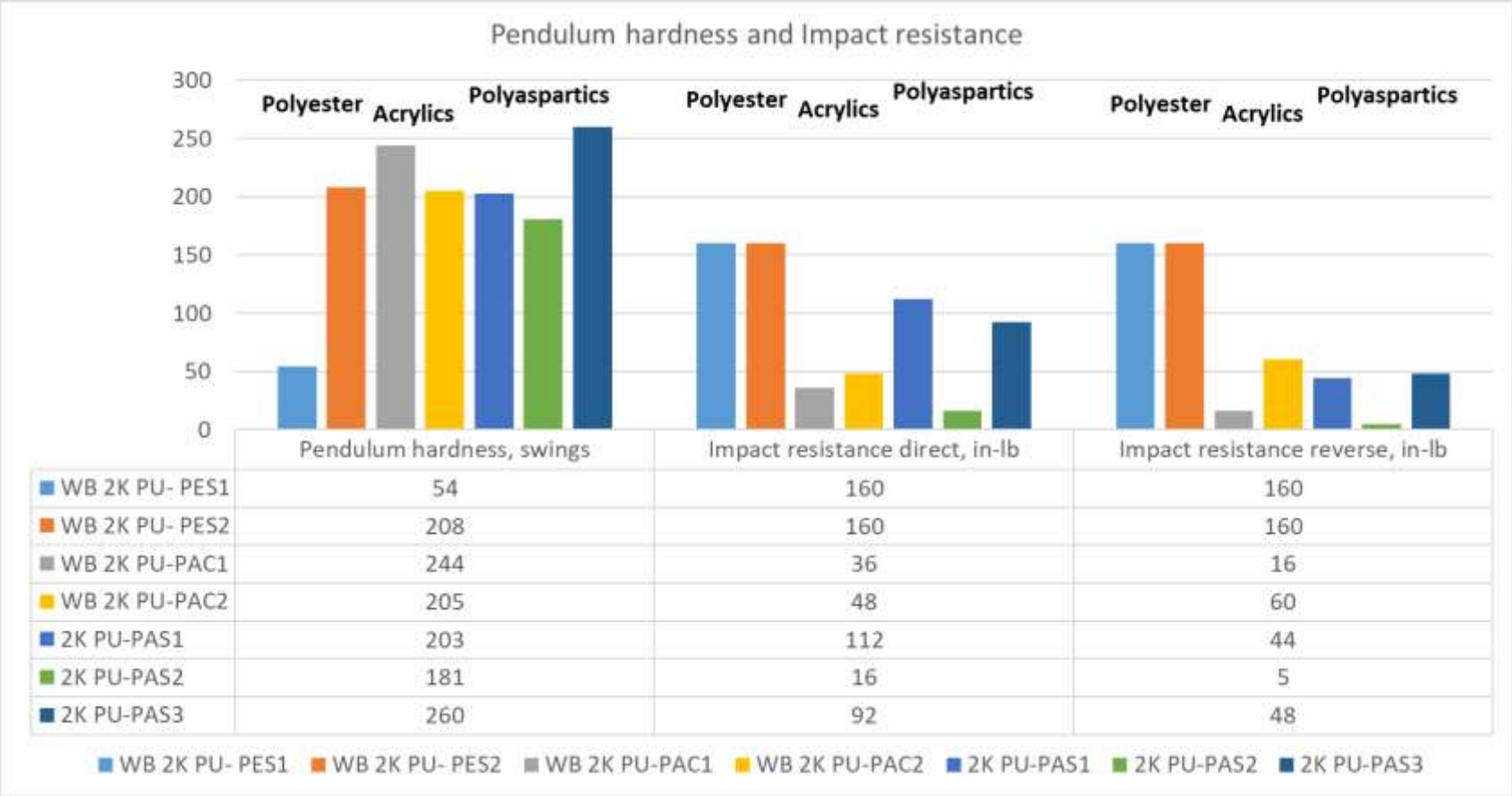



| | 20° Gloss | 60° Gloss | 85° Gloss |
|---|---|---|---|
| WB 2K PU- PES1 | 84 | 91 | 97 |
| WB 2K PU- PES2 | 86 | 93 | 98 |
| WB 2K PU-PAC1 | 6 | 35 | 56 |
| WB 2K PU-PAC2 | 56 | 84 | 97 |
| 2K PU-PAS1 | 88 | 93 | 99 |
| 2K PU-PAS2 | 88 | 92 | 98 |
| 2K PU-PAS3 | 90 | 93 | 98 |

**** The drawdowns for gloss were made on leneta cards.***

# RESULTS – Hardness vs flexibility

Measurements after 7 days cure on Q-Panels




| | Pendulum hardness, swings | Impact resistance direct, in-lb | Impact resistance reverse, in-lb |
|---|---|---|---|
| WB 2K PU- PES1 | 54 | 160 | 160 |
| WB 2K PU- PES2 | 208 | 160 | 160 |
| WB 2K PU-PAC1 | 244 | 36 | 16 |
| WB 2K PU-PAC2 | 205 | 48 | 60 |
| 2K PU-PAS1 | 203 | 112 | 44 |
| 2K PU-PAS2 | 181 | 16 | 5 |
| 2K PU-PAS3 | 260 | 92 | 48 |

WB 2K PU- PES1 WB 2K PU- PES2 WB 2K PU-PAC1 WB 2K PU-PAC2 2K PU-PAS1 2K PU-PAS2 2K PU-PAS3

- Water reducible Polyester Polyol crosslinked with hydrophobic HDI trimer (**WB 2K PU-PES2**) in 1:1 by weight (polyol : iso) show very **Good hardness as well as Flexibility**

# RESULTS – Hardness, Flexibility, Adhesion & Abrasion

Measurements after 7 days cure on Q-Panels

| System | PH Gouge [1] | PH scratch [1] | ¼ inch Flexibility [2] | Cross-cut adhesion | Taber Abrasion [3] |
|---|---|---|---|---|---|
| **WB 2K PU- PES1** | HB | 2H | Pass | 5B | 23 |
| **WB 2K PU- PES2** | 6H+ | 6H+ | Pass | 5B | 20 |
| **WB 2K PU-PAC1** | 6H+ | 6H+ | Pass | 5B | N/A |
| **WB 2K PU-PAC2** | 5H | 6H+ | Pass | 5B | 41.1 [4] |
| **2K PU-PAS1** | 4H | 4H | Pass | 5B | N/A |
| **2K PU-PAS2** | 4H | 4H | Fail | 5B | 105 |
| **2K PU-PAS3** | 6H+ | 6H+ | Pass | 5B | 40 |

[1] ***PH stands for Pencil Hardness***
[2] ***¼ inch flexibility was measured on Conical Mandrel instrument.***
[3] ***Taber abrasion was measured using CS-17 abrading wheel for 1000 cycles with 1000 gm weight, reported as mg of coating lost.***
[4] ***The Taber was measured on WB 2K PU-PAC2 after diluting the A+B mixture to 40% solids to reduce the viscosity.***

- Again, Water reducible Polyester Polyol crosslinked with hydrophobic HDI trimer (**WB 2K PU-PES2**) in 1:1 by weight (polyol : iso) show very **Good hardness as well as Abrasion resistance.**

# RESULTS – Chemical resistance and Spot test

| System | MEK double Rubs* | Mustard | Balsamic Vinegar | Coffee | White Distilled Vinegar | 95% Ethanol |
|---|---|---|---|---|---|---|
| **WB 2K PU- PES1** | 5 | Blisters | Blisters | No effect | Blisters | No effect |
| **WB 2K PU- PES2** | 5 | Stains | No effect | No effect | Blisters | No effect |
| **WB 2K PU-PAC1** | 5 | Light stains | No effect | No effect | No effect | No effect |
| **WB 2K PU-PAC2** | 5 | Light stains | No effect | No effect | Blisters | Blisters |
| **2K PU-PAS1** | 4 | Light stains | No effect | No effect | Blisters | Stains |
| **2K PU-PAS2** | 4 | Blisters | Stains | No effect | Blisters | Stains |
| **2K PU-PAS3** | 5 | Light stains | No effect | No effect | No effect | No effect |

**** Rating 5 = No effect on surface, Rating 4 = Burnished appearance on surface.***

- Water reducible Acrylic polyol crosslinked with hydrophobic HDI trimer (**WB 2K PU-PAC2**) in 2:1 by weight (polyol : iso) show **excellent Chemical and Stain resistance** **But it has poor gloss and incompatibility**
- High solids Polyaspartic amine and Amine diluent crosslinked with standard hydrophobic HDI trimer also shows **excellent Chemical and Stain resistance.**

# GENERAL COMPARITIVE SUMMARY

| | Polyester | Acrylic | Aspartic |
|---|---|---|---|
| | **WB 2K PU-PES** | **WB 2K PU-PAC** | **HS 2K PU-PAS** |
| Isocyanate | Standard hydrophobic HDI-trimer | Water-dispersible hydrophilic-modified HDI | Standard hydrophobic HDI-trimer |
| **GLOSS** | | | |
| **FLEXIBILITY** | | | |
| **HARDNESS** | 2:1 / 1:1 | | |
| **ABRASION RESISTANCE** | | | |
| **CHEMICAL RESISTANCE** | 2:1 / 1:1 | | |
| **POT LIFE** | | | |
| **RETURN TO SERVICE TIME** | | | |
| **FINISHED FORMULA COST** Raw material cost/gallon | **$28.00** | **$37.00** | **$46.00** |
| **FINISHED FORMULA COST** Raw material cost/100 sq-ft | **$9.00** | **$12.00** | **$30.00** |

Excellent
Good
Average

# CONCLUSIONS

The **new waterborne polyester resin** has balanced performance that compares favorably against alternate technologies. (WB acrylic the HS aspartic)

## ADVANTAGES

| | |
|---|---|
| Performance | Flexibility<br>Gloss<br>Resistance Properties |
| Economics | Low cost formulations |
| Sustainability | Meets strictest VOC limits |

# FUTURE WORK

- Test abrasion, UV, weatherability, humidity, standing water, hot tire pickup, etc.
- Additional substrate testing: concrete, wood, plastic
- Include pigmented and matte formulations
- Finish testing WB 2K PU-acrylic at 40% solids
- Future comparative testing to include PUDs and MCPUs
- Additional pot life and dry time testing
- Additional chemical resistance testing, including skydrol
- VOC testing of competing technologies

# THANK YOU

Join us in driving towards more sustainable coatings with COIM's new innovative chemistry.

Visit us at Table

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