Resinate®
MATERIALS
GROUP

Performance-driven green chemistry.™

Performance-driven green chemistry.™



Adam W. Emerson

Michigan Green Chemistry and Engineering Conference

November 4, 2015

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Outline

- Problem Statement
- How Can We Help?
- The Resinate Process
- Performance and Sustainability
- Coating Examples
- Potential Impact
- Conclusions
- Questions

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What is the Problem?
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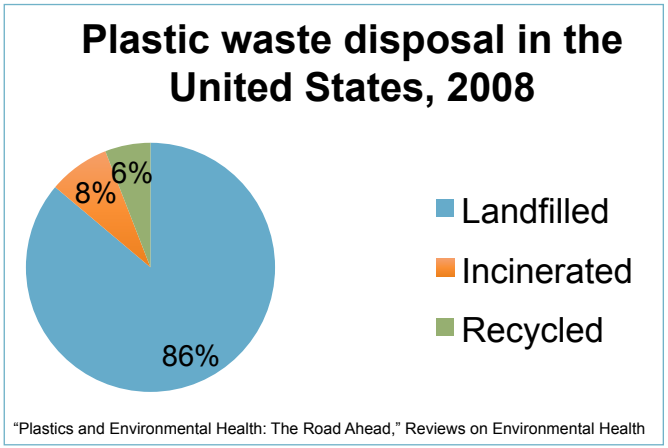
Problem Statement

- The world population is projected to reach 9B by 2050.
- In 2013, Americans generated about 508 billion pounds of municipal solid waste.
- This is equivalent to 4.4 pounds of waste per person, per day.
- About 13% of the waste produced was plastics.
- 80% of all U.S. landfills are currently full.



"Plastics and Environmental Health: The Road Ahead," Reviews on Environmental Health

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What Can We Do to Help?
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Resinate® Philosophy

Performance. Value. Sustainability.

- Deter landfill waste by using recycled resources
- Reuse valuable natural resources
- Lower environmental and human health impacts

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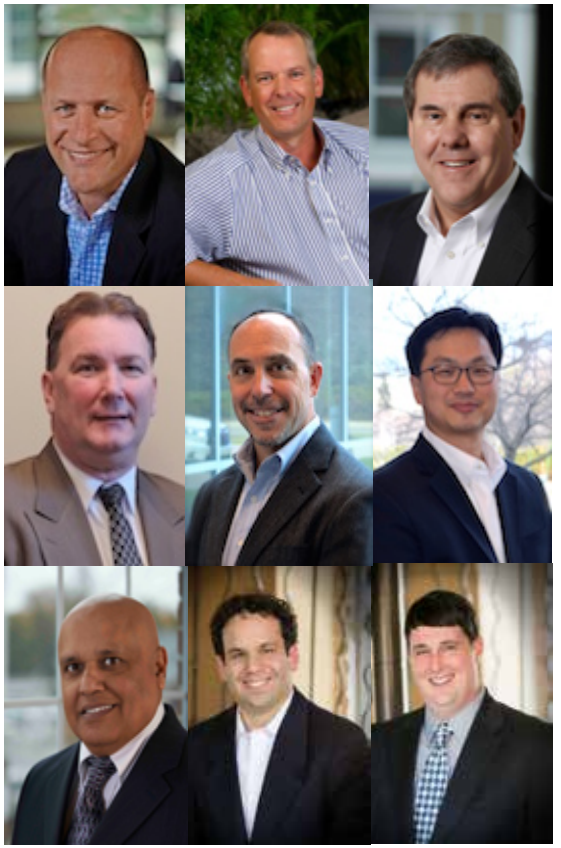
Resinate Team

Brian Phillips	CEO
Brian Chermside	President and COO
Rick Tabor	Executive VP of R&D
Mark Vasconcellos	VP of Sales
Gary Spilman	Principal Scientist
Woo-Sung Bae	Principal Scientist
Shakti Mukerjee	Director of Product Dev.
Mickey Kellerman	Business Director
Adam Emerson	Laboratory Director



Proven Industry Experience:

DOW

Stepan

EASTMAN

BYK Additives & Instruments

BASF The Chemical Company

DOW CORNING

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The Resinate Process
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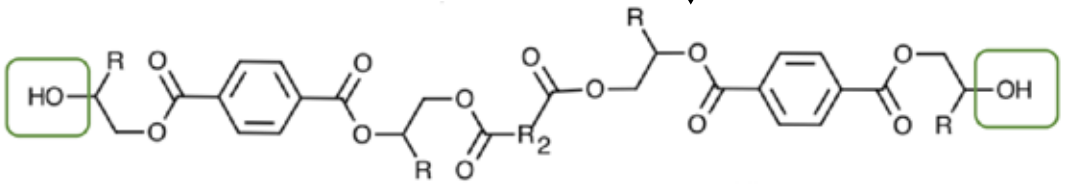
The Resinate® Approach

Recycled Polymeric Materials

Recycled Monomeric Reactants

Biobased Intermediates



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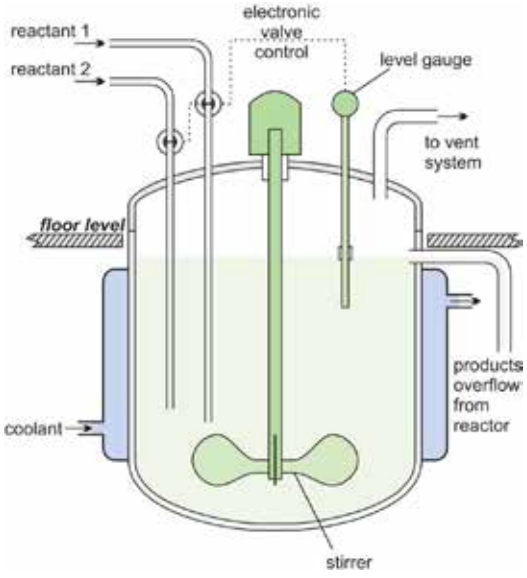
The Resinate® Approach

Glycolysis Reactor



Simultaneously…

- Proprietary process steps
- Combining oligomeric PET (& other sources)
- Building MW with polyfunctional intermediates
- Targeting high performance (structure-property)
- Maximizing “green” content

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The Product

Turning waste streams into high-performance polyols.

- Resinate produces high-performance polyester polyols.
- Polyester polyols are the backbone of coatings, adhesives, sealants, elastomers, foams, and lubricants.
- Polyols are in many of the items you see and use every day.

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Performance and Sustainability

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Why Recycled PET for polyester polyols?

Polyols made with up to 100% recycled and renewable content.

- High-Performance
- Stable Supply
- Lower Impact

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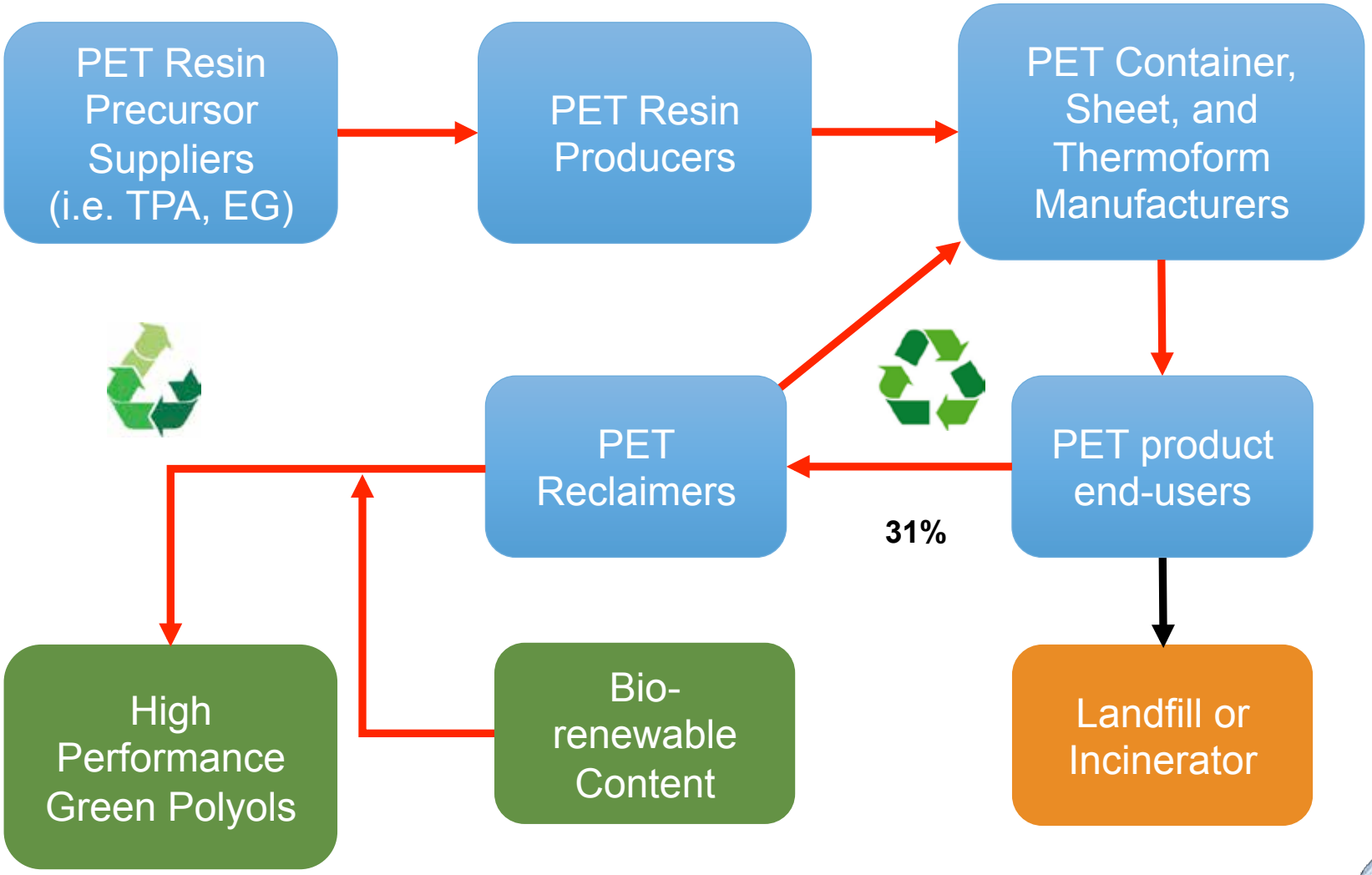
PET Value Chain



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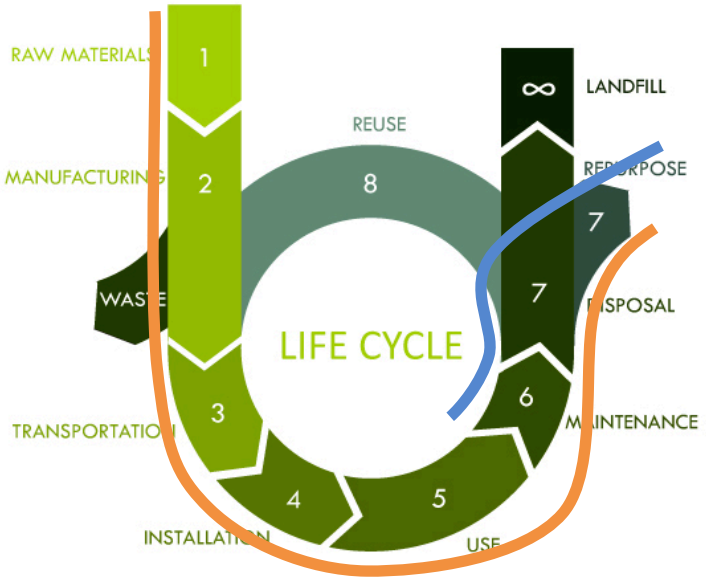
Sustainability Advantage

- The LCA Process
- Technique for assessing the complete environmental impact associated with the summation of all the stages of a product's life.[1]
- "Cradle-to-grave" approach; from gathering raw materials needed from the earth to returning materials to the earth



[1] Life Cycle Assessment: Principles and Practice, Scientific Applications International Corporation (SAIC), Reston, VA, Document EPA/600/R-06/060, May 2006 (www.epa.gov)


Coating Examples
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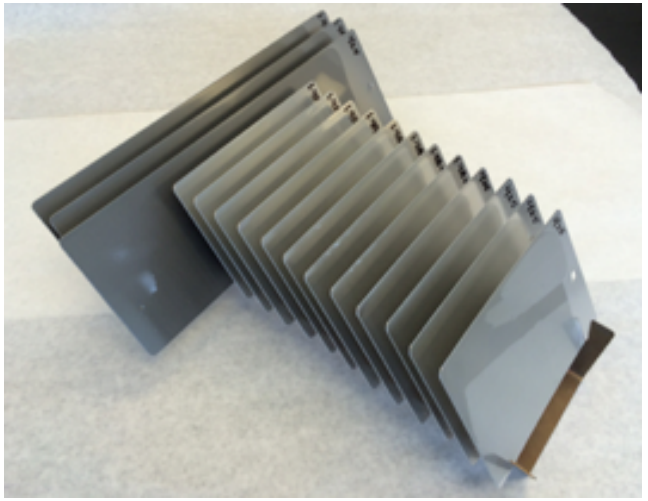
Resinate® Polyols vs. Commercial Polyol Chemistries: Test Procedure

- Procedure:
  - 1000 MW polyols from commercial sources
  - Blended with HDI trimer at 1.05:1.00 index on hydroxyl
  - Solvent-based coatings using MEK, PMA
  - Drawn with wire-wound bar
  - Dry film thickness of 1.0-1.2 mil
  - All applied to aluminum 4x6 panels, wiped with IPA
  - Flashed for 60 min ambient
  - Baked at 130 °C for 30 min
  - Tested according to ASTM guidelines
- Highest performance value used to normalize data for radar charts that follow.



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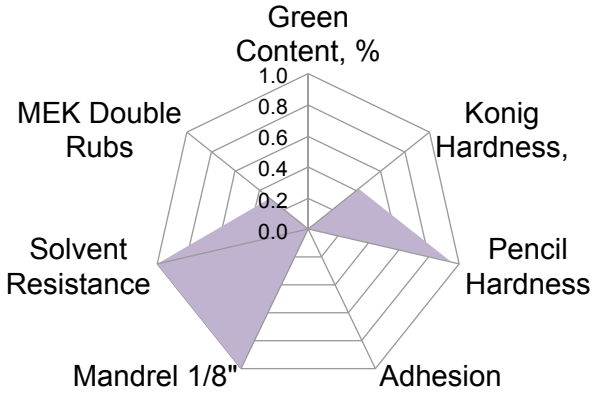
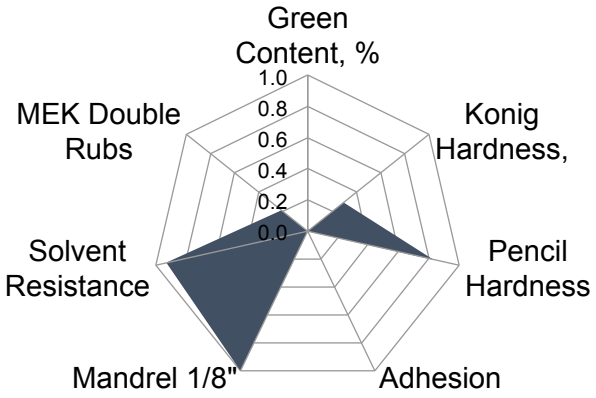
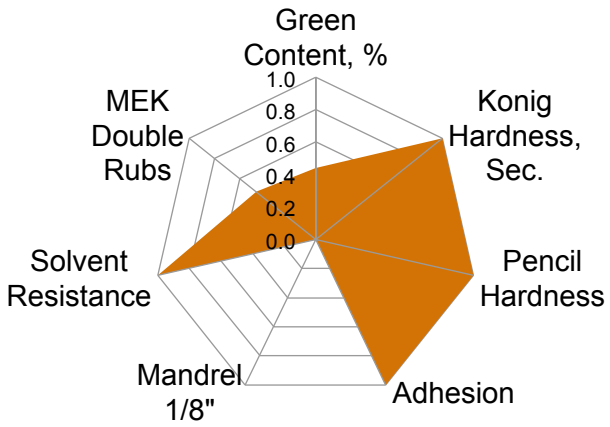
2K Coating Properties of Various Polyol Chemistries



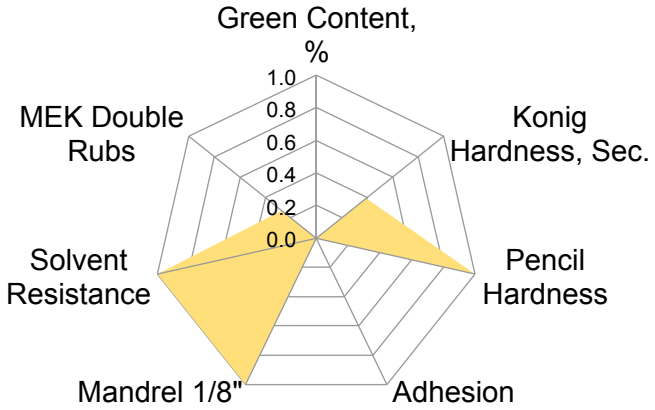
Polycaprolactone



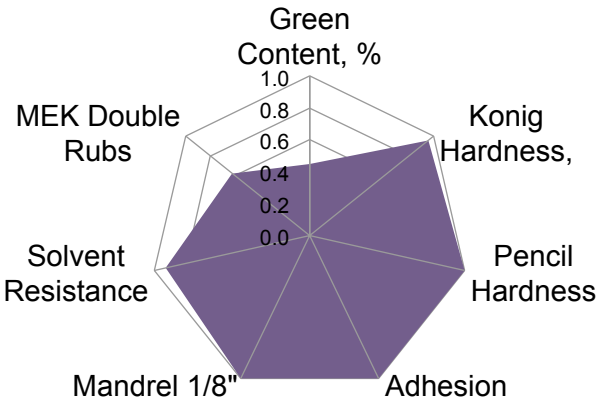
Aliphatic Polyester



Polycarbonate



Polycarbonate/Ester



Aromatic Polyester

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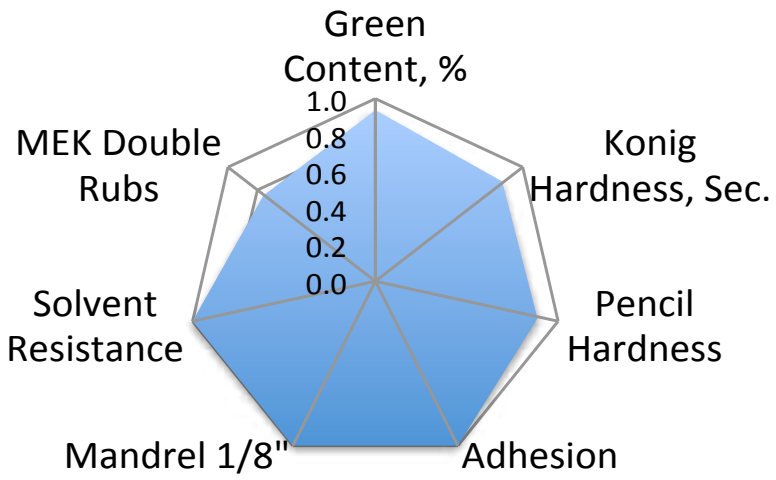
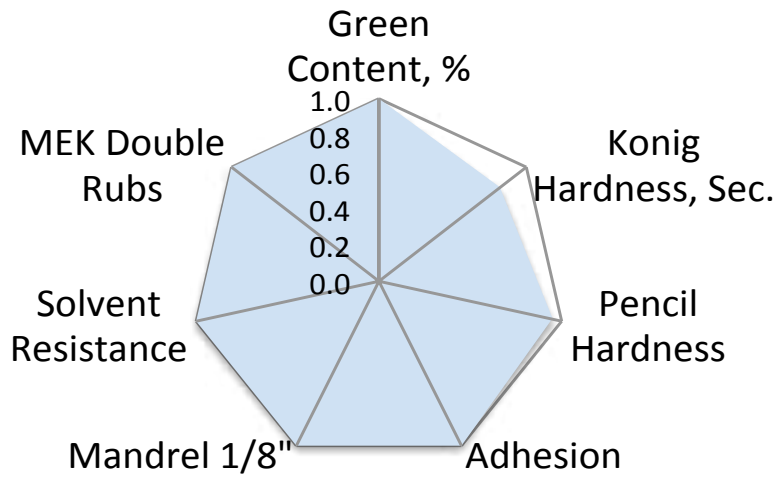
2K Coating Properties of Resinate® Polyols



C0983-94



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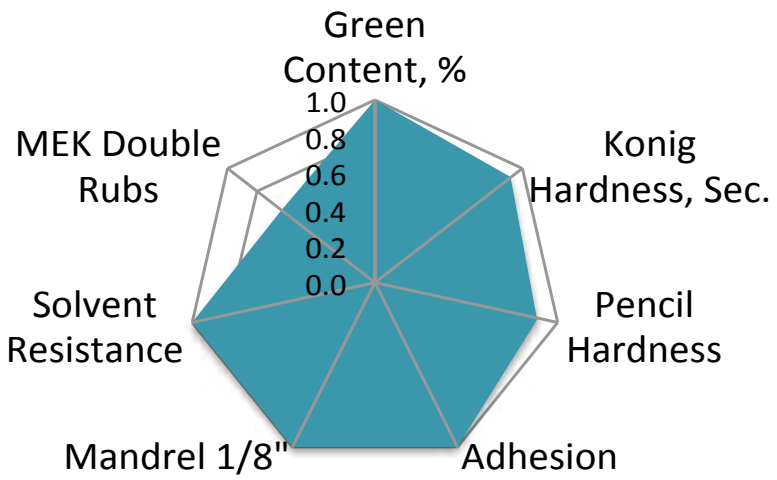

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Direct to Metal Coating Examples

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A. 2K White Primer Testing[1]

- 2 component polyurethane primer
- Substrates are cold rolled steel and phosphated cold rolled steel
- Pigmented systems using TiO_2 and $CaCO_3$
- 130C bake for 30 minutes
- Focus on corrosion resistance
- Direct comparison between commercial paint and Resinate® polyols

[1]Stonebridge Coating Labs, Plymouth, MI

2K Urethane Coatings Salt Spray – Stonebridge Labs, Plymouth, MI

Coating Name	Resinate Polyol	Substrate	514 Hours				
			Field Blistering	Field Corrosion	Scribe Creep Corrosion (mm)	Scribe Creep Rating	Comments *
Commercial Paint	-	CRS	4F Top 1/2 2MD Bottom 1/2	9G-10	0.5-1	8	
SCLI-1003-5	IMP1000-6.5B	CRS	**10**	9G-10	0.5-1	8	16-25mm 2D BL Group of Blisters top right
SCLI-1003-6	IMP1000-6.6B	CRS	**10**	9Sp-10	1-1.5	7.5	3-7mm 2F & 6D
SCLI-1003-7	IMP1000-7.8B	CRS	**10**	9G-10	0.5-1.5	7.5	5-8mm 2F & 6D
Commercial Paint	-	PHOS CRS	6F Top 1/2 6M Bottom 1/2	9Sp-10	0.5	9	0-4mm 2MD BL
SCLI-1003-5	IMP1000-6.5B	PHOS CRS	**10**	9G-10	0.5-1	8	10-12mm 2D BL
SCLI-1003-6	IMP1000-6.6B	PHOS CRS	**10**	9G-10	0.5-1	8	7mm 2F & 4D
SCLI-1003-7	IMP1000-7.8B	PHOS CRS	**10**	9G-10	0.5-1	8	10mm 2D

* Blistering around scribe measured in distance from scribe in mm and size/severity according to ASTM D714.

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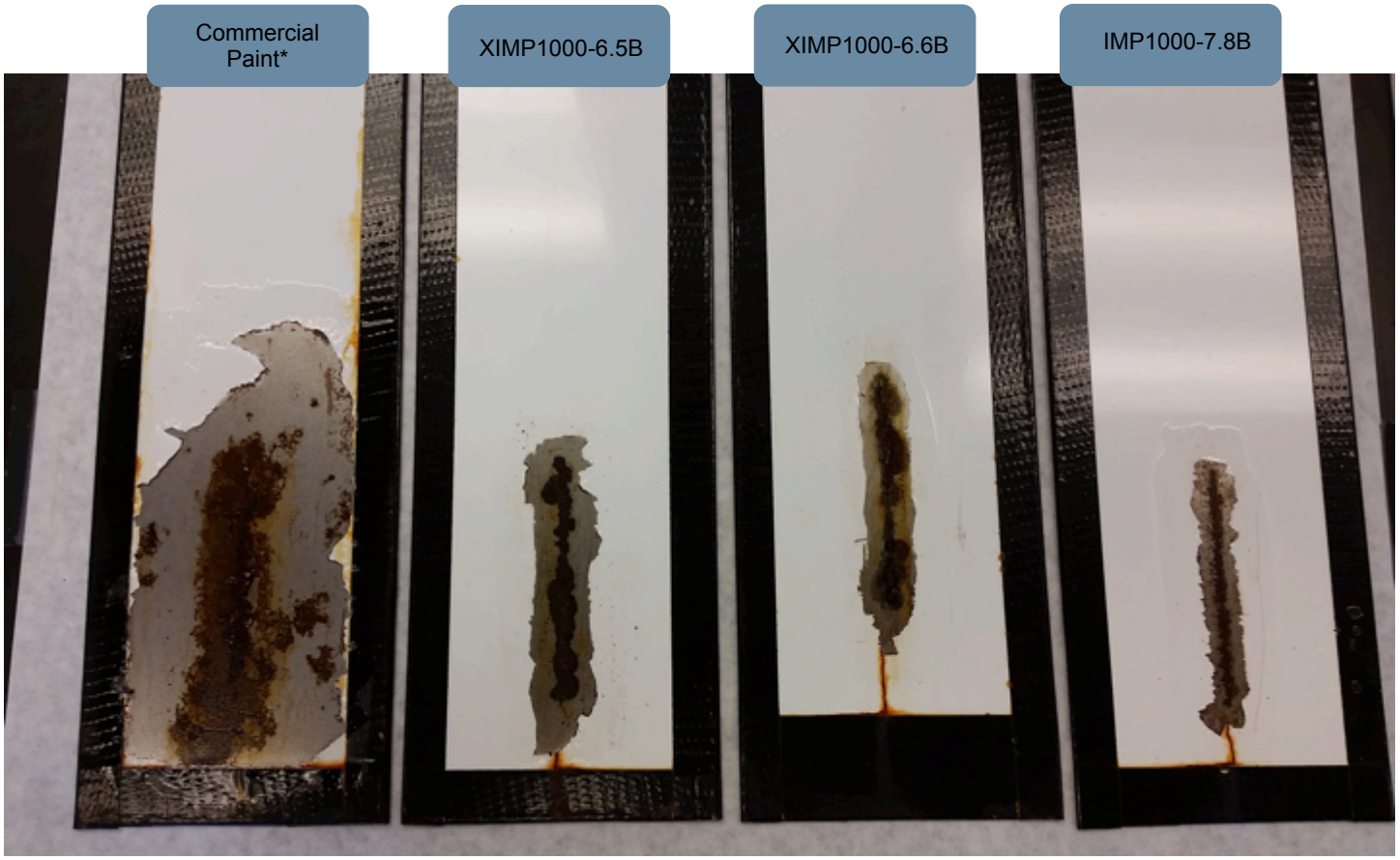
530 Hour Scraped Salt Spray Results



*Contains ca. 3% zinc phosphate corrosion inhibitor

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B. 1K Coil Evaluation[2]

- 1 component melamine bake system
- Substrate is phosphated cold rolled steel
- Pigmented using TiO2
- Baked to a peak metal temperature of 435-450 °F
- Corrosion resistance and carbon oil stain performance
- Direct comparison of commercial polyol and Resinate® polyol

[2]Chemical Dynamics, Plymouth, MI

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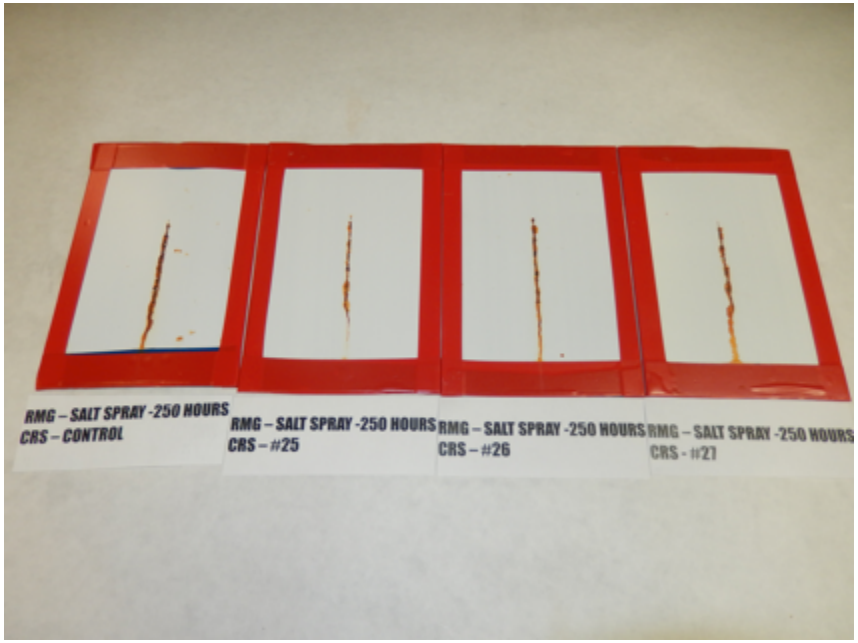
500 Hours CRS Salt Spray Test – Polyester/Melamine Coil Coating

Primer Identity	Field Blistering	Field Corrosion	Scribe Creep [cm]	Scribe Blisters [mm]	Scribe Rating	Visual Rating
B-952 Cold Rolled Steel Panels						
Commercial Polyol	5 2-4 mm D	5 – G*	0.4	2 -4 mm MD	6 0.7 cm UC	2
RMG # 25	4 1-2 mm D	5 – P*	0.3	3-5 mm MD	5 0.4 cm UC	2
RMG # 26	7 1-2 mm MD	6 – G*	NR	2-4 mm M	7 0.3 cm UC	1
RMG # 27	3 2-4 mm D	3 – P*	0.4	3-5 D	4 0.8 cm UC	2



← 250 hours shown

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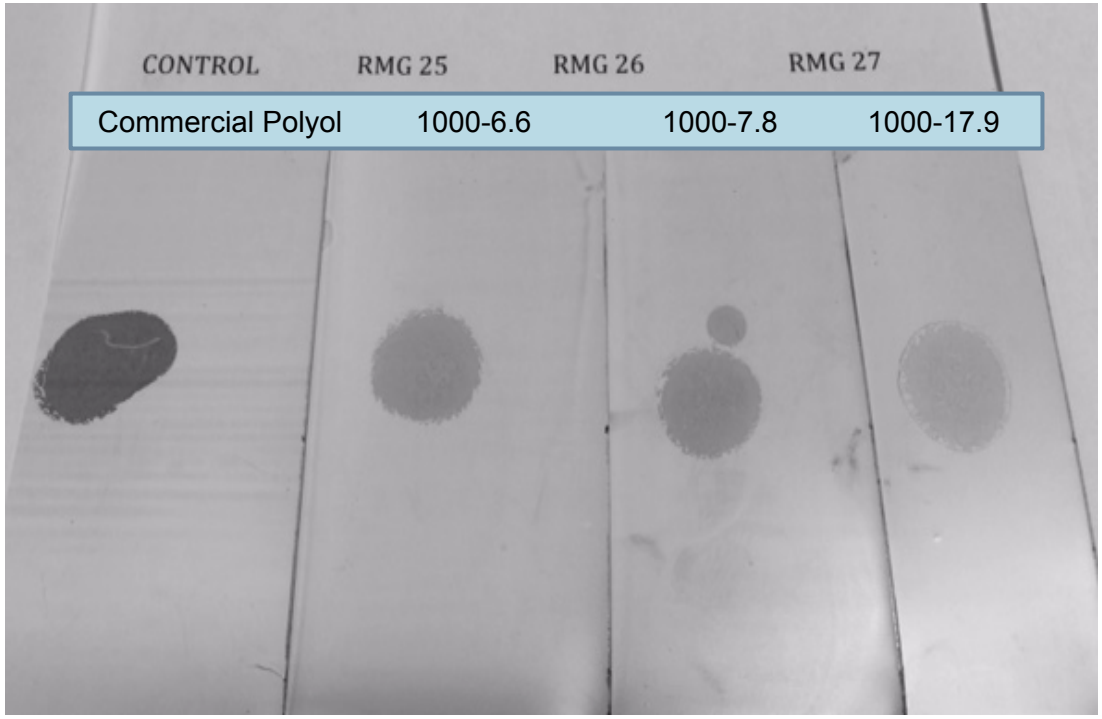
Color Spectrophotometer Readings of Carbon Oil Stain Test Results

Sample	X-Rite L	X-Rite A	X-Rite B	X-Rite ΔL after Stain Test
Chemical Dynamics Control Before Test	90.6	-1.4	-3.3	
Chemical Dynamics Control After Stain	67.4	0.2	3.5	23.2
RMG #25 Before Test	89.9	-1.6	-2.4	
RMG #25 After Stain	80.8	-0.7	2	9.1
RMG #26 Before Test	89.3	-1.6	-1.8	
RMG #26 After Stain	79.2	-0.7	2.6	10.1
RMG #27 Before Test	91.9	-1.9	2	
RMG #27 After Stain	86.1	-1	5.2	5.8



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Potential Impact
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Potential Impact – Automotive Industry

- 89.9 Million Vehicles in 2014[3]
- ~3-6 Quarts of Primer per Vehicle
- What if They Were All Primed with Resinate Technology?

Almost 150 Million Pounds of PET

[3]From Statista.com/ http://www.statista.com/statistics/262747/worldwide-automobile-production-since-2000/

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Summary and Conclusions

- Resinate has demonstrated that recycled content polyols can outperform conventional polyols
- Resinate has expanded the definition of “green chemistry”
- Resinate has developed polyols with up to 100% recycled and renewable content
- Recycled content is a viable path to meet customer’s performance, cost, and sustainability needs

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Questions?

Acknowledgments: Rick Tabor, Gary Spilman, Shakti Mukerjee, Matthew Beatty, Matt Brown, Mike Christy, Gage Fryz, Jack Kovsky, Kevin Rogers, Geo Pullockaren, Michelle Samson, Brian Reid, Tanecia Wilson

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Appendix: Direct to Metal Formulations

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A. 2K White Primer Testing[1]

- Formulated to 2K white PU primers with Ti-Pure R900 TiO2 at 1.0 P/B and adjusted to 36% PVC with Atomite (CaCO3) extender
- No dispersing aid, slight soft settling over time
- Desmodur N3300A used (HDI) at 1.1:1.0 NCO:OH
- Catalyzed with 0.15% DABCO T-12 (tin) on isocyanate/resin total
- MIBK solvent reduced to 70 KUs
- Bake cure 30 min at 130 °C
- Substrates coated with wirewound drawdown bar :
  - CRS
  - iron phosphated CRS
- DFT 1.8-2.2 mils
- VOC 379-427 g/L for the paints
- Commercial paint formulation – used as control; Contains ~3% zinc phosphate corrosion inhibitor

[1]Stonebridge Coating Labs, Plymouth, MI

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B. 1K Coil Evaluation[2]

- Low gloss, one coat coil; TiO2 sole pigment at P/B 1.0 and 22% PVC.
- Cymel 303LF was used (HMMM) at 18/82 on solids.
- Catalyzed with 0.2% TRS of Nacure 1051 (blocked pTSA).
- Stabilizing alcohol N-butanol at 20% TRS
- Modaflow additive, HP-Gasil 270 flattener to Gloss 30 @ 60°
- Aromatic 150 and Butyl Cellosolve (control) and MAK (RMG polyols) solvents; Percent NVM final 68%
- Final viscosity 18-22 sec (#4 Zahn Cup, seconds).
- Substrates:
  - chrome treated Al
  - HDG
  - zinc phosphated CRS
- Bake to PMT of 435-450 °F by infrared (Cen-Tech IR Thermometer) using High Airflow Blue M oven at 550 °F
- Final DFT 0.65-0.70 mils using #RDS-30 wire-wound drawdown rod
- Commercial workhorse industrial polyester polyol formulated as benchmark

[2]Chemical Dynamics, Plymouth, MI