PARTNERING IN THE AUTOMOTIVE SUPPLY CHAIN TO DEVELOP CLOSED-LOOP RECYCLING OF POST CONSUMER PET FOR AUTOMOTIVE FOAMS

Performance-driven green chemistry.™

Resinate Materials Group

Performance. Value. Sustainability.

- **Incorporated 2011: Plymouth, MI**
- **Vision:** To be the leading innovator in Performance Driven Green Chemistry
  - Extending the life-cycle of finite resource
  - Advance the circular economy

- **Technical Expertise**
  - 8200 ft2 Product and Applications Development Facilities
  - Over 200 combined years of specialty chemicals experience
  - More than 20 patent applications based on recycled content
- **Core Technology:** Molecular up-cycling of spent materials into polyester polyols
- **Manufacturing through tolling partners and licensees**
  - Reduce capital investment
  - Expertise
  - Accelerate scale-up

Resinate® MATERIALS GROUP

Innovate

Collaborate

Rethink the way we take-make-use plastics

Recycled PET

PLASTICS INDUSTRY ASSOCIATION

Automotive Waste

PET Pellets or flakes

Flexible Foam

Auto Manufacturing

Circular Economy

THE WOODBRIDGE GROUP

Tier One

- Composites
- Adhesives
- Foams
- Coatings
- Plasticizers

Polyester Polyol

Resinate

Evolution of Resinate-Tier One-Ford Partnership

Ford commitment to Green Chemistry	Resinate dialog with Ford	RMG samples sent	Ford Testing in Flexible Foam applications	Introduction to Tier One	Performance testing at Tier One
	June 2016	Aug 2016	Sep-Dec 2016	Jan 2016	Mar 2016

CLOSED-LOOP RECYCLING OF rPET

Scope/Technical Approach:

- Reducing foam costs and extending raw material supplies
- Create closed-loop model for discarded PET feedstock
- Good mechanical and thermal properties

Problem:

- Unfavorable wet heat aging properties
- Vulnerable to gradual hydrolysis

Objective:

- To determine the stability and viability of rPET polyols in production of PU flexible foams for automotive applications. Physical, mechanical, and thermal properties were measured and compared to control samples purely composed of petroleum-based polyol.

MATERIALS AND FORMULATION

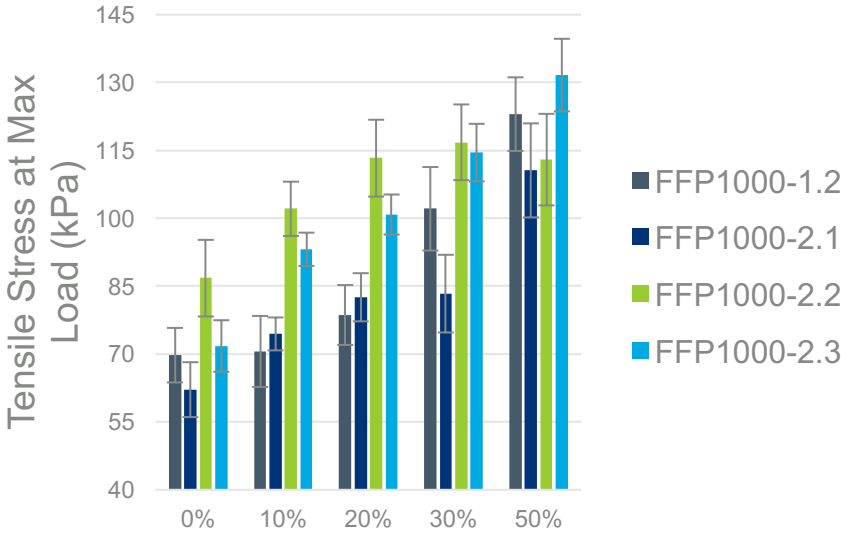
- Description of recycled polyols, including appearance and recycled content

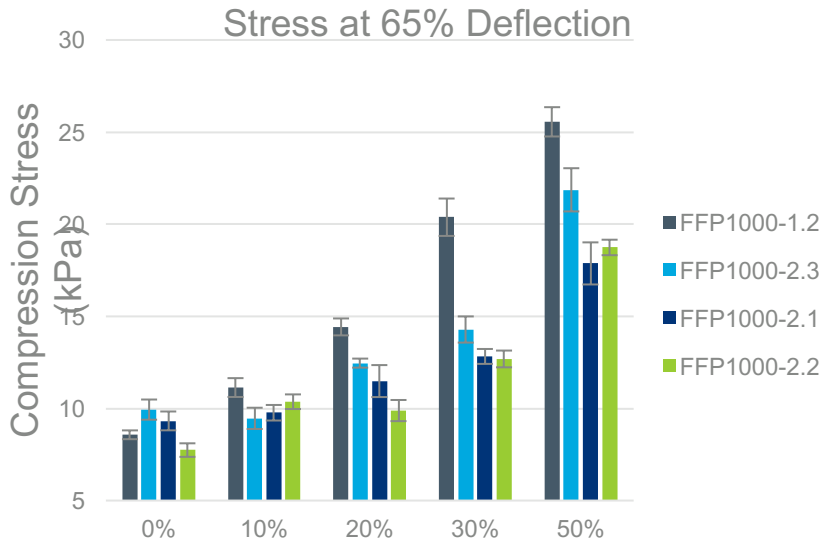
Polyol Name	FFP1000-1.2	FFP1000-2.1	FFP1000-2.2	FFP1000-2.3
% Sustainable Content	95.5%	79.2%	82.1%	81.0%
% Recycled Content	12.7%	29.3%	32.2%	24.0%

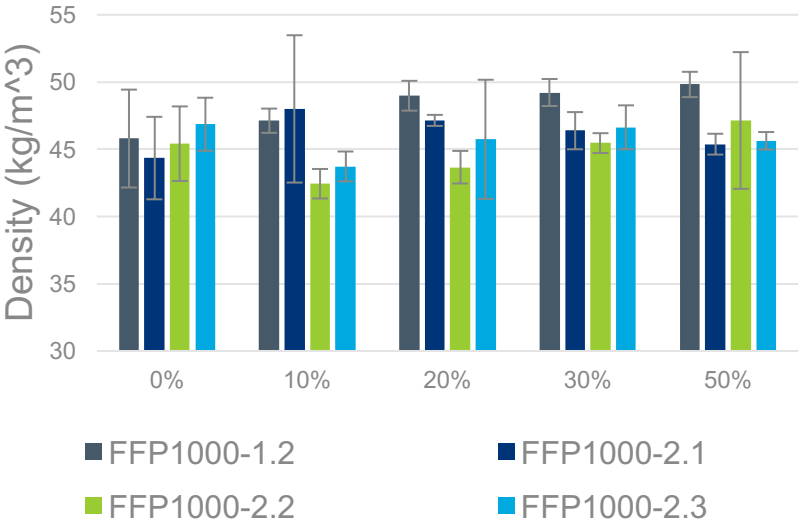
- Formulas used to create individual foams; each component listed in a relative manner, by part

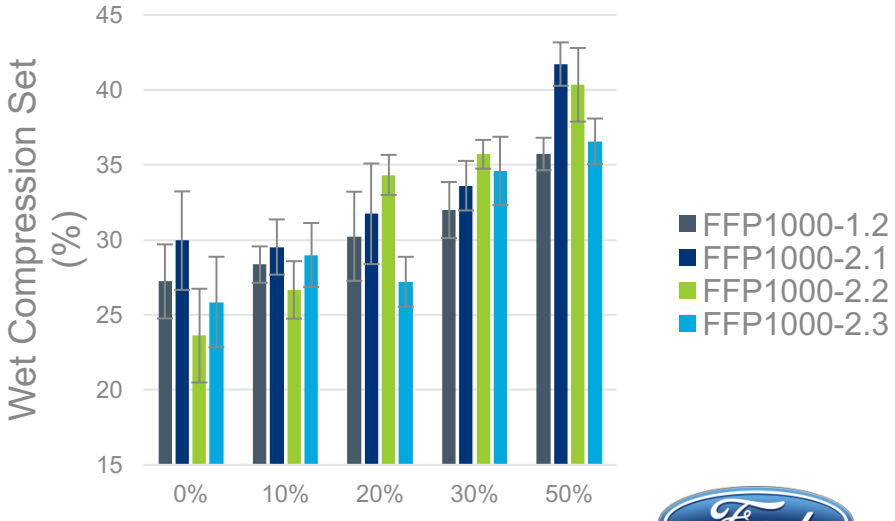
	0%	10%	20%	30%	50%
Polyether Polyol	100.0	90.0	80.0	70.0	50.0
FFP1000-1.2/FFP1000-2.1/ FFP1000-2.2/ FFP1000-2.3	0.0	10.0	20.0	30.0	50.0
Niax A1	0.3	0.3	0.3	0.3	0.3
Tegostab B4690	0.5	0.5	0.5	0.5	0.5
Niax A300	0.6	0.6	0.6	0.6	0.6
Lumulse POE (26) GLYC	1.0	1.0	1.0	1.0	1.0
Diethanolamine	1.5	1.5	1.5	1.5	1.5
Deionized Water	3.0	3.0	3.0	3.0	3.0
Isocyanate	53.8	56.0/53.9/ 53.9/54.3	58.4/54.3/ 54.4/55.1	60.8/54.7/ 54.8/55.9	65.7/54.3/ 55.6/57.4

MECHANICAL AND PHYSICAL PROPERTIES









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Ford Go Further

FOGGING AND ODOR

- Fogging:
  - ✓ SAE J1756, 3 h at 100 °C, 21 °C cooling plate, post-test cond. 16h
  - ✓ Fog Number 70 min
  - ✓ Formation of clear film, droplets or crystals is cause for rejection
- Odor
  - ✓ Rating 3 max
  - ✓ FLTM BO 131-03-Variant C

	Control	FFP1000-1.2	FFP1000-2.1	FFP1000-2.2	FFP1000-2.3
Fog Number	99	99	99	99	99*
Odor (23 °C)	1.5	1.5	1.5	2.0	2.0
Odor (40 °C)	1.5	2.0	1.5	2.0	2.0
Odor (65 °C)	2.0	2.0	2.5	2.5	2.5

*oily spots present

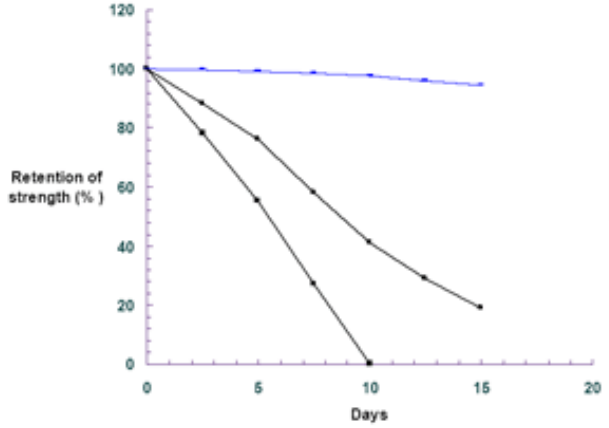
CONCLUSIONS

- ‘Up-cycling’ a waste stream to create a sustainable, value-added polyol
- High rPET content foams are mechanically stronger & stiffer, and more thermally durable
- Positive photometric fogging results
- Odor and flammability test results meet Ford requirements.
- PET required for polyol synthesis and automotive foam production can come directly from automotive PET scrap

ONGOING PROJECTS

- Collaboration with Tier 1 and PDC (Headliner Team, WSS-M15P27-G).

- VOC
  - Micro-chamber and GC-MS



- Hydrolytic Stability
  - 60 °C and 98% Humidity for a duration of 3 weeks
  - Investigation of different glycol systems

- Manuscript submitted to WM journal.

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