20TH-ANNUAL AUTOMOTIVE ENGINEERED POLYOLEFINS CONFERENCE

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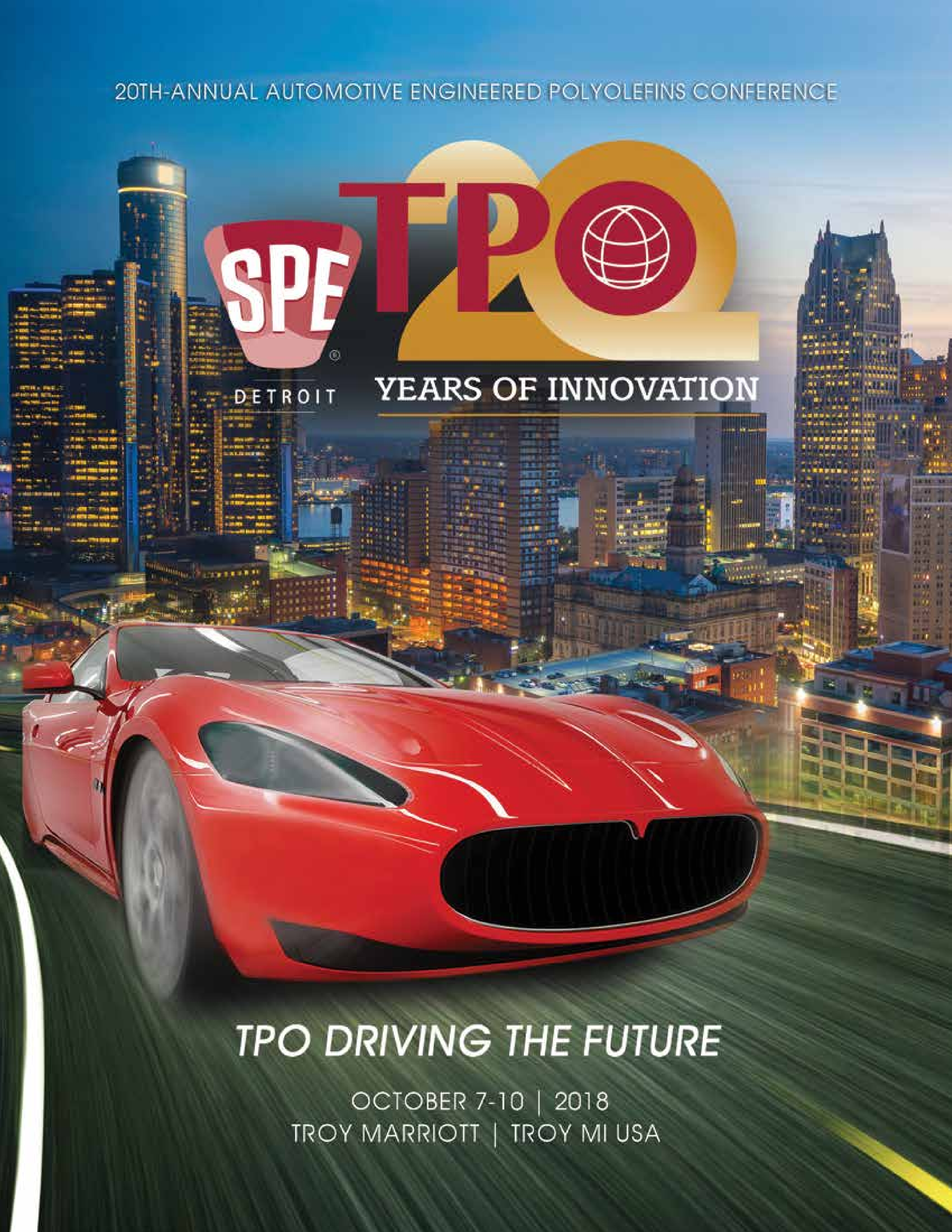
TPO 20 YEARS OF INNOVATION



TPO DRIVING THE FUTURE

OCTOBER 7-10 | 2018
TROY MARRIOTT | TROY MI USA

DRIVING YOU FORWARD

Keeping pace with changing technologies. Managing greater complexity. Doing more with less. Today's automotive engineers face numerous challenges. Our global, industry-dedicated team can help, and make the difference.

Our road-proven technologies, including STAMAX™ composite polypropylene resins and SABIC® PP compounds, can make possible lightweight construction, durability, and high-end aesthetics, among other benefits. And our automotive specialists have the expertise to help you arrive at the optimum design-material-process combination.

Our focus: overcoming obstacles that hold our customers back, so they can go forward. We call this Chemistry that Matters™.

WELCOME TO THE 2018 SPE TPO CONFERENCE

Thank you for attending the 20th-annual **SPE® TPO Automotive Engineered Polyolefins Conference**, **the world's leading automotive Polyolefins forum**. On behalf of our hardworking planning committee and all of SPE, we welcome you to the conference and wish you a very successful event.

Whether you're here to present a paper, exhibit your company's products and/or services, or to find solutions to pressing engineering challenges, we hope you find what you're looking for at this year's show.

This is an exciting year for our conference and it looks like we'll set a lot of records:

- We expect close to 1000 guests from around the world.
- We have our largest technical program ever (81 presentations in ten technical tracks in three parallel sessions throughout the event).
- Two special workshops on early evening Sunday.
- We have our largest exhibition ever thanks to the support of a record number of sponsors and over 80 exhibitors.

Additionally, we have five exciting keynote speakers who are going to help you better understand the complex web of trends and market forces at work in our industry today and those that shapes our tomorrow. Not only will you leave here better informed than when you arrived — assuming you visit our sponsors and catch our technical program — but you also should leave with lots of new contacts. That's because we've built numerous networking opportunities into our 2017 program.

In addition to three receptions (Sunday, Monday, and Tuesday evenings) and daily breakfasts and lunches (Monday through Wednesday), we've also built in morning and afternoon breaks into the program so you can ask questions, meet new people, grab a beverage, and avail yourselves of the tremendous amount of collective automotive-plastics knowledge assembled at this venue.

We'd like to acknowledge all the effort our committee of volunteers have expended helping bring this year's program to you. Our team is hard at work on this conference 11 months of the year. If there's something we could do better, please don't hesitate to tell a member of our committee so we can discuss it in our postmortem. If there's something we did right, please don't hesitate to tell us that too. We're always striving to make this event better.

See you all at the conference!

Sincerely,

Dr. Sassan Tarahomi
Neil Fuenmayor
John Haubert
Conference Co-Chairs

Dr. Sassan Tarahomi
Alterra Holdings

Neil Fuenmayor
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SPE DETROIT TPO 20 YEARS OF INNOVATION

SALUTE TO OUR SPONSORS

The SPE TPO Automotive Engineered Polyolefins Conference would not exist without the gracious support of our sponsors, who underwrote the cost of facilities and equipment rentals, food and beverages, production and printing of our program guide, and many other items, large and small. Hence, it is with great appreciation that we thank and acknowledge the contributions of our 2018 sponsors, exhibitors, and other patrons in making this event a success.

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SCHEDULE OF EVENTS

SUNDAY, OCTOBER 7 | 2018

12:00 PM	EXHIBITION SET-UP STARTS
3:30 PM	TUTORIAL 1: Basics of Polymer Stabilization & Antistatic Solutions for Automotive Parts by **Dr. John Mara**, Amfine Chemical Corporation
4:15 PM	TUTORIAL 2: Automotive TPV – A Solution Approach by **Dr. Morteza Jandeghi,** Alterra Holdings
5:00 PM	**EVENING RECEPTION:** Sponsored by **Formosa Plastics Group**

MONDAY, OCTOBER 8 | 2018

7:00 AM	REGISTRATION & CONTINENTAL BREAKFAST: Sponsored by **Mytex Polymers**
8:30 AM	WELCOME REMARKS: Conference Co-Chair, **Dr. Sassan Tarahomi**, Alterra Holdings
8:45 AM	KEYNOTE 1: **A Look Back and a Look Forward** | **Lon Offenbacher,** CEO & President Inteva Products LLC
9:15 AM	KEYNOTE 2: **What Will the Future Hold for Us** | **Dr. Heiko Pries,** Manager, Quality Assurance - Materials Technology, Audi AG
9:45 AM	TECHNICAL PROGRAM HIGHLIGHTS: **Norm Kakarala** | **David Helmer,** General Motors Co. | **Dr. Alper Kiziltas,** Ford Motor Co.
	LUNCH SPONSOR & RECEPTION SPONSOR REMARKS: Sumitomo Chemical Company & Advanced Composites
10:00 AM	BREAK: Sponsored by **Sirmax North America**

CONFERENCE HALL-I & CONFERENCE HALL-II

REFLECTIONS & FORECASTS SESSION-1
Norm Kakarala | **David Helmer,** General Motors Co. | **Dr. Alper Kiziltas,** Ford Motor Co.

10:30 AM	**An Overview of Key Material Developments in Engineered Polyolefins for Automotive Applications** **Mike Balow,** Asahi Kasei Plastics N.A. Inc.
11:00 AM	**Have Plastic Surfaces Been Enhanced?** **Dr. Rose Ryntz,** IAC Group
11:30 AM	LUNCH: Sponsored by **Sumitomo Chemical Company**

	CONFERENCE HALL-I	CONFERENCE HALL-II	CONFERENCE HALL-III
	MATERIALS DEVELOPMENT **Mike Balow,** Asahi Kasei Plastics N.A. Inc. **Mark Jablonka,** DowDupont **Peter Glenister,** LyondellBasell	**SURFACE ENHANCEMENTS & COATINGS** **Dr. Rose Ryntz,** IAC Group **Jeff B. Crist,** Ford Motor Co. **Jim Keller,** Mankiewicz Coatings, LLC	**PROCESS DEVELOPMENTS & SIMULATIONS** **Kurt Anthony,** Washington Penn Plastic Co., Inc. **Dr. Suresh Shah** **Dr. Li Lu,** Ford Motor Co.
1:00 PM	**An Innovative Polypropylene Compound for a Hybrid Daimler Cowl Vent Grille** **Sunit Shah,** LyondellBasell	**Color Innovations for Automotive Styling** **Paul Czornij,** BASF	**3D Printed Prototype Parts out of Production Material** **Juergen Giesow,** Arburg
1:30 PM	**Characteristics and Applications of Flame Retardant PP/PPE** **Kaz Hashimoto,** Asahi Kasei	**Haptics of Lightweight and Soft TPE Skins for Automotive Interiors** **Alex Green,** IAC & **Peter Botticelli,** Syntouch	**TPO Formulation Scale-Up: The bump in the Road between Development and Commercialization for TPE** **Paul Anderson,** Coperion
2:00 PM	**High-Stiffness Mineral-Filled TPO Material Solutions** **Jason Fincher,** Advanced Composites	**Aesthetic Coating Evolution for Injection Molded Interior Parts** **Janet Robincheck,** General Motors Co.	**Ultrasonic Welding of Thermoplastic Olefins (TPO's)** **Charlie Yang,** LyondellBasell
2:30 PM	**Novel TPO Concepts for Automotive Parts with Improved Dimensional Stability** **Jakob Oliverius,** Borealis	**The future of Micro-Organism Abatement vs. Surface Cleanability in Vehicles** **Eileen Gallihugh,** IAC	**Investigation of the In-flow Effect on Weld Lines Strength in Injection Molding of Polypropylene Compounds** **Luca Gazzola,** Sirmax
3:00 PM	BREAK: Sponsored by **A. Schulman**		

MONDAY, OCTOBER 8 | 2018 CONTINUED

	CONFERENCE HALL-I	CONFERENCE HALL-II	CONFERENCE HALL-III
	MATERIALS DEVELOPMENT **Mike Balow,** Asahi Kasei Plastics N.A. Inc. **Mark Jablonka,** DowDupont **Peter Glenister,** LyondellBasell	**SURFACE ENHANCEMENTS & COATINGS** **Dr. Rose Ryntz,** IAC Group **Jeff B. Crist,** Ford Motor Co. **Jim Keller,** United Paint & Chemical Corporation	**PROCESS DEVELOPMENTS & SIMULATIONS** **Kurt Anthony,** Washington Penn Plastic Co., Inc. **Dr. Suresh Shah** **Dr. Li Lu,** Ford Motor Co.
3:30 PM	Benefits of High Melt Strength PP (HMS-PP) in Cut Sheet Thermoforming **Kim McLoughlin,** Braskem	Surface Energy Modifications of TPE Membranes using Open-Air Plasma Pretreatment **Doug Corrigan,** Chemquest Technology Institute	Predicting and Preventing Defects in Injection Molded Parts **Alex Baker,** Modex3D
4:00 PM	A Method to Modify PP For Improved Melt Strength in TPOs **Brett Robb,** Total Cray Valley	Future-Proof Interior Surfaces for Sustainability and Performance **John Dunn,** Stahl	Prediction and Validation of Warpage on Injection Molded Polypropylene Parts **Xianjun Sun,** Ford Motor Co.
4:30 PM	Thermoplastic Solutions to Replace Paint and Film in High Gloss Piano Black Exterior Appliques **Brent Westbrook, Nymphy Vashisht,** Mitsubishi Chemicals Performance Polymers	Innovative Coatings for the Next Generation Vehicle **Diane Marret,** Red Spot	Simulation Analysis of Residual Stress and Material Characterization Influences under Curtain Airbag Deployment for TPO Interior Trim Part **Hector Hernandez,** Ford Motor Co.
5:00 PM	Flow Instability Perspective of Tiger Stripes with Polypropylenes **Tieqi Li,** Formosa	Multi-Functionality and Sustainability Trends for Coatings **Prof. Jamil Baghdachi,** EMU	CAE Simulation with TPOs: Achievements, Open Debates and Future Challenges **Massimo Nutini,** LyondellBasell
5:30 PM	**EVENING RECEPTION:** Sponsored by **Advanced Composites**		

TUESDAY, OCTOBER 9 | 2018

7:30 AM — REGISTRATION & CONTINENTAL BREAKFAST: Sponsored by **ExxonMobil**

8:00 AM — WELCOME REMARKS: Conference Co-Chair, **Neil Fuenmayor,** Lyondellbasell

8:15 AM — KEYNOTE 3: The Impact of the North American Free Trade Agreement (NAFTA) on the Plastics Industry
Suzanne Cole, CEO of Miller Cole LLC

8:45 AM — KEYNOTE 4: Global Trade for TPO | **Joel Morales,** Polyolefins Americas, HIS Markit

9:15 AM — PRESENTATION OF AWARDS
CONFERENCE SPONSOR RECOGNITIONS
LUNCH SPONSOR & RECEPTION SPONSOR REMARKS: Washington Penn Plastics & Braskem

9:45 AM — BREAK: Sponsored by **Borealis**

CONFERENCE HALL-I & CONFERENCE HALL-II

REFLECTIONS & FORECASTS SESSION-2
Norm Kakarala | **David Helmer,** General Motors Co. | **Dr. Alper Kiziltas,** Ford Motor Co.

10:15 AM — Twenty Years of TPO and TPE Evolution in Auto Interiors and a Vision of the Future
Robert Eller, Robert Eller Associates, LLC

10:45 AM — Driving Innovation and Material Collaboration on Exterior Products
Mark Pilette, Magna Corp.

11:30 AM — LUNCH: Sponsored by **Washington Penn Plastics Co., Inc.**

	CONFERENCE HALL-I	CONFERENCE HALL-II	CONFERENCE HALL-III
	INTERIOR APPLICATIONS **Robert Eller,** Robert Eller Associates LLC **Kevin Lyons,** Inteva Products LLC **Pravin Sitaram,** Haartz Corporation	**LIGHTWEIGHTING TECHNOLOGIES** **John Haubert,** FCA US LLC **Normand Miron,** Washington Penn Plastic Co., Inc. **Hoa Pham,** Freudenberg Performance Materials	**SUSTAINABILITY & EMISSIONS** **Susan Kozora,** IAC Group **Dr. Alper Kiziltas,** Ford Motor Co. **Laura Shereda,** Asahi Kasei Plastics N.A. Inc.
1:00 PM	Polyolefin Solutions Addressing the Main Challenges of Future Mobility **Jacob Oliverius,** Borealis Compounds	Polyolefin Elastomer Impact Modifiers to Meet Lightweighting Needs **Jeff Munro,** Dow Chemical Co.	The Growing Importance of More Sustainable Materials **Alper Kiziltas and Debbie Mielewski,** Ford Motor Co.
1:30 PM	Further Refinement of the Injection Moldable Soft Skin Solution for Automotive Interiors **J. Schulcz, Marcus Greger,** Kraton Polymers LLC	Carbon Fiber Reinforced TPOs: Advancing the Future ofAutomotive Materials **Jue (Jane) Lu,** LyondellBasell	Benefits of THRIVE®/ Celstran® Blends in Semi-Structural Applications **Jorge Cortes,** THRIVE® Cellulose Fiber Composites
2:00 PM	Chemical Foaming Agents: Foaming TPO in Injection Molding and Extrusion **Peter K. Schroeck,** Reedy Chemical Foam & Specialty Additives	Development of New Applications by Advanced LFT Technology **Youngbum Kim,** Lotte Chemical	End-of-Life Vehicle (ELV) Recycling **Meagan Marko,** Noble Polymers
2:30 PM	Durable PP Surface for Future Mobility Solutions **Daniel Bahls,** Borealis Polyolefins	Lightweighting Strategies with Talc in Automotive TPOs **Piergiovanni Ercoli Malacari,** Imi Fabi	Utilizing Recycled Materials in TPO Applications **Matt Velthouse,** PADNOS
3:00 PM	BREAK: Sponsored by **Cimbar Performance Materials**		
3:30 PM	The Investigation on Adhesive Properties of Thermoplastic Liftgate **Dr. Daijong Fu,** KINGFA	Reduced Density TPO Solutions **Jason Fincher or Matt Thompson,** Advanced Composites	Tackling Current & Oncoming Emissions Challenges – Landscape & Development of Emissions Compliant Polypropylene **Jeff Salek,** Braskem
4:00 PM	Non-Reactive Hot Melt Adhesives in Polyolefin Automotive Interior Components **Sebastien Meliot,** Jowat Corp.	Pushing the Boundaries of High Performance Short Fiber Glass Coupled PP **John Oliver,** Sumika Polymer Compounds Europe	Synthetic Minerals for VOC Reduction in TPO for the Automobile Cabin **Rob Lorenzini,** Maroon Group
4:30 PM	Next Generation Reactive Polyolefin Hotmelt – Fast Curing and No Labelling **Dr. Martin Weller,** H.B. Fuller	Development of Lower Cost Natural Fiber Door Trim Panel with Significant Mass Savings and Class "A" Finish **Ed Wenzel,** Inteva Products, LLC	Different Concept on Reduction of VOC in Value Chain **Jungdu Kim,** Songwon
5:00 PM	Conventional and Reactive Hot Melts for Interior Applications **Emilie Smith-Heberer,** Henkel	Weight Reduction of Plastic Components by using Modern Technology **Juergen Giesow,** Arburg	Innovations to Reduce Odor in Talc Filled Polypropylene System **Lily Liu,** Polyone
5:30 PM	**EVENING RECEPTION:** Sponsored by **Braskem**		

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Each day we will have a prize drawing
for those that provide feedback!

WEDNESDAY, OCTOBER 10 | 2018

7:30 AM — REGISTRATION & CONTINENTAL BREAKFAST: Sponsored by **SPE Detroit Section**

8:00 AM — INTRODUCTION OF KEYNOTE SPEAKER: Conference Co-Chair, **John Haubert,** FCA US LLC

8:15 AM — KEYNOTE 5: **How the Industry has Changed over the last 20 years and the What the future Holds for Polyolefins**
James Guilfoyle, Executive Vice President, Advanced Polymer Solutions and Global Supply Chain, LyondellBasell

CONFERENCE HALL-I & CONFERENCE HALL-II

REFLECTIONS & FORECASTS SESSION-3

Norm Kakarala | **David Helmer,** General Motors Co. | **Dr. Alper Kiziltas,** Ford Motor Co.

8:45 AM — **Polypropylene and its use in Structural Automotive Applications**
Matthew Marks, SABIC

9:15 AM — **20-Years of Developments in Process and Equipment Trends – What's Next?**
Jason Holbrook, KraussMaffei Corporation

9:45 AM — BREAK: Sponsored by **SPE Detroit Section**

	CONFERENCE HALL-I	CONFERENCE HALL-II	CONFERENCE HALL-III
	MATERIALS DEVELOPMENT **Mike Balow,** Asahi Kasei Plastics N.A. Inc. **Mark Jablonka,** DowDupont **Ermanno Ruccolo,** Borealis	**SURFACE ENHANCEMENTS & COATINGS** **Dr. Rose Ryntz,** IAC Group **Jeff B. Crist,** Ford Motor Co. **Jim Keller,** United Paint & Chemical Corporation	**INTERIOR APPLICATIONS** **Robert Eller,** Robert Eller Associates LLC **Kevin Lyons,** Inteva Products LLC **Pravin Sitaram,** Haartz Corporation
10:00 AM	**Soft Touch TPE's with Exceptional Overmolding Adhesion to Rigid Substrates** **Tony Samurkus, Marco Meneghetti,** Trinseo	**Recent Progress in Testing and Evaluation of Scratch and Mar Resistance of TPO** **H.J. Sue,** Texas A&M	**New Halogen-Free Flame Retardant Thermoplastic Elastomers (HFFR-TPE) were Developed** **Takahiro Konishi, Ryosuke Kurokawa, and Nobuhiro Natsuyama** Sumitomo Chemical Company
10:30 AM	**Minerals for Noise Reduction** **Dr. Prasad S. Raut,** Imerys	**Accelerated Weathering of Coatings: A Global Perspective** **Mark Nichols,** Ford Motor Co.	**Grain Pattern Effect on Mar Visibility Resistance of Textured TPOs** **Shuang Xiao, D. J. Barksdale and Hung-Jue Sue,** Texas A&M University
11:00 AM	**A Novel TPO Development for the PC-ABS Resins Replacement** **Nadeem Bokhari,** Sumitomo Chemical	**Why Test Inks and Dyne Pens Cannot Tell the Full Truth About Surface Free Energy** **Daniel Frese,** Kruss	**Foamed PP for Visible Automotive Applications- Challenges and Opportunities** **Georg Grestenberger,** Borealis Polyolefins
11:30 AM	**A Solution for Electrostatic Control using a Novel Polymeric Antistatic Agent** **Yota Tsuneizumi,** ADEKA	**Anti-Scratch Improver** **Toru Kato,** NOF Corporation	**Thermoplastic Elastomers for Automotive Window Applications** **Juan Espinosa, Stephen Cranney & Sehyun Kim,** Kraiburg TPE

12:00 PM — BOX LUNCH: Sponsored by **LG Hausys, Ltd**

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2018 KEYNOTE SPEAKERS

20TH AUTO TPO CONFERENCE KEYNOTE SPEAKERS

It's hard to believe that it's been two decades since the SPE TPO Automotive Engineered Polyolefins Conference began. The 20th Annual SPE® TPO Automotive Engineered Polyolefins Conference, the world's leading automotive engineered polyolefins forum, returns to the Troy Marriott in the Detroit suburbs from October 7-10, 2018. The theme of this year's 2018 technical conference and exhibition is "TPO Driving the Future" and will showcase talks by keynote speakers from LyondellBasell, Inteva Products, Miller Cole LLC, and IHS Markit.

This year the conference continues its long-standing tradition of offering in-depth technical sessions covering seven different topic areas, including Materials Development, Surface Enhancements, Interior Applications, Lightweighting Technologies, Process Developments & Simulations, Sustainability & Emissions. These sessions reflect the innovations happening in the polyolefin industry, both in the Detroit region and around the world.

The conference's keynote speakers provide great background information for the technical sessions and encourage attendees to think about the big picture.

Lon Offenbacher
Founder
Inteva Products

A Look Back and a Look Forward

This year's Executive Chair Lon Offenbacher will open this 20th anniversary conference with a focus on how far TPO technologies have come since their origin to today, as well as a look forward to the opportunities the industry offers for further evolution. As the company Lon founded, Inteva Products, celebrates its 10th anniversary this year, Lon will offer real-life examples of how innovations in TPO not only provide competitive advantages but allow for the development and launch of entirely new product lines. He will provide guidance and advice to set the stage for exceptional solution-based dialogue throughout the conference.

Lon Offenbacher is President and CEO of Inteva Products, a position he has held since the successful launch of Inteva in 2008. Prior to taking the helm of Inteva, Offenbacher was the Business Line Executive for the Integrated Closure and Cockpit & Interior Systems business lines for Delphi Corporation, a position he was appointed to in August 2003. Offenbacher began his career in 1971 with the former Inland Division of General Motors in Dayton, Ohio, as part of the Cooperative Education Program at Purdue University. Upon graduation, he went on to hold several positions in operations, engineering and sales. In 1985 he was promoted to Sales Manager and transferred to Troy, Mich., where he established a sales office for Inland. Offenbacher was named 2017 Entrepreneur of the Year, Michigan and Northern Ohio Region, and a finalist in the National Entrepreneur of the Year awards. He received the 2018 Executive Leadership Award from the Marketing & Sales Executives of Detroit (MSED) and has also been recognized as a 2015 Most Valuable Professional (MVP) by Corp! magazine.

Offenbacher has a bachelor's degree in chemical engineering from Purdue University and a master's degree in business administration from the University of Dayton.

2018 KEYNOTE SPEAKERS

Dr. Heiko Pries
Title
VW/Audi

Suzanne Cole
CEO
Miller Cole LLC

What Will the Future Hold for Us?

"What will the future hold for us?" A difficult and hard to answer question. In trying to do so, we will first have a look back at the last 20 years of application of TPO materials in the Volkswagen Group. With this retrospective, we will walk through recent challenges for some interior and exterior applications in the context of the VW global product portfolio, design decisions and functional requirements. After discussing automotive trends to identify challenges and opportunities for technical solutions, we will also understand how and when these challenges and solutions can be most efficiently addressed during the VW product engineering processing in order to best position ourselves for the future . Creating our vision and take a forward look at business opportunities will provide an idea of what the future holds for us.

Dr. Heiko Pries' degree is in Engineering from the University of Braunschweig, Germany. His main career focus was material science and remained so until recently.

Together with his PHD and the cooperation with the University of Magdeburg and VW in Wolfsburg as well as VW in Braunschweig, Dr. Pries introduced a non-destructive testing method based on giant magnetic resistance sensors. He continued his career with VW as Assistant to the head of the Central Laboratory in Wolfsburg.

In 2011, he further branched out into the VW Group by shifting to Audi AG as the leader responsible for the quality of body construction materials, whole car corrosion and lightweight technologies.

In 2016 he was assigned to the Laboratory of VW Chattanooga as the Manager.

Today, he is back at Audi in Ingolstadt working with the Quality of Materials Department. Dr. Pries is sharing with us his view on 20 years of automotive development and some ideas for the future.

The Impact of the North American Free Trade Agreement (NAFTA)

Suzanne Cole, CEO Miller Cole, LLC, a regulatory and legislative advisory firm based in Washington D.C., will discuss NAFTA's status and the potential trade and market implications for the plastics and automotive industries.

When the North American Free Trade Agreement (NAFTA) was signed by President Clinton and went into effect on Jan. 1, 1994, the three countries involved — Canada, the United States and Mexico — probably had little idea of what the net result would be 25 years later.

Attend this keynote presentation to find out:

- What impact steel and aluminum tariffs will have on the automotive and plastics industries.
- Will a revised NAFTA make the U.S. more or less competitive?
- White House trade advisor, Peter Novarro stated in March that there will be no ally exemptions from new tariffs. How will this effect global trade, U.S. jobs and the economy?
- Will the White House stance on NAFTA escalate into a global trade war?

Suzanne Cole is CEO of Miller Cole LLC, an advisory firm in Detroit and Washington, D.C. specializing in legislative and regulatory affairs, trade issues, advocacy and supply chain optimization.

Suzanne has been very active with SPE having served as Chairman of the Automotive and Environmental divisions, Chair of the SPE Automotive Division's Innovation Awards Gala and program and is an SPE Honored Service Member.

Suzanne is Chairman of the University of Michigan International Council for Automotive Medicine Advisory Board of Directors, leading efforts to develop big data tools utilizing a massive data base of global real-world level-one trauma crashes to improve vehicle safety, reduce injuries and fatalities world-wide.

Suzanne is founding partner of Next Generation Technology Matters, LLC in Bloomfield Hills, which is focused on strategy development and financing to create competitive advantage for Next Gen technologies in the automotive, energy, medical, and military sectors.

She has a B.S. in Chemistry from Michigan State University; MBA, from the UM Ross Business School and a Masters in Chemical Engineering from Wayne State University.

Joel Morales
Polyolefins Americas,
IHS Markit

James Guilfoyle
Executive Vice President
LyondellBasell

Global Trade of the Polyolefin Market

Both Polyethylene and Polypropylene are going through some surprising changes both globally and in the North American market, particularly versus what conventional expectations may have been as little as a year ago. The presentation will focus on what has changed in the global markets over the last year and what the outlook looks like for these materials going forward both locally and globally. Global trade patterns will be discussed and what buyers and sellers can expect in the near to medium term.

Joel joined IHS Markit in March 2013 to cover PE and PP in North America. He is currently the service leader of three market advisory subscription services: The Global Plastics and Polymers Report, the North American PE Report and the North American PP report. He brings a wealth of industry knowledge to IHS Markit through multiple stints along the plastics' value chain. He began his career with polyolefins manufacturer, Solvay Polymers, which later became Ineos, in technical services and product development before he was moved into field sales. After 5 years at Solvay Polymers, Joe-el moved into resin distribution sales for both Muehlstein and then United Polychem as a Product Manager where he managed and sold polyethylene and polypropylene resins into various customer segments. In his most recent role prior to joining IHS, Joe-el was a purchasing manager for Silgan Plastics, a major, blow-molding and injection molding plastics converter. Joel graduated from The Massachusetts Institute of Technology in 1999 with a Bachelor of Science in Chemical Engineering and a minor in psychology.

Market Disruptors and Their Impact on Our Industry

LyondellBasell is a global leader in PP and PP Compounds. James (Jim) Guilfoyle, LyondellBasell's Executive Vice President, Advanced Polymer Solutions (APS) and Global Supply Chain, will examine the key trends emerging in the automotive industry, such as stringent emission standards and the emergence of autonomous vehicles, and their impact. To develop innovative solutions to meet these demands, the automotive market has embarked on numerous mergers with tech companies, acquisitions, new joint ventures and alliances.

Recent disruptive trends, such as the U.S. shale gas and oil boom, has led to consolidations within the chemical market. Similar to the automotive market, these consolidations have led to a number of benefits including the pooling of resources to remain viable in the face of demanding and expensive investments. Jim will explore the numerous trends influencing the Chemicals market and how the company is investing to meet the challenges of today while advancing the innovations that will improve tomorrow.

James D. (Jim) Guilfoyle is Executive Vice President, Advanced Polymer Solutions and Global Supply Chain for LyondellBasell, one of the world's largest plastics, chemicals and refining companies.

Prior to this position, he was Senior Vice President, Global Intermediates & Derivatives and Global Supply Chain, and he previously served as vice president of Global Propylene Oxide and Co-Products at LyondellBasell. He also held several managerial and technical positions at the Company within the Olefins and Polyolefins business segment. Guilfoyle started his career as a chemical engineer in 1993 at the La Porte, Texas Olefins Plant with Quantum Chemicals, a predecessor of the Company.

He was recently appointed to serve on the Houston Food Bank Board of Directors.

Guilfoyle earned his Bachelor of Science in chemical engineering from the University of Cincinnati and a Master of Science in the same field from the University of Houston. He holds a Master of Business Administration from the University of Houston and attended the Executive Development Program at the Kellogg School of Management.

karen, What do you want this to say?

Celebrating the Life of Ron Price

RONALD F. PRICE age 79, of Orchard Lake, Michigan and Bonita Springs, Florida, passed suddenly Wednesday, June 13, 2018 in his home in Michigan. Born on May 25, 1939, son of Colonel Franklin Price and Sadie Mae (nee. Lane) Price. Devoted h
(nee. Bilaitis) and loving father to R. Todd, Susan Price Huber (Ra
Hugh (Helen) Price, Philip (Rita) Price and Art Price.

A graduate of Greensboro High School and North Carolina State. Ro
ness Management and Marketing and completed further studies at C

Ron had an outstanding career for over 45 years that spanned the gl
with Borg Warner, Exxon Chemical and Huntsman. He retired from
a successful consultant and expert in the industry. He was the founde
contributor to the SPE Global TPO Conference for over 20 years.

Ron had a passion and exuberance for life. He loved airplanes and was a single engine and glider pilot. An avid sportsman, Ron's passions included: boating, kayaking, hunting, skiing, golf, and most recently pickle ball. Ron had an amazing sense of rhythm and was known as a terrific dancer. His greatest joy was connecting with people making each and every one feel treasured and loved. He will be greatly missed by his
his life and encouraged his loved ones to do
of True Grit.

Family and friends gathered to honor Ron a
Kirk in the Hills Presbyterian Church.

For the plastics community, **the Ron Price**
September 17, 2018, sponsored by the SPE
Conference as a tribute for Ron's incredib
stories regarding Ron's life were shared by
made to South Oakland Shelter.

TPO 20th anniversary

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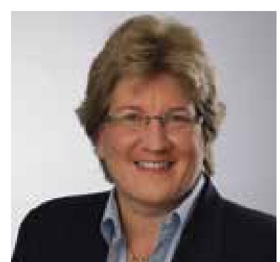
20TH ANNIVERSARY SUPER SESSION SPEAKER HONORING EVENT

SPE® Automotive TPO Engineered Polyolefins Global Conference is now in its 20th year! A milestone achieved with the support of the Society of Plastics Engineers (SPE®), leading global OEMs and Tier Suppliers, as well as the TPO supply chain. This event has created a dynamic, interactive and cost-effective learning experience while becoming ***the world's leading automotive polyolefins forum.***

To commemorate this anniversary, the conference has invited six Super Sessions presenters (each a master in the field) to reflect on the progress made in 20 years and on the future of Materials Developments, Surface Enhancements, Automotive Interior and Exterior Applications, Structural Applications and Process Enabling Technologies. The invited speakers are as follows:


Mike Balow
Asahi Kasei North America

The first Super Session presentation on Materials Development will be given by **Mike Balow.** The former, Vice President of Technology and Application Development (now the Senior Advisor) with Asahi Kasei North America will talk about the evolution of the key components of Engineered Polyolefins. Polymers, elastomers, reinforcements, compounding processes and additives will be reviewed. All of these key ingredients have had alterations and improvements to meet specific automotive industry demands for performance and productivity. While this will serve as a bit of review of the past 20 years, his talk will also speculate on what the next 20 years may hold.


Dr. Rose Ryntz
IAC Group North America

The second presentation on Surface Enhancements will be given by **Dr. Rose Rynt,**, Vice President of Global Advanced Development and Material Engineering at International Automotive Components, IAC Group North America. Dr. Ryntz will talk about a shift in automotive decorated interior and exterior applications in the last two decades toward light weight, crafted appearance and enhanced performance attributes. With scratch resistance, surface integrity, colorfastness, and improved aesthetics still driving the bus, the search continues for the "Holy Grail" of a non-damaged or self-healing surface that can be tuned for haptics, color, texture, and gloss, while maintaining low odor and volatile organic compounds (VOC). Her talk will touch on the transition of key variables modified in the formulation/manufacture of automotive plastics and test methods utilized to assess the improvements achieved in surface abrasion, scratch, and weathering/appearance consistency of decorated and mold-in-color plastics. It will also attempt to delineate current processing and material combinations and what is proposed/investigated for the future to achieve the "Holy Grail".


Bob Eller
Robert Eller Associates LLC

Bob Eller, President of Robert Eller Associates LLC and a founding member of the SPE TPO Conference, will give the third presentation on Automotive Interior Applications and the dynamic, evolutionary, interactive process between target applications, performance requirements, fabrication methods and associated TPO formulations serving the auto interior in the past twenty years. Auto interior needs may have remained the same but many have shifted as the auto interior continues to evolve resulting in new performance needs and fabrication methods. His talk will review the evolution from relatively simple talc filled, monolayer constructions for instrument panel skins and structure, airbag doors and trim to the current generation of high performance components meeting the requirements for smart interiors, airbag deployment, gloss and grain while providing cost and weight savings. Apart from TPOs, two prominent TPEs contending in auto interiors are the styrene block copolymer(SBC) and thermoplastic vulcanizate (TPVs) types. These will be examined, as well, for their evolution from the late 90's thru their current position competing in auto interiors.

The fourth presentation will be given by **Mark Pilette,** Global Product Line Manager of Exterior Trim for Magna Exteriors. Mark will provide us with a brief look back at how TPOs first impacted our industry. Then, he'll take a look ahead at how autonomy is driving material and process innovation, including the potential for carbon fiber and graphene to enable future mobility. TPOs will be front and center in solving packaging, design and aerodynamic challenges.

Mark Pilette
Magna Exteriors

Matthew Marks
SABIC

Matthew Marks, who serves as the Americas Automotive Technical Development Leader for SABIC, will give the fifth presentation on a historical view of polypropylene in Structural Applications. The automotive industry has long viewed polypropylene as a commodity. In the broad material family called plastics, ranging from thermosets to thermoplastics, amorphous to crystalline, and high performance engineered resin to commodity, polypropylene has certainly found itself near the bottom of the thermoplastic pyramid. However, the automotive industry continues to apply significant resources to the development and refinement of this material, heightening its status to that of "engineered thermoplastic." With the addition of fillers – like talc, glass, long glass, and even carbon fiber – the industry has elevated this perceived commodity resin into the realm of thermoplastic composites. Automotive industry needs have driven, and will continue to drive, these material developments and innovations. Fuel economy, vehicle emission, and crashworthiness requirements motivate engineers to develop lightweight, safe solutions. His presentation will provide a historical view of some of these solutions and provide insights into the challenges ahead.

Jason Holbrook, Sales Manager of KraussMaffei Corporation, will give the final presentation on Processing Enabling Technologies where over the last twenty years, our injection molding industry has witnessed many advances in materials, product design, and molding technologies ushering in trends such as – Multi-Component Molding, Gas Assist, MuCell technology, Light Weighting, In-Mold Decorating, & Automation, among others. These trends continue to advance, and we're now experiencing cross-pollination of these technologies, breeding more attractive and efficient products for the consumer's demand.

Jason Holbrook
KraussMaffei Corporation

Continued advances of these technologies will be seen. Light Weighting being one of the most recent trends has experienced leaps in development in just the last 5-years with the use of Organosheet over-molding. New material recipes are now demanding more multi-component molding, Industry 4.0 is focusing on plant & machine integration. All of these recent developments have a direct impact on the type and design of machinery and production cells. Our traditional means of piecing these technologies together is morphing into design specific production cells, while also allowing for flexibility in cell design. His presentation will focus on the 5 leading trends we're seeing:

1. **Light Weighting:** Composite Molding, Foaming,
2. **Multi-Component:** Thermoplastic/Thermoplastic & Thermoplastic/Thermoset
3. **Process Technology:** Scientific Molding, Closed Loop Processing, Adaptive Process Control
4. **Automation:** Integrated robotics, in-mold automation, down-stream automation
5. **Industry 4.0:** Integration of the machine, auxiliary equipment, & plant monitoring

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An Overview of Key Material Developments in Engineered Polyolefins for Automotive Applications

Mike Balow, Senior Advisor, Asahi Kasei Plastics North America, Inc. | Narrated for the 2018 TPO Conference by David Blank

Slides 1 and 2 – Introduction, Materials Development Cycle

The materials development cycle for today's automotive grade TPOs consists of many components and is driven by the increasingly challenging demands for improved performance at equal or lower cost. The product developer must look beyond the formulation and its mechanical properties and morphology, and consider how things like part design, wall thickness, flow length and molding process will affect finished part performance, e.g., impact/stiffness balance, morphology, paintability, and appearance.

Slides 3, 4, and 5 – Bumper Fascia Gating Technologies, Toyota TSOP Approach, Enabling Technologies

Fortunately, in the last 20 years, "enabling technologies" have surfaced that have changed the TPO landscape. Formulations now benefit from improved polypropylenes, elastomers, additives, fillers and reinforcements, and compounding processes, all of which lead to the development of true "engineered polyolefins." Early examples of the latter were TSOP (Toyota Super Olefin Polymer) and Ford's material choice for its first thin-walled TPO bumper fascia (2.2-2.6 mm). Improvements in the injection molding process and sequential gating technology helped to bring these applications forward.

Slides 6, 7, and 8 – Key Enabling Technologies, Materials Overview, Polypropylene Evolution for TPO and Engineered PP

Let's now go back and review some of these enabling technologies in more detail. A key one is polypropylene (PP). It's well-known for low density, reasonable stiffness (modulus), good colorability, and excellent processability. It can be readily stabilized for thermal and UV exposure, making it suitable for interior, exterior and underhood applications. Additionally, it easily incorporates a wide variety of fillers and reinforcements, thus expanding the property profile envelope of the compounds in which it's used.

Even before the advent of TPO, polypropylene was going through a critical change in its manufacturing processes because of cost, yield, and environmental issues. The first-generation PP plants, eventually phased out by the late 1990s, used low yield (by today's standards) catalysts that required washing to remove catalyst residues and needed a solvent recovery step. They were also limited in their ability to make copolymers which, in the early days of TPO, meant that the elastomeric components had to come from a secondary process.

Starting in the 1980s and continuing today, most homopolymer and copolymer PPs come from modern bulk or gas phase polymerization processes made possible by high yield catalysts. Alterations to the catalysts also led to the production of copolymers capable of containing up to approximately 30% ethylene propylene rubber (EPR), and eventually, with high porosity catalysts and "gentle" gas phase processes, the rise of so-called reactor TPOs (RTPOs). RTPOs offered advantages in consistency and cost, but had the disadvantages of long molding cycle times, "floppiness" (low stiffness) of parts during demolding, and the need for almost full support during painting to limit part distortion. Ultimately, their use diminished as the demand—driven largely by the TSOP series of TPOs—for higher flow, higher stiffness, low CLTE (for "zero gap" designs) and improved part cosmetics (low flow marks or "tiger stripes") surfaced.

Slides 9, 10, 11, and 12 - Elastomer Modification of PP, Bale Form of EPR or EPDM for TPO Compounds, Rubber Technology Applied to TPO, Continuous Pelletization from a Batch Process Mixer

Looking at the early generations of TPOs from an elastomer perspective, we must bring in the rubber compounding industry. Formulations that contained large amounts of elastomer required different mixing technologies. Relatively low crystallinity elastomers, which were required to meet low temperature impact requirements, tended to fuse into blocks. The emerging TPO industry really had only 2 choices, 1) use plastics compounding technologies, i.e., extruders, to partition elastomer into pelletized polyethylene or polypropylene masterbatches, or 2) use baled elastomer and sigma blade mixers, e.g., Banbury, Bolling, Kobelco, etc., and guillotines (to cut the elastomer into appropriate proportions) to essentially produce TPOs in a one-step process. While still in use today, more often to make TPVs or other high rubber content compounds, they were largely replaced by twin-screw extruders with the advent of pelletized "plastic elastomers" (plastomers). Plastomer development and the commercialization of metallocene catalysts were revolutionary in their impact on the TPO industry, their most significant contribution being the simplification of TPO compounding using twin-screw extruders.

While we don't often consider this, the two key milestones in TPO development really relate to the development of new catalyst systems for PP and plastomers that resulted in much improved polyolefin building blocks and more favorable costs, both of which helped this industry grow.

Slides 13 and 14 – Rubber Particles: Dispersion and Distribution, Twin-Screw Extruder

As mentioned previously, most of today's TPOs and engineered polyolefins are produced using twin-screw compounding extruders. They are key in producing materials with appropriate morphology and microstructure. Homogenous distribution and dispersion of critical components, including polymers and elastomers, reinforcements, and even pigments, ensures enhanced performance. These machines can be set up in a variety of ways that allow sequential addition of additives (solid or liquid), varying degrees of mixing intensity using a broad range of elements, and more concise control of temperature, mix intensity, and residence time. Their ability to gently disperse and distribute materials using custom screw configurations has also allowed them to be effective in dispersing pigments, fine talc, and fibers while still maintaining good fiber length. They can be scaled up from small experimental machines to large machines providing very high output even with complex, multi-component formulations. Their flexibility has made them the standard for producing TPO and engineered polyolefins from very low to very high modulus. Twin-screw extruders were available when TPOs were first becoming a key material for automotive applications, but their inability to handle various forms of baled rubber limited broader utilization until the advent of pelletized plastomers.

Slides 15, 16, and 17 – Reinforcements for Polyolefins, Talc Reinforcement for TPO, Reinforcements Summary

As varied as the polyolefin/plastomer/elastomer components are, so too are reinforcements. These generally fall into 3 categories: man-made, naturally occurring, and renewable. Man-made reinforcements can be of many shapes but they're typically fibers. These fibers can be relatively flexible (nylon and polyester), or extremely rigid (glass and graphite). They can be hollow (glass bubbles and carbon nanotubes) or round and solid (glass beads). All have their place as reinforcements depending on the application target. Most of these are surface-treated so that they chemically interact with the polyolefin matrix.

Naturally occurring minerals can be fibrous in shape like wollastonite or asbestos, platey in shape like talc and mica, or roughly spherical like calcium carbonate and clays. All except talc, are surface modified, e.g., with organosilanes or fatty acid salts, to improve wettability and/or adhesion to the polymer. Performance of the final compound is very much associated with the particles' overall size and size distribution, shape, aspect ratio—length/diameter (higher is better for reinforcement)—and dispersion/distribution in the polymer, rather than with the chemical composition of the mineral itself.

Renewable materials containing natural fibers like cellulose are starting to be used because of their relatively high stiffness-to-mass/density ratio, but their relatively low thermal stability remains a challenge.

As an example of how the reinforcement industry has adopted and improved performance, consider the range of talc particle sizes used in conventional TPO. In the early days of TPO compounds, talc in microcrystalline form was widely used, but as demand grew for better stiffness, impact and flow, macrocrystalline talc that could be delaminated into thinner, higher aspect ratio platelets was widely adopted. As delamination increased to finer particle sizes, color control also became an important factor, especially in TPOs designed for interior applications.

Slide 18 – Stabilization and Additives

Additives have also played a significant role in the development and maturation of TPO and engineering polyolefins. Improvements in phenolic stabilization along with several co-synergists have resulted in better heat aging performance. (PP-based materials can fail catastrophically if stabilization is not validated in the composition.)

UV stabilization packages have evolved over time to be more efficient. Their compatibility with the polymer and their mobility can relate strongly to their effectiveness. In interior applications, additives that reduce surface tension and tackiness can result in molded-in color compounds that have much better scratch and mar resistance.

Slides 19, 20, and 21 – Future View, Conclusion

Looking ahead on the polypropylene front, we see higher PP capacity in NAFTA and improved monomer supply from propane dehydrogenation. Highly controlled, multi-step reactors portend a wider variety of products. Improved/hybrid (titanium and metallocene) catalyst technology will produce PPs with higher isotactic content (lower xylene solubles) and improved performance of the bipolymer (EPR) phase.

Plastomers/elastomers will also benefit from catalyst improvements, e.g., lower densities, better branching control by catalyst ligands, and improved control of monomer sequencing.

Compounding is poised for higher output of commodity grades, better control of specialty materials, in-line color monitoring and closed loop pigment feeding. Technologies to minimize reinforcement damage during compounding will be further explored.

More emphasis will be placed on stronger, lower density, colorable, and renewable fillers and reinforcements. Improved aspect ratio will always be part of the equation.

Stabilization technologies will emerge that provide enhanced durability and thermal protection. Efforts to improve UV stabilization will continue.

Overall Presentation Summary

Over the last 20 years, enabling technologies have significantly altered the TPO landscape. Formulations now benefit from improved polypropylenes, elastomers, additives, fillers and reinforcements, and compounding processes.

The development of high yield catalysts for PP and metallocene catalysts for plastomers were two key milestones that resulted in greatly improved polyolefin building blocks for TPO formulations. High performance PPs and pelletized plastomers, along with specialty fillers and reinforcements could be transformed into "engineered polyolefins" using highly adaptable twin-screw extruders.

It is expected that future advances in these enabling technologies will expand the material properties envelope for automotive grade TPOs, thus continuing to make them the material of choice for tomorrow's even more demanding interior and exterior applications.

Have Plastic Surfaces Been Enhanced?"

Dr. Rose Ryntz, Vice-President, Global Advanced Development and Material Engineering
International Automotive Components | Narrated for the 2018 TPO Conference by David Blank

Slides 1 and 2 – Introduction, Outline

Today's presentation will first take a brief look at the trend in automotive plastics usage, the myriad of applications in the vehicle, market drivers, and the impact of weight on fuel consumption. We'll then review TPO surfaces and how they're affected by process and "real world" conditions in the field.

Slide 3 – Automotive Plastics Usage

This chart, compiled by Grand View Research in February of this year, shows automotive plastics usage between 2014 and 2026. Note that PP and TPO are the major contributors to steady growth between now and 2026.

Slide 4 – Automotive Plastic Applications

This is a familiar 2016 pictorial from the American Chemistry Council that shows the wide variety of application/material types in a "typical" vehicle. In the last 20 years, components that were made from styrenics, polycarbonate (PC)/styrenic alloys, PC/PBT alloys, and nylons have now been replaced by olefinic compounds.

Slides 5 and 6 – Plastic Application Market Drivers, Weight Impact on Fuel Consumption

I'll close out my introductory comments with a summary of market drivers and the impact of weight on fuel consumption. Key plastic application market drivers today are weight reduction, craftsmanship, safety, toughness/strength, durability, recyclability, and odor. The first one, weight reduction, plays an important role in fuel consumption.

Using a current average vehicle weight of 3,755 lbs. and the premise that a 10% reduction in weight results in a 6% improvement in mileage, MY2025 vehicles will have to be 558 lbs. lighter to meet 54.5 mpg CAFE.

Slide 7 – Painting Thermoplastic Olefins

Here's a brief primer (no pun intended) on painting TPOs. Since adhesion is achieved through mechanical interlocking of the coating, penetration of the paint into the plastic surface must be achieved. Most often, solvents from the paint migrate through the weak boundary layer (amorphous PP) of the substrate and interact with the elastomeric portion of the composition, causing it to swell. The swelling of the elastomer can lead to sub-surface swelling.

Slide 8 – Surface Aesthetics

A typical painted TPO surface includes about 0.25-0.35 mils of adhesion promoter (AP), 1.0-2.0 mils of basecoat (BC), which is color-dependent, and 1.5-2.0 mils of clearcoat (CC).

Slide 9 – Solvent Effect on Swellability

As discussed on the previous slides, solvents from the primer penetrate the surface of the substrate, swelling its elastomeric portion, resulting in mechanical interlocking. In solventborne primers and adhesion promoters, solvents with low solubility parameters such as heptane and aromatics (toluene, xylene) are more effective.

Slides 10 and 11 – Free Solvated Fluorescent Dye Penetration (Room Temperature and 121°C)

The degree of penetration of an adhesion promoter can be determined by attaching a fluorescent dye to the backbone of the chlorinated polyolefin, formulating the primer with selected solvents, cross-sectioning the resultant painted TPO, and analyzing the cross-section with a fluorescent microscope. At room temperature, the depth of penetration is about 150 microns (6 mils).

Since solubility parameter solvents, e.g., a waterborne primer, cannot always be used, heat must be applied to attain a degree of penetration. With increased heat, the depth of penetration of a solventborne primer is enhanced considerably (to 600 microns, 24 mils).

Slide 12 – Damage Resistance of Painted and Molded-In Color Composites

This broad topic includes gouge, weathering, hydrolytic stability, colorfastness, and scratch/mar.

Slide 13 – Damage Resistance of Painted and Molded-In Color Composites, Gouge

A discussion on gouge usually involves adhesion and cohesion, or adhesive vs. cohesive failure modes.

Slides 14 and 15 – Measuring Adhesion, Peel Strength/ Fracture Toughness

The adhesion of an AP/BC/CC layer on TPO is measured using peel strength technology. By placing a polyester scrim mesh between the clearcoat (a two-pass paint system), one can then use the mesh as an anchor to pull the paint from the substrate to measure the adhesive/ cohesive strength of the painted plastic composite.

By using a "fracture toughness" measurement (paint peel from the substrate), a reactor TPO exhibits a higher, less cohesively-fractured surface than that of a similarly-painted compounded TPO. Areas near the injection gate show lower adhesive/cohesive values than those farther from the gate.

Slide 16 – Damage to TPO Fascia

Evidence of "gouging," or cohesive delamination within the painted TPO composite, is easily seen in the field. A bumper fascia that experienced some sort of impact shows an area of cohesive delamination like that of the compounded TPO in the previous "fracture toughness" slide. However, this in an impact/sliding event, not a peel event. To understand this mode failure, another test method was developed.

Slide 17 – Surface Gouge in TPO, Cohesive Delamination

Further examination of other damaged bumper fascias revealed cohesive damage within the TPO substrate, where strands of TPO material elongate and tear. The root cause turns out to be cohesive delamination of a weak boundary layer (WBL).

Slide 18 – Weak Boundary Layers in TPO

This boundary layer can vary with the distance from the gate of a molded part. This picture shows a cross-sectional view of an injection molded substrate using a polarized microscope. The birefringence is caused by the degree of orientation of the polymeric composition within each layer. Near the gate, which freezes off quicker than away from the gate, more to less amorphous layers form going from the surface of the substrate to the core. These are the "boundary layers" that can vary in cohesive integrity depending on the composition of the material.

Slide 19 – Friction-Induced Gouging in Painted TPO

When the painted surface of a TPO substrate is compressed in shear, a gouge is formed. Painted-to-painted bumper impact, for example, can cause this type of damage. The depth of the damage in the paint and the substrate can be predicted.

Slide 20 – Cohesive Integrity of Frozen Layer Fraction

The cohesive integrity of the surface is dependent upon the applied stress, the depth of the WBL, and co-miscibility of the alloy. When the yield strength is measured in the flow (M) vs. cross-flow (Y) direction, the variation in strength is not significant, but the depth of the skin layer is. Injection molding parameters such as injection speed, injection and pack pressures, and melt and mold temperatures can affect boundary layer thickness.

Slides 21 and 22 – Gouge Testing Apparatus, Gouge Nomenclature

Tribology is the study of friction, wear, and lubrication; the science of interacting surfaces in motion. The apparatus shown here runs with precise control of temperature, velocity, acceleration, and load. It's able to quantify the durability of a surface, e.g., painted TPO. Friction-induced paint damage (FIPD) is assessed when a load is applied to a surface at a given shear rate.

Slide 23 – Effect of Molding Conditions on Cohesion

It helps one evaluate things like the effect of molding conditions on cohesive strength. For example, FIPD of a surface has been shown to vary with distance from the gate, i.e., higher near and lower away. As discussed previously, molding conditions and distance from the gate can play a significant role in the damage that occurs in a compression/shear event.

Slide 24 – Gouge Delamination as a Function of Gate Location

Weak boundary layer formation affects the degree of sub-surface cohesion in painted TPO substrates. Nearer the gate, the frozen layer fractions contribute to sub-surface weakness vs. farther away from the gate.

Slide 25 – Clearcoat Type vs. Gouge Performance

This chart clearly shows that gouge performance can be affected by clearcoat type. In this case, clearcoats with slip additives and/or higher crosslink density can eliminate gouge damage over a range of laboratory test conditions. However, this doesn't necessarily mean that the same results will be realized under more severe conditions in the field.

Slides 26, 27 and 28 – Damage Resistance of Painted and Molded-in Color Composites, Weathering of Damaged Painted Plastic, Molded-in Color Parts and Body Paint

Weathering resistance of painted metals and molded-in-color plastics has been widely studied. RIM bumpers, when damaged by something like stone chips, experienced poor durability to outdoor exposure because of the aromatic nature and poor weatherability of the urethane substrate.

In attempts to improve painted plastic durability, the automakers migrated to PBT/PC alloys, but the PC was easily crazed by improperly formulated paint resulting in easily cracked substrates.

The move to olefinic substrates—believed to have good weatherability—for molded-in color exterior parts was not without its problems . . .

Slide 29 – Ultraviolet Light Absorber Migration

UV light absorbers migrate not only within paint layers, but also within TPO. As the UV absorber migrates to the surface, or if the WBL is abraded, the effect of molding conditions (distance from the gate and weld lines) can easily be visualized. Generally, UV absorbers are distributed from the surface and increase in level deeper into the sub-surface.

Slides 30, and 31 – Damage Resistance of Painted and Molded-in Color Composites, Hydrolytic Stability, Cracking

The ability of a substrate to withstand high temperature and humidity conditions (hydrolytic stability) is of paramount importance. Interactions between hindered amine light stabilizers (HALS), humidity, and PC or PC alloys can cause polymer chain bond breakage, leading to cracking.

Slides 32 and 33 – Damage Resistance of Painted and Molded-in Color Composites, Colorfastness

Colorfastness, or the ability to withstand color change upon exposure to nitrous oxides, is also dependent on plastic composition and the additives in the formulation. Loss in colorfastness, e.g., fading, can be caused by interactions between phenolic antioxidants—required for heat stability—and gaseous oxides of nitrogen (NxO). There are, however, non-phenolic stabilizers that eliminate or minimize this problem.

Slides 34, 35, 36, 37, 38, and 39 – Damage Resistance of Painted and Molded-in Color Composites, Scratch/Mar, Scratch Resistance

Surface damage resistance to mild abrasions or scratches is also important. Scratch resistance applies to painted and molded-in color parts. "Scratch" normally implies a surface disturbance that removes material and lightens the disturbed area. "Mar," on the other hand, displaces material and usually results in a darker, glossier disturbed area.

Scratch and mar resistance can be assessed using a variety of tests and equipment, e.g., the "Ford 5-Finger Scratch Test (FLTM BN 108-13), nano-indentor scratch, crockmeter, and Erichsen Scratch. All involve testing a surface with a certain type and configuration of indenter under a prescribed load a given velocity. Images can be obtained that show the degree of penetration into the surface of the substrate and the degree of fracture in the displaced material.

Slide 40 – Strain Distribution

Plastic materials are affected by the cone's angle and the depth of the indenter used in a scratching event.

Slide 41 – Scratch Maps for Polymers

The load of the applied indenter and the cone attack angle affect plastic behavior in the damage event, ranging from an elastic (self-healing) event all the way to a brittle failure as the load and cone angle increase (back to Von Mises yield stress), especially important when exacerbated by weak boundary layer thickness and integrity.

Slide 42 – Scratch Elastic Recovery of 3 TPOs ("A", "B", and "C")

The ability of a TPO to recover from a scratch incident affects the degree of permanent damage and visual scratch assessment. This chart shows Scratch Depth (µm) vs. Scratch Length (mm). At the end of the test, original penetration was high with TPO "A" (50 µm) compared to 25 µm and 30 µm for "C" and "B" respectively. The residual depth after recovery ranged from 2-10 µm. Interestingly, TPO "A" recovered the most, followed by "B" and "C". In other words, don't judge the results of this test immediately thereafter.

Slides 43 and 44 – Damage Resistance of Painted and Molded-in Color Composites, Composite Additive Effects on Tooling

Molding effects on the substrate are of paramount importance, but the composition of the substrate and its effect on the tool are also studied. Interactions between composite additives and process may cause premature tool wear. Such interactions could affect part surface appearance and integrity. MuCell introduction, and its effect on glass sizing and resistance to moisture experienced during rapid decompression near the gate, can lead to acidic and glass wear near the gate.

Slide 45 – The Overall Goal (. . . has been and continues to be . . .)

A systems approach to product performance that considers material science and process control (substrate composition, molding robustness, plastic type, and paint composition), composite reliability and robustness, adhesion/cohesion, and surface damage resistance.

Slide 46 – Conclusion

Thank you.

Overall Presentation Summary

Over the last 20 years, there's been a shift in automotive decorated interior and exterior applications toward lighter weight, crafted appearance, and enhanced performance attributes, e.g., scratch and mar resistance, surface integrity and durability, and aesthetics.

A systems approach to product performance that considers material science, process control, and composite reliability and robustness will continue to be necessary in the search for the "Holy Grail," a non-damageable or self-healing surface that can be tuned for haptics, color, texture, and gloss, while maintaining low odor and low volatile organic compounds (VOCs).

Twenty Years of TPO and TPE Evolution in Auto Interiors and a Vision of the Future

Bob Eller, President, Robert Eller Associates LLC | Narrated for the 2018 TPO Conference by David Blank

Slides 1 and 2 – Introduction, The Humble Origins of our Conference

We've come a long way since 6 of us gathered at a card table in Norm Kakarala's garage back in the closing days of the 20th century. We've become a forum for automotive TPO and TPE technology, and a marketplace for supplier and customer interactions. Along the way, we lost one of our founders and a dear friend, Ron Price. I dedicate this talk to his memory.

Slide 3 – Today's Objectives

Today, I want to examine the evolution of automotive interior grade TPOs and TPEs over the last 20 years with respect to material substitution driving factors, properties improvement, and the role of process technology. We'll also look at the supply chain and globalization (and reverse globalization) of the automotive market and the supply chain that serves it. Last, I'll provide a vision of the future.

Slide 4 – Early Days: TPO Sheet for IPs

This is an illustration of a 2001 Honda Civic instrument panel. The early days of thermoformed TPO sheet/foam IP coverings, TPO was doing battle with PVC skins. At that time, TPO was plagued with poor scratch and mar resistance, high scrap rates, and an inefficient process.

Slide 5 – Maturity Curve for Auto Interior TPOs and TPEs

The maturity curve for automotive interior TPOs and TPEs (demand volume vs. stage in the market) shows that TPO skins are now positioned in a state of maturity, sandwiched in between f-TPVs for glazing seals and rigid TPO/PP for IPs.

Slide 6 – TPO/TPE Interiors Evolution: Up the Value Curve

Increasing value over time shows that legacy TPOs and TPEs will undergo minor improvements in scratch resistance and haptics, coincident with advances in PP foams and in-mold decoration. Reduced fabrication steps result from back injection, multi-shot and in-line compounding/injection molding, extension of reactive compounding, the use of foams in structural roles, and the growth of injection molded skins.

Higher value "smart" TPOs and TPEs, aided by new additives, come on the scene later and provide better acoustics and will be part of an array of new "smart" functions in the interior, e.g., sense, send/receive, display, etc.

Slide 7 – Kraton's Injection Molded Soft Skin (IMSS) Technology: A Fabrication Process and Material Evolution

Materials and processes can evolve together. Take, for example, Kraton's Injection Molded Soft Skin (IMSS) technology, a fabrication process and material evolution. SEBS can now be injection molded into a very large, thin part. An IP skin is pictured here but the process is applicable to other interior parts that require a soft touch skin, e.g., armrests, door panels, console components. Compound properties and tooling design were key contributors to this breakthrough. Features and benefits are numerous for this material/process evolution.

Slide 8 – Injection Molded Interior Skins: A Material/Process Evolution

They're shown in detail here. Material attributes like very high MFI (200), low density, cold temperature flexibility, and "clean" composition translate, respectively, to cost savings vs. slush-molded PVC, vehicle weight savings, safe air bag deployment, low odor, fogging, and VOC/SVOC emissions. Abrasion resistance is good (no special coating required) and a Class "A" surface is achievable without painting. Note: A few slides earlier—the Maturity Curve—this material/process was heading up the "Market Introduction" phase into the "Growth" category.

Slide 9 – Globalization Reverse Flow: Changing Interiors Supply Chain

The changing interiors supply chain features globalization "reverse flow." In the conventional sense, NAFTA/European OEMs look to Asia to benefit from high growth potential. Resins suppliers, compounders, and molders move similarly to follow OEMs and customers.

In the "reverse flow" scenario, Asian OEMs and Tier 1s set up shop in NAFTA/Europe regions by making acquisitions and forming joint ventures. Asian resin suppliers and compounders serve western OEMs by capitalizing on business won in Asia, exploiting cost advantages, and making acquisitions.

Slide 10 – TPO/TPE Competitions in Interiors

TPOs and TPEs compete for interior applications. Application incumbents are challenged by a variety of related, but different, materials. For example, silky feel s-TPV steering wheels are starting to be pursued by f-TPVs and SEBS. Other applications in various states of transition are IP skins, door trim, seals, and gaskets.

Slide 11 – Rebirth of High Melt Strength (HMS) PP

Another interesting transition involves the rebirth of High Melt Strength Polypropylene (HMS PP). HMS PP is a unique type of PP that's suitable for foaming, blow molding, twin-sheet forming, and the thermoforming of large parts, especially those with deep draws. It's currently used as a headliner substrate and has potential in foamed HVAC ductwork. Non-interior applications for HMS PPs could include underbody shields and truck bed liners.

Slide 12 – Air Ducts: Targets for HMS PP Foams

As mentioned previously, HMS PP foams are targeted for air ducts. There are over 10 air ducts in a "typical" vehicle, implying that the potential for this material/process combination is significant. Drivers are reduced weight and BSR (buzz, squeak, and rattle). The HMS PP foam example shown here is produced by Sekisui Alveo AG using a twin-sheet forming process.

Slide 13 – TPO/PP/TPE Foams Have Grown and Will Proliferate in Interiors

Foams made from PP, HMS PP, TPO and TPE will proliferate in interiors. In 1999, PP foam was laminated to PVC — and to some TPOs — for instrument panel skins. The product/application mix in 2018 is varied. In addition to the aforementioned PP foams for headliner and ductwork applications, we see, for example, PP foams laminated to TPO sheet and textiles, SEBS foams, and olefinic TPV (o-TPV) foams for body seals.

Slide 14 – Future Vision: What Will Drive Interior TPOs and TPEs?

The concept of the vehicle interior and, therefore, the functions to be performed, are changing and creating new opportunities for TPOs and TPEs.

Slide 15 – The Requirements Have Changed and Will Drive Future Innovation

Requirements have also changed, and they'll continue to drive future innovation. On the regulatory side, FMVSS201 in 1998 was the stimulus that allowed improved TPOs to proliferate in the interior. More stringent head impact [HIC(d)] requirements increased the use of high impact PP copolymers and TPOs, and the need for low odor, fogging, and VOC/SVOC emissions furthered the use of polyolefins in general.

A few others are the need for better feel, e.g., soft touch, improved scratch and mar resistance, better acoustics (lower BSR), recyclability, and, of course, lightweighting. The latter will be front and center to offset weight gains from added componentry and the growth of autonomous/semi-autonomous vehicles and hybrid electric/electric vehicles (HEVs, and EVs).

Slide 16 – EV/Autonomous Car: New Functions ☛ TPE Opportunities/Challenges

EVs and AVs create new functions and new opportunities/challenges for TPEs. New functions include image projection/display, sensing/touch, and signaling/data transmission. As a result, opportunities may emerge for new, more advanced fillers and reinforcements, and transparent materials. Challenges include the need for continued lightweighting, improved EMI shielding, and better acoustics.

Slide 17 – Autonomous/Semi-Autonomous Vehicles: Effect on TPOs, TPEs

Concentrating on AVs for a moment, some key motivators are 1) less driver attention is required, 2) less or collision risk, 3) display lighting, and 4) signaling and voice activation. If we look at what effect each of these has on the interior, what plastic materials may result therefrom, and what interior parts are affected, we end up with something like:

- Less Driver Attention ☛ Increased Luxury ☛ Softer Touch ☛ Skins, Touch Surfaces
- Lower Collision Risk ☛ Lower HIC(d) ☛ Wider Materials Choice, Lower Impact ☛ Pillar Trim, IPs, Headrests
- Display Lighting ☛ Interior as a Display Surface ☛ Luminescent, Conductive ☛ Headliners, IP Clusters
- Signal/Voice Activation ☛ Smart Surfaces ☛ Acoustical Damping, EMI Shielding ☛ Skins, IPs, Consoles

Slides 18 and 19 – Smart Surfaces via Injection Molded Structural Electronics (IMSE) Will Grow in Interiors—TPEs/TPOs Will Benefit, Examples of IMSE Automotive Application Areas

Smart surfaces via Injection Molded Structural Electronics will grow in interiors, and TPEs and TPOs will benefit. Some examples, courtesy of TactoTek, are shown here. They include multi-function headliners, overhead control panels and seatbacks, smart steering wheels, door handles, and tailgates, and illuminated ventilation trim panels and controls.

Slide 20 – Potential Interior Surfaces for Image Projection and Lighting Surfaces

Elaborating further on illumination, we see that there are many potential surfaces for image projection and lighting, e.g., headliners, upper inner firewalls, and the backs of front seats. These surfaces can be "smart" for command transmission and signaling functions.

Slide 21 – Value Add Examples: Interior Components as Sound System

The value-added concept here is that components can be an integral part of a sound/signal system. Enabled by the transducer, targeted examples are package trays, pillar trim, door trim, and seat backs. Such systems will be on the level of "premium sound" and will benefit from weight savings vs. conventional speaker systems. Challenges exist, however, in the areas of controlling BSR and integrating smart technologies.

Slides 22 and 23 – Designed Additives/Fillers ☛ Role in TPOs/TPEs, Filler Structures: Tailored at Nanoscale via 3D Molding

Looking ahead, designed additives and fillers may play a role in further reducing weight by placing resin only where structural demands dictate and tailoring fillers at the nanoscale level.

Slides 24 and 25 – Presentation Summary and Conclusion

Growth of TPOs and TPEs in automotive interiors will be driven by technological advances in resin and compounding techniques, improved, fabrication processes, inherent properties advantage vs. incumbents, vehicle performance shifts, and changing regulations/specifications. Improvements in properties over the past 20 years have moved this family of materials up the value curve. In the coming years, value-add will be even greater via active additives that lead to new functions.

The interior footprint for PP, TPO, and TPE foams will broaden, driven not only by the rebirth of HMS PP, but also by advances in foaming and forming technology. Improved/tailored additives will play a role in improved TPO and TPE functionality.

Autonomous and electric vehicles (AVs and EVs) will be drivers for interior TPOs and TPVs, and there will be plenty of opportunities for TPOs/TPEs on their way to full implementation in many applications. Vehicle functionality will change. "Smart" applications will open up new opportunities for TPOs/TPEs in sending and receiving signals, displays, acoustics/entertainment, and interior lighting and signaling. "Bio" and recyclability will continue to drive material substitution where appropriate.

The supply chain has been and will continue to be reconfigured by acquisitions (on both the supply and demand side), globalization and reverse globalization, and tariffs(?)

Thank you.

Driving Innovation and Material Collaboration on Exterior Products

Mark Pilette, Global Product Line Manager of Exterior Trim, Magna Exteriors | Narrated for the 2018 TPO Conference by David Blank

Slides 1 and 2 – Introduction, 1998

2018, the 20th anniversary year of the SPE TPO Conference! In 1998, gas averaged $1.15 per gallon, average household income was $38K, the average cost of a new car was just over $17K, and thermoplastic olefins were already on the scene, continuing to expand their influence on automotive exterior applications

Slide 3 – TPO (Quick Look Back)

TPOs first started to appear in automotive exterior applications the mid-1970s. New federal bumper performance requirements had the bumper mounted on energy absorbing shocks which created a gap between the grille and the fenders. An urgent need developed for flexible body color filler panels and end caps to fill this gap. Over the next decade, improvements in material formulations and performance led to the first all-TPO front and rear bumper fascias on the 1985 Chevrolet Cavalier. TPO was chosen to replace RIM on this vehicle because of lower weight, lower cost, improved processing and part performance, styling flexibility, and recyclability.

Slide 4 – Extending Olefins

We see even more emphasis on these drivers today and continue to extend the use of olefins in exterior applications. Why? As fleet CAFE requirements are scheduled to increase to 54 mpg by 2025, lightweighting will continue to increase in importance. Collaboration between OEMs, material suppliers, and part suppliers (many of whom are in this room today) has allowed us to reduce material density and wall thickness without sacrificing performance and perceived quality. New body panel TPOs and PP-based material formulations have made it possible to replace traditional modules and components such as liftgates, fenders and spoilers while, at the same time, offer more styling and design freedom, part integration, and additional weight reduction.

Slide 5 – Transforming TPO

With the focus on lightweighting, we're now further transforming TPO. The collaboration process will continue to help us move forward in our search for possible replacements of traditional metallic components such as vertical body panels, doors, hoods, and decklids. Advanced joining and welding technologies will be necessary to enable the realization of these TPO applications and support sensor integration needed for autonomous driving.

Slides 6 and 7 – Global Megatrends and the Automotive Industry

To understand what's having an impact on change, let's first look at some global megatrends and correlate them to automotive industry trends. Three categories of drivers of innovation are active safety connectivity/autonomous driving, legislative/regulatory and comfort/convenience. When we look at what those drivers mean to automotive, three industry trends rise to the top: the electrification of the powertrain, the influence of autonomy, and new mobility concepts that may change the landscape of vehicle ownership as we know it today.

Slide 8 – Exteriors – Electrification Impact – Active Aerodynamics

In 2017, global electric vehicle (EV) sales totaled 1 million units, about 1% of the global market of 95.5 million units, according to HIS Markit. By 2030, we expect the EV market to grow to 9-17% of the global market. The focus will be on drag reduction to improve EV range. The trend toward more CUVs/SUVs, which have inherently higher drag, will increase the need for active aerodynamics in the form of active body systems and splitters/diffusers/spoilers. The lightweighting capabilities of the family of polyolefins will become increasingly important in this arena.

Slide 9 – Exteriors – Electrification Impact – Liftgates and Exterior Modules

Electrified powertrain architectures shift the need for mass reduction to the rear of the vehicle. By 2025, more than half of all vehicles produced will contain a hatch or liftgate rear closure. CUVs/SUVs present increased opportunities for lightweighting. Liftgates and rear modules, once metal-intensive, are now focused on additional material solutions to enhance mass reduction in the rear of the vehicle.

Slide 10 – Exteriors – Electrification Impact – Front End Modules, Fascias, and Trim

EV cooling airflow needs are significantly different than those in an ICE (Internal Combustion Engine) architecture. This enables the design studio and marketing to re-imagine the grille area for unique EV product differentiation.

Slide 11 – Exteriors – Electrification Impact – Lightweight Composites

Potential exists here to lower weight and reduce the cost of charge port doors and openings.

Slide 12 – Exteriors – Vehicle Autonomy Impact – Autonomous Driving Level

There are 5 levels of autonomy as defined by SAE, ranging from 0 (no automation) to 5 (full automation). It's safe to say that many sensors need to be integrated, even in Levels 3 (conditional automation) and 4 (high automation). We don't expect to see full autonomy beginning to take hold until at least 2025.

Slide 13 - Exteriors – Vehicle Autonomy Impact – Fascias and Front End Modules

Seamless integration into the fascia will be key for styling. Front end modules will be the backbone for the longer-range sensors, while the fascia provides adequate stability for short- and mid-range ones. Transparency to sensor signals will need to be established and monitored.

Slide 14 – Exteriors – Vehicle Autonomy Impact – Fascia Manufacturing Requirements

Increased validation and new internal processes will be necessary. These include thickness monitoring for plastic and paint, traceability of manufacturing data for safety parts, sensor alignment verification, and sensor intensity (functional performance) verification.

Slide 15 – Exteriors – Vehicle Autonomy Impact – Liftgates and Exterior Modules

The integration of additional sensors, e.g., rear-viewing cameras, to replace conventional mirrors will occur.

Slide 16 – Exteriors – Vehicle Autonomy Impact – Lightweight Composites

Here there is potential for roof sensor array modules with further integration into the vehicle design.

Slides 17 – Sensor Integration – RADAR, LIDAR, Camera

Advanced plastics are critical to future sensor integration that will enable autonomous driving. We're working with plastic material supplier partners to develop thin wall materials so that we can add sensors without increasing weight. We're also looking at the development of materials that sensors can transmit signals through. In this photo, one can see where RADAR and LIDAR (a detection system that works on the principle of radar but uses light from a laser) are integrated without the need for a component roof module. The reason for showcasing the Max4 vehicle is to say that one can have a vehicle with a high level of autonomous functionality and still maintain the vehicle's DNA without sacrificing the overall styling theme. To do this, we'll need to ensure that the materials we choose integrate well and enable sensor functionality. TPOs and PPs are and will be instrumental in this effort.

Slide 18 – Exteriors – New Mobility Impact – Fascias and Trim, Front End Modules, Cargo Closures, Exterior Panels

Now let's look at the impact New Mobility has on the exterior. Ride Share/Ride Hailing means less ownership because people only use vehicles when they're needed. While functionality is likely most important, design will still play a role and lightweighting will still be necessary to extend vehicle range.

For fascias and trim, designs will be simple and low cost. Molded-in color (MIC) parts—primarily single colors of white, gray, and black—will be more prevalent. Improved scratch and mar performance is still a "must have."

Front end module design will be dependent upon OEM modular assembly strategy. Simple assembly methods and component standardization will be factors to consider.

Cargo closures will also be of simple and cost-efficient designs. The number of features will be reduced to further lower cost, e.g., no rear glass.

Exterior body panels will include closures made from thermoplastics. They may also have integrated lighting and displays for advertising and notification purposes.

Slides 19 and 20 - Advanced Joining and Welding – No Localized Thickening, No Additional Adhesives

Many of the advancements cited earlier will demand new and innovative joining and welding processes. I want to take a moment to thank the SPE and the SPE TPO committees for the annual awards programs they conduct. It's a tremendous collection of industry innovation from which we've learned so much. We've been fortunate, along with technology, material and OEM partners, to be recognized several times. The torsional welding process presents a new way to join plastics. It features a high-speed twisting motion that creates enough friction-based heat to join a plastic bracket to a thermoplastic fascia. Torsional welding enabled us to offer a 2.5 mm wall fascia on the Skoda Octavia without the need for localized thickening.

Slides 21 and 22 – Thermoplastic Liftgate – Jeep Cherokee, Acura RDX

Building off of our proven success with thermoplastic liftgates on the Nissan Rogue and BMW I3, we have 2 recent examples, 1) the 2019 Jeep Cherokee liftgate that was created in partnership with FCA. (It's one of the highest volume thermoplastic liftgates to date.) and 2) the 2019 Acura RDX, which just began production in North American and begins in China next month. We continue to see huge potential for plastic liftgates in today's market today. Why? Reduced complexity and higher component part integration (overall lower part count), modules with a TPO outer panel and a long glass-reinforced PP inner panel achieve up to 25% weight savings over steel versions, greater design flexibility with deeper draws and tighter radii, lower tooling investment, and increased assembly plant throughput.

Slide 23 – Future Exterior Needs

The automotive industry is changing rapidly. From an exterior applications perspective, these are exciting times. We will continue to be challenged by

- Additional weight savings to offset the additional features that need to be integrated for future mobility.
- OEM Partners who want more styling and design freedom that advanced plastics can offer.
- The end customer who wants more consumer benefits and a lower cost of ownership.

Slide 24 – Design Flexibility

Not knowing exactly what the next generation of vehicles will be —slow, fast, autonomous or electric, curvy or boxy — we must bring new materials and methods to the forefront to further reduce weight and cost and enable even more exciting design themes. With EVs for example, there'll be no need for a grille. This will create a lot of possibilities for integration of ADAS (Advanced Driver Assistance Systems).

Slide 25 - Boldly Imagining the Car of the Future

Looking ahead, it's clear that no matter what future mobility looks like, it's certain that vehicles will still have exteriors. Cars will look different, but many will still need beautiful shapes, beautiful finishes, and an ever increasing level of functionality. Advanced plastics will help us get there as they enable sleek contouring and styling freedom for designers as well as the ability to integrate various systems.

Slide 26 – Advanced Materials

What new materials will enable the future? Graphene-enhanced tailgate panels, like those prototyped for W Motors' FENYR Supersport.

Graphene may enable new possibilities for PPs and TPOs, possibly providing

- Improved thermal conductivity for faster material processing.
- Enhanced nanocomposites to improve mechanical properties, e.g., impact/stiffness balance, possibly allowing the production of even thinner body panels.
- Higher electrical conductivity to improve paint transfer efficiency and "further out" touch screens and sensors.
- Super conductivity for enhanced energy transfer and storage.

Sides 27 and 28 – Extraordinary Customer Experience – Innovation Strategy – Technology, Material Science, Design, Conclusion

To get us where we want to be starts with innovation. To bring our ideas home, we need to focus on investment in technology, material science, and design. Collaboration with OEMs, material suppliers, technology companies, governments, universities, etc. will help us create extraordinary customer experiences!

Overall Presentation Summary

Since TPOs first appeared on the scene in exterior applications in the mid-1970s, more emphasis has been and is being placed on the drivers for its use: lower weight, lower cost, improved processing and part performance, styling flexibility, and recyclability. Extending olefins and TPOs into more applications will be necessary to offset the impacts — primarily weight related — of CUV/SUV growth, and vehicle electrification, autonomy, and mobility.

Liftgates, exterior and front-end modules, body panels, bumper fascias, and trim will come under scrutiny as future growth targets and candidates for further lightweighting. (Remember, MY2025 CAFE at 54 mpg!) The search for more metal replacement opportunities and the increased use of lightweight olefin-based composites will be part of this effort.

Advanced joining, welding, and molding techniques, part and sensor integration, reduced part complexity, heightened collaboration, advanced materials, and last, but certainly not least — innovation — will create exciting times in the next 20 years!

Polypropylene and its Use in Structural Automotive Applications

Matthew Marks, Automotive Americas Senior Manager, Market Development and Technical Service, SABIC
Narrated for the 2018 TPO Conference by David Blank

Slides 1, 2, and 3 – Introduction, Mt. Fuji, The Great Pyramid

Mark opens his presentation with personal remarks about him climbing Mt. Fuji and then comments on how the shape of the pyramid applies later in his presentation.

Slide 4 – Pyramid of Plastics

The Pyramid of Plastics consists of many types of amorphous and crystalline polymers. Its wide base is comprised of standard resins like PVC, LDPE, ABS, and PP. The middle houses the more engineered materials, e.g., PBT, POM (acetal), polycarbonate (PC), and long glass fiber PP (LGF-PP). PEI (polyetherimide), PC copolymers, functional compounds and GFPP tape (GFPP laid up for thermoformed parts) reside in the less populated pinnacle of high performance plastics.

Slides 5 – Outline

In addition to the Pyramid, today we're going to look at global megatrends and automotive industry drivers, the growth of plastics in vehicles, PP-based structural materials and applications and future opportunities for high performance structural PP in ultra-thin wall parts.

Slides 6, 7, 8 and 9 – Megatrends and Industry Drivers, Global Megatrends Impacting Mobility in the Future

Global megatrends have a significant impact on future mobility. For example, population growth, urbanization, "smart" cities, and a "connected" planet result in increased e-mobility, car-sharing/car-pooling, and more integrated mobility solutions. These megatrends will slowly transform the mobility market into a more sustainable, integrated, connected, and automated mobility solution market.

Slide 10 – Global Automotive Market Trends and Needs

Today's automotive market is complex. Demands for lower emissions, better mileage, and more stringent regulations put pressure on lightweighting (mass reduction) and increased safety, cause growth in EVs and HEVs, and bring more attention to autonomous vehicles. A high level of collaboration in the automotive community is necessary now and, in the future, to achieve the best balance of performance, weight, cost, and aesthetics.

Slide 11 – Drivers for Material Technology Change

Accompanying market trends and needs are the drivers for material technology change. Better fuel economy and lower emissions translate to light weight plastics and polymer composites. Performance improvement implies body-in-white structures and energy management systems. Electrification means battery development and storage (housings) solutions. Added content results in light weighting and parts integration and consolidation to offset potential weight gain. Note: The opportunities for plastics in the autonomous vehicle sector are in very early development.

Slide 12 – Industry Research, Weight Reduction

Let's examine weight reduction in more detail. Four industry studies released in the August 2012 to June 2015 time frame predict achievable weight reductions ranging from a low of 18% in MYs 2017-2020, to a range of 20-31% in MYs 2020-2025. The thoroughness of these studies leads to greater confidence that more stringent fuel economy standards are not only feasible, but superior value can be delivered through aggressive development and implementation of plastics and polymer composites.

Slide 13 – Growth in Plastics

If we look at the long-term growth of plastics in the automotive industry, as was published in the Plastics and Polymer Composites in Light Vehicles Report published in November 2017 by the ACC (American Chemistry Council), we see steady growth of plastics all the way back to the 1960s. As this is the 20th anniversary of the TPO conference, we can look back approximately 20 years and see over 220 lbs. of plastic per vehicle in 1995 and over 320 lbs of plastics in 2015. That's 50 lbs. of plastics per vehicle added every decade — pretty impressive!

Slide 14 – PP Usage in Vehicles

As we look closer at the polypropylene market over the past 10 years, we see a low of approximately 76 lbs. of PP in 2008 to a high of 86 lbs. in 2017. Of course, there have been fluctuations over the years, including the downturn in the economy in 2009, a shift from more sedans to SUVs and light trucks, and I'll also note that this is the first year that the ACC will publish the data for all of NAFTA, including Mexico, Canada, and the U.S.

Slides 15 and 16 – Structural Materials, Key Drivers for Structural Materials

Application needs and metal replacement point out product solutions that involve structural composites, e.g., resins reinforced with minerals, glass, and carbon fibers.

Slide 17 – Product Tree

The PP composites product tree consists of continuous fiber and discontinuous fiber composites. The former includes things like glass and/or fabric tape, while the latter includes short and long glass fiber and glass mat technology.

Slides 18 and 19 – Manufacturing Methods, Production Processes for Long Glass Fiber Materials (GMT)

There are several production processes for long glass fiber (LGF) materials. I'll cover them individually and, later on, I'll show you which process was used to produce which parts. For now, the first process is glass mat technology (GMT). GMT uses PP-based materials in a 5-component, compression molding process to produce a random, chopped, unidirectional glass mat containing 30-45% glass. The resulting product has a good stiffness, outstanding toughness, and good chemical resistance. Typical "2½D" applications are bumper C-sections and battery trays.

Slide 20 – Production Processes for Long Glass Fiber Materials (D-LFT)

Direct long fiber technology (D-LFT) involves feeding continuous glass fibers and substrate (base plastic) into a continuous twin-screw extruder. The molten extrudate is accumulated and then injection molded into the desired part. This process focuses on high volume, less complex parts. Investment and quality costs are high, and it requires skilled labor to run highly specialized and dedicated equipment. Since this product is being produced in-house, material responsibility lies with the molder.

Slide 21 – Production Processes for Long Glass Fiber Materials (Pultrusion Process G-LFT)

Pultrusion process granulate long fiber technology (G-LFT) is a melt impregnation process that produces a glass-encapsulated pellet of about 12 mm in length. These pellets are produced at the material supplier and shipped/sold directly to the molder. Material responsibility is with the material supplier.

Slide 22 – Production Processes for Long Glass Fiber Materials (Wire Coating G-LFT)

Wire coating G-LFT uses wire coating technology and, in the case of STAMAX™, produces a pellet of about 15 mm in length. Since finished product is made at the material supplier and supplied to the molder, material responsibility rests with the material supplier.

Slides 23 and 24 – Modeling Methods, Long Glass Fiber-Reinforced Polypropylene

We've discussed some of the manufacturing methods for glass fiber reinforced PP, now we'll spend a few minutes discussing the factors that influence physical properties. The benefits of long glass fiber PP include strength, stiffness and impact, and we'll see how these benefits are leveraged and applied in automotive applications. But first, we need to understand the factors that influence these properties.

Slide 25 – Factors Influencing Material Performance

It's well known that many factors influence end use material and part performance. In compositions that contain glass fibers in a crystalline, high shrinkage base resin, e.g., polypropylene, fiber length, orientation, content, and dispersion lead to anisotropic shrinkage (warpage) and property behavior.

Slide 26 – Effect of Glass Fiber Orientation on Stiffness

Physical properties are affected by fiber length. In the world of long glass fiber polypropylene, we typically process the materials such that the average fiber length is between 2 and 4 mm. By contrast, processing of standard injection molded, glass-filled materials results in measuring fiber lengths in terms of microns, rather than millimeters—and you can see the result in terms of strength, stiffness and impact.

Orientation is also critical. By cutting tensile bar specimens from a large flat plaque in different orientations, the measured tensile modulus can vary from 3000 to 7000 MPa for an injection molded 30% long glass fiber material.

In this comparison, a high stiffness, unfilled PP has a tensile modulus of about 2000 MPa. In real world applications, one is rarely, if ever, purely at 0° or 90°; the norm is somewhere in-between. That's why it's important to understand these orientation effects.

And, of course, good dispersion of glass within the PP matrix is important. Proper screw design (general purpose, non-mixing) is required to get good homogeneous mixing of PP and glass without breaking up the fibers.

Proper development of quasi-isotropic material properties, along with a good understanding of anisotropic material properties allow designers to successfully develop applications in LGF-PP.

Slide 27 – Warpage Prediction Development

Over the past 20 years, we've seen significant improvements in material modeling, including—and importantly—warpage prediction. The industry has moved from measuring warpage on actual parts, to early simulation models, to more advanced models, all with the intent of providing the OEMs with more dimensionally consistent parts. More recently, we're taking this modeling a step further. We're using modeling methods to correct tool geometry to counteract the designed part with minimal warpage. Similar to "windage" cut into tools today, this new method is based solely on predictive modeling.

Slides 28 and 29 – Structural Applications, Typical LGF-PP Applications

Typical long glass fiber PP (LGF-PP) structural applications include front end modules, instrument panel carriers, center consoles, door modules, and tailgates.

Slide 30 – 20 Years of Innovation – Instrument Panels

Let's see how LGF-PP applications have progressed over the years. In the interest of time, I won't talk about all of them, I'll just highlight a few in each category. In 2002, Faurecia produced an in-line compounded IP for DaimlerChrysler using Dow PP and glass fibers. Progressing to 2017, you see examples of D-LFT, G-LFT, the addition of "air" through various foaming technologies, and thinner and thinner geometries, 2.0 mm or less on the Jeep Cherokee, for example.

Slide 31 – 2017 Body Interior Applications - Winner

Another thin-walled example is the BMW Mini Countryman IP carrier. This part is molded by IAC from a blend of SABIC LGF masterbatch and high MFR PP copolymer in a process incorporating structural foaming in a core-back process. It's lightweight, thin-walled (1.9 mm), and meets VDA 278 emission standards.

Slide 32 – 20 Years of Innovation – Front End Modules

A similar story in front end modules. 2007 saw Aksys De Mexico in-line compounding VW Bora, Golf, and Jetta front end carriers from Basell PP and Owens Corning fiberglass. In 2016, Shape corporation used Celstran® LGF-PP to produce a structural front end module for a Ford Super Duty truck. And in more recent developments, we've seen the adoption of active grille shutters to help improve aerodynamics as demonstrated on the Ford Expedition, molded in Celanese material at Magna.

Slide 33 – 20 Years of Innovation – Door Modules

In 2002, Faurecia produced a composite-sealed door module for the Ford Fiesta using SABIC LGF-PP. SABIC LGF-PP was also used by Arkal Automotive in 2010 for a Hyundai Sonata rear door module.

Slide 34 and 35 – Future Opportunities, Thin Wall Design with Standard LGF-PP

Thin wall designs are possible with LGF-PP. Conceptually, IP carriers from 2.2-3.0 mm down to 1.8 mm and door modules from 2.2-3.0 mm down to 1.3 mm! Enablers such as multiple gating, wall thickness optimization, and the use of anisotropy complement this effort. There are ample CAE data available today to provide meaningful mechanical and rheological simulations. Low cycle times and no additional tooling investments are foreseen.

Slide 36 – Ultra-Thin Wall (<1.4 mm) is Happening!

August 2016 was SOP for the BMW 5 Series air duct made from STAMAX™ LGF-PP20YK270E. This part highlights an injection molded partly thin wall solid (0.8 mm), partly core-back foamed (process similar to that used for the aforementioned 2017 BMW Mini Countryman IP carrier. As part of a collaborative effort, SABIC provided mold filling and warpage analysis, advanced processing simulations (sequential injection molding with melt compression) and application design suggestions.

Reliable engineering data allowed "designing to the edge" (<1.0 mm wall thickness) and showed that ultra-thin wall can be achieved with current grades and advanced processing.

Slide 37 – High Flow LGF-PP Grade Flow Behavior – Spiral Flow

The availability of high flow LGF-PP grades allows further wall thickness reduction. For example, at a melt temperature of 210°C and a wall thickness of 2.2 mm, the spiral flow length of a standard 20% LGF-PP grade is about 500 mm. Comparing this to a high flow grade at the same wall thickness, we see a flow distance of about 650 mm. More importantly, the high flow grade can achieve a flow length of 500 mm at only 1.7 mm, suggesting additional wall thickness reductions of 0.5 mm.

Slide 38 – What's Coming . . . and is it Here Yet?

They say a picture is worth a thousand words. This is a photograph taken at the SPE ACCE Conference. I pose these question to you, the audience. What's coming? How can we benefit from long, continuous fibers? What properties can we achieve? How can we take advantage of thin-wall molding? How can we utilize advanced insert molding techniques to take advantage of the physical properties of weaves and tapes, and the parts integration possibilities of injection molding? So many questions . . . so little time.

Slide 39 – In the Pyramid of Plastics, Structural PP is no Longer a Commodity

Structural polypropylene is anything but a commodity. We've shown here today, that through innovative material development, reliable engineering data, and advanced processing methods, we can continue to optimize the use of materials in semi-structural applications, and, with the need for further weight savings, open the door to additional metal replacement opportunities. Structural polypropylene has elevated itself to the level of an engineering thermoplastic.

Slide 40 – Thank you

Overall Presentation Summary

Demands for better mileage and lower emissions put pressure on lightweighting (mass reduction) and heighten attention on light weight plastics and polymer composites. Polypropylene, in general, and long glass fiber polypropylene (LGF-PP), in particular, will continue to play key roles as we gain greater confidence in meeting even more stringent future regulations.

A variety of production processes for LGF-PP materials make them suitable for structural applications such as front end modules, instrument panel carriers, center consoles, door modules, and tailgates. Effective modeling methods and a thorough understanding of the factors that influence material and part performance, e.g., the effect of fiber orientation on stiffness and warpage, will allow us to confidently expand the use of the LGF-PP product family. Advanced injection molding and forming techniques and the availability of high flow grades, will allow the production of even lighter, ultra-thin-walled (<1.4 mm) parts that could become the norm during the next 20 years.

Superior value will continue to be delivered to the automotive market sector with the aggressive development and implementation of LGF-PP materials. The optimization of their use in semi-structural applications, and the ever-present need for further weight savings, will open the door to additional metal replacement opportunities.

Structural polypropylene has, indeed, elevated itself to the level of an engineering thermoplastic.

20 Years of Developments in Process and Equipment Trends – What's Next?

Jason Holbrook, Sales Manager, KraussMaffei Corporation | Narrated for the 2018 TPO Conference by David Blank

Slide 1 – Introduction

Introductory comments.

Slide 2 – We've Come a Long Way Since the Days of Relay Logic

We've come a long way since the days of relay logic. Early machines had open loop controls with no feedback on performance. Conditions were set by timers and limit switches, and processors were so elementary that very few auxiliary controls could be integrated.

Since the old days, there've been significant advances in screw geometries, closed loop controls, robot automation, multi-component molding, integration of auxiliaries, and plant monitoring. I'll touch on all these today.

Slide 3 – The Evolution of Screw Geometry

Early machines usually came equipped with general-purpose (GP) screws. Then came mixing screws that provided a more homogeneous melt, barrier screws that produced a homogeneous melt along with faster melt delivery, and combination screws that offered both. MuCell screws are unique in that they have their own pressure chamber to introduce super-critical fluids for foaming.

Slide 4 – The Development of "Scientific Molding"

Scientific molding has been around for a long time, but it's been largely forgotten or ignored. Most molders used trial and error to develop an acceptable cycle. Using scientific molding, one can calculate every pre-process setting and dial in the parameters before the first shot is taken. Scientific molding also helps to minimize start-up times and scrap.

Slide 5 – Multi-Component Injection Units – "Old School" Bolt-on Units

Early multi-component applications attempted to use an existing standard single-component molding machine with the addition of a "bolt-on" independent injection unit, either in a top-mount (V) or side-mount (L) configuration. These early multi-component applications often required the use of a "bolt-on" rotating platen that minimized mold height and reduced the platen real estate capability of the machine, resulting in the need for excessively large machines to accommodate the real estate requirements of rotating platen and molds.

Being independent, stand-alone units with their own controls and hydraulics, process set-up was cumbersome and molding recipes couldn't be saved as a single program.

Slide 6 – Multi-Component – Today's Many Injection Unit Configurations

Today's many injection unit configurations, e.g., piggyback, side-by-side, and opposing, provide a solution for nearly every application. They enable one to minimize floor space and platen real estate and maximize mold height.

Slide 7 – Multi-Component – Rotating Clamp Configurations

Rotating platens today are integrated to the molding machine's clamp. This minimizes the tonnage required to mold parts and maximizes the area available between tie bars, media delivery (water, hydraulics, and air), and the ability to automate the application.

Slide 8 – GX H 550-1400/1400 Multi-Injection

Much of the multi-component technology we've currently generated has been driven by the demand for lenses. The part shown on this slide is of demonstration in nature. It's molded in two types of polycarbonate (PC), one clear to form the lens, and the other black to form the bezel. A more "conventional" approach would have been to mold the entire part in clear PC and paint the bezel black in a separate, more costly operation.

Slide 9 – Application References – Automotive – Multi-Injection

Shown here is an air deflector for the VW Polo molded from PP and TPE. The use of multi-injection technology allows one to fuse (cohesively bond) dissimilar materials in the mold in a single cycle. Innovation features are an integrated seal lip (in-mold assembly), molded via complete hot runner system with cascading, and a multi-component separator/barrier slide system. One-step process benefits include reduced assembly effort (fewer mistakes), reduced logistics effort, and the elimination of the need for an additional gluing or joining.

Slide 10 – Application References – Automotive – Multi-Injection

This part, a ventilator flap and seal lip for a Mercedes-Benz E Class sedan, is also molded from PP and TPE. Over-molding from both sides (Station 1 substrate, Station 2 seal lip) resulted in reduced assembly effort and logistics, functional integration, and a saving in molds and floorspace.

Slide 11 – Application References – Packaging – Multi-Injection

Going away from automotive for a moment, this closure for Fructis is molded in a multi-cavity (24-48) mold from 2 types of PP. The cap is shut in the mold. Multi-injection brings value in the form of an ergonomic "soft touch" feel, higher productivity, lower unit cost, and good product quality.

Slide 12 – Multi-Component – Co-injection

This process, also called "sandwich molding" has been around for a long time. With today's fast processors and closed loop controls, we can now introduce lower cost materials to the core of the part or use foaming to reduce part weight. Co-injection also allows functional barrier properties to be designed into the part.

Slide 13 – Lightweighting: Composites and Organosheet Over-molding

"Lightweighting" has been a popular buzz word now for more than 10 years, most recently driven by more stringent CAFE requirements in the automotive arena. Historically, most lightweighting of composite parts has been done by compression molding, a labor-intensive process with overly long cycle times. Today, we can do the job much faster and more efficiently using an injection molding process that incorporates something akin to In-mold decorating (IMD).

In one such example, the organosheet consists of a pre-impregnated fibrous weave with a specific type of resin and binding agent. The over-molding of this sheet requires less tonnage because the part is already partially filled with the sheet itself. This technology allows part designers to use different materials for area strengthening, vibration isolation, geometry control, and aesthetic appeal.

Slides 14 and 15 – Lightweighting: Foaming

Foaming has been around for a long time and it's had its "fits and starts" in our industry over the years. Some of the key milestones are shown here, dating from 1969 to 2013. In the early days, foaming agents were pre-blended with resin prior to molding. Good process control was difficult.

Today, we have better, controlled nucleation foaming agents and automated foaming technology like MuCell®. MuCell® involves introducing a super-critical fluid into the melt prior to injection and controlling it in a pressurized system until it's introduced into the mold cavity, where it expands as foam. Along with advancements in machine controls and process integration, foaming is a viable solution for lightweighting. Part surface appearance, however, is still a limiting factor in its use.

Slide 16 – Lightweighting: Foaming + Surface Texture Control

As just mentioned, foaming is often accompanied by poor surface appearance. Class "A" and "B" surfaces suitable for painting are usually not achievable. With the introduction of inductive heating (RocTool), we're able to quickly heat up the surface of the mold and "skin" the part before the gases have their effect. A similar effect can be achieved by heating the mold surface with water or steam. Regardless, all are very energy-intensive and limit their use to smaller parts.

Slides 17 and 18 – Lightweighting: Foaming Examples

Some examples of light weight parts are shown here. Automotive parts include door panels, door lock covers, and instrument panel carriers. Foaming to reduce part weight and reduce warpage is a component in some of these.

Slide 19 – Industry / Plastics 4.0 – What Does It Really Mean?

Industry 4.0 = computerization of manufacturing and the integration of processes and the sharing of information to maximize efficiency. Historically, the first (1st) Industrial Revolution of 1750 mobilized mechanization of production using water and steam power. In 1870, the second (2nd) one introduced mass production with the help of electric power. The third (3rd), in 1960, ushered in the electronic and digital age of information technology (IT), further automating industry. In 2016, the fourth (4th) Industrial Revolution occurred—Industry 4.0—the computerization of manufacturing, allowing "autonomous products" and "real time decision-making processes."

Slide 20 – Industry / Plastics 4.0 – In a Nutshell

Industry / Plastics 4.0 links our localized production cell and all its components to a larger plant production system and, ultimately, to a globally-controlled system. At this point, we're in the early stages of development. Many companies are just now connecting their local cells, some have advanced to the point of linking/interfacing their entire plant, most have not yet connected on a company-wide basis, and very few have linked globally. In Europe, they're finalizing the first specifications for Euromap 77 that will begin to define criteria to harmonize the integration of these components so that any equipment supplier will be able to provide an interface that is recognized by a receiving system, e.g., connectors, protocols, data files, etc.

Slide 21 – Industry / Plastics 4.0 – Intelligent Machines

With Industry / Plastics 4.0, much of the focus is on expanding outward from the production cell, but the same theory can be applied to what's going on within the cell and to the linkage of part data on an in-cycle(!) basis. Some equipment manufacturers have developed software to monitor and control in-cycle. For example, Adaptive Process Control Plus (APC+) develops a viscosity index for the material being molded and adjusts within a given cycle to ensure that the proper amount of volumetric material is introduced into the cavity at the proper time. The software reads the process outputs during the injection profile and adjusts injection speed, pressure, etc. in-cycle to compensate for shot-to-shot deviations.

Slide 22 – Industry / Plastics 4.0 – Intelligent Machines

In any molding operation there are many uncontrollable conditions that must be adjusted as they occur. Smart machines now have the capability to do this automatically (if the user approves it), resulting in reduced material usage, lower energy consumption, and fewer visits to the machine to adjust settings, etc.

Slide 23 – Industry / Plastics 4.0 – Intelligent Machines, Compressibility

One aspect of injection molding that's often overlooked is compressibility, the measure of the relative change in volume of a material in response to pressure. Compressibility, along with melt density, must be taken into consideration when judging whether a certain size machine is adequate for a given material/part combination. For example, if a machine's shot weight capability is based on polystyrene (melt density = 0.91 g/cm3) and PP (melt density = 0.73 g/cm3) is going to be molded, the user must understand that the barrel of the intended machine will hold 20% less (by weight) PP than PS. Compressibility comes into play in discussions regarding mold packing, overpacking, etc.

Slides 24 – Industry / Plastics 4.0 – Intelligent Machines

The viscosity of a given material can change due to changing ambient conditions, material variability, regrind percentage, etc. The resulting fluctuations in melt pressure (resistance to flow) have a direct impact on the volumetric amount of material delivered to the mold, thus causing variations in shot weight, perhaps significant enough to cause an "out of (statistical) control" situation.

Slide 25 – Industry / Plastics 4.0 – Intelligent Machines

Smart machines with intelligent closed-loop controls can also minimize the amount of scrap produced at start-up and reduce start-up times because they automatically know how much material volume must be in the mold and can adjust for any restrictions in flow.

Slide 26 – Industry / Plastics 4.0 – Intelligent Machines

Today's smart machines can improve process capability by a factor of 4, in many cases targeting the actual volumetric needs of the part and adjusting all settings in-cycle to achieve the target. In this statistical chart of part weight vs. time, a 24-hour long process without APC+ resulted in a part weight change of ±0.20% (range of 149.4-150.5g). With APC+, the variation was reduced to ±0.05%, with the weight hovering around 149.8g throughout.

Slide 27 – Industry / Plastics 4.0 – Intelligent Machines

Intelligent machines target overall efficiency. They're now being built with energy efficient hardware and software. They allow constant shot volume by adjusting speed, switch-over position, holding pressure, etc. This results in targeted zero-defect production, reduced material costs, easier handling, and lower cycle times. The name of the game is "avoiding" vs. "detecting" defect parts!

From an energy savings standpoint, an intelligent machine with an Eco-Button can reduce energy consumption by 7-18%. You set up the cycle, turn on the Eco-Button, and the machine will automatically adjust to reduce the energy-consuming variables to their lowest levels.

Slide 28 – Industry / Plastics 4.0 – Integration of Robotics

Robotic automation, too, has been around for a long time. Traditional part-harvesting robots came into maturity in the 1980s with the growth of electrically-powered (over hydraulically-powered) robots. Historically, robot automation was an afterthought to the machine's part producing ability and was considered part of downstream automation. Today, robot automation is being integrated into the machine. This integration process adds to the development of Industry /Plastics 4.0 and was one of the leading innovative technologies that spurred the growth of interconnectivity.

The flexibility of robot automation continues to improve efficiency. What was once an afterthought is now a necessity in remaining competitive on a global platform. We've advanced significantly over the past 20 years and we're ready for the next 20!

Slide 29 – Industry / Plastics 4.0 – Integrated Robot Controls

Integrated robot controls—the robot and the machine working together—allows one to operate the robot from the machine panel or operate the machine from the robot panel. They permit faster data transfer within a cycle, faster start-ups and molding cycles, and lower scrap rates. Robot parameters can be saved with those of the molding machine. Advancement of Industry / Plastics 4.0 capabilities is possible.

Slide 30 – Industry / Plastics 4.0 – Integrated Work Cells

More recent innovations allow complete "mobile" production cells to be integrated to the machine. These cells can be moved from machine-to-machine as demand requires. Integrated production cells minimize floor space requirements, improve part tolerance control, and aid in minimizing scrap. They may contain various types of conveyor belts and a reject or quality parts box for separate quality inspection.

Slide 31 – Industry / Plastics 4.0 – Integrated Hot Runner Controls

Hot runner and valve gate controls are now popular candidates for integration, allowing for the development of a more precise process. Control tolerances are much tighter and process parameters can be saved with the molding recipe. No longer an auxiliary piece of equipment, more floor space is freed up around the molding machine.

Slide 32 – Industry / Plastics 4.0 – Process Recording

Part of Industry / Plastics 4.0 is the sharing of critical data as parts work their way through the supply chain to an end product. We have the capability today to add quick read (QR) codes to every part. This is often used for safety and medical components. It's a permanent part of the component's production record and can be accessed at any time in the future. In the example shown on the right, the QR-Code is associated with a part made on Cycle Number 686 on October 25, 2016 at 6:06:11 p.m. The DataXplorer sheet on the right contains provides a synopsis of all of the information relevant to this part.

Slide 33 – Industry / Plastics 4.0 – Networked, Self-Optimizing Production Cells

Self-Optimized production cells are networked to supply a myriad of inputs. In this scenario, with all of the cells reporting their "current state of affairs," one can imagine how an entire plant could be integrated. Multiple cells communicating amongst themselves allows prioritized situational awareness

Slide 34 – Industry / Plastics 4.0 – Integration of Auxiliary Equipment

Now that we have the ability to interface our production cells, it's time to branch out and interface these cells with our plants, our plants to our headquarters and so on. This connectivity will ultimately improve efficiencies with shared conditional information, reduce excess inventory, maximize just-in-time orders, and improve preventive maintenance programs, the latter extending the production life of machines and plants.

Slide 35 – Industry / Plastics 4.0 – Plant Integration

Our next steps toward Industry / Plastics 4.0 will be integrating the plant monitoring systems of each cell into one cohesive unit reporting to a central server and keeping all those responsible for its efficiency up to date via apps, smart phones, and remote access computers.

Slide 36 – Industry / Plastics 4.0, Data Collection

Today's connectivity gives us live conditional reporting, not as discrete values, but as a continuous curve progression. This provides a means for more efficient production, better predictive modeling and preventive maintenance. For example, consider a situation where a non-return valve is going bad. You'd see the injection profile change over time and you could schedule repairs before a catastrophic shutdown occurred.

Slide 37 – Industry / Plastics 4.0, HQ Monitoring of Plants

The third step in Industry / Plastics 4.0 integration will be the ability for headquarters to monitor each plant with precision in real time. This connectivity will also allow the plant, in turn, to operate more efficiently by having the most up to date requirements from HQ.

Slide 38 – Industry / Plastics 4.0, Integrated Service Assistance

We currently have the ability to allow users to gain access to the machine supplier for remote service assistance. All you have to do is build the machine with a router, give it an IP address, and have your company's IT department allow outside access to the machine. Such a system reduces the amount of downtime because of faster diagnoses of problems, quicker shipment of repair parts, and often the elimination of a paid service call.

Slides 39 and 40 – Questions and Answers, Conclusion

Thank you for your time.

Overall Presentation Summary

The injection molding industry has come a long way since the days of relay logic, early attempts at "scientific molding," and "bolt-on" injection units. Today, one has a choice of many multi-injection units that provide a solution for nearly every application. Dissimilar materials can be molded in a one-step process to form a single part, and co-injection, organosheet over-molding, and foaming (lightweighting) are becoming commonplace.

Industry / Plastics 4.0 is developing apace to prepare us for the next 20 years. It links our localized production cell and all its components to a larger plant and company production system and, ultimately, to a globally-controlled

system. Intelligent machines that can adapt, in-cycle, to changing conditions and the integration of robotics, robot controls, work cells, auxiliary equipment, and real-time data collection make high levels of connectivity and increased efficiencies possible.


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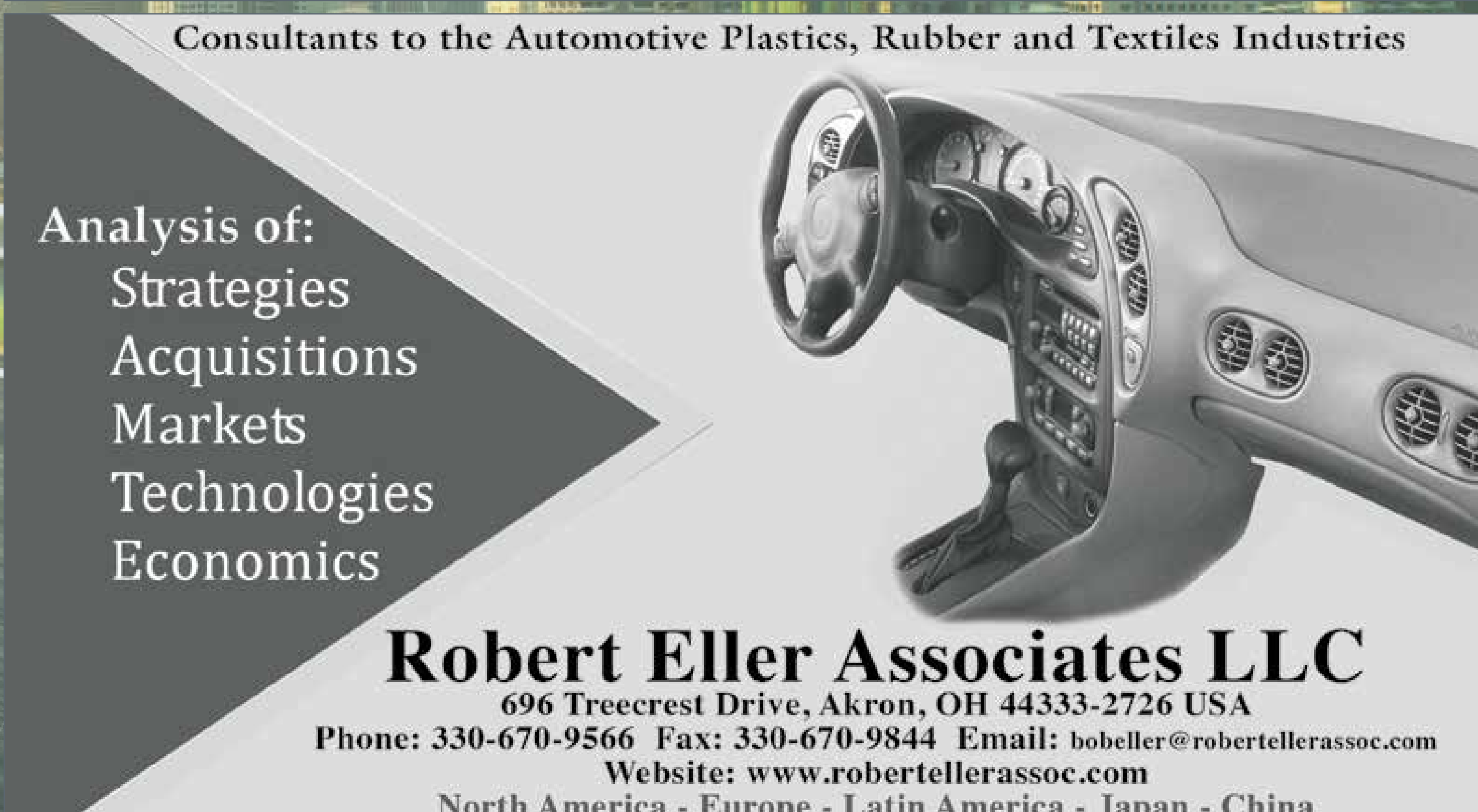
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SUNDAY TUTORIALS

Two tutorials on fundamentals of Polymer Stabilization and Compounding TPVs for Automotive Applications are presented at the Troy Marriott Hotel on Sunday October 7th from 3 to 5 PM.

Conference registration is not required. The tutorials are COMPLIMENTARY and offered as service to the industry. Please participate and gain better understanding of these topics.

3:00 PM: Review of Basic Polymer Stabilization Principles and Advanced Stabilizer & Antistatic Solutions for Polypropylene-based TPO Automotive Applications

Dr. John Mara, Amfine Chemical Corporation

This tutorial will cover the basics of polymer stabilization to inhibit both thermo-oxidative degradation and photo-oxidative degradation of PP-based TPO compounds. The different polymer stabilizer classes and their functions will be introduced after which advanced stabilizer solutions from ADEKA for exterior and interior PP-based TPO automotive compounds will be presented. Our stabilizer solutions and novel polymeric antistatic agent enable PP-based TPO compounds to meet the requirements for improved weatherability, durability and electrostatic control.

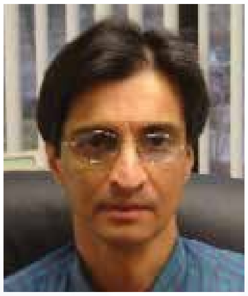
4:00 PM: Automotive TPV – A Solutions Approach

Dr. Morteza Jandeghi, Alterra Holdings

This tutorial will cover both the fundamentals and the challenges of TPV compounding. Automotive applications of TPV materials are discussed along with a detail investigation on a very difficult problem "UV and Rainx degradation of Automotive Exterior TPV Components". A new novel approach in problem solving is presented to tackle this major issue in a short period.

SESSION CO-CHAIRS:
Mike Balow, Asahi Kasei Plastics | Mark Jablonka, Dow | Peter Glenister, LyondellBasell

An Innovative Polypropylene Compound for a Hybrid Daimler Cowl Vent Grille



Sunit Shah,
Equistar Chemicals LP,
a LyondellBasellCompany
Mansfield, Texas
Holger Steeb
Daimler AG
Sindelfingen, Germany
Michael Buedinger
Basell Deutschland GmbH
Frankfurt, Germany

The material characteristic requirements for a hybrid cowl vent grille designed by Daimler are examined in this paper. These combine the requirements of a material designed for both exterior and interior applications, including photo-oxidative stability for exterior exposure and low emissionsfor interiors. An innovative thermoplastic polyolefin (TPO) material, which meets these dual requirements, is introduced. Also reviewed will be commercial cowl vent grille applications on Mercedes platform built in N America.

Characteristics and Applications of Flame Retardant PP/PPE

Kaz Hashimoto, Asahi Kasei

A novel non-halogen flame retardant PP/PPE with good oil and chemical resistance has been developed. With its excellent flowability and low warpage, it is suitable especially for thin wall molding. These advantages realize applications that surrounds EV batteries.

High-Stiffness Mineral-Filled TPO Material Solutions

Matthew Thompson,
Advanced Composites, Inc.

Advanced Composites is expanding the TPO material performance window through the development of high-stiffness mineral-filled TPO solutions. These grades offer potential for replacing glass filled polypropylene and engineered resins while providing the processing benefits of TPO. This technology has been implemented in both structural and mold-in-color applications. Additionally, material solutions have been identified that provide both increased stiffness and low thermal expansion for potential utilization in exterior panels. These grades demonstrate the continuing evolution of TPO material technology to new realms of performance.

Novel TPO Concepts for Automotive Parts with Improved Dimensional Stability

Michael Shoemaker, Borealis

Automotive parts like bumpers, body panels, dashboards, door claddings etc. are nowadays made out of TPO based materials. Apart from the basic properties also the dimensional stability i.e. the shrinkage and coefficient of linear thermal expansion of TPO is largely determined by its polymer design. Within this work a systematic study was performed to analyze the influence of the semicrystalline matrix and the dispersed rubbery phase on dimensional stability of the final TPO.

Benefits of High Melt Strength PP (HMS-PP) in Cut Sheet Thermoforming

Kim McLoughlin, PhD,
Braskem Innovation &
Technology Center,

Polypropylene is used in a wide variety of automotive, industrial, and packaging applications. It offers a balance of high stiffness, heat resistance, and chemical resistance. Polypropylene is readily recyclable and has a favorable environmental footprintrelative to many other materials. However, unmodified polypropylene presents processing challenges for cut sheet thermoforming. In particular, PP sheet sag limits the range of suitable forming temperatures to a very narrow range.Braskem's High Melt Strength Polypropylene (HMSPP) grades, Amppleo 1025MA and Inspire 114, provide significant processing improvements in sheet forming applications. Both grades control sheet sag by modifying the polymer melt viscosity, or, resistance to flow. As a result, blending HMSPP into standard PP can broaden the window of suitable forming temperatures by a factor of two or more. In addition, because Amppleo and Inspire possess different rheological and mechanical properties, an HMSPP product can be selected to tailor both processing performance and mechanical properties to the application.

MATERIALS DEVELOPMENT

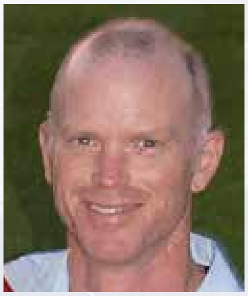
SESSION CO-CHAIRS:
Mike Balow, Asahi Kasei Plastics | Mark Jablonka, Dow | Peter Glenister, LyondellBasell

A Method to Modify PP for Improved Melt Strength in TPOs

Brett Robb, Total Cray Valley

TPOs contain Polypropylene, a semi-crystalline polymer which lacks melt strength. Dymalink9200, a polar zinc salt widely used in the rubber industry, has been shown to assemble into ionic clusters, promoting a unique dynamic network leading to unusually high melt strength behavior in polypropylene at low loadings. This paper will explore the melt strength mechanism in TPOs through rheological tools and show how the change in melt strength improves the properties of injection molded foams.

Thermoplastic Solutions to Replace Paint and Film in High Gloss Piano Black Exterior Appliques



Brent Westbrook,
Nymphy Vashisht,
Naomasa Hatoyama,
Mitsubishi Chemicals Performance Polymers

In the automotive market place, there is a trend to provide appliques with varying levels of gloss and color using paint and specialty films. This new development replaces traditional technologies by providing cost effective solutions to achieve gloss levels ranging as low as 2 and as high as 90 in any color desired. During this discussion we will explore the comparative testing results and the application techniques of the materials that can easily be processed using standard thermoplastic processing technologies.

Flow Instability Perspective of Tiger Stripes with Polypropylenes

Tieqi Li, vFormosa

Tiger stripes in injection molding have been studied with computer simulation using a level-set two-phase flow method. The modeling suggests that this special flow instability may result from the alternative occurrence and disappearance of the large pressure gradient behind the melt front. Wall slip is found to be a minor mechanism for the change of the pressure gradient. Role of resin rheology is demonstrated moderately well through the 3-parameter Carreau-Yasuda model.

Soft Touch TPE's with Exceptional Overmolding Adhesion to Rigid Substrates

Tony Samurkas*,
Marco Meneghetti,
Tony Tognetti,
Joe McCormick,
Michael Ballot,
Trinseo

The demand for combining soft and hard thermoplastic materials is growing with many applications requiring a soft-touch surface over a rigid substrate. Overmolded TPEs provide advantages including wet grip, impact resistance, vibration damping, insulation and enhanced haptics. Durable adhesion between soft TPEs and rigid thermoplastics depends on several variables and the VDI 2019 standard provides a systematic peeling-test method to define and measure bond strength, allowing the reliable selection of optimal material combinations Trinseo's specialized overmolding center is equipped with state-of-the-art technology to enable measuring adhesion according to VDI 2019.

Minerals for Noise Reduction

Dr. Prasad S. Raut*,
Maz Bolourchi,
Imerys

Quiet vehicles are in increasing demand for better cabin experience and changing consumer lifestyles. Efforts towards noise, vibration and harshness (NVH) control in automotive applications are focused on the use of sound/vibration damping layers or barrier/absorber materials. This paper presents the results of a study conducted to evaluate and compare the effect of minerals on noise reduction in PP based formulations. Mechanical, thermal and rheological properties of the formulations will also be discussed.

SESSION CO-CHAIRS:
Mike Balow, Asahi Kasei Plastics | Mark Jablonka, Dow | Peter Glenister, LyondellBasell

A Novel TPO Development for the PC-ABS Resins Replacement

Nadeem Bokhari,
Sumitomo Chemical

A unique Thermoplastic Polyolefin (TPO) formulation was developed by combining Sumitomo's advanced processing and resin technology which is suitable for many PC/ABS applications. This formulation is readily useful for mold-in-color interior applications requiring superior scratch and mar resistance and low gloss aesthetics while reducing weight, improving sound quality and lowering overall part cost. Easy to process TPO formulations have been evaluated showing outstanding property and performance balancesthat may allow the selection of TPO over PC/ABS.

A Solution for Electrostatic Control using a Novel Polymeric Antistatic Agent

Yota Tsuneizumi, ADEKA

In the past, polymeric antistatic agent's main target was electronic parts. But these days, there are growing interest in using them inautomotive interior parts to prevent adhesion of dust. We have developed apolymeric antistatic agent that shows superior effectiveness compared amongexisting productsdue to its excellent compatibility with polyolefins.In addition, wewill introducethe performancewith other additives such as light stabilizer or flame retardant.

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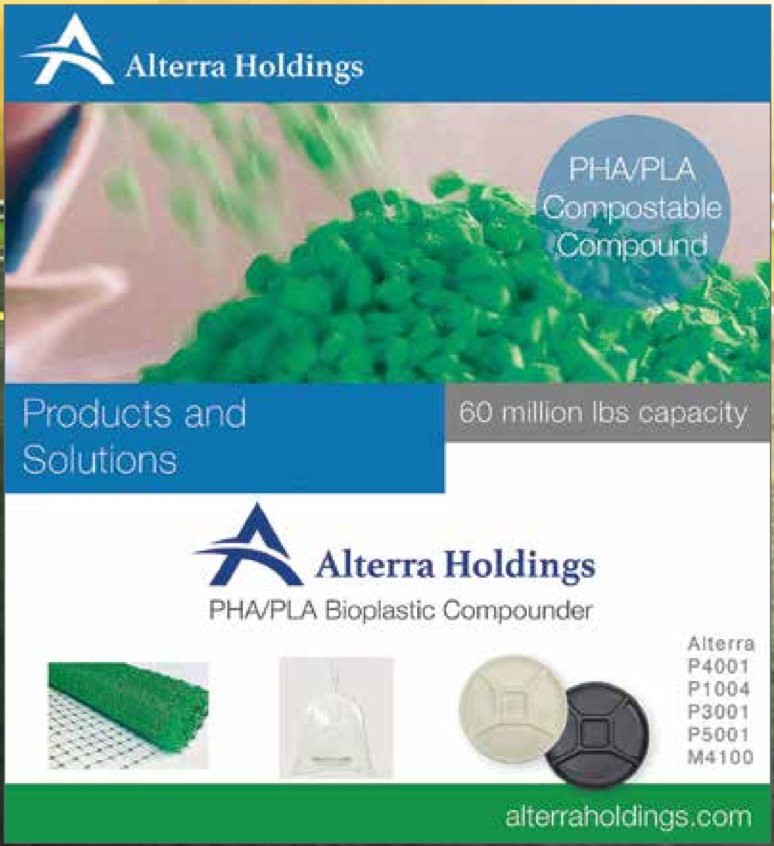


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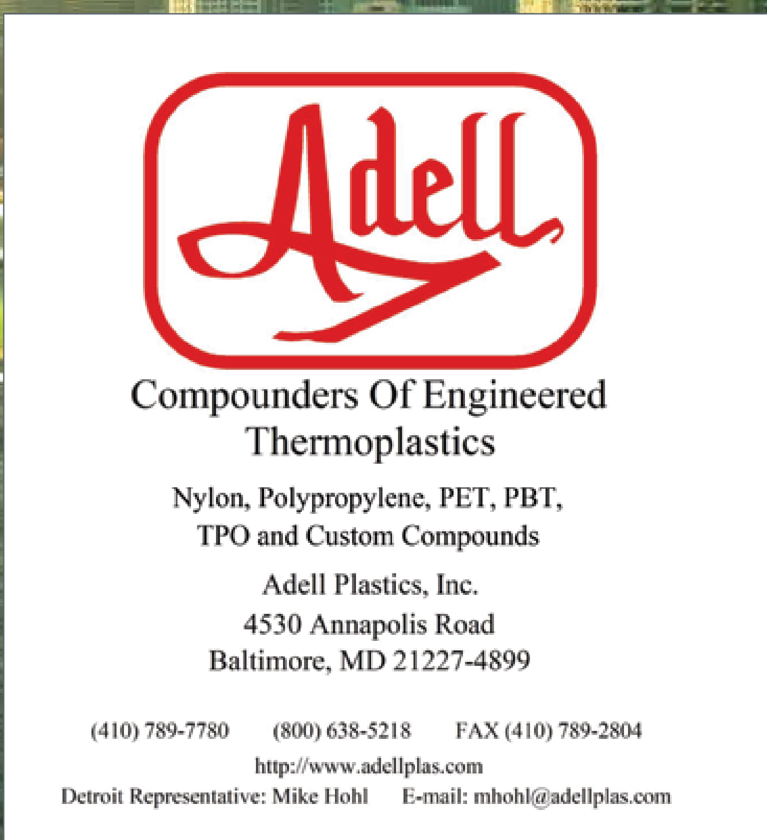
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SURFACE ENHANCEMENTS

SESSION CO-CHAIRS:

Dr. Rose Ryntz, IAC Group | Jeff B. Crist, Ford Motor Company | Jim Keller, Mankiewicz Coatings, LLC

Color Innovations for Automotive Styling

Paul Czornij, BASF

Color development is a highly important area for automotive. It's often cited as one of the most influential factors in purchasing a car, as it has both visible and emotional connections to the buyer. Since it blends both the aesthetic and the technicalelements, careful selection of the color spaceis a complex process. Itinvolves using data from research in color trends, and incorporates innovative colorantsand applications. This presentation will offer a historical and future perspective on color. It will give a retrospective look over the last two decades how colors for cars were engineered and marketed, highlighting key milestones in achieving uniquelooks. And, as new transportation modes continue to unfold, how color may change as a result over the next two decades for automotive will be discussed.

Haptics of Lightweight and Soft TPE Skins for Automotive Interiors

Alex Green*, IAC and
Peter Botticelli, Syntouch

The use of soft skin, lightweight technology continues to grow in interior applications. The customer is becoming more demanding on haptic requirements. This talk will focus on the use of Thermoplastic Elastomers(TPE) in instrument panel skins, namely produced via injection molded processing. The issue of haptic response and quantitative characterization will also be evaluated.

Aesthetic Coating Evolution for Injection Molded Interior Parts

Janet Robincheck,
General Motors Co.

Over the last 20 years, the desire for more luxurious automotive interiors has led to more surfaces being covered with leather or synthetic skin materials. For injection-molded TPO and other plastic parts, specialized coatings have been developed that impart favorable haptic properties, allowing these parts to complement and in some cases replace skin-covered parts. Such coatings have improved customer perception by enabling lower gloss levels and an expanded range of vibrant colors and jet blacks, all while improving weathering and other resistance properties of the parts. This presentation will reflect on the ways General Motors has led the automotive industry through the development of these coatings and our plans to drive future evolution.

The future of Micro-Organism Abatement vs. Surface Cleanability in Vehicles

Eileen Gallihugh, IAC

Future Vehicle usage, including sharing vehicles, presents the challenge of understanding what the future holds for cleanliness within the vehicle. This seminar will explore the questions of what the OEMs want in material performance, the Pro's and Cons of antimicrobial materials, what is available to solve the problems, and what the market might be seeking.

Surface Energy Modifications of TPE Membranes using Open-Air Plasma Pretreatment

Doug Corrigan,
ChemQuest Technology Institute

Low surface energy materials such asthermoplastic elastomers are challenging substrates for wetting and adhesion of applied adhesives, foams, and coatings. Typically, surface-energy activation pretreatment processes such as flame treatment and corona discharge are used in industrial settings to raise the surface energy of the substrate above the surface tension of the applied liquid to provide adequate surface for wettability. These processes also provide active functional groups on the surface that are readily available for subsequentchemical attachment to the corresponding functional groupsof the applied material. In this paper, we discuss and compare the process of surface energy cleaning and activation with an open-air plasma jet on TPE membranes. Dispersive (non-polar) and polar components to the surface energy will be compared using flame treatment and plasma treatment, and changes to these components over time under various humidity and temperature conditionswill be presented.

Future-Proof Interior Surfaces for Sustainability and Performance

John Dunn, Stahl

The interiors of our vehicles are going through a marked transformation. Customer expectation have come to imagine an environment suited more as a mobile living room. One where the comfort and technology they desire are at their fingertips for the extedded service life that today's vehicle can office. Aesthetics and performance expectations in the wear, durability and cleanability remain high, while preserved over a longer duration. This continuing cycle for improvement is happening with added mind for a cleaner and healthier environment and a sense of social responsibility. In the past, these trends have appeared at odds, but with a ground up approach to material construction and surface treatments these expectations can be achieved.

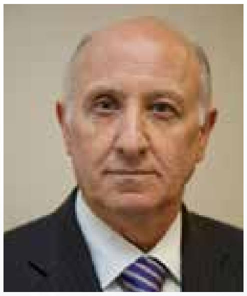
Innovative Coatings for the Next Generation Vehicle

Diane Marret, Red Spot

Increased performance enhancements for interior and exterior automotive applications have encouraged coating development to better address the complex issues of scratch resistance and improved aesthetics. This has paved the way to introduce innovative coating technologies, such as UV curable and dual cure, which not only can achieve newer performance expectations, but also offer a wide array of other advantages such as shorter process times, less work-in-process and lower energy costs.

Multi-Functionality and Sustainability Trends for Coatings

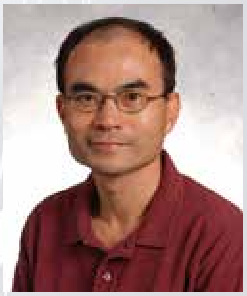
Prof. Jamil Baghdachi,
Eastern Michigan University



Traditionally TPO substrates are coated to enhance aesthetics, barrier properties and to improve surface qualities and properties. In recent yearswith increased demands forcoatings that can be responsive, perform multifunctional tasks has emerged a new class of coating materialsand processes. Amongthis class are scratch resistant and self-healing,super-hydrophobic,color-shifting, antimicrobial and shape-memory coatings.The main objectives have been to provide multi-functionality while maintainingtraditional protective and decorativefunctions. Considering recent advances in coatings technologies, the next decades will most likely witness lightly cross-linked recyclable TPO substrates, VOC-freeand primer-less coating applications, and highly interactive/stimuli responsive coatings. In this talk we will discuss technology and examples of such materials and highlight commercial opportunities and global research and development trends.

Recent Progress in Testing and Evaluation of Scratch and Mar Resistance of TPOs

H.J. Sue*, S. Xiao, M.M. Hossain, M. Hamdi, S. Du, M.S. Gundi,
Polymer Technology Center
Department of Materials Science and Engineering, Texas A&M



Significantfundamental research on scratch behaviorsof bulk polymers, films,and coatings has been carried outat the Texas A&M University Polymer Scratch Behavior Consortiumto address theever-increasing needson aesthetics, structural integrity, and protective functionalityof polymer surfacesformany engineering applications. Sincescratch performance is nowrecognized as an important engineering property for polymers, it is highly desirableto establish quantitative testing and evaluation methodology that can offer not only straightforwardranking of scratch performancebut alsomeaningfulcorrelationbetween material parameters and scratch resistance, which would then provide guidelinesfor effective design and preparation of scratch resistant polymeric systems. A standardizedtest methodology based on materials science and mechanics tools for evaluating scratch resistance of polymers has been developed at our laboratoryand subsequently recognized asanASTM/ISO standard (D7027/ISO19252). This new test method allows for simple, unambiguous quantitative evaluation and ranking of scratch resistance of polymeric materials, coatings, and films. Finite element methods (FEM) simulation hasalso been performedto facilitate correlationbetween material parameters and surface damage observed during the scratch process, and to predict scratch performance. In the meantime, based on the same principle, a new mar testing and evaluation method has been proposed for the automotive industry. The merits of the new mar testing methodology will bedescribed and discussed.

Accelerated Weathering of Coatings: A Global Perspective

Mark Nichols,
Ford Research and Advanced Engineering

The growth of automotive markets outside of North America and Europe and the emergence of new mobility modes could potentially alter the durability expectations for automotive exterior materials. To address these issues, climatevariables such as UV exposure, temperature extremes, and rainfall amounts have been quantified for various geographic regions and weighted for local population densities. For different coating failure modes, the germane exposure variable were scaled to south Florida exposure variables and used to generate lifetime distributions for each failure mode and region. Failure modes such as gloss loss, cracking, delamination, and color change were examined. These results are placed in context with both global vehicle distribution and newtransportation modes, which may incorporate higher vehicle utilization and shorter vehicle lifetimes.

Why Test Inks and Dyne Pens Cannot Tell the Full Truth About Surface Free Energy

Daniel Frese*, Dr. Thomas Willers, Ming Jin, KRÜSS Gmb

Polyolefin-based lightweight materials are widely used in automotive industry due to their superior properties. However, the low energy surfaces of such materials demand activation in order to achieve sufficiently strong adhesion and wettability of any layer that is to be applied to, like coatings, adhesives, decorative foils, lacquers, just to name a few. The effect of cleaning and activation procedures, like degreasing, flame, plasma or corona treatment, is often tested by using dyne pens or test inks, as well as contact angle analysis.We will present a comparative study between test inks and contact angle measurements for a variety of different materials, including plasma activated polymers. Our results show that surface free energy results for most of the tested samples diverge significantly between test inks and contact angle measurements. This is most pronounced for surfaces with a significant fraction of polar chemical groups in their surface, such as plasma activated materials. Considering wetting theory, the observed discrepancy can be explained by test inks disregarding the interfacial tension between the ink and the solid. This finding calls into questions the surface free energy results (dyne/cm) of an ink test for many samples.For this study, a newly developed dosing mechanism was used for the contact angle measurements, which we termed "liquid needle". The benefits of this method will be elaborated, including operator-independent results and the speed of measurements. In summary, we believe that the presented contact angle measurements can be a useful tool for quality control in surface activation and cleaning

Anti-Scratch Improver: NOF®-ALLOY KA series

Toru Kato, NOF

NOF®-ALLOY KA series is a specially designed additive for Polyolefins, Thermoplastic Olefin Elastomers, Thermoplastic Styrene Elastomers and rubbers, and drastically promotes its scratch proof property with no big impact on surface, mechanical and thermal properties, and moldability. In addition, NOF®-ALLOY KA series can also prevent a noise problem which is a concern with the automotive interior parts made up of Polyolefins.

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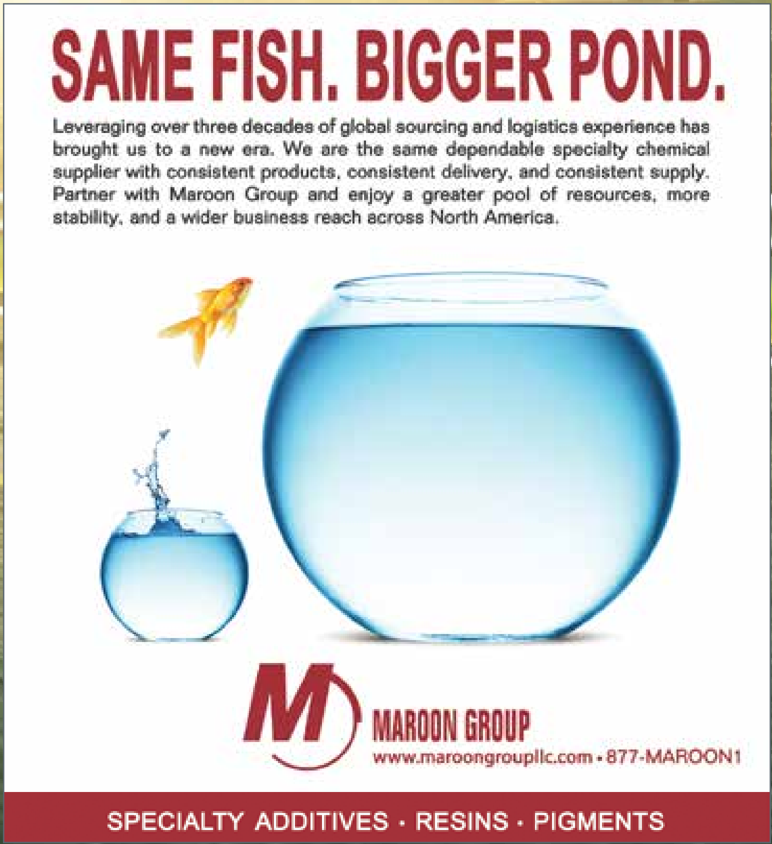

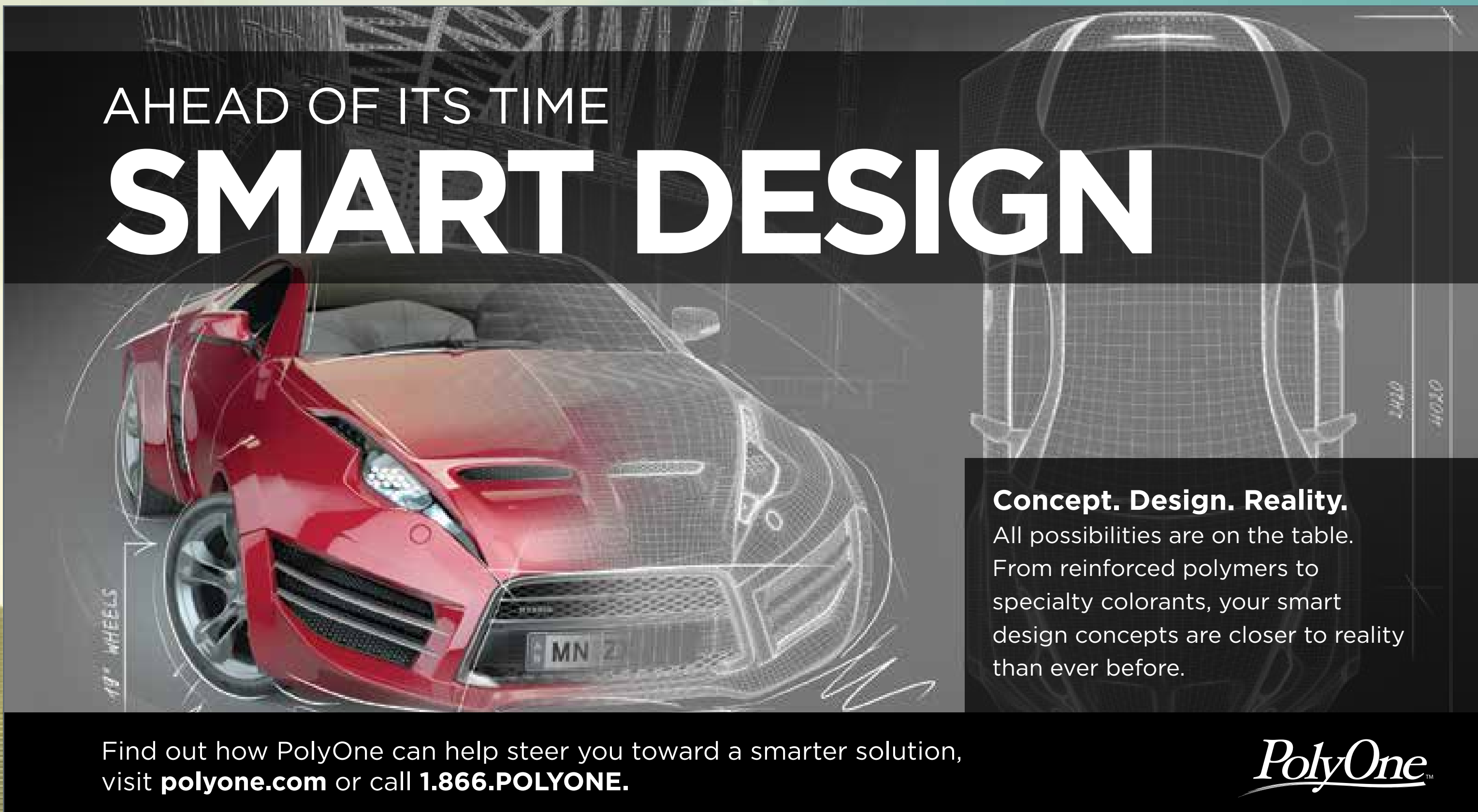
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PROCESS DEVELOPMENTS & SIMULATIONS

SESSION CO-CHAIRS:

Kurt Anthony, Washington Penn Plastic Co., Inc. | Dr. Suresh Shah | Dr. Li Lu, Ford Motor Co.

3D Printed Prototype Parts out of Production Material

Juergen Giesow, Arburg

Rapid Prototyped parts through freeforming capabilities with exactly the material that the part will be produced in mass production. Discussion on how this technology works and how it can help to quickly go though the Prototype stage and convert the generated information into the final product. Further we will review the capability of Freeforming and individualizing mass produced parts quickly in very unique was.

TPO Formulation Sacle-Up: The bump in the Road between Development and Commercial-ization for TPE

Paul Anderson, Coperion

Automotive requirements for Thermoplastic Elastomer compounds continue to push the performance envelope for these materials. For either TPO, TPE or TP-V compounds, the required properties can be extensive such as improved compression set, modulus vs. elongation at break, heat deflection temperature, surface quality, flow characteristics and cost to name a few. However, in order to achieve material specifications such as those listed above; the material scientist has to be very creative. As a result many of these formulations can be very complex. Subsequently, the product development engineer charged with compounding the new formulation in the lab needs to understand the characteristics of the individual components in the recipe and then implement the proper sequence of compounding unit operations. Some of the compounding challenges for TPO formulations can be how to melt/mix polymers that have widely different melting points or viscosities, incorporate high loadings of low bulk density mineral filler, and/or efficiently incorporate high levels of liquid such as extender oil. As might be inferred from the previous paragraph, scale-up from lab to production is generally not the primary focus of the material scientist working on a new formulation with enhanced "properties". Also in many instances scale-up is not the primary focus of the development engineer charged with successfully compounding the new formulation. However scale-up is the headache of the production engineer who has to process the newly developed product successfully at commercially viable rates. Even though traditional guidelines such a scale-up factor based power (Kw of commercial unit divided by Kw of development unit) or volume (production unit diameter cubed divided by the lab/development unit diameter cubed) indicate sufficient rate is achievable on the commercial unit, there are many pitfalls that can detour the path to success. These can include, elevated material discharge temperature due to reduced heat transfer on the commercial unit as compared to the lab unit, feed limitations due to insufficient conveying efficiency of the feedstock on the commercial unit, particle entrainment resulting in vent blockage due to increased vapor velocity, and product quality issues due to less efficient stress transfer through the melted matrix material. This presentation will review these and other "bumps in the road" as they relate to compounding TPO formulation and discuss ways to minimize the probability that they will impact your success.

Ultrasonic Welding of Thermoplastic Olefins (TPOs)

Charlie Yang, LyondellBasell

This pap

PROCESS DEVELOPMENTS & SIMULATIONS

SESSION CO-CHAIRS:

Kurt Anthony, Washington Penn Plastic Co., Inc. | Dr. Suresh Shah | Dr. Li Lu, Ford Motor Co.

Investigation of the In-flow Effect on Weld Lines Strength in Injection Molding of PP Compounds

Luca Gazzola, Sirmax

Weld or knit lines occur whenever the flow of the polymer melt splits and rejoins. In injection molded parts, weld lines occur when the part is either injected through multiple gates or the melt flows around an obstacle within the mold cavity such as a core or a pin. These weld lines act as flaws and weaken the overall mechanical properties in the region where they occur. This paper explores the influence of in-flow on the strength of weld lines for two polypropylene compounds, respectively reinforced with glass fibers and talc. In-flow is defined as the flow within the mold cavity, below the solidified layer, that continues after the local region of the mold cavity is filled. In particular, the comparison of the weld line strength between specimens manufactured with and without in-flow was carried out and related to the reinforcement distribution in the welding zone.

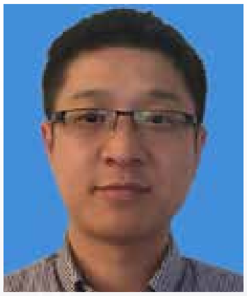
Predicting and Preventing Defects in Injection Molded Parts

Alex Baker, Moldex3D

This pap

Prediction and Validation of Warpage on Injection Molded Polypropylene Parts

Xianjun Sun*, Danielle Zeng, Patricia Tibbenham, Anthony Yang, Srikar Vallury
Ford Motor Co.



Warpage is attracting numerous interests for injection molded plastic parts because it will lead to dimensional issues of products and thus bring tons of challenges to the part design and part assembly. The commercial software for injection molding process simulation is widely used to help design the mold and part due to its capability of providing virtual solutions. However, the simulation software is struggling to provide the consistently accurate warpage prediction at different molding conditions. In order to validate the accuracy and consistency of predicted warpage in Moldex3D, the geometries of both plaque and hat-section beam are investigated. The plaques and hat-section beams are injection molded under different process conditions where mold temperature, melt temperature, packing pressure and cooling time are taken into consideration. The warpage prediction of all the cases is performed in Moldex3D. The results are compared to the real part shape obtained from Digital Image Correlation (DIC) analysis. The study shows that good agreements are obtained in most of the cases between experiments and simulation results after considering the effects of cooling rate on crystallinity, material viscos behavior and gate freeze time. It is also found that the results are more accurate under lower mold temperature condition.

SESSION CO-CHAIRS:

Kurt Anthony, Washington Penn Plastic Co., Inc. | Dr. Suresh Shah | Dr. Li Lu, Ford Motor Co.

Simulation Analysis of Residual Stress and Material Characterization Influences under Curtain Airbag Deployment for TPO Interior Trim Part

Hector Hernandez,
Ford Motor Co.

This study focuses on the dynamic analysis for a body interior trim part under curtain airbag deployment at high and low temperatures. A method for capturing cracking and buckling failure modes of the TPO made part under the mentioned load conditions that cannot be predicted at room temperature; by considering residual stresses due to injection molding process and material CAE characterization to the corresponding temperatures and high strain rates.

CAE Simulation with TPOs: Achievements, Open Debates and Future Challenges

Massimo Nutini*, Maria Chiara Ferrari, Consuelo Garcia Mickey Sinopoli, Mario Vitali,
LyondellBasell

This contribution reviews the advancements in Computer Aided Engineering (CAE) to OEMand Tier supplierpartners by LyondellBasell with thegrowth of TPO materialsin ever demandingapplications. Significant developments are highlighted, covering a variety of applications and product families. Examples of recent achievements (failure modeling), open debates (warpage) and future challenges (fatigue testing) are discussed, focusing on the need fordedicated material testing and validation methodologies as necessary tools to improve the quality of thesesimulations.

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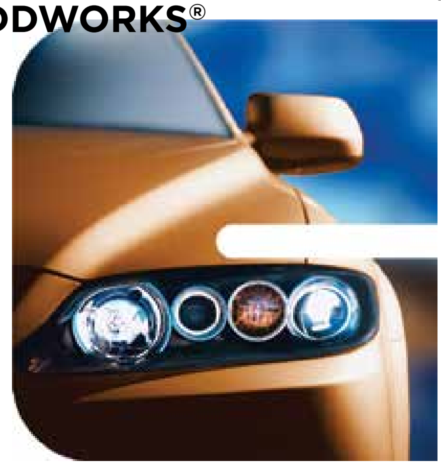

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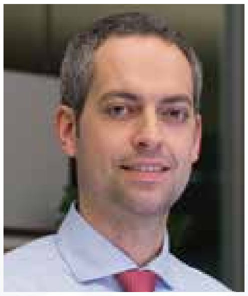
INTERIOR APPLICATIONS

SESSION CO-CHAIRS:

Robert Eller, Robert Eller Associates | Kevin Lyons, Inteva Products LLC | Dr. Pravin Sitaram, Haartz Corporation

Polyolefin Solutions Addressing the Main Challenges of Future Mobility

Jakub Oliverius, Borealis Compounds



Mobility concepts are changing and vehicles need to become more energy efficient and environmental friendly. In this study will be presented a polyolefin based material solutions that enable a more effective use of alternative energy sources. Starting with the evaluation of a new polyolefin based encapsulant for photovoltaic modules, moving to novel high purity polyolefin solutions that make the transportation of energy over long distances more efficient and finally polyolefin materials that enable the short-term energy storage.

Further Refinement of the Injection Moldable Soft Skin Solution for Automotive Interiors

Joe Schulcz*, Marcus Greger,
Kraton Polymers LLC

The latest generation TPE polymer chemistry meets soft-touch haptics and vehicle weight savings while using a preferred conversion method: Injection Molding. Kraton™ Injection Molding Soft Skin (IMSS) technology enables the injection molding of large, thin-walled soft skin parts, including instrument panel skins as thin as 0.8mm. The Kraton Technology Days in January 2017 formerly introduced the IMSS technology to the automotive marketplace with the successful demonstration of the technology by injection molding a full size instrument panel skin in Rochester Hills, Michigan. Based on feedback from this demonstration the Kraton development team has continued to refine the technology (i.e. colorability, haptics and molded-in air-bag scoreline, etc.). This presentation covers the following:

- Review the features/benefits of the IMSS technology]
- Examine the latest IMSS technical advancements
- Discuss the progress of the technology in the automotive marketplace

Kraton IMSS products continue to look and feel great in applications such as instrument panels, trim panels and center consoles. The presentation will conclude with a review of the latest development samples.

Chemical Foaming Agents: Foaming TPO in Injection Molding and Extrusion

Peter K. Schroeck,
Reedy Chemical Foam
& Specialty Additives

Chemical foaming agents are additives that are used in the molding of automotive parts. Creating a cellular structure in TPO parts allows faster cycle times, part stability and density reduction. TPO has become the dominate thermoplastic used in auto part development. It is important to understand the synergies of formula components and potential effects on physical properties of finished parts. The speaker will have case studies demonstrating cost savings and foam processing tips.

Durable PP Surfaces for Future Mobility Solutions

Daniel Bahls,
Borealis Polyolefins

High scratch resistance, low gloss, and a uniform, homogeneous appearance are primary requirements for the surfaces of visible plastic components in automobile interiors for decades. New mobility concepts like car sharing will further increase the need for durable polymer surfaces. The current study discusses main mechanical damage mechanisms for polymer surfaces, as well as strategies to improve the scratch resistance of polypropylenes in particular. The effect on surface appearance and haptics of polypropylene parts will be analysed and an outlook on future trends and developments will be given.

INTERIOR APPLICATIONS

SESSION CO-CHAIRS:

Kurt Anthony, Washington Penn Plastic Co., Inc. | Dr. Suresh Shah | Dr. Li Lu, Ford Motor Co.

The Investigation on Adhesive Properties of Thermoplastic Liftgate

Dr. Daijong Fu*, Zhengrui Xie, Peng An, Guiji Chen, Yan'an Chen, Gang Sun, Bo Yang
KINGFA

Liftgate of SUVs manufactured by thermoplastics has become trending with the demand for more lightweight cars under the stricter emission regulations globally. Thermoplastic liftgate usually includes two parts: interior panel which acts as the structural part and exterior panel. The interior structural panel is typically made of LGFPP while the exterior panel is PP-Talc composites. The two parts are assembled together by using adhesives. To achieve good adhesive strength, both parts need to be surface flame treated before adhesion. However, in practical use the adhesion has been a barrier that inhibits the widespread use of thermoplastic liftgates. In this work, a systematic study on the effects of different factors including the crystallinity of PP, talc, lubricants and other additives on adhesion properties between the two parts of liftgate were performed. Different characterization methods including DSC, SEM, surface tension analysis and XPS etcetera were adopted to investigate the possible mechanisms that determined the adhesive properties.

Non-Reactive Hot Melt Adhesives in Polyolefin Automotive Interior Components

Sebastien Meliot,
Jowat Corp.

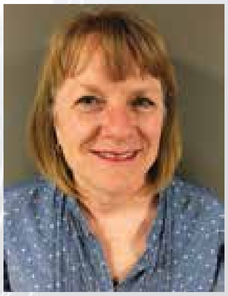
The demand for polyolefin based material for lamination of automotive interior components is continuously growing. Lamination process of polyolefin based materials can be simplified by using non-reactive polyolefin thermoplastic adhesives. In this presentation we will discuss the advantages and disadvantages of polyolefin thermoplastic adhesives and will review the benefits of pre-applied adhesive applications. The use of non-reactive thermoplastic adhesives for headliner and trunk floor applications will also be discussed.

Next Generation Reactive Polyolefin Hotmelt – Fast Curing and No Labelling

Dr. Martin Weller,
H.B. Fuller

The increasingly common use of light weight, cost-effective polypropylene creates new laminating and processing challenges for interior trim manufacturers. Plasma and Corona pre-treatment are well known to raise the surface energy of the substrate when using polar adhesives such as reactive polyurethane hot melts. This processing step is not required with reactive polyolefin (r-APAO) hot melts. However, the relatively longer cycle times and rate of strength development and increase of heat resistance of r-APAO's create new processing bottlenecks. This presentation gives a deeper analysis of these historic trade-offs and presents a new generation of safe, fast-curing r-APAO hot melt solutions that enable parts producers to increase cycle times and reduce finished goods inventory.

Conventional and Reactive Hot Melts for Interior Applications



Emilie Smith-Heberer,
Henkel

The hot melt adhesive family is an integral base of Henkel's adhesive portfolio for applications above and below the belt line, including headliners, carpet and acoustic pads and foams. Olefin-based adhesives have risen in popularity due to cost-effectiveness and ability to meet temperature requirements. Although olefin polymers are present in many of our most advanced adhesive solutions, we always seek to develop products to improve environmental factors, sustainability and be cost effective while delivering superior performance. This presentation will provide an introduction into Henkel's interiors chemistry portfolio.

INTERIOR APPLICATIONS

SESSION CO-CHAIRS:

Kurt Anthony, Washington Penn Plastic Co., Inc. | Dr. Suresh Shah | Dr. Li Lu, Ford Motor Co.

New Halogen-Free Flame Retardant Thermoplastic Elastomers (HFFR-TPE)

Takahiro Konishi*, Ryosuke Kurokawa, and Nobuhiro Natsuyama,
Sumitomo Chemical Company

HFFR-TPEs have wide range of hardness and excellent flame retardant while exhibiting significantly lower toxic gas than similar halogen flame retardant material. And also, HFFR-TPEs would meet UL-94 flammability rating of V-0 and global train material standards. HFFR-TPEsare easy to mold and can be used for wide range applications, such as connector cover, architecture gasket, railway vehicle applications and so on.

Grain Pattern Effect on Mar Visibility Resistance of Textured TPOs

Shuang Xiao, D. J. Barksdale and Hung-Jue Sue,
Texas A&M University

This pap

Foamed PP for Visible Automotive Applications- Challenges and Opportunities

Georg Grestenberger,
Borealis Polyolefins

More stringent government legislation are driving the change of mobility concepts increasing the demand for new lightweight solutions. Plastic parts obtained from the foam injection moulding process can offer high potential weight saving when compared to compact plastic parts. However, there are no harmonised methods or OEM standards available to describe the properties foamed parts. Within this work, a systematic investigation on the influence of processing parameters on the properties of foamed polypropylenes was performed. Different blowing agents were analysed and a concept for visible automotive interior applications was developed.

Thermoplastic Elastomers for Automotive Window Applications

Juan Espinosa*, Stephen Cranney, Sehyun Kim,
Kraiburg TPE

TPV (thermoplastic vulcanizate) and PVC (polyvinyl chloride) have been the traditional soft polymeric materials used for automotive window applications. Each material has certain drawbacks like surface quality, cycle time, and higher cavity pressure for TPV, or higher density and EH&S impact for PVC.

In an effort to overcome such drawbacks, KRAIBURG TPE has developed a variety of engineered TPE compounds with advanced formulation technology. These TPE compounds have been designed specifically for window surroundings, such as glass encapsulation, water deflector, and corner molding. This presentation introduces various TPE compounds that have been applied and commercialized for usage at multiple OEM's.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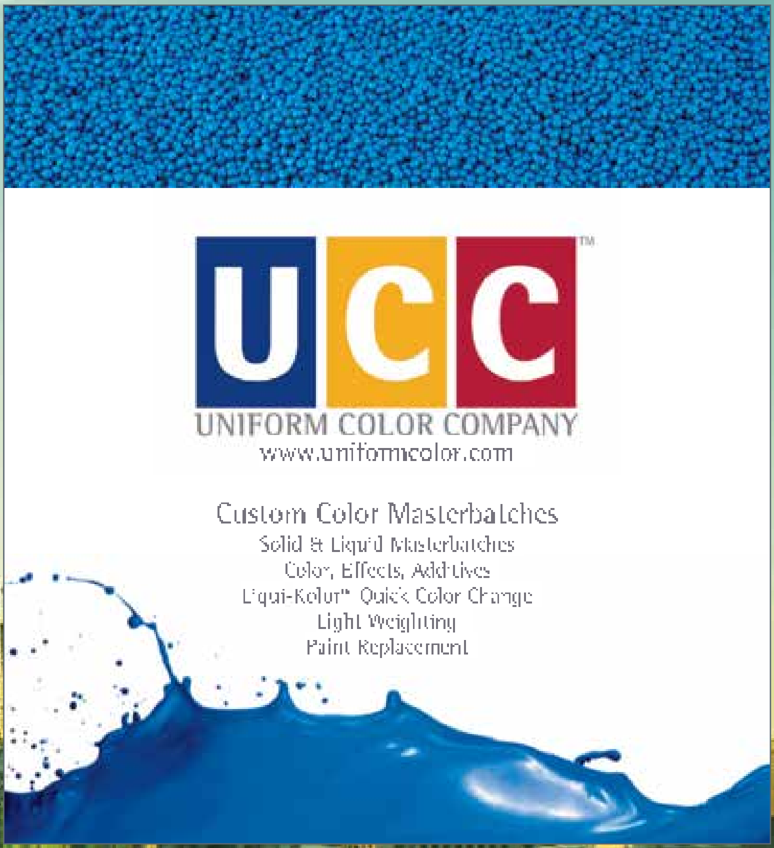
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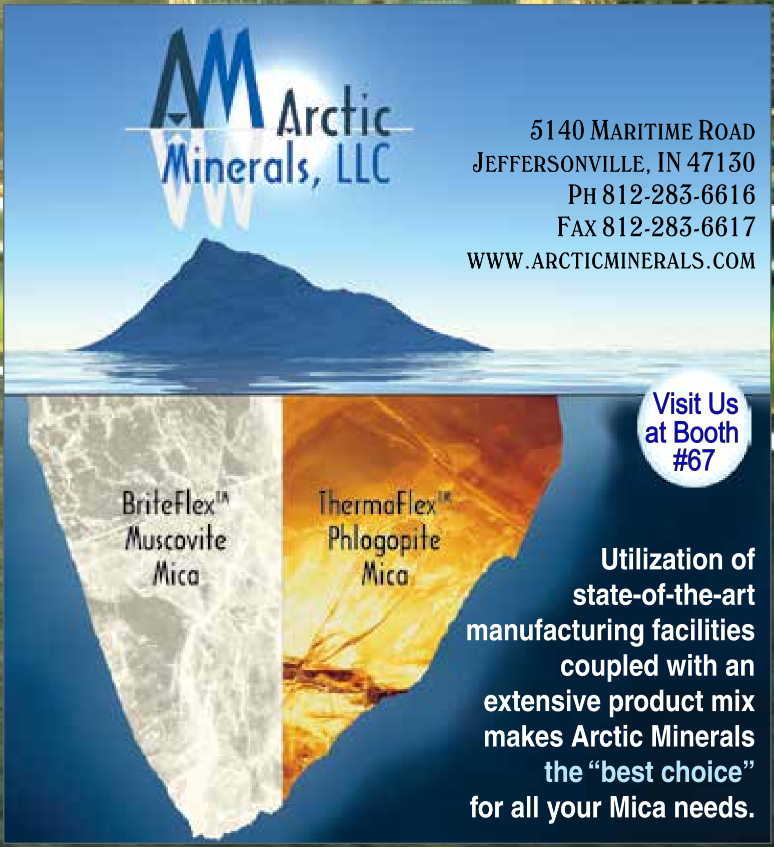
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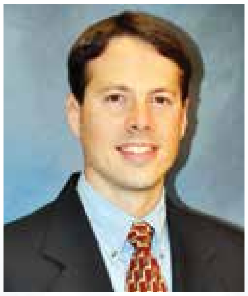
LIGHTWEIGHTING TECHNOLOGIES

SESSION CO-CHAIRS:

John Haubert, FCA US LLC | Normand Miron, Washington Penn Plastics | Hoa Pham, Freudenberg Performance Materials

Polyolefin Elastomer Impact Modifiers to Meet Lightweighting Needs

Jeff Munro, Dow



Lightweighting isa significant trend in the automotive industry. To enable lightweighting of existing TPO parts and expansion into new TPO parts, material development is needed. New polyolefin elastomerswere evaluated in TPO compounds with standard and high aspect ratio talcs. The influence of compounding conditions with highaspect ratio talcs will be discussed. Novel polyolefin elastomersprovide new opportunities to balance flow, toughness, stiffness, and CLTE properties required for future TPO compounds.

Carbon Fiber Reinforced TPOs: Advancing the Future of Automotive Materials

Dr. Jane Lu, LyondellBasell

The automotive industry pursues weight reduction for vehicles to comply with increased fuel efficiency goals and other standards having an environmental impact. Carbon fiber has been used as reinforcement in polymer composites for its light weight, high stiffness, excellent thermal stability, and/or electrical conductivity. However, adding carbon fiber to a polyolefin-based composition typically results in a decrease in cold temperature ductility. This disadvantage, along with the high cost of carbon fiber, limits the use of carbon fiber reinforcement in the automotive TPOs. LyondellBasell has conducted extensive research and developmental work on carbon fiber reinforced PP compounds for broad applications in automotive. This paper will present economical use of carbon fiber, design innovation and comprehensive performance evaluation of carbon fiber reinforced polyolefin with balanced stiffness/ impact properties that resolve this impact deficiency and enable exterior applications such as painted fascia and body panels.

Development of New Applications by Advanced LFT Technology

Youngbum Kim, Lotte Chemical

This research describes the new development of long fiber-reinforced thermoplastics (LFT) for lightening automobile. Beyond conventional injection molding, we develop the advanced LFT technology that combines material with Design and structural analysis. For example, bumper back beam was newly designed to be manufactured from the injection molding using LFT pellets. The stiffener for Pedestrian protection by profile-extrusion molding with LFT is developed. In addition, new molding techniques such as high-pressure compression molding and foaming injection can be applied. Using design and structural analysis and molding techniques, LFT materials can be applied to more structural parts to further reduce weight.

Lightweighting Strategies with Talc in Automotive TPOs

Piergiovanni Ercoli Malacari,
Imi Fabi

Automotive plastics market is a very demanding and growing business. Talc is a functional mineral for polymer modifications in this market where it plays a relevant role in TPOs where the very unique final performances can be achieved. IMI Fabi has developed a full range of products to fulfil the most demanding request in this area with a global presence, to satisfy the main automotive requirements. In this paper, some specific examples how to approach lightweighting by using IMI Fabi Talc grades will be showed .

LIGHTWEIGHTING TECHNOLOGIES

SESSION CO-CHAIRS:

John Haubert, FCA US LLC | Normand Miron, Washington Penn Plastics | Hoa Pham, Freudenberg Performance Materials

Reduced Density TPO Solutions

Jason Fincher,
Advanced Composites

Although talc is the densest component of talc-filled TPO, it provides benefits for modulus and dimensional stability. Novel TPOformulations are required tomaintain mechanical propertiesat lower talc content. Advanced Composites has designed compounds suitable for both interior and exteriorapplications that provide opportunities for reducing weight while maintaining mechanical properties. This presentation will consider new reduced density product offerings for weight savings in the context of alternative weight savings strategies being implemented in the industry.

Pushing the Boundaries of High Performance Short Fiber Glass Coupled PP

John Oliver,
Sumika Polymer
Compounds Europe

Providing cost-savingand light weight solutions are dominant themes in the automotive industry. Innovative product development in high performance glass coupled PP compounds has driven the substitution of engineering thermoplastics like polyamide in structural parts,contributing to weightsaving and meeting CO2 targets.SUMIKA will present a new family of engineering PP compounds as part of the THERMOFIL HP product range which meet this development challenge.

Development of Lower Cost Natural Fiber Door Trim Panel with Significant Mass Savings and Class "A" Finish

Ed Wenzel, Inteva Products, LLC

Door trim panels constructed with a natural fiber based substrate material have been in production for a number of years. Typical applications generally offer mass savings over conventional injection molded designs, but at a cost penalty. This presentation reviews a technology development that produces a low cost class "A" finish NF based door trim panel in addition to offering significant mass savings.

Weight Reduction of Plastic Components by using Advanced Process Technologies

Juergen Giesow, v Arburg

With the continued focus on the increased cost of energy there is an excellent opportunity to increase energy efficiency through weight reduction of injection molded components. 'Light weighting' of parts while maintaining, or even improving, their performance in their respective application fields, such as automotive and aerospace fuel efficiency, is now a focal point in the injection molding industry. Direct Fiber Compounding, MuCell or ProFoam are technologies that will be discussed.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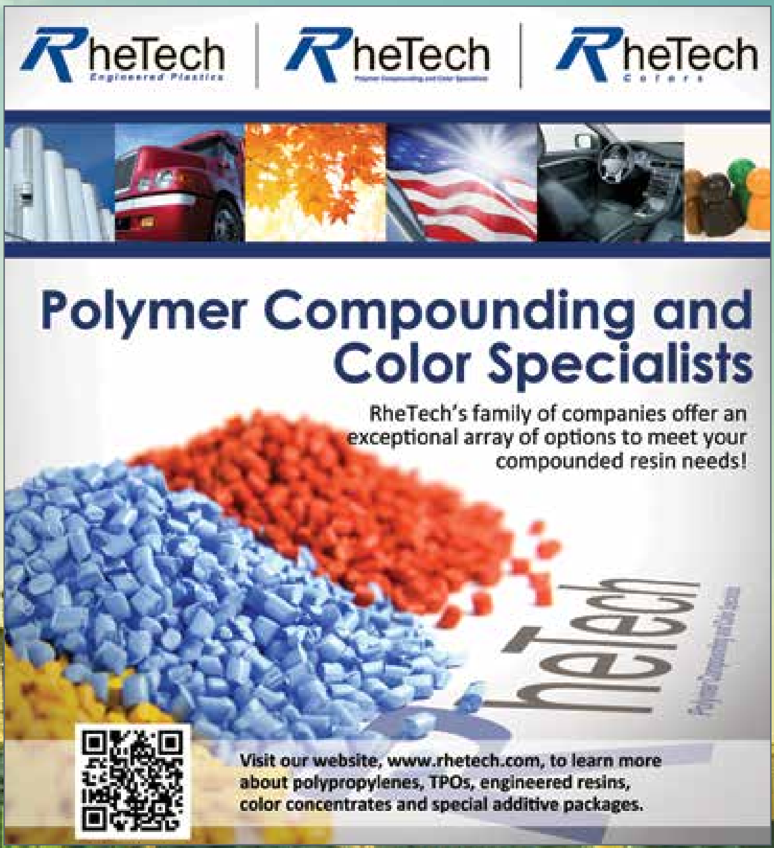
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SUSTAINABILITY & EMISSIONS

SESSION CO-CHAIRS:

Susan Kozora, IAC Group | Dr. Alper Kiziltas, Ford Motor Co. | Dr. Laura Shereda, Asahi Kasei

The Growing Importance of More Sustainable Materials

Alper Kiziltas and Debbie Mielewski,
Ford Motor Company

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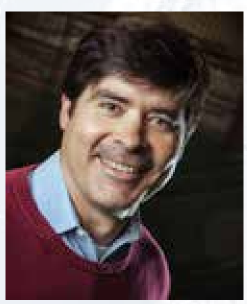
Benefits of THRIVE® / Celstran® Blends in Semi-Structural Applica-tions

Jorge Cortes,
THRIVE® Cellulose Fiber Composites



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End-of-Life Vehicle (ELV) Recycling

Meagan Marko,
Noble Polymers

With plastics progressively becoming a material of choice for major parts and components in the automotive industry, The Plastics Industry Association (PLASTICS) set out to explore the feasibility of recovering plastics from end-of-life vehicles (ELVs). Working with member companies, the technical andeconomic feasibility of the collection and reprocessing of bumpers was explored. This pilot project demonstrated the recovery of ELV bumpers from a broad range of vehicles and showed that the resulting material exhibited properties very similar to post-industrial bumpers reprocessed under the same conditions. As a result of this work, PLASTICS is continuing to explore new end-market opportunities that have the potential to bridge the supply and demand gap to scale collection of bumpers across the U.S. and create a new feed stream of TPO for remanufacturing.

Utilizing Recycled Materials in TPO Applications

Matt Velthouse,
PADNOS

As molders continue to look for ways to be environmentally responsible and manage resin costs, one of the ways they can be most impactful is to include recycled content material into their products. This presentation will focus on applications currently being targeted for this goal, and how this material is being sourced and processed to ensure molders receive a high quality product suitable for the automotive market.

SESSION CO-CHAIRS:

Susan Kozora, IAC Group | Dr. Alper Kiziltas, Ford Motor Co. | Dr. Laura Shereda, Asahi Kasei

"Tackling Current & Oncoming Emissions Challenges" – Landscape & Development of Emissions Compliant Polypropylene

Jeff Salek, Braskem

Global OEMs are establishing specifications for emissions compliance for various dynamic automotive applications based on regional preferences and potential risks from long term exposure. Additionally, the industry is fragmented on test methodologies that have yet to coalesce. Braskem is committed to advancing and understanding the role polypropylene plays in meeting these oncoming requirements. This paper will briefly examine the landscape, trends, technology, and testing protocols that Braskem is using to engineer and optimize our polypropylene portfolio to meet current and future requirements.

Synthetic Minerals for VOC Reduction in TPO for the Automobile Cabin

Rob Lorenzini,
Maroon Group LLC

Automotive TPO producers, compounders, and molders are aggressively responding to calls from government organizations and OEMs to reduce the volatile organic compounds (VOCs) that consumers are exposed to within the automobile cabin. While many consumers enjoy the "new car smel", scientists and medical professionals are becoming increasingly concerned with the effects of these odors on human health, especially during repeated and prolonged exposures. Herein, industry standard testing methods, typically based on separation via gas chromatography and various detectors, are utilized to quantitatively demonstrate the reduction of various VOCs in interior TPO grades by addition with synthetic zeolite minerals. The mechanism of VOC reduction is the selective adsorption of materials within the highly porous crystal structure of the zeolite additives.

Different Concept on Reduction of VOC in Value Chain

Jungdu Kim*, C. Malchaire, K. Keck, & T. Schmutz
Songwon

Emissions from polypropylene are gaining more and more attention. In automotive interior applications in particular, emissions can be generated by the quality (purity) of the polyolefin, the degradation of the polyolefin, and the solubility and inertness of the additives used. This paper presents solutions for reduction of Volatile Organic Content (VOC) in the value chain (from resin producers to OEMs). Our idea is special additives, which contribute to lessening VOC.

Innovations to Reduce Odor in Talc Filled Polypropylene System

Lily Liu, Polyone

A new-car smell no longer represents a differentiation and a sense of happiness, but increasingly causesconcerns and sometimes even panic instead. Such trenddemands more stringent regulations and drives car manufacturers to focus more on seeking suppliers which provide lower-odor and lower-emission products. While emission level is objective, as it can be quantified by standardized equipment, odor level is highly subjective, as it is still evaluated by humans. Previous studies have been focus on identifying odor-active compounds, mostly in neat polymer systems. In this paper, we will discuss filled polypropylene system, and specifically, practical means to reduce odor in talc filled polypropylene.

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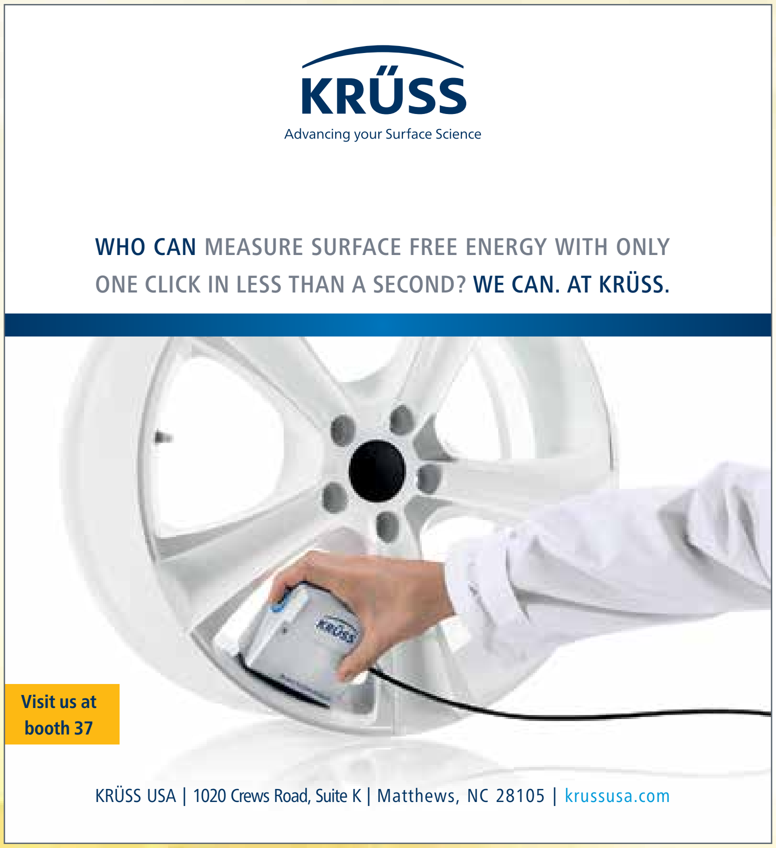

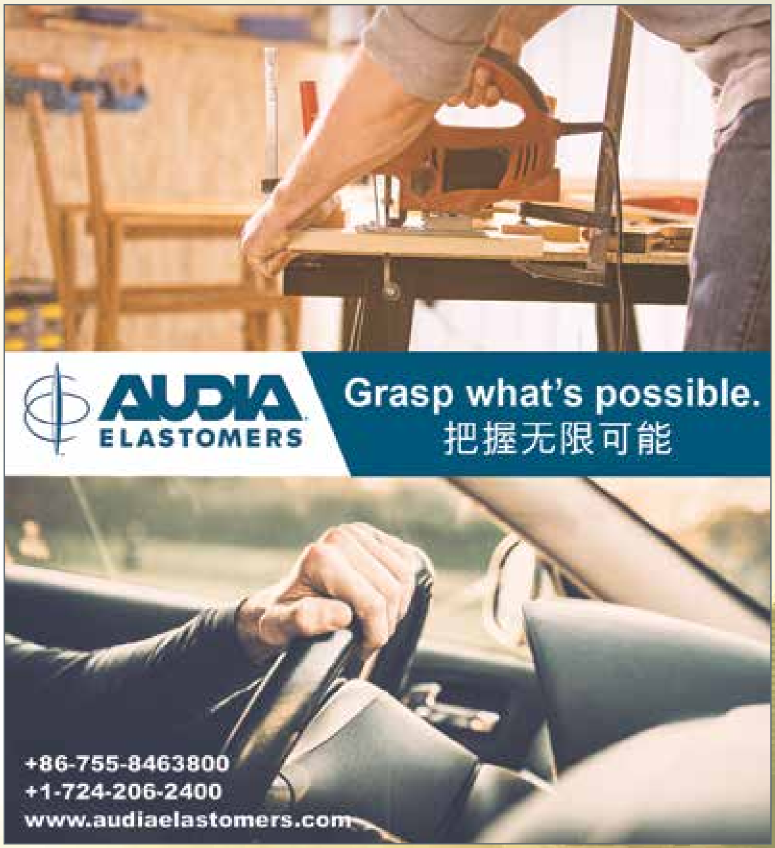

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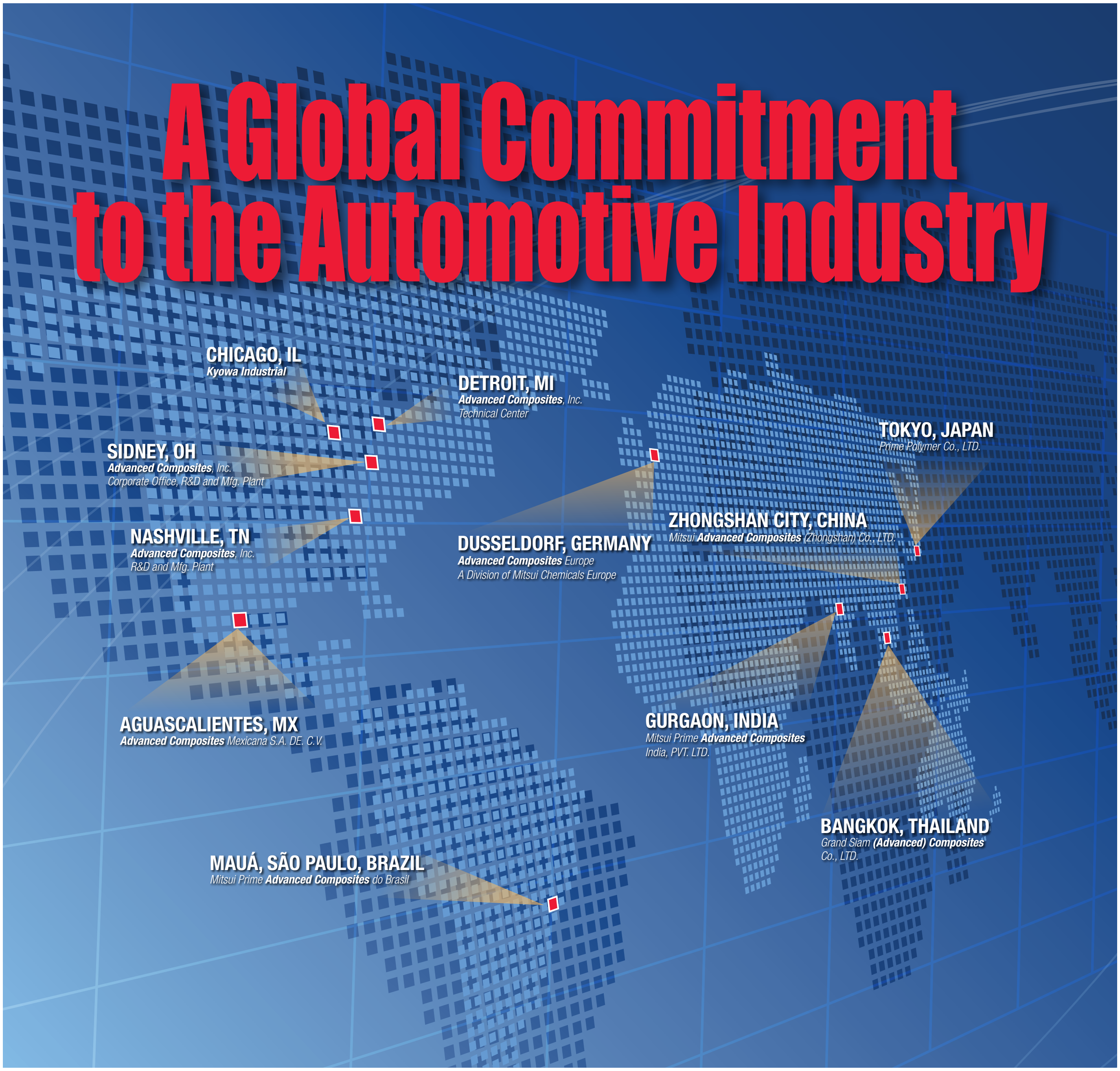

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