NEW DEVELOPMENTS IN SPECIALTY ADDITIVES TO OPTIMIZE TPE PERFORMANCE AND PROCESSABILITY
Johnson Thomas earned his Ph. D degree in Polymer Technology in 1998 from Mahatma Gandhi University, India. The focus of his research was developing novel TPE's and has gained an in depth knowledge in all aspects of Polymer processing. After graduation he has conducted advanced research at National University of Singapore and University Bordeaux in France and Center for Nanoscale Science & Engineering at North Dakota State University, U.S.A. Working in the polymer processing industry both in India and the U.S., Dr. Thomas created unique solutions for generating low compression set TPE's. Over all he has 14 years of research experience and his accomplishments include several peer reviewed journal articles and five U.S. patents. Currently he is a senior application scientist at Eastman Chemical Company.

Rob Banning is the founder of Trimax. He is a mechanical engineer with 25 years of experience in plastics product design and market development for TPE's and elastomeric components. Robert Banning is also a senior member of SPE, ACS-Rubber Division and he has authored over twenty technical/marketing presentations centered on product development and trends in the thermoplastics elastomer industry. He has contributed to many plastics industry trade journals over the years, including Plastics News, Injection Molding Magazine.
AGENDA

- Introduction
- Market Overview/ Challenges
  - Chemistry of Eastman Performance Additives
  - Additives for SEBS/ PP Systems
    - Morphology
    - Mechanical Properties
    - Elastic Properties
  - Additives for SEBS Systems
- Applying Additive Benefits to TPE Applications
- Summary
- Questions & Answers
Eastman Chemical

- A global manufacturer of chemicals, plastics and fibers
  - 2006 sales revenue of $7.5B
- Corporate headquarters in Kingsport, Tennessee USA
- Extensive expertise in polymers and polymer modification
  - Coatings, Adhesives, Specialty Polymers, Compounding
  - Specialty Plastics
  - Fibers
  - Performance Chemicals and Intermediates
  - Performance Polymers

Applying our strong base competencies to bring value to thermoplastic elastomers
Global TPE Market

- SBC: 44%
- TPO: 27%
- TPV: 9%
- TPU: 8%
- Other*: 7%

COPE, COPA: 5%

* New elastomer alloys and high temp TPEs

Based on Volume

Eastman provides complimentary technology to 85% of the industry
Traditional Tradeoffs/Challenges
In SBC Based TPE Compounding

- Achieving targeted mechanical properties with favorable rheology
- Achieving lower compression set economically
- Improving toughness while maintaining good injection moldability
- Optimizing mechanical properties with favorable economics

*Eastman additives help reduce these tradeoffs and challenges*
Performance Additives
“GOALS/EFFECTS”

- Management of TPE Rheology
  - For injection molding
  - For extrusion (profile/sheet)
  - For blow molding

- Optimization of Mechanical Properties

- Obtaining Required TPE Elasticity
  - Compression set
  - Tension set
  - Compression stress relaxation (CSR)
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Four Additive Families:

- Aromatic Additives
- Aliphatic Unsaturated Additives
- Aliphatic Saturated Additive
- Mixed Aromatic/ Aliphatic

Among each group there are variations based on feedstock origin, molecular weight and glass transition temperature.
Additive Chemistry

- **Aromatic resins**
  Endex™, Kristalex™, Picco™, Piccolastic™
  *(Based on Styrene, Substituted Styrenes and Indenes)*

- **Aliphatic unsaturated**
  Piccotac™ 1XXX
  *(Based on Isoprene System)*

- **Aliphatic saturated**
  Regalite™, Regalrez™, Eastotac™
  *(Hydrogenated Resins)*

- **Mixed Aromatic/Aliphatic**
  Regalite™, Piccotac™, Regalrez™, Eastotac™
  *(Partially Hydrogenated)*
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### Study Formulation (SEBS/ PP)

<table>
<thead>
<tr>
<th>Formulation Ingredient</th>
<th>PHR</th>
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<tbody>
<tr>
<td>Kraton® G 1651 (SEBS)</td>
<td>100</td>
</tr>
<tr>
<td>Marlex® HGL 120 (Polypropylene)</td>
<td>60</td>
</tr>
<tr>
<td>Eastman Additive</td>
<td>10, 30</td>
</tr>
<tr>
<td>Drakeol® 34 (Process Oil)</td>
<td>200</td>
</tr>
<tr>
<td>Omymcarb® 3 (Calcium Carbonate)</td>
<td>100</td>
</tr>
<tr>
<td>Irganox® 1010 (Antioxidant)</td>
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<td>Stabilizer</td>
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Structure/ Property Relationship in TPE's

Rubber/PP Ratio, Particle Size and Compatibility

- Elastic Prop
- Thermal
- Hardness
- Elong. At Break
- Tensile

Mainly by PP Phase

PP Phase

Rubber Phase, Particle Size and Co-continuity
Morphology of PP/SEBS Control
Effect of Eastman Aromatic Additives on SEBS/PP

Aromatic additives migrate to styrenic phase thereby increasing the overall rubber volume fraction. This has a positive effect on the physical properties of the compound.
Effect of Eastman Aliphatic Additives on SEBS/PP

Aliphatic unsaturated resins are more compatible with styrenic phase. This changes the overall morphology of the elastomeric phase which leads to improved mechanical properties.
**Mechanical Properties (SEBS/ PP)**

- **Tensile Strength, Psi**
  - Control: 1000
  - Aromatic: 1200
  - Aliphatic: 1100
  - Mixed: 900

- **Ultimate Elongation, %**
  - Control: 1400
  - Aromatic: 1600
  - Aliphatic: 1500
  - Mixed: 1300

- Aromatic additives migrate to the elastomeric phase
- Aliphatic additives are compatible with both phases
- Mixed system leads to incompatibility
Mechanical Properties (SEBS/ PP)

- Aromatic additives increase the volume fraction of elastomeric phase
- Aliphatic additives soften the hard phase
Aromatic additives migrate to the styrenic domains and generates a better phase separated morphology. This also increases the effective physical crosslink density in the elastomeric phase.

Aliphatic additives are more compatible with elastomeric phase and effectively increases the elastomeric volume fraction.
Effect on Compression Set on SEBS/PP

Compression Set @ 70°C

- Control
- Aromatic
- Aliphatic
- Mixed

Comparison of Compression Set-%

- 10phr
- 30phr
Effect of Resin Loading on Key Properties
SEBS/PP

Aromatic Additive- Endex 160

Hardness-Shore A

Additive Loading

Control 5phr 10phr 15phr 30phr

0 seconds 15 seconds

Tensile Strength

Additive Loading

Control 5phr 10phr 15phr 30phr

Ultimate Elongation

Additive Loading

Control 5phr 10phr 15phr 30phr
Capillary Rheology - Aromatic Additives (SEBS/ PP)

Resistance to flow would increase with increasing size and decreasing flexibility of dispersed domains.
Capillary Rheology - Aliphatic Additives
SEBS/PP

Miscibility of aliphatic additives with PP phase decreases the Melt rheology
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In the case of Aromatic additives there is no shift in the Rubbery Tg.
Aliphatic additives increase the Tg of the rubbery phase.
This suggests that Aliphatic additives are compatible with rubber phase and aromatic additives goes to the hard phase.
Eastman Additives in an SEBS Compound

- Aromatic additives in pure SEBS migrate to styrene which is the hard phase
- Aliphatic and mixed additives are compatible with soft elastomeric phase
Eastman Additives in an SEBS Compound

- Aromatic additives increase the volume fraction of the hard phase which increases the tear strength and hardness.

- Aliphatic additives migrate to the soft rubbery phase and toughen the soft phase.
Eastman Additives in an SEBS Compound

- As the aromatic additives increase the hard phase volume fraction, there is a loss in compression set properties at higher loading of aromatic additives
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TPE Compound Selection
Performance Environment

- Environment
  - UV, Ozone
  - Chemical/Oil
  - Temperature

- Baseline Elastomeric Characteristics
  - Compression Set
  - Tensile Set
  - Processability
  - Flex Fatigue

- Interaction
  - Adhesion to Substrates
  - UL Requirements
  - USP or FDA Requirements
  - Specialized Fluid Resistance Needs
Performance Enhancement through Use of Eastman Additives

Management of TPE Rheology
- For injection molding
- For extrusion (profile/ sheet)
- For blow molding

- Aromatic additives improve the shear viscosity which provide dimensional stability to extrudate

- Aliphatic additives lower the compound viscosity improving the processability and mold flow

- Aliphatic saturated additives (Regalites) provide very low viscosity at low frequencies

New Fundamental "controls" to achieve desired shear rate/ viscosity relationship
Performance Enhancements From Eastman Additives

- **Optimization of Mechanical Properties**
  - Softer or Harder compounds with improved tensile strength
  - Limited compromise on Tear strength

- **Obtaining the required Elastic Properties**
  Eastman additives provide the flexibility to obtain the required elastic properties
  - Aromatic additives increases the overall rubber volume fraction thereby improving the compression set properties
  - Aliphatic additives improve the compression set and ultimate elongation by improving the compatibility/co-continuity between the dispersed and continuous phases
Enabling Improved and New Applications

**ESTABLISHED (1990-current)**
- Closures
- Kitchenware grips & food storage
- Plumbing gaskets
- Construction seals
- Automotive boots
- Dishwasher boots/seals
- Toothbrush/razor soft grips
- Hand/power tools
- Automotive ducting
- Wire and cable insulation
- Athletic shoe soles
- Caster wheel treads

**NEW/GROWING (2005 to Next Decade)**
- Moldable gels
- Softer oil resistant grips
- Industrial products
- Sterilizable medical seals
- Wine bottle seals
- Cosmetics packaging
- Food contact diaphragms
- Solar collector seals

Plus many others limited only by your imagination!
Committed to Help Expand TPE Industry Growth

Eastman performance additives help provide new value in creative new SBC based TPEs

Additional work is ongoing in polyolefin based TPEs and polyester based elastomers

* New elastomer alloys and high temp TPEs
Use of Eastman's performance additives in SBC based TPE compounds offers:

- Better control of molding and extrusion processability
- Improved mechanical properties of TPE compounds
- Enhanced elastic properties of TPE compounds
- New tools to control TPE hardness
- Broader SBC-based TPE temperature performance
QUESTIONS??
Thank you for participating in the Webinar

For additional information, including technical assistance or samples, please feel free to contact us:

Technical Assistance:
If you would like to be contacted by a Technical Expert, please feel free to use the TechDirect service on SpecialChem4Adhesives:

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Visit our website: www.tpeadditives.com for additional product information