Effects of Environmental Issues and the Impact on Future Growth of TPEs

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Green Issues and their Impact on TPEs

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GLS Elastomers
PolyOne Corporation
McHenry, Illinois
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Robert Eller Associates LLC
CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES

- Robert Eller Associates is a 17 year-old global plastics consulting company
  - Assist companies in the strategic decision making process by analyzing technical, marketing and economic implications for their business and market sectors
  - Focus on Elastomers, ETP’s, PP Compounds/TPO, Automotive, Compounding and Foams
  - Eighth year active in China
- Offices in Akron, Ohio (main office), France, China, New Zealand
- Multi-client studies
- Single client studies
- Mergers and acquisitions
Major development areas in TPEs driven by Green issues:

• PVC replacement
  – Trace residuals migration
  – Halogen free/low smoke requirements

• Sustainability:
  – Carbon footprint
  – Lightweighting
  – Bio-renewable and biodegradable thermoplastic elastomers
    • Reduce petroleum base
    • Biodegradable
  – End-life/recyclability
PVC is a Major Substitution Opportunity

**Advantages**

- Price
- Incumbent in medical tubing and infusion bags, wire and cable, slush molded auto skins

**Disadvantages**

- High specific gravity
- Thermal stability
- Difficult to recycle
- Lower heat distortion
- Poor low temperature performance
- Plasticizer volatility
- Phthalate plasticizers (migration)
- Dioxin generation on combustion/incineration
- Halogenated (RoHS restrictions)

Source: Robert Eller Associates LLC, 2011
BPA Model

- Analytical technology improvements in measuring “de minimis” levels of trace residual chemicals in body fluids
- BPA impacts epoxy applications (metal can coatings) and durable good items produced from polycarbonate including baby bottles, sports bottles, water bottles and medical applications.
- Increasing societal sensitization to this as an issue: minimal chronic exposure levels
- Efforts more successful than attacks on PVC (bottle banning)
  - PVC has both phthalate leaching potential and dioxin generation when combusted causing long term medical issues
  - With the attack on BPA being successful, will the attack on PVC (specifically in medical applications) be successful?
PVC Substitution

Three major targets
- Wire and Cable
- Automotive Interior Skins
- Medical IV bags and tubing
Wire and Cable

- > 300 kT PVC market with major substitution ongoing globally
- Europe driven: RoHS and WEEE requirements
- Major global OEMs have issued directives to eliminate PVC and halogen containing products on a global basis to eliminate potential risk of any of their branded manufactured electronic product containing halogen materials being disposed in landfills in Europe
- Low smoke requirements increasing
- Target applications are household cables and wires typically less than 200 Volts used for household power, electrical, electronic, computer, media and network applications
- SABIC IP was early compound supplier with Flexible Noryl
- Combustion toxicity: a new consideration
Flame Retardancy

- Flammability requirements: UL62 VW-1 and UL94 V-O
- Halogen free
  - Combustion toxicity
  - Environmental persistance
  - Chronic exposure
  - Bio accumulation
  - Old technology
    - Magnesium Hydroxide
  - New technologies:
    - Ammonium Polyphosphate
    - Melamine Polyphosphate
    - Melomine cyanurate
    - Metal phosphinates
- SEBS resin is used to modify/create several compounds including TPE-S, TPU, PPE and COPE
- Low smoke
Wire and Cable Materials

- Flexible Noryl (PPE + PE)
- Xlinked PE
- Fluropolymers
- PE, PP, POE
- SBC
- TPV
- TPU
- COPE
### Wire and Cable

#### Classification of Automotive Wire and Cable Materials

<table>
<thead>
<tr>
<th>W/C CLASS</th>
<th>MATERIALS COMPETITORS</th>
<th>NOTE</th>
</tr>
</thead>
</table>
| T4-T5      | - Fluoropolymers (PTFE, ETFE)  
              - Silicones  
              - AEM type elastomers  
              - COPE  
              - XLPE | - High temperature requirements  
              - COPE may challenge fluoropolymers  
              - AEMs are ethylene acrylic elastomers |
| T3         | - XLPE  
              - TPE-S  
              - TPE-O  
              - TPES-V  
              - PVC | - High growth segment, especially for thermoplastic elastomers  
              - Will grow due to conductor (copper) down-gauging to achieve weight savings |
| T1-T2      | - PVC  
              - PE | - Dominated by PVC  
              - Represents approx. 75% of automotive wire/cable materials |
| Flat Cable | - TPU | - Growth segment |

**SOURCE**: ROBERT ELLER ASSOCIATES LLC, 2011

- Increased use of wire/cable is a result of growing electrification of vehicles, which represents a potentially high growth segment for TPOs and several other types of TPEs
Auto TPE Target Markets: Interior Surfaces

Targets:

• Instrument panel, door trim, console, steering wheel
• Objective is to “soften” the haptics of hard plastic feel and look
• Point of quality differentiation in the vehicle
  • Upgraded interiors will be less “plastic” feeling

Manufacturing:

• Multi-materials molding (2-shot)
• Skins
  o Thermoformed skins
    - TPO
    - TPV (usually partially crosslinked grades)
  o Slush molded skins (PVC major incumbent), primarily for instrument panels
Multi-material Molding

- Cost save vs. incumbent skins methods
- TPVs and SBC-TPEs competing
- Foaming will accelerate penetration
- Capital investment vs. labor costs (an issue in Asia)
- TPEs with high flow (large area/thin cross-section) required
- Craftsmanship improvement
- Recyclability

Lower IP and door medallions are entry points for 2-shot molded (TPE skin/substrate)

- 2-color
- Grain is less critical than upper
Automotive Interiors TPE Target: Door Trim

Example Multi-material (2-shot) Door Trim Panel
• Application: Door trim (dark areas)
• TPE Supplier: A. Schulman
• TPE Type: o-TPV
• OEM: Chrysler
• Vehicles: Caliber, Commander, Grand Caravan

TPE Benefits:
• Haptics → soft (luxury) touch
• Enhanced craftsmanship/multi-color capability
• Single step process/labor cost savings
• Cost save vs. multi-step approach
• Multi-material molding cycle time approaching single shot

TPE Skin Candidates: SEBS (TPE-S), o-TPV, TPU modified TPE (for use over PC/ABS)

Key TPE Challenge:
• Adequate flow (large area/thin cross-section (1-2 mm)
• Capital investment required
• Ability to incorporate foam
• Competition with textile inserts

Incumbents: Thermoformed/backfoam PVC or TPO sheet, PU spray (declining)
Interior Skins Target: Instrument Panel

Grain reproduction: key parameter

Logos

Craftsmanship

Hidden airbag doors
2011 Chevrolet Cruze

Examples of Upgraded Interior on Small Car:

- Steering wheel mounted audio control
- Leather wrapped steering wheel (2LT and Eco models)
- 2-tone instrument panel
- Bluetooth® connectivity
- USB port
- Increased soft touch surfaces
2012 Ford Focus SE 5-Door:
Another example of small car luxury
Process breakdown

• Instrument Panels: 70% soft/30% hard
• Soft Instrument Panels: 70% slush molded
• Door Panels: x% hard/ y% soft
• Door Panels: z% slush molded
IP Skin PVC Substitution Objectives

**Environment**
- Halogen free?
- Improve recyclability
- Reduce VOC/fog

**Performance**
- Satisfactory hidden passenger airbag deployment at -30ºC
- Grain reproduction
- Haptics
- Craftsmanship/fit & finish (shrinkage on heat aging effects)
- Mass reduction
- Long-term UV resistance (low Δ E)
- Heat aging resistance

**Cost**
- Reduce IP system costs
- Reduce skin costs
- Maintain current labor requirements???

**Weight**
- Reduce part/car weight
# Comparison Of Slush IP Skin Capabilities

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>PVC</th>
<th>TPE</th>
<th>TPU</th>
<th>SPRAY PU</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material cost, $/lb.</td>
<td>Lowest</td>
<td>Moderate</td>
<td>Highest</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Typical skin weight, lbs.</td>
<td>3 – 3.5</td>
<td>1.6</td>
<td>2 – 2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low temp. airbag deployment (heat aging effect)</td>
<td>Some degradation after heat aging</td>
<td>No deployment performance</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>$\Delta E$ after UV exposure (2500 kJ, 89ºC)</td>
<td>Highest</td>
<td>Very low (&lt; 1)</td>
<td>Very low (&lt; 1)</td>
<td>Moderate</td>
<td>OEMs require $\Delta E = &lt; 3$</td>
</tr>
<tr>
<td>Shrinkage on heat aging</td>
<td>Moderate curling</td>
<td>Remains flat (no curling)</td>
<td>Minor curling</td>
<td>--</td>
<td>Shrinkage increases visibility of tear seam</td>
</tr>
<tr>
<td>VOC</td>
<td>Medium</td>
<td>Lowest</td>
<td>High</td>
<td>High</td>
<td>High = &gt; 100</td>
</tr>
<tr>
<td>Fog</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>High</td>
<td>Acceptable</td>
<td>Acceptable = ~ 125 µg/gram</td>
</tr>
<tr>
<td>Process window</td>
<td>Narrow</td>
<td>Wide</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Scratch &amp; mar resistance</td>
<td>Good</td>
<td>Unknown</td>
<td>Very good</td>
<td>Very good</td>
<td></td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2011
Car Model: Audi E8
Part: Instrument Panel Skin Slush Molded
Raw Material Resin: Kraton
Compound: Laprene S formulated by SO.F.TER
Fabricator: Peguform
Features: Halogen free, phthalate free
30-40% lighter weight than PVC
Better low temperature performance than PVC
Better aging characteristics than PVC
Lower processing costs
Recyclable
Deep soft touch/haptics feel

Source: Robert Eller Associates LLC 2010
Technology

Two major stakeholders: Inteva and Kraton

• Inteva
  – Tier one manufacturer of automotive interiors
  – Has US patent on SEBS slush molded skin technology (2004)
  – Licensed A. Schulman to produce compounds
  – Has at least one vehicle model in production
  – Seeking licensees

• Kraton
  – SRC resin/compound supplier
  – Launched SEBS slush compounds with S.O.F.T.E.R. in 2010
    Commercial on Audi E8
  – Uses proprietary resin for compound taking advantage of Kraton’s
    skill and knowledge of molecular tailing the SEBS resin structure

• Other suppliers
  – Reportedly at least two other compounders working in this space
Medical
Bio TPEs

• **Driving forces:**
  – Emotive from the consumer perspective
  – Sustainability from the manufacturer

• **Applications**
  – Driven by marketing to consumers/consumer oriented products (both disposable and durable goods)
  – Footwear

• **Definitions**
  – Renewable or Sustainable Compounds
    • Produced from renewable raw material sources that are sustainable from plant or animal base
  – Bio-degradable
    • Produced from renewable raw material sources that are sustainable from plant or animal base
    • compostable
    • can be either synthetic or bio-based
    • how effective is in debate
    • impact on recycle stream also under debate
Feedstock Sources for Polymer Matrices and Elastomers

Non-Renewable
• Petroleum
• Coal

Renewable
• Corn
• Castor Bean
• Starch
• Sugar
• Algae
• Yeasts
# Non-Petroleum Feedstock Activity

<table>
<thead>
<tr>
<th>Feedstock Source</th>
<th>Status and Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>Shenhua/Dow in China: Plant under construction</td>
</tr>
<tr>
<td>Corn</td>
<td>PLA, polyols (COPE, TPU) Materials in production</td>
</tr>
<tr>
<td>Castor Bean</td>
<td>COPA In production</td>
</tr>
<tr>
<td>Starch</td>
<td>Teknor Apex In production</td>
</tr>
<tr>
<td>Sugar</td>
<td>Braskem (in production for PE) Dow Mitsui JV (Project Crystal) (pilot plant)</td>
</tr>
<tr>
<td>Algae</td>
<td>Algenol (Dow) Solarzyme (Dow) Synthetic Genomics (ExxonMobil) All in Pilot Plant stage</td>
</tr>
<tr>
<td>Yeasts</td>
<td>Amyris (Kraton) In R&amp;D phase</td>
</tr>
</tbody>
</table>
Plant-based Fillers/Fibers for Bio-plastics/elastomers
Oils

- Petroleum based oils have better thermal stability and are typically more effective than plant based oils
- Petroleum based oils are typically less expensive
- Plant based oils
  - Epoxidized soy bean oil
  - Castor oil
  - Sorbitol
  - Glycols
  - Natural oil polyols
# TPE Compounds based on Renewable Raw Materials

<table>
<thead>
<tr>
<th>ELASTOMER FAMILY</th>
<th>RENEWABLE/SUSTAINABLE RESOURCE</th>
<th>MARKET DRIVER</th>
<th>PRODUCERS</th>
<th>RENEWABLE CONTENT (%)</th>
<th>HARDNESS RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPA</td>
<td>Polyamide based on castor oil</td>
<td>Footwear</td>
<td>Arkema Evonik</td>
<td>25-94</td>
<td>35-72 Shore D</td>
</tr>
<tr>
<td>COPE/TPEE</td>
<td>Polyols derived from plants (corn)</td>
<td></td>
<td>DuPont DSM</td>
<td>20-60</td>
<td>35-55 Shore D</td>
</tr>
<tr>
<td>TPU</td>
<td>Polyols derived from plants (corn)</td>
<td>Footwear</td>
<td>Merquinsa Bayer API GLS</td>
<td>20-70</td>
<td>70 Shore A to 55 Shore D</td>
</tr>
<tr>
<td>SBC</td>
<td>Plant based oils</td>
<td></td>
<td>GLS API CTS</td>
<td>20-80</td>
<td>22-85 Shore A</td>
</tr>
</tbody>
</table>

Source: Robert Eller Associates LLC 2010
Biodegradable Thermoplastic Elastomers

- API has introduced the first biodegradable thermoplastic elastomer: Apinat
- Based on TPU and aliphatic copolyester
- Two series of biodegradable, one from
  - synthetic raw materials
  - renewable raw materials (polyols derived from plant (mainly corn))
- Softness grades from 55 Shore A to 78 Shore D
- What’s next: Lactide based copolymers from Arkema?

Source: Robert Eller Associates LLC 2010
Summary

• PVC substitution is finally occurring
  – Wire and Cable is happening now
  – Automotive skins is in development stages
  – Medical is still needing the strong driver for critical mass

• Bio-elastomers/polymers
  – Lot of R&D and development activity, particularly on the matrix side
  – Select consumer driven markets, still a niche play
  – Where does bio-degradable fit

• Next emerging issue
  – Carbon footprint: already a factor in Europe

Source: Robert Eller Associates LLC 2010
Thank You!

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