TPEs: POSITIONING FOR SUCCESS IN THE GLOBAL AUTOMOTIVE SECTOR

PRESENTED BY:
Robert Eller
Robert Eller Associates LLC
Phone: +1 330-670-9566
Email: bobeller@robertellerassoc.com
Web Site: www.robertellerassoc.com

PRESENTED AT:
SPE TPO AUTOMOTIVE ENGINEERED POLYOLEFINs CONFERENCE 2012
Detroit, MI
October 1, 2012
b/papers/spetpo 2012
OUTLINE

- **Global Trends:**
  - Global automotive market/regional differences
  - Asia shift implications
  - TPE industry structure shifts

- **Automotive TPEs**
  - The auto TPE product life cycle/looking toward the future
  - Recent automotive TPE target applications
  - Overview of the automotive TPE battleground

- **s-TPVs:** role in automotive

- **Bio-TPEs:** potential in automotive/sustainable applications
GLOBAL VEHICLE SALES OUTLOOK

- **Annual Growth**
  - 1990-2000: 2.4%
  - 2000-2005: 3.6%
  - 2005-2015: 2.5%
  - 2020-2025: 3.0%

- **2009:** 9% decline followed by:
  - recovery in 1H/2010
  - slowing 2H/2010

- **2012:** On track for 83MM units. 6% gain vs 2011 despite European sales decline

- **2025:** 48% in China and BRI countries
  - 44% in U.S./Europe/Japan

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
r/mydox/Auto Industry/Global Ind Volume 073112.xlsx
THE ASIA SHIFT: EFFECT ON AUTO TPEs

• Auto production in China
  - Focused on domestic market (only 4% of production is exported)
  - Domestic market → saturated by 2020 (at 25-30MM units)

• Supply chain effects as Asia infrastructure matures:
  - Western companies become dependent on Asian supply chain even for products with low labor cost share
  - Supply chain infrastructure becomes established
  - Shift of R/D to region (technology and innovation shift?)
  - Scale of Asia resin supply and compounding plants → competitive

• Current TPE usage/vehicle is below global average, creating growth opportunity via:
  - Vehicle production growth
  - Increased usage/vehicle
VEHICLE PRODUCTION SHIFT TO CHINA CONTINUES

PRODUCTION GAINS RE-START 4Q ‘13

- 10 MM UNIT GAIN = TPE
- CAGR = 8.3%/YR
- SATURATION

3.3 %/YR
3.7%/YR

PRODUCTION SHIFT

Prod'n, MM Units

Europe | China | N. America | Japan/Korea | S/SE Asia | S. America | MEA

SOURCE: IHS

auto/gloal prod volumes091812
GLOBAL AUTO SALES FORECAST FOR MAJOR OEMs

VW RETAINS AND ENHANCES #1 POSITION.
CONTINUED GLOBAL PLATFORM RELIANCE

Source: IHS
EUROPEAN UNION CAR SALES: 20% DECLINE SINCE 2007, OVERCAPACITY REMAINS

SALES, MM VEHICLES

SOURCE: EAMA/EUROPEAN COMMISSION

b/mydox/aut/european sales 07-12
• Rollout of MQB (modular architecture) platform:
  - Cost savings (plant flexibility, reduced production time)
    - 6MM units/40 models by 2020
  - More integrated systems/modular constructions

• Global positions
  - On course toward retaining global #1 position
  - Very strong position in developing markets (Brazil and China)
  - Benefit from structural changes in European auto sector (currently 25% share)
  - N. American turnaround (currently 5% share)

• Pricing power vs mass market competitors
VALUE OF CHINA AUTOMOTIVE PARTS EXPORTS

EXPORTS TO N. AMERICA = $12.9 BN IN 2011

EFFECT OF US/WTO TRADE COMPLAINT?

SOURCE: STEWART AND STEWART, ROBERT ELLER ASSOCIATES LLC
2011 estimated based on first 9 months
b/mydox/auto china parts
GLOBAL INVESTMENT, TECHNOLOGY, AND MATERIAL FLOWS IN AUTO TPEs

ASIA:
- DOMESTIC AUTO DEMAND GROWTH
- EXPORT: SMALL CURRENT SHARE

MANUFACTURING

INVESTMENT: COMPDG/ RESIN
INVESTMENT PROFITS

COMPOUND EXPORT

FABRICATED AUTO PARTS

MATURE WESTERN ECONOMIES/AUTO MKTS
• EUROPE STAGNANT
• U.S. AUTO MKT. GROWTH

ASSET-RICH REGIONS:
• MIDDLE EAST

INVESTMENT
INVESTMENT, TECHNOLOGY TRANSFER

• INVESTMENT
• RAW MATERIALS

CURRENT SHARE
THE TPE FAMILIES

OLEFINIC (o-TPEs)

STYRENIC (SBCs)

SUPER-TPVs

OTHER, E-TPEs

PVC TPEs

TPO

SBS

SEBS (TPE-S)

H-SBC

VULCANIZED SBC TPVs (TPES-V) OR HMS-SEBS

SILICONE

OTHER

COPE

COPA

TPU

OTHERS

p-TPV (PARTIAL CROSSLINKED)

f-TPV (FULLY CROSSLINKED)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
<table>
<thead>
<tr>
<th>SHIFT TYPE</th>
<th>EXAMPLE/IMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition by major TPE supplier</td>
<td>- Lubrizol acquisition by Merquinsa</td>
</tr>
<tr>
<td>Distributor entry into TPEs</td>
<td>- Albis TPV entry. Expansion into N. America</td>
</tr>
<tr>
<td></td>
<td>- Alliance entry into compounding</td>
</tr>
<tr>
<td>Resin supplier → compounding</td>
<td>- TSRC, PP resin suppliers, others</td>
</tr>
<tr>
<td>Investment: Asia to West</td>
<td>- Nantong Polymax (TPE compound supply)</td>
</tr>
<tr>
<td></td>
<td>- TSRC acquisition of Dexco*</td>
</tr>
<tr>
<td>Growth of domestic China/Korean/Indian TPV compd’rs</td>
<td>- Hyundai EP, Shandong Dawn, Zylog, Nantex</td>
</tr>
<tr>
<td>Product line broadening by major TPE suppliers</td>
<td>- Teknor Apex acquisition of DSM Sarlink®*</td>
</tr>
<tr>
<td></td>
<td>- Kraiburg entry, high temperature TPE (Hipex®)</td>
</tr>
<tr>
<td>Major TPE suppliers emphasizing specialty vs commodity grades</td>
<td>- Kraton entry into higher performance grades*</td>
</tr>
<tr>
<td></td>
<td>- Creates opening for new TPE compounders</td>
</tr>
<tr>
<td>Shifts to Asian production and market development</td>
<td>- Many TPE suppliers, recently: Hexpol, CTS, Dow Corning/Multibase</td>
</tr>
</tbody>
</table>

*= Major raw materials company exiting “commodity” grades

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
AUTOMOTIVE: KEY TARGET MARKET FOR NEW TPEs

THE AUTO MARKET
- 40-50% of current TPE demand
- Key incumbents: EPDM, PVC, TPO
- Global footprint

- Role for lightweighting, systems cost-save
- Key target properties: low V.O.C., thin wall, low odor, oil/fuel resistance, heat resistance, sustainable
- Role for process technology, co-processing innovations

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

BUMPER FASCIA
SBC AS PP MODIFIER (SUZUKI SSPP)

UNDERHOOD
- s-TPV
- COPE

BODY/GLAZING SEALS
- o-TPV
- HI MELT STRENGTH (HMS)
CROSSLINKED SEBS

WINDOW
ENCAPSULATION
HIGH FLOW SEBS, o-TPV

RADIATOR
HOSE
o-TPV

WIRE/CABLE
- COPE
- o-TPV

SKINS

COATED FABRICS
- SEBS
Note: China/India demand growth shifts the product life cycle curves

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
## AUTO TPE PRODUCT LIFE CYCLE STAGES

<table>
<thead>
<tr>
<th>MARKET INTRO</th>
<th>GROWTH</th>
<th>MATURITY</th>
<th>SATURATION (DECLINE?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales vol.</td>
<td>0→Low</td>
<td>Increasing</td>
<td>Steady</td>
</tr>
<tr>
<td>Dev. costs</td>
<td>High</td>
<td>Reduced</td>
<td>None</td>
</tr>
<tr>
<td>Branding</td>
<td>None</td>
<td>High</td>
<td>None (commodity)</td>
</tr>
<tr>
<td>Mkt. approach</td>
<td>“Shaping”</td>
<td>Order seek</td>
<td>Order take</td>
</tr>
<tr>
<td>Inter TPE competition</td>
<td>Varies</td>
<td>Starts</td>
<td>Cascades to lowest cost TPE</td>
</tr>
<tr>
<td>Incumbent</td>
<td>Entrenched</td>
<td>Resistance</td>
<td>Replaced</td>
</tr>
<tr>
<td>Systems</td>
<td>None yet</td>
<td>Stimulates growth</td>
<td>Refined</td>
</tr>
<tr>
<td>Fab. tech</td>
<td>Standard</td>
<td>Adopt starts</td>
<td>Accepted</td>
</tr>
<tr>
<td>Asia role</td>
<td>None</td>
<td>Slight</td>
<td>Adopt</td>
</tr>
<tr>
<td>Global spec</td>
<td>No</td>
<td>Starts</td>
<td>In place</td>
</tr>
<tr>
<td>Example</td>
<td>Radiator hose</td>
<td>Body/glazing seals</td>
<td>TPO fascia</td>
</tr>
</tbody>
</table>

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2012
## NEW PROPERTY/APPLICATION EXAMPLES FOR AUTO TPEs

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TPE TYPES</th>
<th>AUTOMOTIVE APPLICATION</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-TPV</td>
<td>Hose</td>
<td>EPDM dominant incumbent</td>
<td></td>
</tr>
<tr>
<td>Foam</td>
<td>SEBS, o-TPV, COPE</td>
<td>- Body/glazing seals - Skins, steering wheel</td>
<td>- 2 shot molding, extrusion - Challenge EPDM, PVC</td>
</tr>
<tr>
<td>High flow</td>
<td>o-TPV, SEBS</td>
<td>Glazing seals, skins</td>
<td>Soft touch is market driver</td>
</tr>
<tr>
<td>- Hi temp, - Oil resist</td>
<td>s-TPV</td>
<td>Under-hood</td>
<td>Challenges specialty rubbers and COPE (TPEE)</td>
</tr>
<tr>
<td>“Sustain ” “Green”</td>
<td>SEBS, TPU, COPE</td>
<td>All applications where properties fit</td>
<td>Achieved via: - monomer, filler, oils</td>
</tr>
<tr>
<td>Transparency/ translucency</td>
<td>TPU, o-TPVs, SEBS</td>
<td>Skins/instruments</td>
<td></td>
</tr>
<tr>
<td>Slush moldable</td>
<td>SEBS</td>
<td>Skins</td>
<td>Range of process competitors</td>
</tr>
<tr>
<td>High melt strength (HMS)</td>
<td>SEBS</td>
<td>Foam (skins)</td>
<td>HMS allows foaming, blow molding</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
• The function usually (not always) remains: design approach shifts the
  - TPE being used (e.g. passenger airbag doors, some boots/bellows)

• Globalization:
  - Shifts the PLC curve (re-start in China)
  - Global TPE specifications starting
  - Differences between multinationals and domestic OEMs (e.g. China) and associated price/quality requirements
  - Introduces new TPE suppliers

• Fabrication processes can shift:
  - Position on the PLC curve, creating new fabrication process/TPE combination (e.g. two shot molding)
  - Systems costs → new TPE opportunities (e.g. body/glazing seals)
### CO-PROCESSING DRIVES TPE GROWTH IN RIGID/FLEXIBLE SYSTEMS

<table>
<thead>
<tr>
<th>TYPE</th>
<th>STRUCTURE</th>
<th>NOTE/EXAMPLE APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overmold, Film coex, 2-shot mold</td>
<td>TPE</td>
<td>- Soft touch phones</td>
</tr>
<tr>
<td></td>
<td>Substrate (rigid segment)</td>
<td>- Some 2-tone applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Vibration damping</td>
</tr>
<tr>
<td>Side by Side</td>
<td>TPE</td>
<td>- 2-tone</td>
</tr>
<tr>
<td></td>
<td>Rigid Segment</td>
<td>- Door trim, console, IP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Bumper fascia</td>
</tr>
<tr>
<td>Edging</td>
<td></td>
<td>- Body/glazing seals (profiles)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Cowl vent seals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Co-extrusion or 2-shot</td>
</tr>
<tr>
<td>Co-blow Mold</td>
<td>TPE (flexible)</td>
<td>- Boots/bellows, hose</td>
</tr>
<tr>
<td></td>
<td>Rigid</td>
<td>- Ducting</td>
</tr>
<tr>
<td>Co-extrusion Blow Mold or Co-extrusion</td>
<td>o-TPV s-TPV or ETP inner</td>
<td>Under-hood:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Hose (e.g. fuel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Duct</td>
</tr>
</tbody>
</table>

Source: Robert Eller Associates LLC, 2012

r/mydox/Visio/Two Shot OM approaches 2012.vsd
TPEs IN WINDOW ENCAPSULATION

- Application: Rear quarter window encapsulation seal
- Candidates: PUR, o-TPV, SEBS (H-SBC), PVC, EPDM
- Key requirements:
  - High flow (to reduce breakage)
  - Glass adhesion
  - UV/weather resistance
  - Low compression set
  - Squeak resistance
  - Scratch resistance

- Notes: Example of intense inter-material competition
  - Example of static seal application
  - Two shot adds value
  - Colors?
  - Narrower profiles?
  - Systems cost save opportunities
  - Polycarbonate glazing could shift requirements
FLUID PASSAGE

POLYAMIDE OR s-TPV INNER LINER (a)

O-TPV FOR ABRASION RESISTANCE

AUTOMOTIVE HOSE: ADDING VALUE VIA COEXTRUSION
EXAMPLE OF SEBS REPLACEMENT OF EPDM AND o-TPV

• Application: Door lock assembly bellows
• TPE type: SEBS
• Compound supplier: Star
• Molder: Altratek; Longmont, CO
• Key properties/economics:
  - Moldability
  - Remain flexible at low temperatures (to – 40°C)
  - Cost save vs EPDM and o-TPV
NEXT TPE GROWTH PHASE: TECHNOLOGY PUSH/MARKET PULL

**TECHNOLOGY PUSH**
- E.G.
  - HEAT RESIST
  - ADHESION
  - SCRATCH RESISTANCE
  - FOAMING
  - HAPTICS
  - HMS (SBCs)
  - CO-PROCESSING

**MARKET PULL**
- E.G.
  - GREEN INITIATIVES
  - AUTO DRIVERS:
    -- WEIGHT SAVE
    -- COST SAVE
    -- LUXURY LOOK/FEEL
    -- GLOBAL SUPPLY

**BARRIERS**
- Entrenched incumbent technology
- Low cost incumbents (e.g. PVC)
- In-house compounding by fabricators (e.g. rubber)
- Shift to commodity strategy by major TPE suppliers

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
TECHNOLOGIES THAT WILL DRIVE AUTO TPEs

TPE Materials
• HMS-SEBS
• High flow TPV and TPO
• s-TPVs
• Higher heat COPE (TPEE)
• Adhesion to engineering plastic substrates

Fabrication processes
• Foaming
• Two shot molding/core back technologies
• Controlling surface friction in body/glazing seals
• Continued penetration of 3-D blow molding
• Bumper fascia:
  - Injection molded TPO remains dominant incumbent.
  - Gains in painting, thin-walling, recycling

• Boots/Bellows:
  - TPEs have dominant position vs rubber
  - Broad performance range. CV joints to simple dust covers.
  - TPE competitors: o-TPV (the major challenger), COPE, SEBS, s-TPV and TPU.

• Body/glazing seals:
  - EPDM the dominant incumbent. Potentially high volume application.
  - Continued (moderate) penetration by o-TPV and (recently) SEBS.
  - Systems cost savings opportunities.
  - Static seals easier to penetrate than dynamic seals.
  - Foaming, hollow profile extrusion, two shot are game changer processes.

• Coated fabrics:
  - PVC the dominant incumbent (extensive seating use).
  - PU dispersions in high end applications.
  - New challenge from SEBS
• Ducting:
  - o-TPV, COPE, TPO, s-TPV and silicones contend.
  - COPE, silicone, s-TPVs serve the increasingly important high temp. segment.

• Interior skins (foils/soft touch) –
  - Slush molded PVC: major incumbent.
  - Systems cost savings opportunities
  - Slush molded SEBS, two shot molding and core-back processes are potential game changers.

• Radiator hose:
  - EPDM dominates, potentially large TPE application.
  - Recent o-TPV offerings show promise.
  - Co-extrusion (with polyamides), 3-D blow molding systems cost savings potential.

• Under-hood seals:
  - s-TPVs are challenging incumbent high performance specialty rubbers
• PVC: the dominant incumbent strongly entrenched, cost effective
• SBC-TPEs: Phthalate-free, UV resistance, low temp properties, hand/drape range
SUPER-TPV (s-TPV) FAMILIES

- ACRYLIC RUBBER BASED
  - DuPont™ E-TPV (DuPONT) WITHDRAWN FROM MARKET
  - ZEOTHERM® TPV (ZEON CHEMICALS)

- FLUOROPOLYMER BASED
  - FluoXprene® (FREUDENBERG-NOK)
  - DAI-EL FLUORO TPV™ (DAIKIN)

- SILICONE BASED
  - TPSiV® (DOW CORNING-MULTIBASE)

- EVA BASED
  - HIPEX® (KRAIBURG)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
r/mydox/.../Super TPV Families 2012.ppt
**UNDER HOOD TEMPERATURE RISE ➔ USE OF HIGH HEAT TPEs**

- **Application:** Air duct cuff
- **TPE type:** s-TPV (Zeotherm)
- **Key properties:**
  - Heat resistance
  - Ease of processing
  - Polyamide adhesion

Note: Example of metal replacement (e.g. polyamide) pulling TPEs into under-hood applications

- **Application:** Hot air duct (primarily turbo engines)
- **TPE type:** s-TPV (Zeotherm)
- **Key properties:**
  - Heat resistance
  - Processing ease
- **Processing:** Blow molding
# BIO-TPEs BEGIN AUTO MARKET PENETRATION

<table>
<thead>
<tr>
<th>TPE FAMILY OR COMPONENT</th>
<th>RENEWABLE RESOURCE</th>
<th>SUPPLIERS</th>
<th>NOTE/RENEWABLE CONTENT, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPA</td>
<td>Castor oil</td>
<td>Arkema, Evonik</td>
<td>25-94</td>
</tr>
<tr>
<td>COPE, (TPEE)</td>
<td>Polyols from corn</td>
<td>DuPont, DSM</td>
<td>20-60</td>
</tr>
<tr>
<td>TPU</td>
<td>Polyols from corn</td>
<td>- Lubrizol, BMS, - API,GLS/PolyOne</td>
<td>20-70</td>
</tr>
<tr>
<td></td>
<td>Bio-propylene glycol</td>
<td>BASF/Oleon</td>
<td>From fats/oils</td>
</tr>
<tr>
<td>PP, PE (a)</td>
<td>Ethanol from sugar</td>
<td>Braskem, Dow</td>
<td>In TPE formulations</td>
</tr>
<tr>
<td>Bio-butadiene</td>
<td>Biomass</td>
<td>Versalis</td>
<td>Via butanediol</td>
</tr>
<tr>
<td></td>
<td>Waste gas CO</td>
<td>Invista/LanzaTech</td>
<td></td>
</tr>
<tr>
<td>SEBS (H-SBC)</td>
<td>Oyster shell (filler)</td>
<td>CTS</td>
<td>Many other bio-based fillers/fibers (b)</td>
</tr>
<tr>
<td>SEBS (H-SBC)</td>
<td>Starch/hydrocarbon graft (Gaialene®), Roquette</td>
<td>CTS</td>
<td>Substitute for PP in TPE formulation</td>
</tr>
</tbody>
</table>

Note:
(a) Toray will use bio-based PE in polyolefin foam sheet. Several auto applications
(b) At least 7 families of plant-based families provide bio-fillers for TPEs and plastic compounds

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

29
SUMMARY: POSITIONING STRATEGIES FOR GLOBAL AUTO TPE SUCCESS

• Asia:
  - “Be” there

• Global position:
  - Establish global supply capability
  - Seek benefit from global platform trend
  - Seek global specification opportunities
  - Be willing to adjust to glocal/local requirements

• Technologies:
  - View the opportunities as a fabrication process/TPE material couple
  - Be willing to partner with fabrication technology source to renew a mature application
  - Establish fit with bio-TPE offerings
• Auto TPE life cycle/targets:
  - Avoid mature/commodity targets
  - Target rubber applications
  - Follow plastics applications
  - Provide value via systems approaches
  - Be willing to “shape” new markets/applications

• Seek opportunities from auto technology drivers:
  - Lightweighting (the major driver): Increased TPE in systems (2 shot; insert molding, 3D blow molding)
  - Optimized engine performance (especially turbo engine increase):
    -- Under-hood metal replacement by high temp plastics → s-TPVs and other high temp TPEs in sealing applications
  - Sustainability: bio TPEs, recycling solutions
  - Electrification: TPEs in wire/cable
  - Increased luxury in small/medium cars: soft touch

SUMMARY: POSITIONING STRATEGIES FOR GLOBAL AUTO TPE SUCCESS(Cont’d)
THANKS FOR YOUR ATTENTION

ANALYSIS

TECHNICAL

ECONOMIC

MARKET

Management DECISIONS

Robert Eller Associates LLC
CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES