CURRENT AND FUTURE PROSPECTS FOR TPEs
IN A SHIFTING GLOBAL MARKETPLACE

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

PRESENTED AT:
THERMOPLASTIC ELASTOMERS
U.S. SUMMIT
JUNE 27, 2017
PHILADELPHIA, PA
USA

B/mydox/smithers 2017/Smithers 2017 present
Examine current and evolving status of TPEs with respect to:
- Maturity,
- Commoditization,
- Supply chain position,
- Globalization and reverse globalization,
- Paths to TPE innovation and the innovation process,
- Intra-TPE competitive interfaces,
- Property demands/opportunities from the marketplace,
- Challenges/opportunities from new materials/processing methods,
- And how these factors will affect a global, evolving TPE marketplace
TPE MATURITY CURVE: STARTING POINT FOR STRATEGY FORMULATION

INTRODUCTION

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017

r/mydox/Visio/Prod Life CycleTPEs 081512.vsd
<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solve a performance problem/opportunity</td>
<td>- Wet grip</td>
</tr>
<tr>
<td></td>
<td>- Anti-slip formulations</td>
</tr>
<tr>
<td></td>
<td>- Transparency</td>
</tr>
<tr>
<td></td>
<td>- In-line crosslinking</td>
</tr>
<tr>
<td></td>
<td>- Conductivity; Piezoelectric effects</td>
</tr>
<tr>
<td>Reduce assembly costs</td>
<td>Via co-injection, coextrusion ,etc.</td>
</tr>
<tr>
<td>Piggy-back on non-TPE industry developments</td>
<td>- Autonomous vehicles</td>
</tr>
<tr>
<td></td>
<td>- 3D “printing”;</td>
</tr>
<tr>
<td></td>
<td>- ”Smart” surfaces</td>
</tr>
<tr>
<td>Target a higher priced TPE or other plastic</td>
<td>- SEBS substituting for o-TPV</td>
</tr>
<tr>
<td></td>
<td>- o-TPV substitute for silicone</td>
</tr>
<tr>
<td>Add high end features</td>
<td>- TPO skin with easy wrap (like leather) and stitches</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
LOOK FOR THE OPPORTUNITY HOLES: EXPANDED TPE MARKET EXAMPLE

GLOBALIZATION

NEW ENTRANTS

QUALITY/PERFORMANCE TIERS

CURRENT TPE MARKET SPACE

EXPANDED TPE MARKET SPACE WITH OPPORTUNITY HOLES

SUPPLY CHAIN ECONOMICS

OPPORTUNITY HOLES

COMMODITIZATION

REGIONAL ECONOMICS DIFFERENCES

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
FILLER STRUCTURES: TAILORED AT NANOSCALE

Ceramic cube:
50 micrometers per side, ultralight-mostly air
Strong, not brittle
Precise control of structure at nanoscale
- increased energy density of batteries with weight save
- space at nanoscale to precisely control flow of heat and light
- others?

SOURCE: MIT Technology Review, vol. 118 no. 2, Caltech
DEMAND
• AP accounts for ~ 50% of global TPE demand
• High TPE demand growth rate
• Shift of Western compound customers to AP

SUPPLY
• Large share of global neat resin production
• Tendency toward overcapacity → global price setter
• Major shift of TPE end product producers to AP
• Large TPE compounding infrastructure
• TPE production cost advantages vs West
• Willing to serve price/quality tiers... (global/glocal/local/bottom end)

GLOBAL SHIFT
• Reverse globalization (East → West shift)
• Path to materials research and artificial intelligence leadership

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
EXAMPLE OF TPE VS. SILICONE APPLICATION

FACE MASK GASKET
- Silicone is the dominant incumbent
- May be over-engineered for some applications
- TPEs have started penetration
TPE IN HEALTH CARE: DRIVEN BY PVC REPLACEMENT PRESSURES

Application: IV bag
TPE type: H-SBC (SEBS)
Key properties: Elasticity, low temp , clarity, PP compatibility, melt strength. PVC replacement start in China market
Processing: Extrusion, calendering

PHOTO: KRATON

Application: Infusion bottle closure
TPE type: H-SBC (SEBS)
Key properties: Re-sealing, bond to polyolefins
Processing: 2 component injection

PHOTO: KRAIBURG

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
## PROPERTIES: WHAT’S HAPPENING WITH TPEs

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>TPE TYPE</th>
<th>STATUS/CURRENT MATL’S</th>
<th>NOTE/TARGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft touch</td>
<td>SBC, TPO</td>
<td>Current(a)</td>
<td>Composition shift, 2-shot molding</td>
</tr>
<tr>
<td>Silky feel</td>
<td>SBC, s-TPV(b)</td>
<td>Silicone-based</td>
<td>Steering wheel, electronics</td>
</tr>
<tr>
<td>Body/glazing seals</td>
<td>SEBS TPV</td>
<td>Improving</td>
<td>SEBS slow share gain/low end applications</td>
</tr>
<tr>
<td>Improved c’set</td>
<td>SBC, o-TPV</td>
<td>Still targeting</td>
<td>Seals, gaskets; multiple markets</td>
</tr>
<tr>
<td>Lower hardness</td>
<td>TPU, TPO, SBC</td>
<td>TPO starting</td>
<td>Coated fabrics; Medical</td>
</tr>
<tr>
<td>Smart surfaces</td>
<td>TPO, SBC,</td>
<td>Starting</td>
<td>Sensing, controls. electronics interior auto</td>
</tr>
<tr>
<td></td>
<td>conductives</td>
<td></td>
<td>moldings</td>
</tr>
<tr>
<td>Scratch resistance</td>
<td>TPO</td>
<td>Steady gains</td>
<td>Has been a long term target</td>
</tr>
<tr>
<td>Foam cell size</td>
<td>TPEs and also</td>
<td>Starting (MIT, others)</td>
<td>Vibration damping/structure control</td>
</tr>
<tr>
<td></td>
<td>ETPs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leather look, feel</td>
<td>SEBS, TPU, TPO</td>
<td>Getting there slowly</td>
<td>Auto interiors: IP skins, door trim, coated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>fabrics</td>
</tr>
</tbody>
</table>

(a) Via coatings, some materials innovations/fabrication process innovation
(b) Via silicone-based s-TPV. Note combination of soft touch and silky feel

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2017
## Globalization Reverse Flow: Changing the AutoPlastics Supply Chain

<table>
<thead>
<tr>
<th>NAFTA/EUROPE</th>
<th>FLOW</th>
<th>ASIA</th>
<th>NOTE/EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEMs</td>
<td>To Benefit from High Growth Potential</td>
<td>GM Stopped India Product’N</td>
<td></td>
</tr>
<tr>
<td>Resin Suppliers/Compounders/Molders</td>
<td>To Follow OEM Customers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology Flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic Establish Supply Chain to Serve Western Transplants</td>
<td>TECHNOLOGY BARRIERS ARE POROUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Via Acquisition/Greenfield</td>
<td>Asian OEMs, Tier 1s</td>
<td>- Joyson/Key Safety Systems - Yanfeng</td>
<td></td>
</tr>
<tr>
<td>Serve Western OEMs:</td>
<td>Asian Resin Suppliers and Compounders</td>
<td>- King Fa - Pret - Is Cost Advantage Transferable?</td>
<td></td>
</tr>
<tr>
<td>- Business Won in Asia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Exploit Cost Advantage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Via Acquisitions?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Robert Eller Associates LLC, 2017
• Forces driving TPE supplier transplants to NAFTA:
  - Access Western markets
  - Learn Western business/marketing skills
  - Access Western distribution channels (in some cases via tolling)
  - Employ large cash holdings from China
  - Serve existing customers in West that were developed in China
  - Access to rich, stable Western markets
  - Seek benefits of “global” presence

• Regional compounders expanding globally

• Paths to NAFTA TPE market: Greenfield, Tolling, Distribution
  - Follow the customer (reverse globalization)

SOURCE: ROBERT ELLEER ASSOCIATES LLC, 2017
# SECOND WAVE OF TPE TRANSPLANT COMPOUNDERS/(EXAMPLES)

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>HOME</th>
<th>PATH TO NAFTA</th>
<th>ROLE</th>
<th>COMP’D TYPE</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>King Fa</td>
<td>China</td>
<td>Greenfield</td>
<td>Compdr</td>
<td>TPO</td>
<td>Also in Germany</td>
</tr>
<tr>
<td>LCY</td>
<td>Taiwan</td>
<td>Acquisition</td>
<td>Resin</td>
<td>SBCs</td>
<td></td>
</tr>
<tr>
<td>Mitsubishi/CTS</td>
<td>Japan</td>
<td>Acquisition (France)/existing U.S. plant</td>
<td>Compdr</td>
<td>SEBS</td>
<td>Acquired CTS (France) to get presence in Europe</td>
</tr>
<tr>
<td>Polymax</td>
<td>China</td>
<td>Greenfield</td>
<td>Compdr</td>
<td>SEBS, TPV</td>
<td></td>
</tr>
<tr>
<td>Pret</td>
<td>China</td>
<td>Acquisition</td>
<td>Compdr</td>
<td>TPO</td>
<td>Acquired Wellman</td>
</tr>
<tr>
<td>So.F.teR</td>
<td>Italy</td>
<td>Greenfield</td>
<td>Compdr</td>
<td>SBCs, TPV</td>
<td>In Mexico, U.S., LATAM</td>
</tr>
<tr>
<td>TSRC</td>
<td>Taiwan</td>
<td>Acquisition</td>
<td>Resin supplier</td>
<td>SBCs</td>
<td>Expand SIS expertise, gain US market share</td>
</tr>
</tbody>
</table>

Note: Does not include some major Chinese compounders

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
## TPEs: A COMPOUNDER’S WORLD

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy entry: low capex</td>
<td>Low capex→ increased competition</td>
</tr>
<tr>
<td>Ability to add value</td>
<td>An extra step on the path to market</td>
</tr>
<tr>
<td>Adaptable via formulation shift</td>
<td>Occasional resin supplier challenge</td>
</tr>
<tr>
<td>Tactical, fast moving vs. strategic</td>
<td>Little IP protection</td>
</tr>
<tr>
<td>Able to survive as regional player</td>
<td>Branding protection is limited</td>
</tr>
<tr>
<td>Able to adapt to price/quality variations</td>
<td></td>
</tr>
<tr>
<td>Able to profitably → short campaigns</td>
<td></td>
</tr>
</tbody>
</table>

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2017
<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ride piggyback on auto/non auto developments</td>
<td>- Smart devices</td>
</tr>
<tr>
<td></td>
<td>- Autonomous vehicle</td>
</tr>
<tr>
<td></td>
<td>- Replace over-engineered TPEs.</td>
</tr>
<tr>
<td></td>
<td>- The cascade effect</td>
</tr>
<tr>
<td></td>
<td>- SEBS vs o-TPV</td>
</tr>
<tr>
<td></td>
<td>- Reactor TPOs(a) (r-TPOs) compete with SEBS</td>
</tr>
<tr>
<td>Modify during molding</td>
<td>Foam, 3D printing of complex shapes</td>
</tr>
<tr>
<td>3D molding</td>
<td>Fit with Industry 4.0 programs</td>
</tr>
<tr>
<td>New reinforcements</td>
<td>Carbon fiber ; modified fillers</td>
</tr>
<tr>
<td>Direct to market</td>
<td>- Post reactor compounding</td>
</tr>
<tr>
<td></td>
<td>- Reduce fabrication steps/combine parts</td>
</tr>
<tr>
<td>Benefit from equipment supplier developments</td>
<td>- At press additions (fibers, additives)</td>
</tr>
<tr>
<td></td>
<td>- Multi-shot, multi-layer</td>
</tr>
<tr>
<td>New functionalities</td>
<td>Conductivity; Piezoelectric effects</td>
</tr>
</tbody>
</table>

Note: (a) For example Catalloy

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
• Acoustics
• Shielding
• Signaling/data transmission
• “Windows”/transparent sections in the surface
• Lighting
• Image projection
• Sensing.smart surfaces
• Smart touch
• Damping
• Conduction

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
- Illumination & control solutions in curved decorative panels
- Force and capacitive sensing integration for enhanced applications, preventing unintentional activations
- Illumination adjustment

**EXAMPLES OF IMSE AUTOMOTIVE APPLICATION AREAS**

- Multi-function headliner
- Multi-function seatbacks
- Smart tailgates and lighting
- Soft fabric sensing e.g. seat sensors
- Smart door handles e.g. keyless entry
- Re-architected controls e.g. Door controls relocated into dash panels
- Smart steering wheel
- Multi-function overhead control panels
- Illuminated ventilation trim panels and controls
- Curved & flush designed smart center consoles

**SOURCE:** TACTO TEK, 2017
SELECTIVE 3D MOLDING: ROLE IN TPEs?

- Weight save potential
- Putting resin where structural requirements dictate
- Deposition via sintering (suited for some TPEs (e.g. SEBS, PP powders?))

PHOTOS: PLASTICS TECHNOLOGY MAGAZINE 042017; COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2017
TPE PROCESSES/MATERIALS: FUTURE DIRECTION EXAMPLES

MATERIALS:
- New fillers (3D based, conductive)
- Role for graphenes/graphene-based foams
- Role for carbon fibers
- Smart surfaces/thin film sensors

PROCESSES:
- 3D printing/molded structures
- Smart/Luminescent coatings
- Slush molding of SBCs
- Skins injection processes

BROADER FUNCTIONS:
- Lighting/display
- Sensing/switching
- Voice activation
- Shielding

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
TECHNICAL/ECONOMIC TRENDS: SBC COMPOUNDS

• Improved SEBS grades
  - Slush moldable
  - High flow molded IP skin grades
  - Coated fabric grades
  - Competitive with o-TPV, PVC in some applications (e.g. appliance seals)

• Competition from improved PVC grades to answer SEBS challenge

• Bio-TPEs

• Continued growth of multi-component technology
  - Overmolding/2-shot and extension to foaming methods
  - Co-blow molding
  - Profiles

• Evolution of soft touch, silky feel in multiple sectors
POEs COMPETE IN THE TPE MARKETPLACE

- Includes both POEs and OBCs(a)
- Relatively new technologies in early part of growth curve
- Production capacity expanding rapidly
- Producers will benefit from shale gas economics (current USA advantage)
- Direct TPE competition and as formulation ingredient (TPOs and SBC compounds)
- Competes with:
  - SBS as formulation ingredient
  - Direct competition with f-PVC (both are semi-crystalline, different morphology, melting behavior, rheology)
Note: (a) for example INFUSE™ Olefin Block Copolymer from Dow

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
COMPETITION WITHIN A TPE TRIAD (EXAMPLES)

Many apps:
- Body/glazing seals
- Soft touch
- Medical

Slush (IP skins)
Injection molded

Improved soft touch

Bottom line:
- o-TPV under attack, on the defensive
- TPOs steadily improving via catalysts technology, compounding

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
**GLOBAL TPE STRATEGY ANALYSIS WHEEL**

**GLOBALIZATION/REGIONAL MARKET SECTOR SHIFTS**
- CHINA (STRONG AUTO GROWTH),
- PRICE/QUALITY TIER DIFFERENCES
- QUALITY/PERFORMANCE TIER DIFFERENCES

**SUBSTITUTION EFFECTS**
- CASCADE EFFECT → LOWER COST TPEs
- BIO-TPEs STARTING
- CHALLENGE TO RUBBER CONTINUES

**ECONOMICS**
- REGIONAL MFG COST DIFFERENCES
- REGIONAL SUPPLY CHAIN DIFFERENCES
- GDP/CAPITA DIFFERENCES
- INVESTMENT FROM ASIA/EUROPE

**BROADER PROPERTY RANGE**
- SOFT TOUCH
- IMPROVED ADHESION
- HIGHER TEMP CAPABILITY
- SURFACE QUALITY
- ENTRY OF POEs
- CONDUCTIVE/SENSING

**NEW APPLICATION DRIVERS**
- ORGANIC AND SUBSTITUTION GROWTH
- LUXURY (SOFT TOUCH/SILKY FEEL APPROACHES)
- RIDING ETP AND CARBON FIBER THERMOPLASTICS COATTAILS
- RIGID/FLEXIBLE COMBINATIONS
- GROWTH OF “SMART APPLICATIONS”

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2017
SUMMARY

TPE SECTOR IS MATURING with the usual consequences:
- Commoditization
- Intense price competition
- Overcapacity, especially in Asia SBC

KEY GROWTH SECTORS:
- Automotive, including autonomous/semi-autonomous vehicles
- Medical/Pharma
- Packaging

INNOVATION STRATEGIES:
- ”Internal” improvements adding to properties footprint
- “External” evolution via piggy-backing on other industries/technologies
- Role for 3D molding and digitization
- New additives (conductive, sensing, foaming, etc.)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
SUMMARY (Cont’d.)

• ASIA PACIFIC Continues to be key priority:
  - Demand growth
  - Reverse globalization
  - Focus of resources (and capex?)

• AUTONOMOUS /SEMI AUTONOMOUS CARS opportunities for new TPEs:
  - Integrating electronics
  - Providing display, sensor and switching functions
  - Operating as “smart surfaces ”
  - Improving acoustics
  - Acting as display surfaces
ABBREVIATIONS USED

• o-TPV - Olefinic TPV

• p-TPV - partial olefinic TPV (o-TPV)

• SBC - Styrene block copolymer (also TPE-S and HSBC for hydrogenated version)

• POE - Polyolefin elastomer

• COPE (TPEE) - Co-polyester type TPE

• TPE - Non-specific, covers all TPE types

• TPO - Thermoplastic polyolefin

• TPU - Thermoplastic polyurethane. Used alone and as additive

• s-TPV - Super TPV (several types based on different rubber/ matrix combinations)

• OBC - Olefin block copolymer (e.g. INFUSE™ from Dow Elastomers)