GLOBAL TPEs: MATURING SECTORS, INTRA-TPE COMPETITION, COMMODITIZATION AND REGIONAL MARKET SHIFTS

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PREPARED FOR:
SPE TPE TOPCON
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• TPE industry dynamics

• TPEs and the product life cycle/maturity curve

• Beating the commodity trap

• Global manufacturing shift implications

• Intra-TPE competition

• What do consumers want from TPEs

• Transplant compounder challenges to the NAFTA TPE industry

• How TPEs are capturing value and profitable growth

• Future view of TPE evolution
• Global competition

• Some viewed as commodities

• Slowed growth

• Impacted by global economic conditions

• Industry structure shifts

• Intense price pressures

• Overcapacity at several points in the supply chain

• Market saturation in some end use sectors

• Search for value add strategies/specialties
TPE INDUSTRY SHIFTS AND PRODUCT LIFE CYCLE

INTRODUCTION

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
TPE INDUSTRY DYNAMICS CHANGE WITH MATURITY

- **Market Intro**
  - Dominated by Majors
  - Technology proliferates
  - Prices decline: Competitive intensity
  - Western transplants to Asia
  - Quality/price tiering → re-shape product line

- **Growth**
  - Some Majors reduce participation or exit
  - Some Majors seek specialties
  - Smaller compounders enter
  - Distribution channels broaden
  - Overcapacity in compounding and some raw materials

- **Maturity**
  - Asia learns, Asians → West

- **Decline/Stagnate (Commodity)**
  - capacities in compounding and some raw materials

TPE FAMILIES . . . CHANGING COMPOSITION, POEs AS MODIFIERS BROADENED PROPERTY FOOTPRINTS

TPE FAMILIES

POEs ENTERING

SUPER-TPVs
- SILICONE
- ACRYLATES
- NEW ENTRANTS
(d)

OTHER e-TPEs (e)

BIO-TPEs: STARTING

POE

POE/POP

OBC (b)

s-TPO (c)

o-TPV

COMMODITY TPO

OLEFINIC (o-TPEs)

STYRENIC (SBCs)

- H-SBC
- SIS
- SBS

TPO

p-TPV (f)
(PARTIALLY CROSSLINKED)
(a) Recyclate-based TPV
(b) e.g. Dow Infuse®
(c) Specialty grades of TPE produced by independent compounders or in-house via reactive compounding
(d) e.g. Hipex from Kraiburg
(e) e.g. COPE, COPA, TPU; PVC-based TPEs not shown
(f) Can be made during extrusion compounding of TPO

f-TPV (FULLY CROSSLINKED)

NEW LOW MW GRADES OPEN NEW APPLICATIONS

r-TPV (a)

NEW APPLICATIONS

ROBERT ELLER ASSOCIATES LLC, 2016
• Inter-TPE competition:
  - SBCs continue to challenge o-TPVs, where over-engineered
  - SBCs, COPE-type TPEs competing in airbag doors
  - COPE vs o-TPV when higher heat required
  - COPE in medical breathables
  - OBCs vs and with SEBS
  - POEs vs SBCs

• Formulation shifts:
  - SBCs and p-TPVs used in “TPO” formulations
  - OBCs in SBC formulations
  - Direct extrusion compounded p-TPVs challenge purchased p-TPVs

• Upgrading:
  - Radiation crosslinking of TPOs (e.g. for skins)
  - Higher heat SEBS formulations (to challenge o-TPVs)
COMPETITION WITHIN A TPE TRIAD (EXAMPLES)

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

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

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
EMERGING MARKETS GROWTH SLOWED - CHINA & INDIA REMAIN TPE GROWTH TARGETS

- Slowed auto growth
- Renminbi devaluation
- Rising wages
- Capital outflow
- Holding $1TN in US debt

- Very weak economy
- Oil dependency

- Political & economic turmoil
- Minus 3.8% GDP Growth (2015)

- Rising (high growth)
- Attracting investment

PHOTO: THE ECONOMIST
CHINA HAS BECOME LARGEST GLOBAL INVESTOR

SHARE OF GLOBAL INVESTMENT, %

CHINA GDP GROWTH SLOWING : TPE DEMAND EFFECTS

- Still enviable growth compared to other nations
- Shift to increase consumer spending (TPE effect?)
- Continued infrastructure investment
- Manufacturing sector profit slowdown
- Accelerated overseas investment

COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2016
## WHAT CUSTOMERS WANT FROM TPEs (EXAMPLES)

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>TPE</th>
<th>STATUS</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft touch</td>
<td>SBC, TPO</td>
<td>Current(a)</td>
<td>Auto</td>
</tr>
<tr>
<td>Silky feel</td>
<td>SBC, s-TPV(b)</td>
<td>- Silicone-based</td>
<td>- Mobile electronics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- s-TPV was first</td>
<td>- Auto interiors</td>
</tr>
<tr>
<td>Wet grip</td>
<td>SBC</td>
<td>Available</td>
<td>Multiple Markets</td>
</tr>
<tr>
<td>Improved compression set</td>
<td>SBC, o-TPV</td>
<td>Still targeting</td>
<td>- Seals, gaskets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Multiple markets</td>
</tr>
<tr>
<td>Lower hardness w/o compromise</td>
<td>TPU, TPO, SBC</td>
<td>- TPO starting</td>
<td>- Coated fabrics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- TPU difficult</td>
<td>- Grips</td>
</tr>
<tr>
<td>Higher temp resistance</td>
<td>o-TPV, s-TPV, COPE</td>
<td>Battleground at &gt;150° C</td>
<td>Auto under-hood</td>
</tr>
<tr>
<td>Controlled cell size in foams</td>
<td>SBC, TPU(c), o-TPV</td>
<td>O-TPV and SBC no success yet</td>
<td>- Vibration damping</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Footwear</td>
</tr>
<tr>
<td>Scratch Resistance</td>
<td>TPO</td>
<td>Improve needed</td>
<td>Has been long term objective</td>
</tr>
<tr>
<td>Sealing like butyl rubber and silicone</td>
<td>New s-TPV?</td>
<td>Seeking</td>
<td>Medical stoppers, septums</td>
</tr>
</tbody>
</table>

(a) Via coatings in auto
(b) Via silicone-based s-TPV. Note combination of soft touch and silky feel
(c) TPU’s recent entry via bead foam (see slide)

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2016
NEW LIGHTWEIGHT SOLUTIONS NEEDED: PLASTICS, COMPOSITES, TPEs COMPETE WITH ALTERNATIVES

GETTING TO 54.5 BY 2025 DIFFICULT WITH SALES MIX SHIFT TO PUTs AND SUVs

Source: Michael Sivak and Brandon Schoettle, University of Michigan Transportation Research Institute

THE WALL STREET JOURNAL.

COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2016
Paths to market:
- Greenfield
- Tolling
- Distribution of imported TPE
- Follow the customer

Driving forces:
- Access Western markets
- Learn Western business/marketing skills
- Exploit compounding skills to serve glocal (lower priced) market segments
- Access Western distribution channels (in some cases via tolling)
- Employ large cash holdings from years of profitable operations in China
- In some cases, serve existing customers in West that were developed in China
- Perception of rich, stable Western markets
- Need for “global” presence

Some Chinese compounders have moved up the quality scale:
LOCAL ➔ GLOCAL ➔ GLOBAL

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
## SECOND WAVE OF ASIAN/EUROPEAN TRANSPLANTS (EXAMPLES ONLY)

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>HOME</th>
<th>PATH TO NAFTA</th>
<th>ROLE</th>
<th>MAJOR TPEs</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 supplier</td>
<td>SBCs</td>
<td></td>
</tr>
<tr>
<td>Mitsubishi/CTS</td>
<td>Japan</td>
<td>Acquisition (France)/ existing US 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 compounding?</td>
</tr>
</tbody>
</table>

Note: Does not include some major Chinese compounders

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2016
AUTOMOTIVE TPE TARGETS: GROWTH AND INTER TPE COMPETITION

NOTES:
* = RUBBER/TPE INTERFACE
(a) DOES NOT INCLUDE RIGID-FILLED TPOs USED IN INTERIORS
(b) E.G., FUEL, COOLANT, OILS, OTHER HOSE
(c) HIGH GROWTH APPLICATION (in SEBS)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
AUTO BODY GLAZING SEALS: o-TPVs AND SBCs CHALLENGING EPDM

Window encapsulation (wincap)
Door seals
Hood seals

Glass run channels (GRC)
Inner belt/outer belt seals
Upper reveals/appliques
Auxiliary seals
Rear compartment seals

SOURCE: HENNIGES AUTOMOTIVE
<table>
<thead>
<tr>
<th></th>
<th>NAFTA/EUROPE</th>
<th>FLOW</th>
<th>ASIA</th>
<th>NOTE</th>
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<tbody>
<tr>
<td>1</td>
<td>OEMs</td>
<td></td>
<td>TO BENEFIT FROM HIGH GROWTH POTENTIAL</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RESIN SUPPLIERS/COMPOUNDERS/MOLDERS</td>
<td></td>
<td>TO FOLLOW OEM CUSTOMERS</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TECHNOLOGY FLOW</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
<td>DOMESTICS ESTABLISH SUPPLY CHAIN TO SERVE WESTERN TRANSPLANTS</td>
<td>TECHNOLOGY BARRIERS ARE POROUS</td>
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<tr>
<td>5</td>
<td>VIA ACQUISITION/GREENFIELD</td>
<td></td>
<td>ASIAN OEMs</td>
<td></td>
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<tr>
<td>6</td>
<td>TO SERVICE WESTERN OEMs:</td>
<td></td>
<td>ASIAN RESIN SUPPLIERS AND COMPOUNDERS</td>
<td>IS COST ADVANTAGE TRANSFERABLE?</td>
</tr>
<tr>
<td></td>
<td>- BUSINESS WON IN ASIA</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- EXPLOIT COST ADVANTAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- VIA ACQUISITIONS?</td>
<td></td>
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</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
• Dominant Incumbent: EPDM

• TPE Challengers: o-TPV, SEBS

• Dynamic vs. static requirements differ:
  - Dynamic seals require low compression set
  - Acoustic/wind noise performance (requirements increasing)
  - Adhesion (to glass, polycarbonate)
  - Parts integration opportunities
  - Surface friction properties (controlling COF)
  - Meeting regional performance differences
  - Overcoming institutional resistance
  - Small cars (lower requirements, profitability challenge)

• Movement into:
  - Primary door seals
  - Trunk seals
GROWTH MARKET FOR SBC-TYPE TPEs: FLOOR MATS

- Early-mid growth stage
- OEMs entering to capture market
- Ability to add styling cues
- Post consumer, post industrial recycle
- High value–add
- An aftermarket product
- Key enabler: laser mapping

- Based on SEBS/SBS formulations
- Typical hardness 50-75 Shore A
- Non slip, scratch /abrasion resistant
- Can be used in multiple positions
- Easily colored
- High capital investment for molding equipment

PHOTO: THERMOFLEX CORP; HEXPOL TPE; COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2016
KEY CHARACTERISTICS:
• Condensation polymer → bio ingredients/a “green” polymer
  - Polyols based on plants (corn and fats/oils)
• Can be made via reactive extrusion
• Broad range of smaller suppliers

IMPORTANT PROPERTIES:
• Abrasion resistance
• Adhesion
• Elasticity
• Tear strength
• Breathability: challenge from COPE

KEY MARKETS/CHARACTERISTICS
• Footwear shift to Asia → intense globalization
• Price pressure from globalization
• Large multi-nationals → specialization to avoid commodity pricing trap
• Broad application range

WHAT’S NEW
• Bead foam from BASF (Infinergy™) starting market entry
• Biopolymer capability
- Steam chest molded TPU bead foams (Infinergy™ from BASF)
- Stiffness/weight ratio, energy absorption/rebound characteristics, softness + resilience
- Next markets beyond footwear?: Auto, laminates, flooring, tires, matting, vibration damping applications?

PHOTO: BASF; SAMPLE: ADIDAS; COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2016
TPO SNAPSHOT

KEY CHARACTERISTICS:
• The forgotten TPE but large stable market/broadening applications footprint
• Can be modified via in-house reactive extrusion (to make p-TPV)

KEY MARKETS/CHARACTERISTICS
• Follows the automotive market ➔ Asia
• Commoditized/low cost TPE
• Dominated by large multinational polyolefin suppliers
• Application range ➔ broadening with specialty variants
• In-house compounding by fabricators
• Difficult for small independent compounders to compete
• High growth in roofing market (vs. EPDM)

WHAT’S NEW
• Growth in auto interior skins← challenge from SEBS?
• Full potential of modifiers being realized (p-TPV, SBCs, OBC, POEs)
• Backflow from Asian compounders
EXAMPLE OF EMERGING FROM COMMODITY TRAP

• Requires low MW resin
• May fit existing slush molding machines
• Must compete with TPO skins

PHOTO: So.F.teR
APPLICATIONS FOR r-TPVs: ECO-FLEX™ RTPV
INNOVATION EXAMPLE: COMBINING MATERIALS TECHNOLOGIES ➔ SYNERGY

HIGH STIFFNESS/LIGHTWEIGHT SHEET

Combination yields:
- high stiffness from graphene-like layers
- lightweight and thickness effect of polyolefin foam
- easily molded

Target applications:
- auto
- building/construction
- electronics

PHOTO: EKISUI CHEMICAL CO., LTD

GRAPHENE

Scanning probe microscopic image of graphene, an allotropic form of carbon in a 2 dimensional, atomic scale hexagonal lattice. One atom at each vertex.
- 100x stronger than steel
- efficient heat, electrical conductor
- nearly transparent
- used in semiconductor, electronics,
- battery, composites industries

PHOTO : WIKIPEDIA
MEDICAL: HIGH GROWTH TPE SECTOR

• Global TPE demand: ~ 300kT

• Pricing: can be 2-3x commodity TPE applications

• Fastest growth TPE sector: (~ 8-9%/yr)

• SEBS is the dominant TPE: ~ 60% share of global medical TPE demand in 2015

• U.S. is largest producer of global medical devices: ~ 43% market share

• COPE in breathable/impermeable films and laminates: high growth sector

• Example applications:
  - films
  - tubing
  - catheters
  - syringe plunger seals
  - IV systems
  - resealable membrane
TODAY IS THE FRONTIER OF TPE FUTURE: SOME EXAMPLES

**Today**

- **Solid interior**
- **Haptics via coating**
- **Foamed or solid interior**
- **Standard “islands” in o-TPVs**
- **SBCs dominated by standard grades, some specialty grades**
- **Soft touch**

**Future**

- **“Silky” feel via compound properties + soft touch**
- **Foamed or solid interior**
- **New s-TPV grades (new islands/ some new seas)**
- **Greater share of specialty grades in SBC. Lower MW allows plasticizer reduction or elimination**
- **More versatile “TPOs”**
- **Elasticity and vibration damping control**
- **TPEs used in “smart” applications possibly via use of graphenes**

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
<table>
<thead>
<tr>
<th>TPE</th>
<th>FUTURE VIEW</th>
</tr>
</thead>
</table>
| O-TPV | - Continued challenge from: SBCs, p-TPVs where appropriate  
        - Core business for integrated EPDM suppliers (ExxonMobil, Sumitomo, Mitsui, Kumho)  
        - New TPEs entering (e.g. from Dow) to serve independent o-TPV compounders  
        - Reduction of grade range.tech service $\rightarrow$ commodity  
        - Penetration by smaller compounders as technology proliferates  
        - EPDM overcapacity keeps prices down |
| SEBS  | - Commoditization/resin overcapacity forces shift to specialties for some compounders and resin suppliers  
        - Broadened property range via crosslinking, compounding  
        - Impact of SEBS neat resin overcapacity  
        - Entry by resin suppliers into compounding in NAFTA  
        - High growth in medical applications |
| TPO   | - Broadened application and performance range  
        - Competition from higher performance PP copolymers |
| COPE  | - Continued position as fastest growth TPE (8-9%/yr)  
        - Growth in medical impermeable/breathable textile laminates |
| SBS   | Continued strength in footwear and component in SEBS formulations |
| TPU   | Bead foam breakthrough |
| S-TPVs| New “island/sea” combinations for higher temp resistance and surface prop’s |

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2016
A LOOK AHEAD: WHAT COULD BE COMING FOR TPEs

• s-TPVs: Based on other rubber islands (butyl, natural rubber)

• Vibration damping: Tunable frequencies both foam and solid

• Foam revolution: Broadening range of TPE foam grades. TPU bead foam

• Elastic films: High growth in SEBS and COPE (breathables)

• Shape recovery: Already available from PolyOne

• Boundaries: Further blurring of lines between TPEs

• SBCs: Broadening range of specialty grades

• Non slip surfaces

• “Smart” TPEs

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

EXPANDING GLOBAL TPE OPPORTUNITIES

GLOBALIZATION/REGIONAL MARKET SECTOR SHIFTS
- CHINA (STRONG AUTO GROWTH)
- RE-BALANCING TOWARD CONSUMER MARKETS
- PATH-TO-MARKET DIFFERENCES
- QUALITY/PRICE TIER DIFFERENCES

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

SUBSTITUTION EFFECTS
- CASCADE EFFECT \(\rightarrow\) LOWER COST TPEs
- BIO-TPEs STARTING
- CHALLENGE TO RUBBER CONTINUES

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

NEW APPLICATION DRIVERS
- GROWTH VIA BOTH ORGANIC GROWTH AND SUBSTITUTION
- LUXURY (SOFT TOUCH/SILKY FEEL APPROACHES)
- RIDING ETP SUBSTITUTION’S COATTAI
- RIGID/Flexible COMBINATIONS

SOURCE: ROBERT ELLER ASSOCIATES LLC
SUMMARY

• Some TPE sectors maturing with usual consequences
• Medical: High growth TPE market dominated by SEBS
• Auto: High volumes, some commodity applications
• Investment: Flowing both ways (East-West and West-East)
• Bio-TPEs: Especially in condensation chemistry-based TPEs
• Asia: Major TPE volume growth
• Customer: Wish list still offers TPE opportunities
• TPE foams: Remain under-developed opportunities
• TPU bead foams: Growth opportunity
• TPOs: Expanding beyond mature application boundaries
• r-TPVs: Gaining share in auto. Will attack other markets
• Graphenyes: Extend TPE capabilities in conductive/smart applications
THANKS FOR YOUR ATTENTION

Robert Eller Associates LLC
CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES