TPE INDUSTRY STRUCTURE EVOLUTION, NEW TECHNICAL DEVELOPMENTS AND GLOBAL MARKET SHIFTS

PRESENTED BY:
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• Market maturity and commoditization of some TPE grades

• Global market shifts: Asian impact on TPE markets

• Industry structure shifts: adapting to new challenges

• The next TPE growth phase: drivers and barriers

• Example growth markets: health care, automotive

• Super TPVs: expanding the performance envelope

• Bio-TPEs
### MARKET MATURITY: SOME TPEs EVOLVING TOWARD COMMODITIES

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>COMMODITY</th>
<th>SPECIALTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of grades</td>
<td>- Many standard grades</td>
<td>- Few grades</td>
</tr>
<tr>
<td></td>
<td>- Compete for same business</td>
<td>- Highly targeted</td>
</tr>
<tr>
<td>Major TPE suppliers</td>
<td>Continue supply or exit</td>
<td>Enter compounding</td>
</tr>
<tr>
<td>Competitive basis</td>
<td>Price. Trend toward global price</td>
<td>Performance (tailored)</td>
</tr>
<tr>
<td>Property differentiation</td>
<td>None→minor</td>
<td>Highly differentiated</td>
</tr>
<tr>
<td>Sales/marketing approach</td>
<td>- Pursue existing markets</td>
<td>“Shape” new markets</td>
</tr>
<tr>
<td></td>
<td>- Take orders/Use distributors</td>
<td></td>
</tr>
<tr>
<td>Tech support, Applications</td>
<td>Minimal</td>
<td>Substantial</td>
</tr>
<tr>
<td>Brand recognition</td>
<td>- Incumbent TPE suppliers(have it)</td>
<td>No: must be built</td>
</tr>
<tr>
<td></td>
<td>- New entrants enter without it (e.g. Sinopec, TSRC)</td>
<td></td>
</tr>
<tr>
<td>TPE examples</td>
<td>- Standard SEBSs, SBS, TPO</td>
<td>- New SEBS grades</td>
</tr>
<tr>
<td></td>
<td>- Some o-TPVs, TPUs</td>
<td>- s-TPVs, Bio-TPEs</td>
</tr>
<tr>
<td></td>
<td>- Some COPEs</td>
<td>- Health care grades</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- New acrylic grades</td>
</tr>
</tbody>
</table>

Source: ROBERT ELLER ASSOCIATES LLC, 2012
EXAMPLE PRODUCT LIFE CYCLE POSITION OF TPEs

- SBCs, TPE in Footwear
- TPO Bumper Fascia
- Soft Touch in Sports/Leisure, Appliance/Tool
- SBC-TPEs in Housewares
- s-TPVs Under-Hood Seals/Gaskets (Auto)
- TPVs in Auto Body/Glazing Seal
- Several TPEs in Wire/Cable
- SBC-TPEs in Food/Pharma Packaging
- TPE in Medical Tubing
- SBC-TPEs in Auto Body/Glazing Seals
- SBCs in Medical Film/Tubing
- Bio-TPEs
- TPUs in Medical Tubing
- α-TPVs Auto Radiator Hose
- Examples Product Life Cycle Position of TPEs

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
Manufacturing Share of GDP
Current National Currency Units
1970 to 2010

Source: United Nations
THE ASIA SHIFT

• TPE demand effects:
  - Decreased demand in Europe/N. America
  - Especially for consumer products-related TPEs

• Supply chain effects as Asia infrastructure matures:
  - Western companies can 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 plants becomes competitive
  - Flexibility/speed of response

• Investment flow coming out of Asia. Some into TPE sector (e.g. TSRC)

• Re-shoring starting in U.S.
THE CHANGING POSITION OF CHINA

• Shift within China as cost of labor exceeds cost of capital and real estate costs rise
  - Labor intense businesses no longer subsidized
  - Textiles, toys, shoes under pressure
  - Start of sector shift: higher technology automotive, electronic and healthcare

• Domestic volume becomes the business model and export business incremental

• Asian gov’t decisions can create rapid growth, high volume markets

• China costs remain competitive despite wage increases

• Auto production in China
  - Focused on domestic market (only 4% of production is exported)
  - Domestic market could become saturated by 2020(at 25-30MM units) → exports?
  - Current TPE usage/vehicle is below global average → growth opportunity
### THE ASIA SHIFT AFFECTS WESTERN TPE MARKETS DIFFERENTLY

<table>
<thead>
<tr>
<th>TPE SECTOR</th>
<th>HIGH ASIA GROWTH INDEPENDENT OF WESTERN CONDITIONS</th>
<th>ASIA GROWTH DECREASES WESTERN TPE MARKETS</th>
<th>ASIA GROWTH NO EFFECT ON WESTERN TPE</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>X</td>
<td></td>
<td></td>
<td>High Asia TPE growth market</td>
</tr>
<tr>
<td>Footwear</td>
<td>X (a)</td>
<td></td>
<td></td>
<td>Shifted long ago</td>
</tr>
<tr>
<td>Bldg/Const.</td>
<td></td>
<td>X</td>
<td></td>
<td>A classical stay at home market</td>
</tr>
<tr>
<td>Consumer</td>
<td>X (a)</td>
<td></td>
<td></td>
<td>Shifted long ago</td>
</tr>
<tr>
<td>Wire/Cable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food/Pharma</td>
<td></td>
<td></td>
<td>X</td>
<td>Packaging</td>
</tr>
<tr>
<td>Health care</td>
<td>X</td>
<td></td>
<td>X</td>
<td>Hi growth West/Asia TPE market</td>
</tr>
<tr>
<td>Appliance/Tool</td>
<td>X (a)</td>
<td></td>
<td></td>
<td>Re-shoring candidate</td>
</tr>
<tr>
<td>Personal Care/</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cosmetics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid Handling</td>
<td></td>
<td></td>
<td>X</td>
<td>Rubber hose is a recent o-TPV target</td>
</tr>
<tr>
<td>/Industrial</td>
<td></td>
<td></td>
<td></td>
<td>Re-shoring candidate</td>
</tr>
<tr>
<td>Sports/Leisure</td>
<td>X (a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coated Fabrics</td>
<td>X</td>
<td></td>
<td></td>
<td>Asia very dominant in textiles</td>
</tr>
<tr>
<td>Elec/Electronic</td>
<td>X (a)</td>
<td></td>
<td></td>
<td>Major shifts already occurred</td>
</tr>
</tbody>
</table>

Note: (a) market shift to Asia has already affected Western markets

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
Wage stagnation and lower raw material costs could lead to re-shoring.


MANUFACTURING COSTS (2016): CHINA REMAINS COMPETITIVE

SOURCE: EIU, WORLD BANK, L.E.K., ROBERT ELLER ASSOCIATES LLC 2012
GLOBAL INVESTMENT, TECHNOLOGY, AND MATERIAL FLOWS

ASIA:
- DOMESTIC DEMAND GROWTH
- EXPORT GROWTH?

MANUFACTURING
- INVESTMENT: COMP/ RESIN
- INVESTMENT PROFITS
- COMPOUND EXPORT
- MANUFACTURED GOODS EXPORT ($400BN)

MATURE WESTERN ECONOMIES
- EUROPE STAGNANT
- U.S. GROWTH RESTARTING
- MANUFACTURING DECLINE

ASSET-RICH REGIONS:
- MIDDLE EAST

• INVESTMENT
• RAW MATERIALS

INVESTMENT
INVESTMENT, TECHNOLOGY TRANSFER
## TPE Industry Structure Shift Examples

<table>
<thead>
<tr>
<th>SHIFT TYPE</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition by major TPE supplier</td>
<td>Merquinsa acquisition by Lubrizol</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>Small TPE producer acquisitions</td>
<td>New England Urethane acquisition by PolyOne</td>
</tr>
<tr>
<td>Resin supplier → compounding</td>
<td>TSRC, PP resin suppliers , others</td>
</tr>
<tr>
<td>Compounding equipment</td>
<td>Coperion designs with Chinese gearbox, drives</td>
</tr>
<tr>
<td>Investment and imports: Asia to West</td>
<td>- Nantong Polymax (TPE compound supply), LCY</td>
</tr>
<tr>
<td></td>
<td>- TSRC acquisition of Dexco*</td>
</tr>
<tr>
<td>Product line broadening</td>
<td>- Teknor Apex acquisition of DSM’s Sarlink®*</td>
</tr>
<tr>
<td></td>
<td>- Kraiburg entry, high temperature TPE (Hipex®)</td>
</tr>
<tr>
<td>Major TPE supplier emphasizing specialty vs commodity grades</td>
<td>- Kraton entry into higher performance grades</td>
</tr>
<tr>
<td></td>
<td>- Kuraray entry into di-block/tri-block acrylic TPEs</td>
</tr>
<tr>
<td>Shifts to Asian production and market development</td>
<td>Recently: CTS, Hexpol, Dow Corning/Multibase</td>
</tr>
<tr>
<td></td>
<td>Mitsui(Milastomer o-TPV)startup 2014</td>
</tr>
<tr>
<td>TPE entry from other sectors</td>
<td>-Automotive foils → health care films (O’Sullivan)</td>
</tr>
<tr>
<td></td>
<td>-Hexpol acquisitions: Elasto, Horst Mueller Kunstoffe</td>
</tr>
</tbody>
</table>

*= Major raw materials company exiting “commodity” grades

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
NEXT TPE GROWTH PHASE: TECHNOLOGY PUSH/MARKET PULL

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

MARKET PULL
E.G.
- GREEN INITIATIVES
- ANTI-PVC PRESSURES
- AUTO DRIVERS
  - WEIGHT
  - COST SAVE
  - LUXURY LOOK/FEEL
  - GLOBAL SUPPLY

• 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
MARKET FACTORS PROMOTING GROWTH OF N. AMERICAN TPEs

• Auto:
  - Recovery of production (adding 0.8-1.0 MM vehicles/yr through 2016)
  - Increased penetration, e.g.:
    - Body/glazing seals
    - Hose
    - Exterior body side molding

• Health care:
  - PVC substitution
  - Continued spending growth (3%/yr 2000-2012, in real 2005$)

• Construction: recovery starting (slowly)

• Packaging: continued TPE penetration, especially SBCs for soft touch

• Re-shoring: in industrial, health care, consumer, appliance

• Raw material cost reduction: Abundant gas, effect on polyolefins
# NEW PROPERTY/MARKET DIRECTION EXAMPLES

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TPE TYPES</th>
<th>EXAMPLE MARKETS</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet grip</td>
<td>SBS → SEBS?</td>
<td>- Health care</td>
<td>With/without tackifiers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Tools, sports/leisure</td>
<td></td>
</tr>
<tr>
<td>Foam</td>
<td>SBC, TPV COPE</td>
<td>- Auto: steering wheels</td>
<td>- 2 shot molding, extrusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Body seals, skins</td>
<td>- Challenge EPDM, PVC, PU</td>
</tr>
<tr>
<td>High flow</td>
<td>TPV, SEBS</td>
<td>- Auto: glazing seals, skins (soft touch)</td>
<td>Auto interior soft touch is high growth application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Pkg., housewares</td>
<td></td>
</tr>
<tr>
<td>- Hi temp, Oil resist</td>
<td>s-TPV</td>
<td>Auto under-hood</td>
<td>Challenges specialty rubbers</td>
</tr>
<tr>
<td>- “Sustain” “Green”</td>
<td>SBC, TPU COPE</td>
<td>- Auto</td>
<td>Achieved via: monomer, filler, oils</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Consumer</td>
<td></td>
</tr>
<tr>
<td>Transparency/ translucency</td>
<td>TPU, TPVs, SBCs</td>
<td>Med., consumer, pkg., fluid delivery</td>
<td>Translucent TPU with long glass reinforcement (Plasticomp)</td>
</tr>
<tr>
<td>Slush moldable</td>
<td>SEBS</td>
<td>Auto interior skins</td>
<td></td>
</tr>
<tr>
<td>High melt strength (HMS)</td>
<td>SEBS</td>
<td>Auto, Health care</td>
<td>HMS allows foaming, blow molding, film extrusion</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
INTRODUCTION OF TRANSLUCENT FIBER REINFORCED TPU's

PHOTO: PLASTICOMP
TPE type: TPU
Reinforcement: Long glass fiber
EXTENDING THE SBC PROPERTY RANGE

• The challenges:
  - Steep melt viscosity decline with temperature (good for high filler applications, high flow applications but limits processing and properties)
  - High compression set, especially at elevated temperatures

• Melt strength improvement allows:
  - Blow moldability
  - Foamability
  - Film extrusion/calendaring (for PVC film substitution)
  - Profile/tubing extrusion
  - Thermoformability

• Reduced compression set allows:
  - Competition with o-TPV for rubber substitution (e.g. body/glazing seals)
  - Sealing applications (packaging, automotive)
### 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>
</table>
| Overmold, Film coex, 2-shot mold | TPE Substrate (rigid segment) | - Soft touch phones  
- Some 2-tone applications  
- Vibration damping  
- Coex films (medical) |
| Side by Side                | TPE Rigid Segment          | - 2-tone  
- Door trim, console, IP  
- Bumper fascia          |
| Edging                      |                            | - Body/glazing seals (profiles)  
- Cowl vent seals  
- Co-extrusion or 2-shot |
| Co-blow Mold                | TPE (flexible) Rigid       | - Auto: Boots/bellows, hose  
- Medical               |
| Co-extrusion Blow Mold or Co-extrusion | o-TPV s-TPV or ETP inner | Under-hood:  
- Hose (e.g. fuel)  
- Duct                  |

Source: Robert Eller Associates LLC, 2012  
r/mydox/Visio/Two Shot OM approaches 2012.vsd
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
CHINA AUTO PARTS EXPORTS ARE INCREASING

EXTRACTION VALUE, $BILLION

SOURCE: STEWART AND STEWART, ROBERT ELLER ASSOCIATES LLC

2011 estimated based on first 9 months
b/mydox/auto china parts
VEHICLE PRODUCTION GROWTH IN CHINA ➔ MAJOR TPE OPPORTUNITY

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

PRODUCTION SHIFT

DATA SOURCE: IHS
auto/global prod volumes 2012-2017
PVC: the dominant incumbent strongly entrenched, cost effective
SBC-TPEs: Phthalate-free, UV resistance, low temp properties, hand/drape range
TPEs IN HEALTH CARE: A HIGH GROWTH SECTOR

• High value market

• Driven by PVC replacement:
  - Kaiser Permanente PVC ban
  - PVC in IV bags ban in China (major stimulus in the region)

• Example health care targets:
  - Film for range of bag and film applications
  - IV tubing sets
  - Respiratory therapy
  - Closures

• Key TPE properties:
  - Re-sealing
  - Bondability to polyolefins (e.g. for closures and film production)
  - Clarity
  - Melt strength
  - Elastic properties

• Note: Vinyl Institute resistance. Major R/D focus of TPE industry

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
PHOTO: KRATON
Application: IV bag
TPE type: H-SBC (SEBS)
Key properties: Elasticity, low temp, clarity, PP compatibility, melt strength
Processing: Extrusion, calendering

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

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
THE SUPER TPVs (s-TPVs)

- High temperature/oil-chemical resistance: traditionally dominated by specialty thermoset rubbers that have the disadvantages of:
  - High cost
  - Thermoset processing (associated cost disadvantages)
  - Non-recyclable

- s-TPV benefits:
  - Conventional thermoplastic processing
  - Combine benefits of high performance xlinked rubbers with high performance engineering thermoplastics
  - Reduced processing costs vs thermoset rubbers
  - Ability to be integrated into thermoplastic systems
  - Adequate rubberlike elasticity

- Major property focus: high temp, high oil/fluid resistance (auto under-hood)

- Dominated by rubber suppliers: TPE suppliers entering (e.g. Kraiburg)

- Example applications: seals, underhood ducting (in high temp applications)
SUPER-TPV FAMILIES

ACRYLIC RUBBER BASED

DuPont™ E-TPV (DuPONT) WITHDRAWN FROM MARKET

ZEOTHERM® TPV (ZEON CHEMICALS)

FLUOROPOLYMER BASED

FluoroXprene® (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
## RENEWABLE BIO-TPEs BEGIN MARKET PENETRATION (EXAMPLES)

<table>
<thead>
<tr>
<th>TPE FAMILY OR COMPONENT</th>
<th>RENEWABLE RESOURCE EXAMPLE</th>
<th>EXAMPLE 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, GLS</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</td>
<td>Ethanol from sugar</td>
<td>Dow, Braskem</td>
<td>In TPE formulations</td>
</tr>
<tr>
<td>Butadiene</td>
<td>Biomass</td>
<td>Versalis (ENI – Italy)</td>
<td>2 step via butanediol</td>
</tr>
<tr>
<td></td>
<td>Waste gas CO</td>
<td>Invista/Lanza Tech</td>
<td></td>
</tr>
<tr>
<td>SEBS (H-SBC)</td>
<td>Oyster shells</td>
<td>CTS</td>
<td>Other renewable fillers</td>
</tr>
<tr>
<td>SEBS (H-SBC)</td>
<td>Starch/Hydrocarbon</td>
<td>CTS using Gaialene®/Roquette</td>
<td>Substitute for PP in formulations</td>
</tr>
<tr>
<td>Starch/TPE</td>
<td>Starch</td>
<td>Cereplast</td>
<td>30 – 50% starch</td>
</tr>
<tr>
<td>PP carbonate</td>
<td>(CO₂+ PP oxide copolymer)</td>
<td>Novommer</td>
<td>- 40% CO₂ by weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- PP substitute?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Clarity/O₂ barrier</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
SUMMARY

• TPE life cycle: Maturing, separating into commodity and specialty segments

• Global manufacturing shift toward Asia:
  - Decreases Western TPE demand
  - Large Asian petrochemical producers entering TPE sector
  - Investment coming toward West from Asia
  - Large multinationals adapting to broader range of Asian quality/price tiers
  - Gov’t. decisions \(\rightarrow\) rapid shift in TPE demand (health care, auto subsidies)
  - China remains competitive despite wage increases

• TPE industry structure: Shifting in response to
  - Maturing supply side TPE markets (maturing of some TPE grades)
  - Search for low cost raw materials (effect of gas abundance in U.S.)
  - Global market shifts toward Asia (partially modulated by re-shoring to U.S.)

• TPE properties envelope expanding:
  - New applications in auto, health care, packaging, consumer
  - SBCs, most rapid properties expansion
• Auto: Remains major global TPE demand driver
  - Demand recovery in U.S.
  - EPDM substitution (e.g. hose, body/glazing seals)
  - Interior skins/soft touch remains battleground
  - Under-hood (enhanced role for s-TPVs)

• Global recession effects:
  - Decline of China exports → Europe
  - Slowing China economy
  - Europe in severe auto, consumer and housing recession
  - Some raw material price declines

• Health care:
  - Fast growth TPE market
  - PVC replacement decisions (China and West)

• s-TPVs: Reaching for high performance specialty rubber markets

• Bio-TPEs: Momentum starting. Capable of competing in the marketplace
THANKS FOR YOUR ATTENTION

Robert Eller Associates LLC
CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES