GLOBAL TPEs: NEW TECHNOLOGY, REGIONAL MARKET SHIFTS AND COMMODITIZATION

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b/papers/topcon 2014
• Role of macroeconomics in TPE globalization
• Automotive market: effects on TPEs
• China snapshot
• Re-shoring and TPE in NAFTA
• Global TPE frontiers and shifts
• Overcapacity perspectives
• Expanding the TPE family footprint
• Market trends and applications examples
• TPE strategy wheel
Emerging markets are changing the global TPE footprint (volumes, grade range and industry structure)

DATA SOURCE: IMF
COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2014
CHANGE IN U.S. JOBS SINCE DECEMBER, 2007

+ 12.2% EDUCATION, HEALTH CARE
+ 4.1% PROFESSIONAL, BUSINESS
- 0.8% TOTAL NON-FARM
- 2.4% GOVERNMENT
- 12.5% MANUFACTURING

Some mfg recovery but net loss has affected TPE demand

SOURCE: BUREAU OF LABOR STATISTICS
FALLING U. S. WAGES WILL HELP SUPPORT RE-SHORING

Change since June 2009, the end of the recession

Financial services +5.5%
Education, health +1.4
-0.1% Information
-0.5 All private-sector jobs
-1.3 Retail
-1.7 Leisure, hospitality
-1.9 Construction
-2.4 Manufacturing
-10.0 Auto industry

Auto recovery has stimulated auto TPE demand, especially TPOs

SOURCE: BUREAU OF LABOR STATISTICS

A Stubborn Gap
U.S. trade deficit in goods, in trillions

SOURCE: IHS
The Wall Street Journal
AUTO WAGES: STILL MAJOR GAP BETWEEN HIGH AND LOW PAYING COUNTRIES

Automobile industry average hourly compensation in 2012, including benefits:

- **Canada**: $39.04
- **Britain**: $38.28
- **France**: $45.77
- **Germany**: $58.82
- **Japan**: $41.65
- **United States**: $45.34
- **Mexico**: $7.80
- **Brazil**: $18.78
- **Poland**: $9.53
- **India**: $2.10
- **China**: $4.10
- **S. Korea**: $25.74

Mexico is auto TPE growth market

... and lower-paying countries. Number of workers for the same cost as one U.S. worker.

Sources: Bureau of Labor Statistics: Center for Automotive Research
USA AND CHINA ECONOMIES DIFFER IN GDP USAGE (2013)

Note:
(a) China rebalancing policy could → shift to increased domestic consumption → increased TPE usage for domestic products with associated quality/price levels
(b) USA in trade deficit since mid-70s, China in trade balance surplus since 1994

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
GAS PRODUCTION IN U.S.

38% increase in gas production since 2006 shifts ethylene economics, stimulates U.S. exports of ethylene–based TPEs and rubbers.

Source: Robert Eller Associates LLC, 2014
CHINA IS A HIGH GROWTH LIGHT VEHICLE (LV) MARKET

China:
- exceeds USA sales in 2009
- capacity overbuilt, dropped to 60% utilization in 2012 (OEM consolidation likely)
- solid growth continues through 2017 (excellent TPO and TPE growth prospects)
- potential slowing of vehicle growth > 2017 (e.g. 28-29 MM in 2018)

USA: likely to top out at ~17-18 MM LV sales/yr in 2017-2018

DATA: Wards Auto
COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2014
## IMPORTANCE OF AUTOMOTIVE VARIES BETWEEN TPEs

<table>
<thead>
<tr>
<th>TPE TYPE</th>
<th>AUTO SHARE OF GLOBAL DEMAND</th>
<th>RECENT INCUMBENT</th>
<th>NOTE/ AUTO TARGETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPO</td>
<td>80%</td>
<td>None – TPO dominates</td>
<td>Bumper fascia, interior trim, skins Growth in non-auto markets</td>
</tr>
<tr>
<td>o-TPV</td>
<td>50%</td>
<td>NBR/PVC, ECO, CPE, EPDM</td>
<td>Boots/bellows, hose, short air ducts, Body/glazing seals</td>
</tr>
<tr>
<td>SEBS</td>
<td>15%</td>
<td>EPDM, o-TPV</td>
<td>Auto share growing via soft touch, skins, body/glazing seals, airbag doors</td>
</tr>
<tr>
<td>TPU</td>
<td>11%</td>
<td>EPDM, o-TPV</td>
<td>Grommets, sleeves, door sills, overmolded films, shift knobs, lamp seals, slush molding, wire/cable</td>
</tr>
<tr>
<td>COPE</td>
<td>10%</td>
<td>EPDM, o-TPV, fluorosilicones</td>
<td>Under-hood ducting(higher temp capability), wire/cable, soft touch trim panels</td>
</tr>
</tbody>
</table>

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2014
Western TPE → China to serve → Invest in local prod’n compounders → OEM transplants

Domestic TPE → Serve domestic → Move up Q/P tiers → Serve Western mkts → Invest compounders → quality/price tiers via distribution in West

China/Taiwan- → Serve domestic → Move up Q/P tiers → Serve Western mkts → Invest resin suppliers → quality/price tiers via distribution in West

Western resin → Export → Invest in local suppliers → Asian prod’n

SOURCE: ROBERT ELLER ASSOCIATES LLC,  2014
Re-shoring drivers
- Increasing wages in low cost countries (15-18%/yr in China for last 3 years)
- Transportation costs
- Shorter/more controllable supply chain in NAFTA

Challenges
- Finding enough skilled, educated workers in US
- Redesign/re-engineering required for higher cost environment
- Consumers willing to pay a bit more

Some examples of re-shoring to NAFTA
- Apple (mobile electronics)
- GE (water heaters, refrigerators)
- Ford (various auto parts)
- Whirlpool (washing machines)
- Foxconn/Hon Hai, Taiwan (electronic components for Apple, auto)

TPE benefits
- Efficient manufacturing (2 shot, core-back techniques)
- Reduced assembly costs
- Reduced labor content vs hand assembly
- Attracting Asian TPE suppliers
GLOBAL TPE FRONTIER: CHINA/TAIWAN

- TPEs in growth phase
- Substantial investment by Western TPE compounders
- Domestic TPE compounders and resin suppliers are very competitive
- TPOs driven by continued auto production growth (o-TPVs lagging)
- State-owned enterprises (SOEs) present in TPE marketplace (e.g. SBC resin)
- Importance of quality/price (Q/P) levels impacting TPE product lines
- Overcapacity/overinvestment $\rightarrow$ downward TPE price pressures
- China “re-balancing” policy shifting from export $\rightarrow$ increased domestic consumption and developing SE Asia markets
- TPE Investment coming out of region $\rightarrow$ NAFTA, Europe

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
GLOBAL TPE FRONTIER: MEXICO

• New TPE geographic growth frontier

• Population 111 MM (+40MM in Central America) = 45% of US population

• Economy:
  - on a well managed growth trajectory
  - credible management
  - structural reforms passed
  - GDP/capita $8,519 vs $3,344 in China
  - currently driving immigration to US

• Benefit from US recovery (85% of exports → US)

• Widening of the Panama Canal allows mega-ships, will → new ports

• TPE, (especially TPO) increase driven by high growth auto sector

• U.S., European TPE compounding and sales investment (e.g. So-F-Ter, RTP, Kraiburg)

• Ability of Southern U.S. TPE compounders to service market from U.S. will be tested

• Infrastructure, immigration, crime, and border transfer are concerns

SOURCE: ROBERT ELLER ASSOCIATES, LLC
OVERCAPACITY IN SOME ASIAN TPE SECTORS: EXAMPLE SEBS RESIN

SEBS RESIN CAPACITY IN CHINA/TAIWAN (2015)

ANNUAL CAPACITY, kT

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014

Specialty grade focus
TPE FAMILIES . . . EXPANDING FOOTPRINT, INTRA-TPE COMPETITION, ENTRY OF POEs

Notes: * = Production dominated by resin suppliers
(a) Recyclate-based TPV
(b) e.g. Dow Infuse™
(c) Specialty grades of TPE usually produced by independent compounders
(d) e.g. Hipex from Kraiburg®

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
**TPE SNAPSHOT: ETHYLENE ALPHA OLEFINS (POEs AND POPs)**

- **Key characteristics**
  - Low modulus
  - Low HDT
  - Poor compression set
  - Good impact modifier

- **Low cost:** 0.80-1.00 $/lb (1.80-2.2 $/kg)

- **Global volume:** ~ 800kT

- **Raw materials(a):**
  - Ethylene, Propylene
  - Co-monomers (octene, hexene)

- **Major suppliers(a):**
  - Dow (Engage, Versify, Amplify)
  - ExxonMobil (Exact, Vistamaxx)
  - Mitsui (Tafmer)
  - LG, other entries likely

- **Markets/applications:**
  - Impact modification (e.g. TPO is largest app)
  - Footwear
  - Packaging
  - Adhesives
  - Healthcare and personal hygiene
  - Blown film additive

- **Growth potential:**
  - High (> 6%/yr globally)
  - New plants in Singapore (ExxonMobil) and Thailand (Dow/SCG group)
  - Swing trains (producing EPDM in same plant)

- **Intermaterials competition:**
  - SBC compounds (SBCs have better: oil absorption, compression set, heat distortion temperature)
  - EPDM (e.g. in TPOs
  - Reactor TPOs, PVC

(a) Gas economics (shale and non-shale) will shift competitive positions of materials, suppliers and US vs Europe-based suppliers

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
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, 2014
SHALE GAS BOOM

US becomes 21st Century energy giant

- Export to Europe at competitive prices after capex investment for infrastructure
  - Challenge Russia’s political leverage
  - Prosperity and TPO market growth in Central & Eastern Europe

- Favorable C\textsubscript{2} economics
  - Further enhance already favorable economics of TPO, SBC compounds, PP compounds
  - Growth based on favorable economics and broadened property envelope in:
    - Auto,
    - Other (e.g. Packaging, Construction, Sheet)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
TPE MARKET TRENDS

• Comoditization:
  - Market segments into specialties and commodities. Associated concentration by TPE suppliers
  - Back integration by distributors into compounding (e.g. Albis, Ravago, PTS, Alliance)

• Demand growth in non-China/non-India emerging markets:
  - Middle class empowerment;
  - Growth of auto demand (e.g. Indonesia)

• Increased importance of quality/price tiers (global, glocal, local, bottom end)

EXAMPLE TPE GROWTH MARKETS

<table>
<thead>
<tr>
<th>TPE TYPE</th>
<th>MARKET</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEBS</td>
<td>Packaging</td>
<td>Soft touch labels, caps</td>
</tr>
<tr>
<td>SEBS/TPO/o-TPV</td>
<td>Auto</td>
<td>Auto: Skins, body/glazing seals</td>
</tr>
<tr>
<td>SBS</td>
<td>Several</td>
<td>Increased use in SBC formulations</td>
</tr>
<tr>
<td>SEBS, COPE</td>
<td>Electronics</td>
<td>Silky feel.</td>
</tr>
<tr>
<td>o-TPV, SEBS</td>
<td>Auto</td>
<td>Body/glazing seals</td>
</tr>
<tr>
<td>SEBS</td>
<td>Medical</td>
<td>High growth: films, tubing. PVC challenge</td>
</tr>
<tr>
<td>SEBS, o-TPV</td>
<td>Wire/cable</td>
<td>Must compete with f-PPO</td>
</tr>
<tr>
<td>Bio– TPU, SEBS, COPE</td>
<td>Several</td>
<td>Multiple approaches to bio-TPEs</td>
</tr>
<tr>
<td>TPU foam</td>
<td>Footwear</td>
<td>BASF process. Application to other markets</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
UPWARD TPE PRICE PRESSURES/STRATEGIES: SBC COMPOUNDS

CURRENT PRICES

UPWARD PRICE PRESSURES

GRADE MIX
- INCREASE SPECIALTIES AND HIGH QUALITY

SUPPLIER STRATEGIES
- DE-EMPHASIZE COMMODITY MARKETS
- CONSOLIDATION/ACQUISITION(a)

MARKETS
- HIGHER PERFORMANCE MARKETS
- COMPETITION WITH o-TPE

RAW MAT’L
- BUTADIENE PRICES

Note:
(a) As part of globalization strategy

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
PRICE PRESSURES ON TPEs - DOWNWARD

CURRENT PRICES

DOWNWARD PRICE PRESSURES

COMPETING MAT’LS.
- OBC
- POEs
- EPDM (d)

TECHNOLOGY
- PROLIFERATION

MACRO ECONOMICS
- SOFT GLOBAL ECONOMY
- EMERGING MKTS SLOWING (e)

INDUSTRY STRUCTURE
- NEW ENTRANTS (a)
- NEW REGIONAL COMPOUNDERS

REGIONAL SHIFTS
- SHIFTED BRIC MARKETS
- SHIFT TO LOWER QUALITY/PRICE TIERs (b)
- GENERALLY LOWER PRICED MARKETS
- CHINA PRICING/MODEL (c)

RAW MAT’LS COSTS
- SBC OVERCAP’Y
- EPDM OVERCAP’Y
- NR GLOBAL GLUT (f)
- SHALE GAS ECONOMICS (g)

MARKETS
- MATURING COMMODITY MARKET SECTORS
- SLOWING BRICs GROWTH

(a) Asian suppliers entering Western market
(b) e.g. Global, glocal, local, bottom-end
(c) e.g. Cash flow vs. return on capital pricing model
(d) EPDM is in global overcapacity
(e) (e.g.) Slowdown of China and other emerging economies
(f) Natural rubber glut has driven prices down. Pressures SBS prices where they compete
(g) Shale gas economics currently favor U.S. producers

ROBERT ELLER ASSOCIATES LLC, 2014
PARADIGM SHIFTING IN GLOBAL TPEs

- Increased importance of quality/price tiers
- N. American shale gas/oil shifts economic competitiveness in polyolefins
- Emerging-region auto markets increase TPE demand via unit volume growth and substitution
- Supply chain broadening and consolidating:
  - new entrants
  - acquisitions
- Emergence of Asian TPE competition challenging large global incumbents via localization of supply chain
- Emergence of global:
  - auto platforms
  - standards/performance requirements
SHORT AIR DUCTS: MODERATE TEMPERATURE
UNDER HOOD APPLICATION

• Application: Short clean-air duct

• TPE Candidates: o-TPV, PVC/NBR

• Rubber competition: EPDM

• Key Properties:
  - Constant temp resistance to 135°C
  - Oil resistance
  - 75A hardness

• Fabrication process: Injection or blow mold

• Notes:
  - Recent example (not shown) is Hyundai short air duct based on Santoprene™ TPV
  - s-TPVs and COPE for higher temp ducts
  - Weight and cost save vs TS rubbers
  - Recyclability a benefit of TPE use

Photo source: ExxonMobil
POLYCARBONATE AUTO GLAZING:
NEW OPPORTUNITIES FOR TPEs

Sunroof:
- key PC glazing target
- TPE glazing seals starting

Injection molded rear window glazing:
PC from SABIC:
- 35% weight save vs glass
- plasma coating (Exatec E900)
- opens opportunity for TPE encapsulation

Rear quarter windows:
- entry point for PC
- battleground for TPE window encapsulation (wincap)
  --SEBS, o-TPV vs PU-RIM, PVC

Vehicle: Ford Fusion multi-material lightweight vehicle MMLV)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
TECHNICAL TRENDS AFFECTING AUTOMOTIVE TPEs

• COPEs:
  - High temperature resistance
  - Adhesion
  - Haptics
  - Multi-shot

• TPOs:
  - High flow
  - Thin wall capabilities
  - Use in acoustic components
  - Role of POEs
  - Renewed skins growth

• o-TPVs:
  - High flow/glass adhesion grades for window encapsulation
  - Continued penetration into body seals and glass run channels
  - Improved attachment systems for body seals
  - Strength of the EPDM incumbency
The challenge: Reduce total parts cost

Background:
- TPEs generally cost more than incumbent
- OEMs (finally!) working to examine total system costs (not $/kg)
- OEMs demand high performance, form and function, perceived quality
- Avoiding “cheap plastics” look

TPE solutions:
- Parts consolidation
- Redesign for ease of assembly
- Labor cost reduction
- Design for disassembly and recycling
## GATEWAY TECHNOLOGY PLATFORMS FOR TPE, TPO, AND PP COMPOUNDS

<table>
<thead>
<tr>
<th>TECHNOLOGY PLATFORM</th>
<th>EXAMPLE GEN 1 AND 2 APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DYNAMIC VULCANIZATION</td>
<td>NEW FAMILIES OF SUPER-TPVs FOR HIGH TEMPERATURE APPLICATIONS</td>
</tr>
<tr>
<td>MALEIC ANHYDRIDE AND VARIANTS FOR ADHESION IMPROVEMENT</td>
<td>ALLOYS/BLENDS HARD/SOFT COMBINATIONS</td>
</tr>
<tr>
<td>CROSSLINKING SEBS COMPOUNDS</td>
<td>TARGET O-TPV APPLICATIONS</td>
</tr>
<tr>
<td>FOAMING TECHNOLOGIES</td>
<td>LIGHT WEIGHT, SOFT APPLICATIONS</td>
</tr>
<tr>
<td>CORE-BACK MOLDING</td>
<td>SIMPLIFIED FABRICATION OF MULTILAYER CONSTRUCTIONS (IP, DOOR TRIM)</td>
</tr>
<tr>
<td>POE ENTRY/SHALE GAS ECONOMICS</td>
<td>BROADEN TPO PROPERTY PROFILE/COST</td>
</tr>
<tr>
<td>SHAPE MEMORY TPEs (PolyOne)</td>
<td>CUSTOMIZED ERGONOMICS; REPAIRS</td>
</tr>
</tbody>
</table>

**Source:** ROBERT ELLER ASSOCIATES LLC, 2014
TECHNICAL/ECONOMIC TRENDS: SBC COMPOUNDS

• Improved SEBS grades
  - Slush moldable
  - Coated fabric grades
  - Competitive with o-TPV, PVC in some applications (e.g. appliance seals)
  - Substitution of SBS where feasible. Role for POEs

• 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

• Chinese/Taiwan commodity resin suppliers catching up in quality and versatility, not there yet
The challenge (usually to rigid plastics):
- Improved adhesion is an application enabler/cost save
- Value add potential

Background:
- Application in coatings, multi-materials, construction, blends, fillers, reinforcements, surface decorations
- Logos

TPE solutions:
- Sprayed surface adhesion promoters
- Additives and compounds
- Usually polar/non-polar combinations
  -- MA/resin combinations
  -- SMA
  -- Other
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 → LOWER COST TPEs
- BIO-TPEs STARTING
- CHALLENGE TO RUBBER CONTINUES

PROCESS INNOVATIONS
- FOAMING APPROACHES
- MULTI-SHOT MOLDING/CORE BACK
- SLUSH MOLDING
- TEXTILE COATING

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 LS
- RIGID/Flexible COMBINATIONS

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2014
SUMMARY

• Growth markets: Auto, packaging, medical, wire/cable, sports/leisure (TPU)
• Industry structure: Bifurcation into specialty and commodity suppliers as commoditization affects grades
• US:
  - Manufacturing share of GDP has declined
  - Re-shoring will recover some markets lost to Asia
  - Wage decline helped competitiveness in some sectors, reduced buying power
• China (a global frontier):
  - High growth LV sector will drive TPO, o-TPV, SBC growth
  - “Rebalancing” → domestic consumption helps consumer products sector
  - Quality/price tiers → shifts TPE grade slate/properties footprint
• Mexico: Could emerge as a new global (smaller)TPE frontier
• Prices: Overcapacity will pressure TPE prices. Higher quality tiers can resist
• POEs: Have entered TPE sectors, will continue to enhance TPE mkt position
• Shale gas boom:
  - Shifting competitive position of POEs.
  - US → potential advantage in olefinic-based TPEs
THANKS FOR YOUR ATTENTION

Robert Eller Associates LLC
CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRES