CURRENT STATUS AND FUTURE POTENTIAL FOR POLYOLEFINS, TPOs, AND TPEs IN THE GLOBAL AUTOMOTIVE MARKET

PRESENTED BY:
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PRESENTED AT:
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OVERVIEW

1. Global Automotive Market: Regional Shifts and Global Platforms
2. Asia-Pacific Role in the Global Auto Market
3. The North American Auto Market/Supply Chain
4. Automotive PP Compounds and TPO Types and Trends
5. The TPE Families
6. Automotive TPE Substitution: Key Drivers
7. Automotive TPE Target Applications, 2012
8. Summary
Global automotive sales growth has shown steady increases since 1975 at a rate somewhere between 2.4-3.6%/yr.

China has become the No. 1, fastest growth, global automotive market.
GLOBAL VEHICLE DEMAND SHIFT BY REGION

![Graph showing demand shift by region for 2010 and 2013.]

**Source:** ROBERT ELLER ASSOCIATES LLC, 2012

b/mydox/auto/prod’n outlook 013112.xlsx
## REGIONAL VEHICLE PROD’N. GROWTH RATES – 2000/2015

<table>
<thead>
<tr>
<th>REGION</th>
<th>PRODUCTION, MM VEHICLES</th>
<th>CAGR %/YR.</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2015</td>
<td></td>
</tr>
</tbody>
</table>
| China          | 2.5  | 22   | 16%                                     | - Reduced gov’t. incentives will slow growth in 2012  
- Recent barriers to non-Chinese OEM investment  
- Possible overcapacity by 2020?                      |
| India          | 1.0  | 5    | 11%                                     | - Brazil dominates                                                                                                                |
| S. America     | 2.5  | 5    | 5%                                      | - Brazil dominates                                                                                                                |
| Europe         | 19.0 | 23   | 1%                                      | - Current overcapacity  
- Stagnant market                                                                                                                  |
| Japan/Korea    | 12.5 | 13   | 0%                                      | - Yen strength → Japan shift to non-domestic production                                                                            |
| NAFTA         | 17.0 | 17   | 0%                                      | - 13.8MM in 2012                                                                                                                  |

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
SEGMENT SHIFT IN N. AMERICAN AUTO SALES,
2000/2005/2010

Sources: WardsAuto.com; Robert Eller Associates LLC, 2012
### GLOBAL PLATFORM STRATEGY SHIFTS

<table>
<thead>
<tr>
<th>OEM</th>
<th>CURRENT/ FUTURE EXAMPLES</th>
<th>GLOBAL PLATFORM STRATEGY</th>
<th>NOTE</th>
</tr>
</thead>
</table>
| VW  | - Passat                 | - Has been in place for 30-40 years (e.g., Golf platform)  
- Shifting from global platforms?  
- U.S. Passat is departure from global platform strategy | - Borrows components and modules from other models, as appropriate  
- Strong VW entry into European “A” vehicle segment |
| Honda | - Civic  
- Accord  
- Acura | - Shifting from strict adherence to global platforms | - Flexible assembly lines allow multiple models/regional differentiation |
| GM  | - Cruze  
- Malibu | - Reduce number of vehicle platforms (30 in 2010 → 14 in 2018)  
- Increase vehicles per core global platform | - Cruze is first global model  
- Malibu to follow  
- Core platforms → 90% of production in 2018  
- Have been slower to → global platforms |
| Ford | - Fiesta  
- Focus  
- CUVs  
- C/D platform (Fusion/Edge) | - “One Ford” strategy  
- Single Focus model for U.S./Europe | - Move to global platforms  
- Reducing number of global platforms from 11 → 9 by 2013 |

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
2011 Chevrolet Cruze – Example of a global vehicle
1. GLOBAL AUTOMOTIVE MARKET: REGIONAL SHIFTS and GLOBAL PLATFORMS

- Trend line for global sales volume: steady sales gain ~ 3%/yr.
- BRIC countries: rapid growth vs. stagnation in Western regions
- Globalization: a new world automotive reality → global:
  - Platform strategies: Ford, GM moving forward, VW already there
  - Platform share of global vehicle production will → ~40% by 2015, from 34% in 2010
  - Global vehicles/platforms reshaping the supply chain: need for global supplier footprint
    - Specifications: evolving, e.g., 3-4 global TPE specs
      Asia: benefit of arriving with TPE spec in hand
2. ASIA-PACIFIC ROLE IN THE GLOBAL AUTO MARKET

- China
  - Economic growth: 8.5% in 2011; Inflation: 5% in mid-2011
  - Exports: export boom in 2011
    production capacity → 40MM in 2020, drives export threat?
  - GM and VW: major market shares (combined = ~ 27%)
  - Central government limit foreign investment >2012?

- China automotive PP compounding capacity: expanding (e.g., China XD/Sumitomo joint venture)

- Acquisition investment coming out of Asia, seeking Western technology affecting Western TPE supply chain and customers – examples:
  - Chongqing Light Industry acquisition of Saargummi (sealing systems)
  - Ruia Group (India) acquisition of Sealynx (France)
  - TSRC acquisition of Dexco (SBS resins)
  - Toyota Boshoku (Japan) acquisition of Polytec’s interiors business
  - Motherson Sumi (India) acquisition of Peguform (Germany)
## Automotive PP Copolymer and TPO Industry Structure

### Industry Sector Share, %

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Share, %</th>
<th>Examples</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin Supplier/Captive Compounder</td>
<td>70</td>
<td>LyondellBasell, Mitsui/Prime, ExxonMobil, Styron, Sabic, Mytex, Sumitomo</td>
<td>Global</td>
</tr>
<tr>
<td>Independent Compounder</td>
<td>30</td>
<td>Rhetec, Ferro, Wash Penn</td>
<td>Regional</td>
</tr>
</tbody>
</table>

### Industry Structure Trends

- Resin suppliers integrating toward compounding
- Tier 1s back-integrating to in-house compounding (IAC, Inteva)
- Market globalization/supply chain shift
- Offshore resin companies → N. American market (natural gas driver?)
- Western OEMs, Tier 1s → Asia expansion (major portions of supply chain)
4. AUTOMOTIVE PP COMPOUNDS, TPOs: DRIVERS AND TRENDS

- **PPC/filled:** Talc is dominant filler, improvements → improve compound properties (flow, stiffness/impact balance). Some growth in metal replacement. Next step: functional fillers, highly engineered PP copolymer compounds.

- **Shift to eco-friendly PP compounds** (e.g., 2012 Ford Escape door trim panel from 50% Kenaf/PP).

- **TPO:** Reaching maturity, growth tied to auto production. Demand shrinkage with thinner walls and smaller vehicles.

<table>
<thead>
<tr>
<th>DEMAND DECREASERS</th>
<th>DEMAND INCREASERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small car/CUV trend</td>
<td>Scratch resistant PP compounds and TPOs</td>
</tr>
<tr>
<td>Thin walling</td>
<td>Increased demand for semi-structural PP grades</td>
</tr>
<tr>
<td>Recycling</td>
<td>Integral soft surface treatments</td>
</tr>
<tr>
<td></td>
<td>Cost benefits of direct LGF-PP compounds</td>
</tr>
<tr>
<td></td>
<td>Drive for lightweighting. 10% weight reduction → 5-7% fuel save</td>
</tr>
</tbody>
</table>

**Source:** ROBERT ELLER ASSOCIATES LLC, 2012
# AUTO POLYOLEFIN SHARES: NAFTA

<table>
<thead>
<tr>
<th>PP FORM</th>
<th>SHARE, %</th>
<th>EST. 2011 DEMAND, MM LBS.</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neat copolymer Filled/reinforced</td>
<td>47</td>
<td>565</td>
<td>Includes battery (neat copolymer)</td>
</tr>
<tr>
<td>grades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPO</td>
<td>53</td>
<td>635</td>
<td>TPOs have grown at the expense of copolymer (driven by safety and performance requirements)</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>1,200</td>
<td></td>
</tr>
</tbody>
</table>

Source: Robert Eller Associates LLC; Global Polymer Solutions LLC

- **PP penetration (% of all plastics and use/vehicle increased steadily from 2000 → 2011):**
  - 2000: 7.6% of all plastics used
  - 2010: 9.6% of all plastics used

- **Usage per vehicle will increase slightly in next 5 years:**
  - Smaller vehicles → usage decline, thin-walling
  - Increased usage for LGF-PP, some new applications
SOME AUTO PP COMPOUND/TPO APPLICATIONS ARE MATURE

- Bumper fascia (but growth in size/vehicle)
- Interior trim (instrument panel structure?, airbag door, kick panels)
- Exterior trim (grill, body molding, cowl vents)
- Some trunk liner applications
- Fender liners
## EXAMPLE GROWTH APPLICATIONS FOR AUTO PP COMPOUNDS

<table>
<thead>
<tr>
<th>APPLICATIONS</th>
<th>COMP’D.</th>
<th>DEMAND TREND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake manifold/Other under-hood</td>
<td>SGF-PP</td>
<td>Competes with SGF-nylon</td>
</tr>
<tr>
<td></td>
<td>PP-resin</td>
<td>Started at VW (Borealis development)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WIT process for 3-D hose</td>
</tr>
<tr>
<td>IP substrate</td>
<td>LGF-PP</td>
<td>Soft touch trim adds value</td>
</tr>
<tr>
<td>Underbody shields</td>
<td>LGF-PP</td>
<td>Competes with neat copolymer, SGF-PP</td>
</tr>
<tr>
<td>Door hardware modules</td>
<td>LGF-PP</td>
<td>High growth application</td>
</tr>
<tr>
<td>Exterior panel inners</td>
<td>SGF-PP</td>
<td>Started on Ford Kuga (Europe)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very early; uncertain application</td>
</tr>
<tr>
<td>Trunk inserts</td>
<td>Talc-PP</td>
<td></td>
</tr>
<tr>
<td>Bio-fiber reinforced</td>
<td></td>
<td>Several applications(e.g. door panels), generally modest performance</td>
</tr>
<tr>
<td>Body/glazing seal systems</td>
<td>Talc-PP</td>
<td>Replaces metal. Offers systems cost savings when combined with TPEs</td>
</tr>
</tbody>
</table>

Note: LGF-PP competes with SGF-PP and with SGF (and LGF) polyamides

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
EXAMPLE OF PP SYSTEMS COST SAVE VIA INTEGRATION OF FUNCTIONS

Photo: Teklas, A. Schulman, PME Fluidtech

Part: Drain channel (note integrated bellows/clip functions)
Material: Unreinforced PP (Polyfort PPC 03 SP-E from A. Schulman)
Fabricator: Teklas (Turkey)
Equipment supplier: PME Fluidtech GmbH
Process: Water Injection Technology (WIT), also suitable for GF-PP, GF-PA
Note: Hutchinson and Contitech possibly will use WIT for similar parts
Commercial status: To be used on Opel “Delta” platform, 1.4 liter engines (Astra, others)

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
5. THE TPE FAMILIES

- OLEFINIC (o-TPEs)
  - TPO
  - o-TPV
  - p-TPV (PARTIAL CROSSLINKED)
  - f-TPV (FULLY CROSSLINKED)

- STYRENIC (SBCs)
  - SBS
  - SEBS (TPE-S)
  - Vulcanized SBC TPVs (TPES-V)

- SUPER-TPVs
  - SILICONE
  - ACRYLATES
  - OTHER

- OTHER E-TPEs
  - COPE
  - COPA
  - TPU
  - OTHERS(a)

- PVC TPEs

NON-TPO TPEs COMPETING IN THE AUTO TPE SECTOR

Note:
(a) e.g., recently introduced melt processable polyurea-based TPEs

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
6. AUTOMOTIVE TPE SUBSTITUTION: KEY DRIVERS

- **Cost save vs. direct substitution for rubber**
  - Rigid/flexible combinations (important for under-hood)
  - Net shape potential: systems cost savings/reduced assembly cost

- **Luxury upgrade (important for small car and CUV interiors)**
  - Soft touch (growing area coverage in interior)
  - Foamability: still under-exploited
  - Elimination of buzz, squeak, rattle (BSR) between adjoining surfaces

- **Recyclability/Sustainability Emphasis (e.g., PP/Kenaf door trim panels)**

- **Steep rise in fuel economy standards/fuel costs → weight save emphasis**
  - Cost efficiency of TPEs vs. alternative fuel efficiency measures
  - Demand for systems/features that add to vehicle mass → weight save emphasis to offset
**SOME EPDM-RELATED ISSUES**

- **Supply**
  - Currently tight, will remain so until 2014
  - Has driven up pricing
  - Expansions are in Asia and Middle East

- **EPDM types**
  - Most expansions (2011-2014) are metallocene-based
  - Petro-Rabigh in KSA (Sumitomo/Aramco) is exception (ZN-based)
  - Medium-high Moody and medium-high diene content work best for TPVs
  - ZN-based EPDM has some advantages vs metallo-EPDM grades
  - Bio-based EPDMs starting (from Lanxess via Braskem)

- **EPDM vs POEs**
  - For TPOs the shift from EPDM to POEs for most applications
  - Swing capacity (POE and EPDM) in some plants
### 7. AUTOMOTIVE TPE TARGET APPLICATIONS, 2012

<table>
<thead>
<tr>
<th>TARGET COMPONENTS</th>
<th>HIGH STIFFNESS TPOs</th>
<th>LOW STIFFNESS TPOs</th>
<th>SEBS</th>
<th>r-TPOs</th>
<th>o-TPV</th>
<th>COPE</th>
<th>s-TPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rocker Panel</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fascia</td>
<td>X</td>
<td>X*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body/Glazing Seals</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airbag Door</td>
<td>X*</td>
<td>X*</td>
<td>X*</td>
<td>X*</td>
<td>X*</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Trim</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP Skins</td>
<td></td>
<td>X*</td>
<td>X?*</td>
<td>X*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door trim skins</td>
<td>X</td>
<td></td>
<td>X*</td>
<td>X*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steering Wheel</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>HVAC Louvers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under-carpet floor acoustic mat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X* = multi-shot injection molding, multi-material blow molding, or co-extrusion candidate

(Cont’d.)
<table>
<thead>
<tr>
<th>TARGET COMPONENTS</th>
<th>TPO or TPE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH STIFFNESS TPOs</td>
</tr>
<tr>
<td>Under-hood:</td>
<td></td>
</tr>
<tr>
<td>Cowl Vent Seal</td>
<td>X*</td>
</tr>
<tr>
<td>Ducting</td>
<td></td>
</tr>
<tr>
<td>Boots/Bellows</td>
<td>X</td>
</tr>
<tr>
<td>Hose</td>
<td></td>
</tr>
<tr>
<td>Wiring</td>
<td>X</td>
</tr>
<tr>
<td>Oil/Gas Resistant</td>
<td></td>
</tr>
<tr>
<td>Underbody shields</td>
<td>X</td>
</tr>
</tbody>
</table>

X* = multi-shot injection molding, multi-material blow molding, or co-extrusion candidate

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
# Approaches to 2-Shot or Overmolding of TPEs for AutoPlastic Components

<table>
<thead>
<tr>
<th>TYPE</th>
<th>STRUCTURE</th>
<th>NOTE/EXAMPLE APPLICATION</th>
</tr>
</thead>
</table>
| Overmold, Multi-material Mold, 2-shot Mold | TPE Substrate (rigid segment) | - Soft touch interiors  
- Small, tactile parts  
- Some 2-tone applications |
| 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       | - Boots/bellows  
  - Under-hood          |
| Co-extrusion Blow Mold or Co-extrusion | TPE outer ETP inner | Under-hood:  
  - Hose  
  - Duct  |

Source: ROBERT ELLER ASSOCIATES LLC, 2012

AUTOMOTIVE TPE TARGET ZONES

- Oil seals
- Ducting
- Acoustic barrier role for POEs
- Exterior skins
- Glazing seals (static, dynamic)
- Body seals
- Lighting seals
- Exterior skins
- Skins: IP, door trim
- Glass run channels
- Belt line molding
- Under-carpet acoustic mats
- Dust covers (bellows)
- Cowl vent gasket
- Acoustic mats

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012

r/mydox/Visio/TPE Battle Zones 2012.vsd // lg/myfiles/Visio/TPE Battle Zones 2012.vsd
Targets:

• Instrument panel, door trim, console, steering wheel

• Multi-materials (2-shot) molding benefits:
  - Cost save vs. incumbent skin methods
  - TPVs and SBC-TPEs competing
  - Foaming will accelerate TPE penetration
  - Capital investment vs. labor costs (an issue in Asia)
  - TPEs with high flow (large area/thin cross-section) required
  - Craftsmanship improvement
  - Recyclability

• Lower IP is entry point for 2-shot molded TPE skin/substrate
  - 2-color
  - Reduces BSR
  - Grain is less critical than upper
INSTRUMENT PANEL SKIN SUBSTITUTION OBJECTIVES

Environment
- Eliminate chlorine?
- Improve recyclability/sustainability
- Reduce VOC/fog

Performance
- Scratch/Mar resistance (improved via radiation crosslinked TPO)
- Satisfactory hidden passenger airbag deployment at -30ºC
- Grain reproduction
- Haptics (“deep” soft touch)
- Craftsmanship/fit & finish (shrinkage on heat aging effects)
- Mass reduction
- Long-term UV resistance (low Δ E)
- Heat aging resistance

Cost
- Reduce IP system costs (2-shot molding; eliminate skin?)
- Skin cost reduction
Car Model: Audi E8
Part: Instrument panel skin (slush molded/cast)
Raw Material Resin: Kraton
Compound: Laprene S formulated by SO.F.TER
Fabricator: Peguform (80% owned Motherson Sumi)
Features:
- Halogen free, phthalate free
- 30-40% lighter weight than PVC
- Better low temperature performance than PVC
- Better aging characteristics than PVC
- Lower processing costs
- Recyclable
- Deep soft touch/haptics feel

Photo Source: News-On-Tour

Source: Robert Eller Associates LLC, 2012
# IP SKIN PROCESS SHARES IN N. AMERICA

## HARD/SOFT IP BREAKDOWN

<table>
<thead>
<tr>
<th>IP TYPE</th>
<th>%</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>60</td>
<td>Primarily PP-based</td>
</tr>
<tr>
<td>Soft</td>
<td>40</td>
<td>See process shares below</td>
</tr>
</tbody>
</table>

## SOFT IP MATERIALS SHARES

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>SHARE, %</th>
<th>MATERIAL TYPE</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slush (cast) molding</td>
<td>72</td>
<td>- PVC dominates (about 70%)</td>
<td>- SEBS-based slush seeking entry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- TPU at Japanese OEMs</td>
<td>- Inteva patent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- TPO has not made significant penetration</td>
<td></td>
</tr>
<tr>
<td>Thermoform</td>
<td>15</td>
<td>- TPO compact and foam backed dominate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Still some PVC/ABS</td>
<td></td>
</tr>
<tr>
<td>PU spray</td>
<td>10</td>
<td>- Expensive</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Primarily on high end models</td>
<td></td>
</tr>
<tr>
<td>Leather, other</td>
<td>3</td>
<td>- High end models</td>
<td>- Hand wrap</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
INTERIOR SOFT TRIM/SOFT TOUCH MATERIALS/PROCESSES

INJECTION

- CONV. INJECTION
- 2-SHOT
- OVERMOLD
- BACK INJECTION

SOFT TOUCH PAINT

- SEBS
- TPV
- TPU
- COATED FABRIC
- FOILS
- UNCOATED FABRICS

SKIN PROCESSES

- BACK INJECTION
- LOW PRESSURE MOLDING

SLUSH MOLD (CAST)

- TPU
- TPO

VAC FORM FOILS

- THERMOFORM
- BACK INJECTION OR LOW PRESSURE MOLDING

- TPO
- PVC
- TPU ALLOY SHEET

COATED FABRICS (a)

- HAND WRAP (a)
- BACK INJECTION

NOTE: (a) Polyurethane dispersion (PUD) coated fabrics gaining share

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
AUTO INTERIOR: COST/VALUE ADD CURVE for MATERIAL/PROCESS COMBINATIONS

- Leather is dominant incumbent
- PUD/coated fabrics are challenger

Hand Wrapping

Slush Molding: TPU or TPE-S

Slush Molding: PVC

Thermoformed Foils: Typically TPO or PVC compact or PO foam backed

Compression Molding: Typically textiles(a) for trim or acoustic components(c)

2-shot: Injection, (b)
- In-mold decoration
- Knobs, gearshift, door handles

Single-shot Injection: Typically PP copolymers, rigid TPO
- Filled or (recently) long-glass fiber reinforced PP or nylon

Notes:
(a) For door trim medallions
(b) Door trim medallions or upper elbow rest
(c) TPE growth target

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
## COMPARISON OF SLUSH/SPRAY IP SKIN CAPABILITIES

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>SLUSH TYPE</th>
<th>SPRAY PU</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PVC</td>
<td>TPE (TPE-S)</td>
<td>TPU</td>
</tr>
<tr>
<td>Raw material cost, $/lb.</td>
<td>Lowest</td>
<td>Moderate</td>
<td>Highest</td>
</tr>
<tr>
<td>Typical skin weight, lbs.</td>
<td>3 – 3.5</td>
<td>1.6 – 2.0</td>
<td>2 – 2.5</td>
</tr>
<tr>
<td>Low temp. airbag deployment (heat aging effect)</td>
<td>Some degradation after heat aging</td>
<td>No deployment performance loss</td>
<td>--</td>
</tr>
<tr>
<td>$\Delta E$ after UV exposure (2500 kJ, 89°C)</td>
<td>Highest</td>
<td>Very low (&lt; 1)</td>
<td>Very low (&lt; 1)</td>
</tr>
<tr>
<td>Shrinkage on heat aging</td>
<td>Moderate curling</td>
<td>Remains flat (no curling)</td>
<td>Minor curling</td>
</tr>
<tr>
<td>VOC</td>
<td>Medium</td>
<td>Lowest</td>
<td>High</td>
</tr>
<tr>
<td>Fog</td>
<td>Acceptable</td>
<td>Acceptable</td>
<td>High</td>
</tr>
<tr>
<td>Process window</td>
<td>Narrow</td>
<td>Wide</td>
<td>--</td>
</tr>
</tbody>
</table>

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2012
AUTO TPE TARGET APPLICATIONS: BODY/GLAZING SEALS

- Incumbents: PVC, EPDM, (dense[solid] and foamed [sponge]), PU
- TPE challengers: o-TPV, SEBS (“TPE” or TPE-S), SEBS-V (TPES-V)
- Tier 1 portion of supply chain has undergone consolidation
- TPEs offer systems cost savings opportunities
- Hollow cross-sections competing with foams
BODY/GLAZING SEALS – MAJOR TPE TARGETS

- Trunk seal
- Rear light seal
- Sun roof seal
- Cowl vent seal
- Hood seal
- Fixed glazing
- Windshield (difficult target, but TPE substitution starting)
- Belt line seal
- Door seal
- Glass run channel
- Door sill plate
- Mirror gasket
- Wheel arch seal
- Lighting seal
- Engine shield (recyclate?)

Photo Source: Toyoda Gosei
Foaming has proven to be difficult for TPVs. Recent low Shore A hardness grades (25-35) can compete with foam EPDM using solid wall TPV with hollow cross-sections.
BODY/GLAZING SEALS – MAJOR TPE TARGET

- Difficult profitability

- Key role for systems approach (combine rigid/flexible):
  - TPV/TALC-PP compound co-extrusion vs. EPDM/encapsulated metal

- Static and dynamic seals have different performance requirements:
  easier TPE penetration in static seals

- Key trends:
  - Tier 1 supplier consolidation
  - Penetration of TPES-Vs (starting in Europe)
  - Faster TPE penetration in Europe/Japan

- Drivers:
  - Cost save vs. EPDM seals
  - Getting to net shape via systems approach
Evolution and globalization as well as shrinking the number of platforms (claim increased quality/lower costs) is resulting in Tier 1 consolidation:

- Increases Tier 1 buying power for raw materials, reduces lead time and development costs
- Driven (in part) by OEM increased concern about financial viability of weaker suppliers
- Places increased price pressure on compound suppliers
- Strengthens Tier 1 willingness (and incentives) to compound in-house (for example - TPV compounds for body/glazing seals)
- Examples:
  - Cooper Standard acquisition of Sigit (Europe - sealing systems)
  - Faurecia acquisition of Plastal (Germany, Spain, France), exteriors
  - Plastic Omnium acquisition of Plastal Poland, exteriors
• Emerging as new TPE competitive zone
  - Rubber
  - Plastics (PVC is major incumbent)
  - TPEs (o-TPV, will be COPE and TPU type TPE opportunity targets)

• Will grow for TPEs via increased hybrids, EVs, 42 volt electrical systems

• Temperature requirements increasing:
  - Hotter engine compartments
  - Smaller conductor cross-sections/higher voltage

• Process:
  - Co-extrusion
  - Extrusion coating (flat cables)
SUMMARY

• The auto market
  - Global auto sales growth likely to continue at 3-3.2%/yr.
  - Growth regions will be China, the BRI countries, (and recently N. America)
  - Global platforms will gain share (~ 40% of global prod’n. in 2015):
  - Global supply capability necessary for auto TPE suppliers
  - Global TPE specs evolving
  - Supply chain consolidation/acquisitions

• Asia:
  - Investment (compounding, Tier 1s) starting to look toward West
  - OEM/Tier 1 investment in China (slows?)
  - China vehicle export threat from China by 2020?
  - Importance of domestic markets
  - Supply chain in place and highly efficient/responsive

• Demand drivers:
  - Sustainability
  - Vehicle size downshift
  - TPO growth/vehicle may slow
  - Systems cost savings
  - Softening the interior
SUMMARY (Cont’d.)

• **Supply chain:**
  - Resin supplier/ integrated compounders dominate PP, TPO
  - Independent compounders and integrated resin supplier/compounders share the TPE market
  - Back integration to compounding by some tier 1s

• **Materials shifts:**
  - Higher performance TPEs under-hood (COPE vs. o-TPV)
  - SEBS challenging o-TPV in some auto applications
  - SEBS slush skins vs. TPU (and PVC) (starting?)
  - Biopolymers penetration starting in the auto TPE sector
  - PP still a growth polymer (intake manifold); long glass reinforced
  - TPEs and PP compounds shift to higher performance grades