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VALUE AND GROWTH OPPORTUNITIES FOR OLEFINIC-TPEs IN AUTOMOTIVE INTERIORS

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Presented by:
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Abstract – Olefinic TPEs (o-TPEs) have matured in some automotive interior applications and have growth and value opportunities in others. This paper reviews and identifies:

- The effects of economic pressures on o-TPE markets and technology
- Value-added opportunities
- Path-to-market shifts and the role of o-TPEs
- Key intermaterials competitions in auto interiors
- The role of nano-fillers on o-TPE market potential in auto interiors
- The potential role of super-TPVs in auto interiors
- The potential role of recently introduced high propylene plastomers (hi-P-M-TPO)
- Foam and fiber growth opportunities.

The presentation is based on REA's:

- Recent automotive TPE research in Europe, North America, Japan and China
- Automotive interior soft trim study (1)
- (In process) second global TPE multiclient study (2)
- Multiclient analysis of advanced technology nonwovens in the automotive sector (3).

References and abbreviations are included at the end of the paper.

Definitions: We have used the term olefinic-TPEs (o-TPEs) to represent the complete grouping of olefinic thermoplastic elastomers including (see Exhibit 1):

- TPOs
- Partially crosslinked TPVs

- Fully crosslinked TPVs
- Plastomers
- High ethylene PP copolymers.

Where it is appropriate to distinguish between these members of the o-TPE family, we have so indicated.

Operating Hypotheses -- Some of the operating hypotheses upon which the conclusions reached in this paper are based include:

Technology Drivers:

- Intermaterials competition for interiors applications has broadened (see Exhibits 1 and 2).

- The substantial differences in automotive interior technology between Europe, N. America and Japan are being driven toward rapid convergence.

- Current interior soft trim constructions and manufacturing methods are inefficient and wasteful of both materials and labor.

- Instrument panels will continue to be the source of intense material and process development efforts with respect to substrate, foam, and skin.

Economic Drivers:

- The current severe price pressures will lead to shifts in the o-TPE value chain.

- The rigid interior trim segment of the interiors market has descended into commodity pricing levels and can only support minimal levels of tech service.

- There are a number of value-added opportunities in automotive interiors, which are currently under-exploited (see Exhibit 3).

- Growth in Asian demand will:
  - Keep monomer prices high
  - Place pressure on fabricated part prices
  - Impact profitability all along the supply chain
  - Shift the geographic investment focus.

Growth Drivers:

- Head impact applications are a growth segment of automotive interiors that offers value-added and technological innovation opportunities.

- Acoustic properties and passenger protection will be major interior soft trim technology shift drivers.

- Olefinic foam demand in interior applications and will pull o-TPEs into the market.

- Both materials and process cost savings are possible with o-TPE interior soft trim constructions.

Realities of the Automotive PP/TPO Marketplace -- The automotive polyolefins marketplace has been shaped by a number of realities. These include:

- Price Drift -- Prices for automotive PP copolymer drifted from a high of $0.58/lb. in 1996 to a low of $0.28/lb. in 2002. A volatile cost and capacity-driven recovery to the current level (about $0.45/lb.) has shaped the market with respect to:

  - The search for value
  - Global sourcing pressures
  - Technical development
  - Tech service levels
  - Contracting
  - Resin supplier participation
  - OEM price/purchasing pressures
  - The role of distributors
  - The use of recyclate-based compounds.

- European, Japanese and Korean OEMs will continue to gain share of the North American market, bringing new Tier 1s, resin suppliers, and compounders into the market. (Lifting European quotas in 1998 has elevated the Japanese and Korean share to 17.2% in 2004.)

- Low resin supplier profitability levels are reshaping the supply chain.

- High labor costs, competition, and a weak economy will continue to pressure vehicle pricing (U.S. and Europe).

- The entry of private equity groups.

- Bundling of resin/compound sales has become an advantage/requirement.

- Several major resin suppliers have announced exit plans.

- Offshore resin suppliers are cautiously entering the automotive polyolefins sector.

- Compounding excellence continues to command value.

- Supply chain consolidation is:
  - Shifting entry points
  - Changing industry structure
  - Changing the role of the independent compounder.

Impact of New Technologies on TPE Families – As illustrated in Exhibit 1, new technologies are impacting o-TPE families differently. The super-TPVs have reached the market and begun penetration. Nano-TPEs have also started penetration in both interior and exterior markets.

Broadened Competition -- As illustrated in Exhibit 2, the number of competitive TPEs and compounds seeking auto interior applications has increased. The property envelope associated with these new offerings has broadened not only with respect to the key stiffness/impact balance but also with respect to other properties such as:

- Scratch/mar resistance
- Quality of molded-in color applications
- Foam properties
- Low temperature performance
- Energy absorption capability
- Performance in value-added fabrication processes such as co-extrusion, multi-shot molding, sequential molding, etc.

Value-added Opportunities – In this price/profitability shaped auto interiors market, paths to value addition remain to be exploited as shown in Exhibits 3 and 4. See also References 1, 4, 6.

Nano-olefinic TPEs -- The physics of incorporating relatively large particles into thermoplastic matrices (often with agglomerates) dictate a conflict between the positive benefits of improved stiffness and heat resistance and the deterioration of other properties (impact strength, processability, surface characteristics, etc.).

Nano-sized mineral fillers offer the capability of making nano-olefinic TPEs that achieve the benefits of filler addition at lower concentrations (e.g., 3-5% vs. 12-20%), thereby:

- Avoiding the damage to the composite morphology that results from conventional-sized filler particles

- Gaining the benefits of lower density and lower filler concentration
  - (Potentially) lower volumetric costs
  - Easier processability (higher polymer content, less viscosity increase)
  - Wider processing window (reduces scrap rate)
  - Thin wall molding capability

- Improved scratch/mar resistance

- Lower CLTE, better dimensional tolerance (important for close tolerance moldings and craftsmanship without high scrap or labor costs)

- As has been widely documented, clay/TPO nano-TPOs have begun to penetrate North American vehicle exteriors at GM.

Clay is the dominant incumbent nano-mineral at present, but nano-talc offerings are reaching the market (from Nanova and possibly others) and may offer competitive advantages (for example, less energy for exfoliation of the filler lamellae).

The ability to increase stiffness, and therefore make thinner walls with closer dimensional tolerances, is an advantage in many o-TPE interior applications. The nano-o-TPEs also offer the benefit of reduced CLTE (while maintaining good surface characteristics). It should be noted, however, that there are alternative, non nano-o-TPE approaches to low CLTE grades. For example, the BMW Series 1 bumper and rocker panels use a zero gap, close tolerance TPO (from Borealis). Some of the target applications for nano-olefinic TPEs in interiors are shown in Exhibit 4.

Nano-fillers in TPVs – Clay fillers are used in TPV formulations. A key objective of dynamic vulcanization is to control and reduce the size of the elastomer dispersed phase.

The substitution of nano-clays in the EPDM portion of o-TPV formulations (Reference 7) is reported to:

- Improve rheology to give better processability (e.g., in blow molding and profile extrusion)
- Reduce tan δ values (e.g., less "lossy")
- Increase storage modulus (e.g. increased elasticity).

Super-TPVs – A new generation of super-TPVs (s-TPVs) based on a broadened range of elastomeric components in a variety of matrices has entered the market. They offer enhanced temperature and oil resistance and could begin penetration of the automotive interiors sector. The current generation of candidates and their compositions are shown in Exhibit 5. Examples of interior applications are shown in Exhibit 6.

> **Silicone-based s-TPVs –** Dow Corning's silicone-based s-TPV (TPSiV), introduced in 2002, consists of crosslinked silicone elastomer islands in a polyamide or TPU matrix. In addition to oil and temperature resistance and the ability to make butt joints via thermoplastic processing (e.g., in hose applications), the TPSiVs offer a dry, "silky" touch, which has allowed them to gain applications in high end, two-shot molded cell phones and suggests their potential use in automotive interior soft touch applications such as:

- Glazing seals
- Airbag doors
- Soft touch components
- Chemical resistance (e.g., to insect repellents and suntan oil)
- Skins.

Acrylic Elastomer-based Super-TPVs – DuPont's candidate in the s-TPV category is based on a modified ethylene-acrylate rubber (AEM) in a copolyester (COPE) matrix. Heat resistances up to 3000 hrs. in a hot (150ºC) oil environment are possible with DuPont's E-TPVs.

Zeon's super-TPV candidate utilizes polyacrylate rubber (ACM) in a polyamide (Nylon 6) or a COPE matrix.

Styrenic Elastomers – Styrene-butadiene rubber (SSBR) or hydrogenated styrene block copolymer (H-SBC) can also be used as the elastomeric island. Goodyear's Serel super-TPVs are based on SSBR islands; Teknor Apex uses H-SBC. Both approaches use a polypropylene matrix to produce hybrid TPVs with improved oil resistance, wet coefficient of friction, and good long-term compression set.

The styrenic rubber approaches are offered in masterbatch form for blending with either styrenic or olefinic TPEs and provide substantial performance improvement over styrenic TPEs and intermediate performance between o-TPVs and the s-TPVs. They may also operate in the competitive range targeted by reactive or crosslinked SEBS compounds.

Body Seals – While o-TPVs and SEBS have gained in secondary body seals and glazing seal applications as previously forecast (Reference 2), they have yet to make a significant penetration in dynamic primary seals. The development of better foams and improved compression set may accelerate penetration.

Role for High Propylene Plastomers – The new generation of high propylene plastomers from Exxon, Dow, Mitsui, and others offers the potential for high elasticity TPOs either alone or as an ingredient in TPO/TPV formulations. They have the potential to be used in elastic fiber applications in advanced nonwovens (References 4, 6) and in TPO coated fabrics.

Two-shot Molding and Sequential Valve Gating – Auto interiors continue to be a major growth opportunity for o-TPEs. Key among these interior growth opportunities are skin/foam laminates, coated fabrics, airbag doors, and non-carpet flooring. Growth of TPO skins for instrument panels has lost some momentum but has continued in door trim panels and will be accelerated by the benefits of negative forming.

Two-shot molding is widely used for small, soft touch components. Innovations in two-shot molding (larger area parts, e.g., skinned door trim panels) and sequential valve gating will stimulate the growth of TPEs in interiors and rigid/flexible body/glazing seals.

Coated Fabrics – PVC dominates the automotive interior coated fabric sector. These are usually used in conjunction with leather seating. TPO and styrenic TPE coated fabric penetration has started in European vehicles. The high propylene plastomers may have a role in this application, but TPE coated fabrics must compete with polyurethane dispersion (PUD) coatings and TPU coatings.

Role of Foams -- As described previously (References 1, 4, 6), the limited capabilities of the first generation of o-TPE foaming technologies have restricted the realization of the potential of foamed o-TPEs in applications such as sheet, acoustic barriers, injection moldings, foam ducting, body seals, and glazing seals. Because of their favorable viscosity characteristics, o-TPV foams appeared earlier on the market than foamed SEBS. Foaming technologies based on the use of supercritical blowing agents offer the potential for very fine particle dispersion in extruded profiles.

The recent licensing of the Trexel MuCell® process to AES, Nishikawa Rubber, and Jyco suggests that the use of this technology could accelerate the penetration of TPV into the body seals sector. JCI is using the MuCell® technology for door trim panels in Korea.

Role of Foams in Skins – The current generation of TPO skins relies upon lamination to a crosslinked polyolefin sheet foam. The new generation of foam technology could introduce the capability of combining the foaming process with the sheet extrusion process to make an integral skin/foam extrudate, which should offer cost savings.

Role of Masterbatch – Masterbatches have found a role in LGF-PP production, TPVs, and s-TPVs. They represent a shift in the path to market for TPE compounders and the potential for cost savings by processors.

Biopolymers in Auto Interiors (see References 1, 4, 8) -- Wood fiber reinforced PPs have been used extensively in European interiors (and to a lesser degree in N. American interiors). A new generation of natural fiber composites (NFCs) based on bast fibers (kenaf, hemp, jute) and other natural fibers show promise of share in auto interiors based on:

- Fiber reinforced PP molding compounds with improved properties (via better flow additives)
- Natural fiber-based mats (both low and high density) competing with glass/PP mats
- Matrix resins (e.g., PLA, soy-based) reinforced with natural fibers and synthetic biopolymer fibers.

SUMMARY

A range of new compounds and TPEs is entering the interiors competitive arena to both compete with and enlarge the o-TPE performance envelope. Nano-TPEs, s-TPVs, and biopolymers will find a role in interior polyolefin applications.

Economic pressures, new resin and compounding technology, new TPEs, and global competition are reshaping the auto interior polyolefin supply chain.

Due to the inefficiencies of traditional interior component fabrication processes, there are substantial opportunities for value-added compounds and fabrication processes.

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7. “The Effects of Dynamic Vulcanization on the Morphology and Rheology of TPVs and Their Nano-composites;” H. Thakkar, Lloyd A. Goettler; *Rubber World*, pg. 44, (October 2003)

8. “Future Potential and Intermaterials Competition in Lightweight Automotive Composites;” SPE Automotive Composites 2004; Detroit, MI; Robert Eller (October 2004)

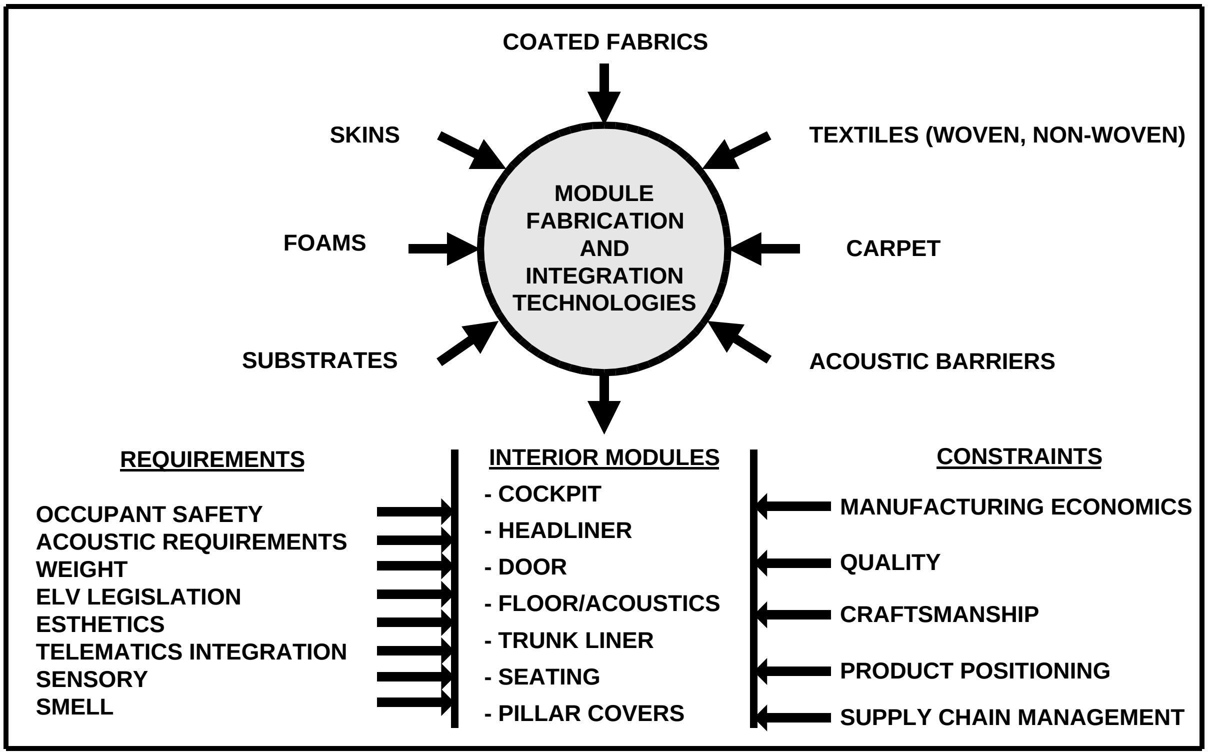
See other publications, company background, and study prospectuses on REA web site: www.robertellerassoc.com

GLOSSARY OF ABBREVIATIONS

ACM	- Polyacrylate rubber
AEM	- Ethylene-acrylate rubber
CLTE	- Coefficient of linear thermal expansion
COPE	- Copolyester type TPEs
E-TPV	- DuPont's super-TPV
EPDM	- 1. Ethylene-propylene-diene monomer; 2. Ethylene propylene rubber
H-SBC	- Hydrogenated styrene block copolymer
HI-P-M-TPO	- High propylene metallo TPOs (plastomers)
LGF-PP	- Long-glass fiber reinforced PP
LGF-TP	- Long-glass fiber thermoplastics
m-PO	- Metallocene polyolefin
NFC	- Natural fiber composites
o-TPE	- Olefinic TPE
o-TPV	- Olefinic TPV
PUD	- Polyurethane dispersion (used in coated fabrics)
RF	- Radio frequency
SBC	- Styrene block copolymer TPEs (SEBS, SBC)
SEBS	- Styrene-ethylene-butadiene-styrene TPEs
SSBR	- Styrene-butadiene rubber
s-TPV	- Super-TPV
TPE	- Thermoplastic elastomer
TPO	- Thermoplastic polyolefin
TPSiV	- Dow Corning's silicone-based s-TPV
TPU	- Thermoplastic polyurethane
TPV	- Thermoplastic vulcanizate

Automotive Interior Soft Trim:

Skins, Foams, Coated Fabrics, Textiles, and Acoustic Barriers



REQUIREMENTS

- OCCUPANT SAFETY
- ACOUSTIC REQUIREMENTS
- WEIGHT
- ELV LEGISLATION
- ESTHETICS
- TELEMATICS INTEGRATION
- SENSORY
- SMELL

INTERIOR MODULES

- COCKPIT
- HEADLINER
- DOOR
- FLOOR/ACOUSTICS
- TRUNK LINER
- SEATING
- PILLAR COVERS

CONSTRAINTS

- MANUFACTURING ECONOMICS
- QUALITY
- CRAFTSMANSHIP
- PRODUCT POSITIONING
- SUPPLY CHAIN MANAGEMENT

A Europe / North America Multiclient Analysis

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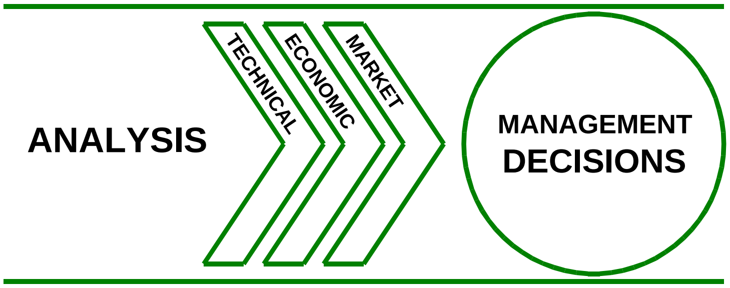
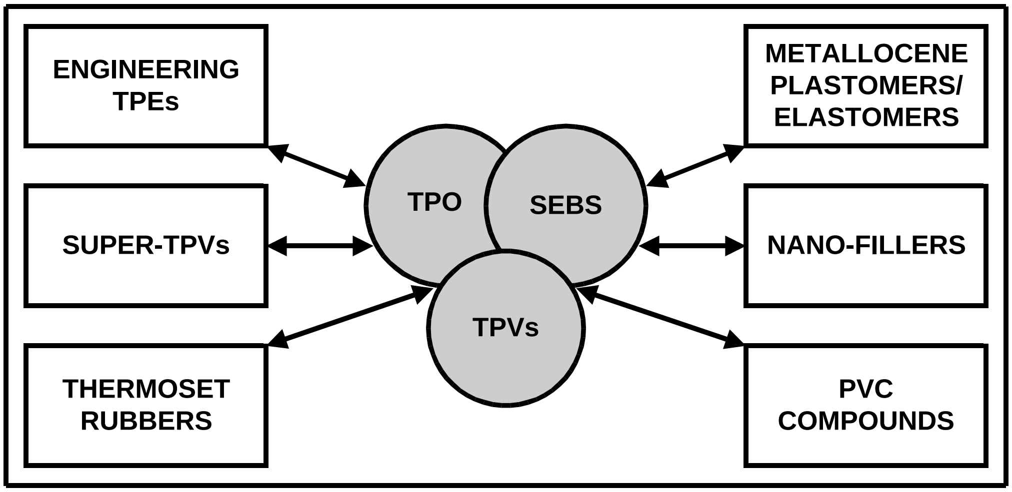


Specialty Thermoplastic Elastomers . . . Markets, Economics, Technology, Intermaterials Competition



Prospectus for a Europe/U.S./Japan Multiclient Industry Analysis

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EXHIBIT 1

NEW TPE COMPETITORS, TECHNOLOGIES, AND TARGETS

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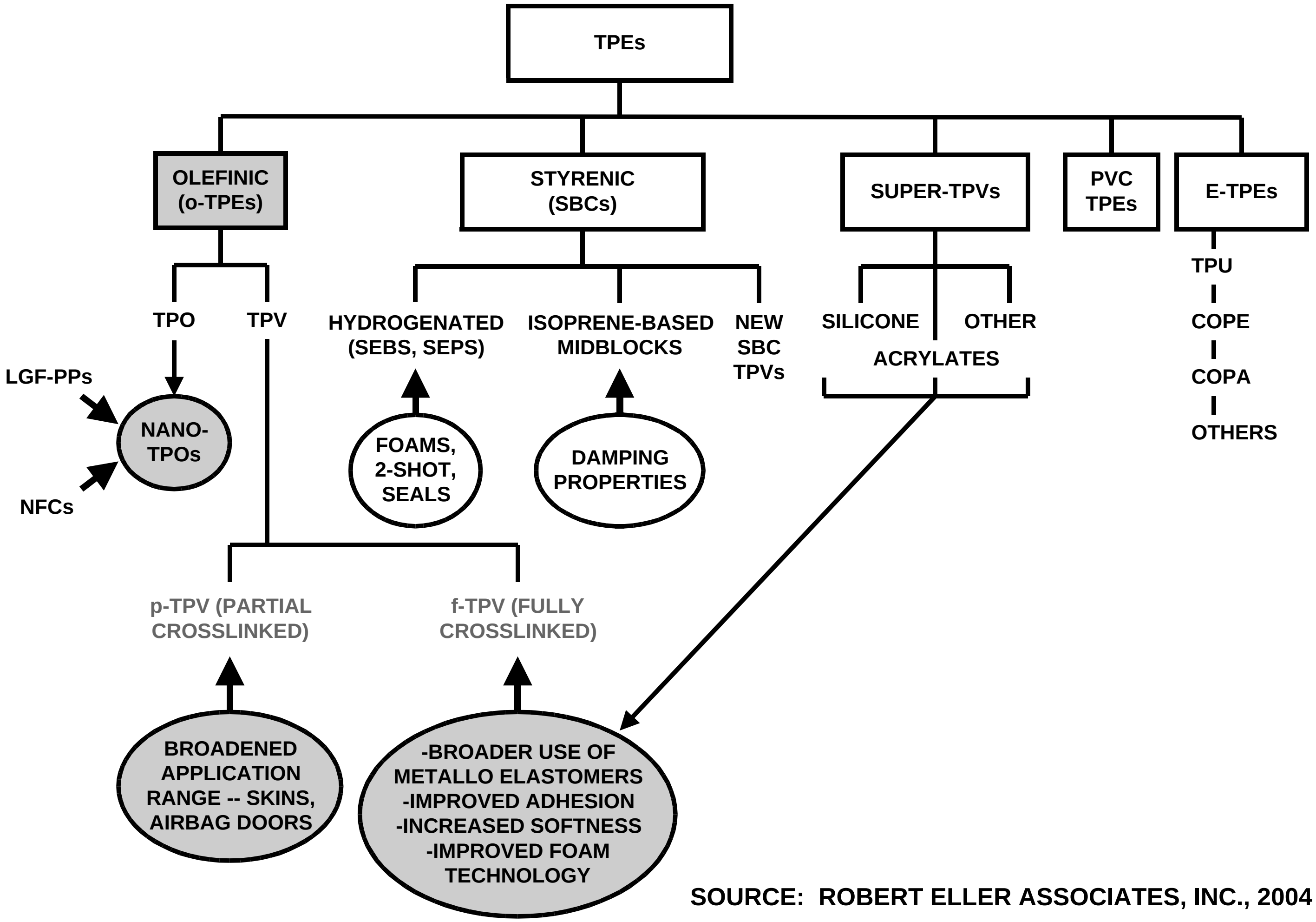
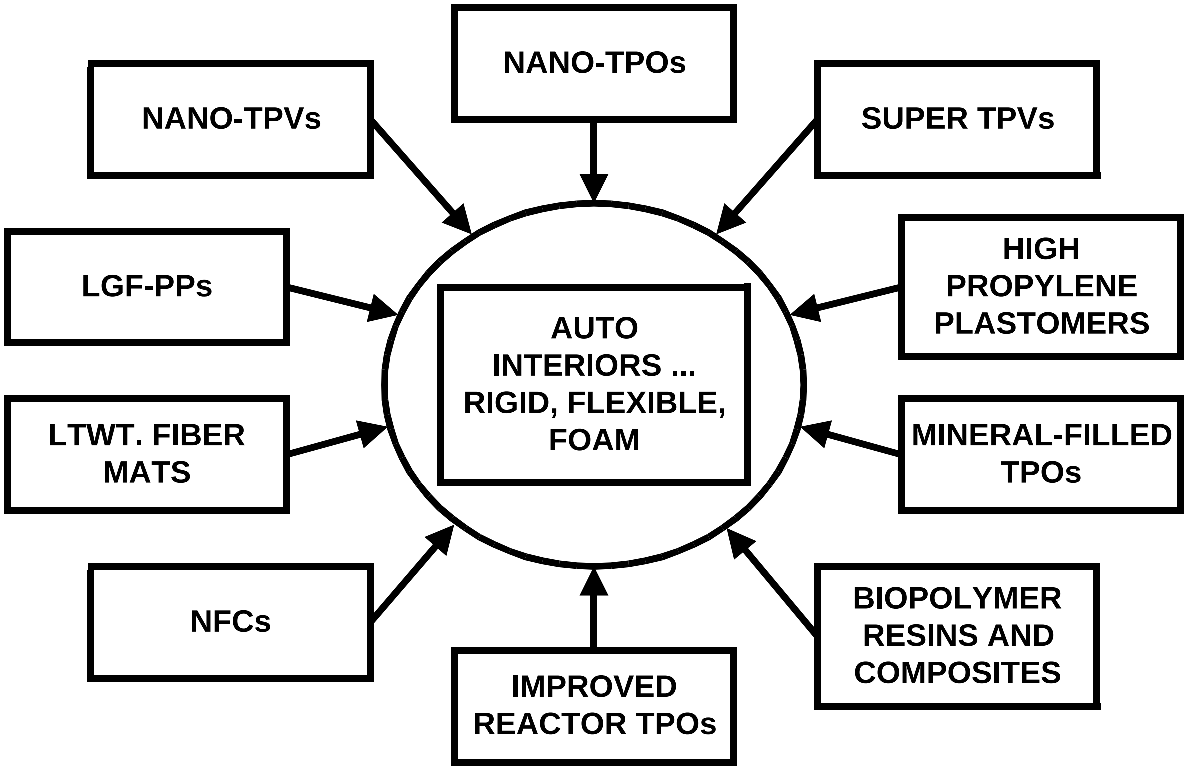
lg/myfiles/new TPE comp 04.vsd



SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

EXHIBIT 2

BROADENED INTERMATERIALS COMPETITION FOR AUTOMOTIVE INTERIORS APPLICATIONS



ROBERT ELLER ASSOCIATES, INC., 2004

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EXHIBIT 3

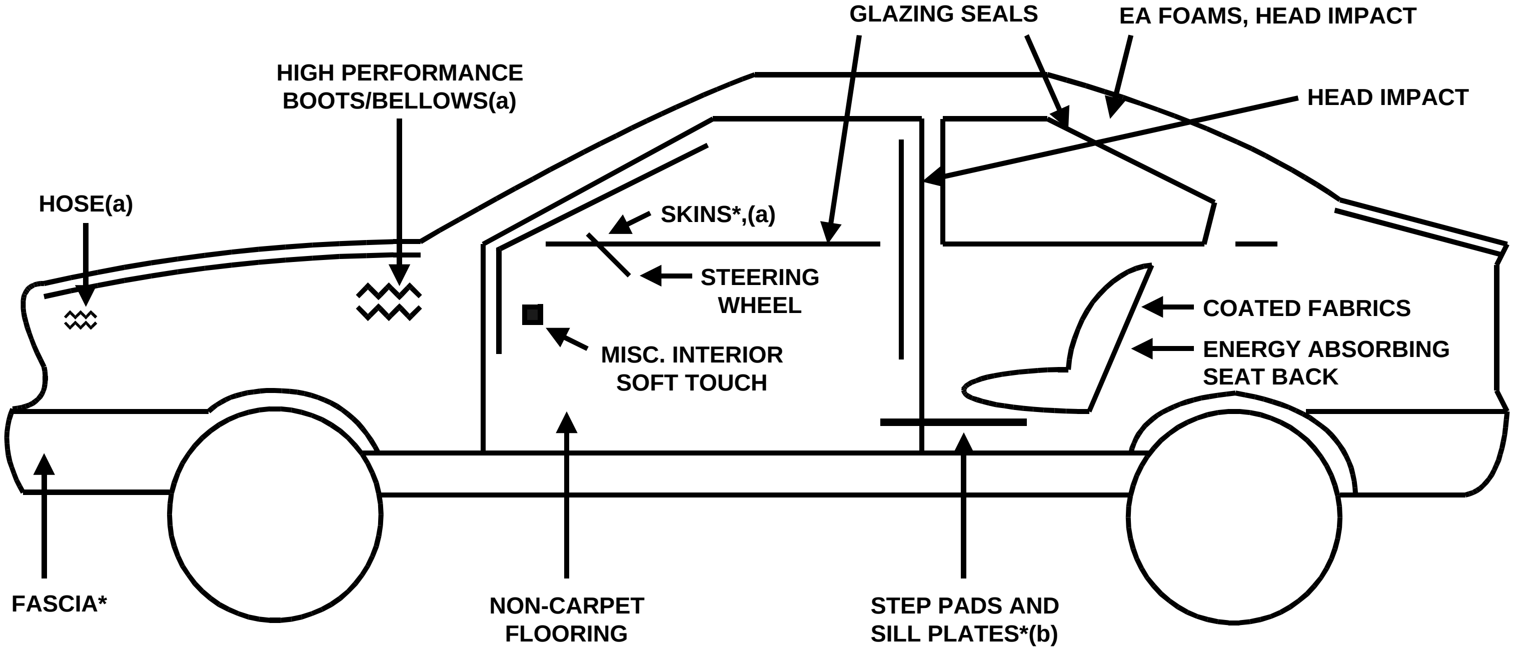
VALUE CREATORS FOR O-TPEs IN AUTOMOTIVE INTERIORS

VALUE CREATOR	EXAMPLE(S)
SUPPLY CHAIN CONSOLIDATION	-DIRECT COMPOUNDING/FABRICATION -CO-PROCESSING -USE OF CONCENTRATES -RIGID/FLEXIBLE COMBINATIONS
ELIMINATING LAYERS	-SKIN/FOAM COEXTRUSION -TWO-SHOT MOLDING OF LARGE PARTS
ELIMINATING COATINGS	-MOLDED-IN COLOR -BARRIER/ADHESIVE COATINGS
IN-PROCESS CRAFTSMANSHIP	-DOOR MEDALLIONS -DOOR TRIM -IP TRIM -NANO TPEs WITH LOW CLTE
SOFT TOUCH	-TWO-SHOT MOLDING (LARGE PARTS) -CO-EXTRUSION OF SOFT TOUCH SURFACED TPEs -INCREASES WITH INCREASED HARD SURFACE USE (IP AND DOOR TRIM)
IMPROVED SCRATCH/MAR RESISTANCE	-NANO-TPOs
IMPROVED RHEOLOGY	-LONGER FLOW -MULTI-SHOT MOLDING -THIN WALLING -PARTS CONSOLIDATION
SAVING WEIGHT	-VALUE WILL INCREASE WITH CONTINUED HIGH FUEL PRICES
FOAMING	-BODY SEALS -SKINS -DOOR TRIM PANELS
MOLDED-IN COLOR	-O-TPEs WITH IMPROVED COLOR CONTROL -LOWER FILLER LEVELS
MONOMATERIALS SANDWICHES	-SCRAP REDUCTION -REDUCED PROCESS STEPS
ACOUSTIC PERFORMANCE	-CONTROLLED DENSITY FOAMS -ELIMNATION OF HEAVY LAYER CONSTRUCTIONS IN FLOOR/ACOUSTICS MODULE
ON-BOARD ACOUSTICS/ENERGY ABSORBERS	-HEADLINERS -DOOR TRIM -PILLAR TRIM -FLOOR MODULE
IMPROVED STIFFNESS/IMPACT BALANCE	-DOOR TRIM -SUBSTRATES -THINWALLING
USE OF RECYCLATE	-FLOOR MODULES -DOOR TRIM PANELS

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

EXHIBIT 4

EXAMPLE INTERIOR APPLICATIONS FOR RECENTLY DEVELOPED o-TPEs AND NANO-TPEs



NOTES:
*** INDICATES NANO-TPO OPPORTUNITY**
(a) SUPER-TPV TARGET
(b) LGF-PP AND NANO-TPO COMPETITIVE TARGET

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004

b/mydox/papers/SPE TPO 04/SPE TPO 04-int oTPE nTPE 04.vsd
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EXHIBIT 5

THE SUPER-TPV AND SBC TPV COMPETITORS

GRADE NAME	ELASTOMER TYPE	MATRIX RESIN(S)	SUPPLIER
TPSiV	SILICONE	PA, TPU	DOW CORNING
ZEOTHERM	POLYACRYLATE (ACM)	PP, PA, POLYESTER	ZEON
E-TPV	ETHYLENE ACRYLATE (AEM)	COPE	DUPONT
UNIPRENE XL	HYDROGENATED SBC (H-SBC)	PP	TEKNOR APEX
SEREL(a)	STYRENE BUTADIENE (SSBR)	PP	GOODYEAR

NOTE:
(a) AVAILABLE IN MASTERBATCH FORM

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004 (Reference 2)

EXHIBIT 6

INTERIOR APPLICATIONS FOR RECENTLY DEVELOPED TPEs AND KEY COMPETITOR TYPES

INTERIOR APPLICATION	o-TPE, COMPETITOR TYPE					
	NANO-TPO	s-TPV	PVC ALLOYS	HI-P-M-TPOs	LGF-PPs	SBC TPVs
AIRBAG DOORS		X	X			X?
COATED FABRICS				X		X
DOOR TRIM/QUARTER PANELS	X					
ELASTIC FIBERS/TEXTILES				X		
IN-MOLD DECORATION FILMS	X?					
IP SUBSTRATES	X				X	
SKINS	X		X			
SEAT BACKS	X				X(b)	
SOFT TOUCH		X				
STEP PADS	X				X	
PILLAR TRIM	X?			X?		
FLOOR MODULE					X	

NOTES:

SEE GLOSSARY OF ABBREVIATIONS

(a) AN ANNOUNCED TARGET FOR DuPONT'S E-TPV

(b) WHERE IMPACT STRENGTH REQUIRED

SOURCE: ROBERT ELLER ASSOCIATES, INC., 2004 (References 1 and 3)