Robert Eller Associates LLC

CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES

Effects of Environmental Issues and the Impact on Future Growth of TPEs

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GLS Elastomers
PolyOne Corporation
McHenry, Illinois
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CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES

- Robert Eller Associates is a 17 year-old global plastics consulting company
  - Assist companies in the strategic decision making process by analyzing technical, marketing and economic implications for their business and market sectors
  - Focus on Elastomers, ETP's, PP Compounds/TPO, Automotive, Compounding and Foams
  - Eighth year active in China
- Offices in Akron, Ohio (main office), France, China, New Zealand
- Multi-client studies
- Single client studies
- Mergers and acquisitions

Agenda

Major development areas in TPEs driven by Green issues:

- **PVC replacement**
  - **Trace residuals migration**
  - **Halogen free/low smoke requirements**
- **Sustainability:**
  - **Carbon footprint**
  - **Lightweighting**
  - **Bio-renewable and biodegradable thermoplastic elastomers**
    - **Reduce petroleum base**
    - **Biodegradable**
  - **End-life/recyclability**

PVC is a Major Substitution Opportunity

Advantages

- Price
- Incumbent in medical tubing and infusion bags, wire and cable, slush molded auto skins

Disadvantages

- High specific gravity
- Thermal stability
- Difficult to recycle
- Lower heat distortion
- Poor low temperature performance
- Plasticizer volatility
- Phthalate plasticizers (migration)
- Dioxin generation on combustion/incineration
- Halogenated (RoHS restrictions)

Source: Robert Eller Associates LLC, 2011

BPA Model

- Analytical technology improvements in measuring “de minimis” levels of trace residual chemicals in body fluids
- BPA impacts epoxy applications (metal can coatings) and durable good items produced from polycarbonate including baby bottles, sports bottles, water bottles and medical applications.
- Increasing societal sensitization to this as an issue: minimal chronic exposure levels
- Efforts more successful than attacks on PVC (bottle banning)
  - PVC has both pthalate leaching potential and dioxin generation when combusted causing long term medical issues
  - With the attack on BPA being successful, will the attack on PVC (specifically in medical applications) be successful?

PVC Substitution

Three major targets

- **Wire and Cable**
- **Automotive Interior Skins**
- **Medical IV bags and tubing**

Wire and Cable

- > 300 kT PVC market with major substitution ongoing globally
- Europe driven: RoHS and WEEE requirements
- Major global OEMs have issued directives to eliminate PVC and halogen containing products on a global basis to eliminate potential risk of any of their branded manufactured electronic product containing halogen materials being disposed in landfills in Europe
- Low smoke requirements increasing
- Target applications are household cables and wires typically less than 200 Volts used for household power, electrical, electronic, computer, media and network applications
- SABIC IP was early compound supplier with Flexible Noryl
- Combustion toxicity: a new consideration

Flame Retardancy

- **Flammability requirements: UL62 VW-1 and UL94 V-O**
- **Halogen free**
  - **Combustion toxicity**
  - **Environmental persistance**
  - **Chronic exposure**
  - **Bio accumulation**
  - **Old technology**
    - **Magnesium Hydroxide**
  - **New technologies:**
    - **Ammonium Polyphosphate**
    - **Melamine Polyphosphate**
    - **Melomine cynaurate**
    - **Metal phosphinates**
- **SEBS resin is used to modify/create several compounds including TPE-S, TPU, PPE and COPE**
- **Low smoke**

Wire and Cable Materials

- Flexible Noryl (PPE + PE)
- Xlinked PE
- Fluropolymers
- PE, PP, POE
- SBC
- TPV
- TPU
- COPE

Wire and Cable

Classification of Automotive Wire and Cable Materials

W/C CLASS	MATERIALS COMPETITORS	NOTE
T4-T5	- Fluoropolymers (PTFE, ETFE) - Silicones - AEM type elastomers - COPE - XLPE	- High temperature requirements - COPE may challenge fluoropolymers - AEMs are ethylene acrylic elastomers
T3	- XLPE - TPE-S - TPE-O - TPES-V - PVC	- High growth segment, especially for thermoplastic elastomers - Will grow due to conductor (copper) down-gauging to achieve weight savings
T1-T2	- PVC - PE	- Dominated by PVC - Represents approx. 75% of automotive wire/cable materials
Flat Cable	- TPU	- Growth segment

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2011

- **Increased use of wire/cable is a result of growing electrification of vehicles, which represents a potentially high growth segment for TPOs and several other types of TPEs**

Auto TPE Target Markets: Interior Surfaces

Targets:

- Instrument panel, door trim, console, steering wheel
- Objective is to "soften" the haptics of hard plastic feel and look
- Point of quality differentiation in the vehicle
    - Upgraded interiors will be less "plastic" feeling

Manufacturing:

- Multi-materials molding (2-shot)
- Skins
    - Thermoformed skins
        - TPO
        - TPV (usually partially crosslinked grades)
    - Slush molded skins (PVC major incumbent), primarily for instrument panels

Multi-material Molding

- Cost save vs. incumbent skins methods
- TPVs and SBC-TPEs competing
- Foaming will accelerate 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 and door medallions are entry points for 2-shot molded (TPE skin/substrate)

- 2-color
- Grain is less critical than upper

Automotive Interiors TPE Target: Door Trim

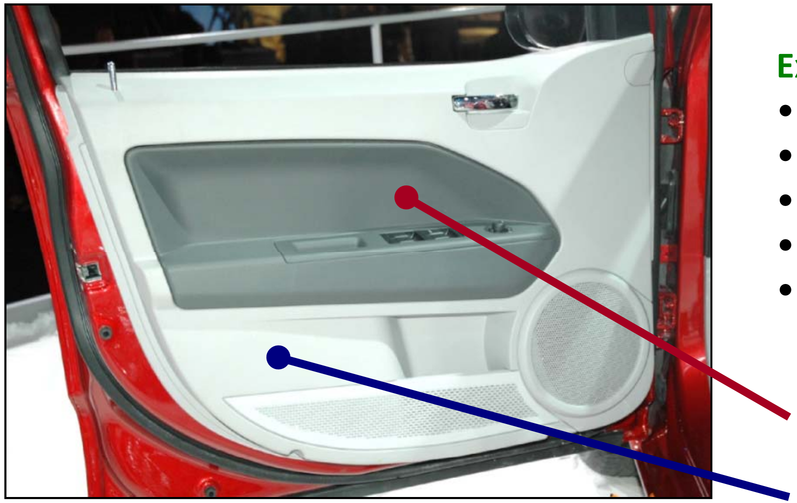


Photo Source: A. Schulman

r/mydox/SPE TPO 2011/A. Schulman 2-shot … .ppt

Example Multi-material (2-shot) Door Trim Panel

- Application: Door trim (dark areas)
- TPE Supplier: A. Schulman
- TPE Type: o-TPV
- OEM: Chrysler
- Vehicles: Caliber, Commander, Grand Caravan

TPE Benefits:

- Haptics → soft (luxury) touch
- Enhanced craftsmanship/multi-color capability
- Single step process/labor cost savings
- Cost save vs. multi-step approach
- Multi-material molding cycle time approaching single shot

TPE Skin Candidates: SEBS (TPE-S), o-TPV, TPU modified TPE (for use over PC/ABS)

Key TPE Challenge:

- Adequate flow (large area/thin cross-section (1-2 mm)
- Capital investment required
- Ability to incorporate foam
- Competition with textile inserts

Incumbents: Thermoformed/backfoam PVC or TPO sheet, PU spray (declining)

Interior Skins Target: Instrument Panel

Grain reproduction: key parameter

Logos

Photo Source: Robert Eller Associates LLC
r/mydox/SPE TPO 2011/Fit Fin Grain 1 0062.jpg

Photo Source: Robert Eller Associates LLC
r/mydox/SPE TPO 2011/Fit Fin Grain 2 0061.jpg

Hidden airbag doors

Photo Source: Robert Eller Associates LLC
r/mydox/SPE TPO 2011/Fit Fin Grain 3 0054.jpg

Photo Source: ©GM Corp.

2011 Chevrolet Cruze

Examples of Upgraded Interior on Small Car:

- **Steering wheel mounted audio control**
- **Leather wrapped steering wheel (2LT and Eco models)**
- **2-tone instrument panel**
- **Bluetooth® connectivity**
- **USB port**
- **Increased soft touch surfaces**

r/mydox/SPE TPO 2011/Chevrolet Cruze-061.jp[1].jpg

Photo Source: *AutoWeek*

2012 Ford Focus SE 5-Door:

Another example of small car luxury

Process breakdown

- Instrument Panels: 70% soft/30% hard
- Soft Instrument Panels: 70% slush molded
- Door Panels: x % hard/ y % soft
- Door Panels: z% slush molded

IP Skin PVC Substitution Objectives

Environment

- Halogen free?
- Improve recyclability
- Reduce VOC/fog

Performance

- Satisfactory hidden passenger airbag deployment at -30ºC
- Grain reproduction
- Haptics
- 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
- Reduce skin costs
- Maintain current labor requirements???

Weight

- Reduce part/car weight

Comparison Of Slush IP Skin Capabilities

PROPERTY	SLUSH TYPE				NOTE
	PVC	TPE	TPU	SPRAY PU	
Raw material cost, $/lb.	Lowest	Moderate	Highest	--	
Typical skin weight, lbs.	3 – 3.5	1.6	2 – 2.5		
Low temp. airbag deployment (heat aging effect)	Some degradation after heat aging	No deployment performance	--	--	
∆ E after UV exposure (2500 kJ, 89ºC)	Highest	Very low (< 1)	Very low (< 1)	Moderate	OEMs require ∆ E = < 3
Shrinkage on heat aging	Moderate curling	Remains flat (no curling)	Minor curling	--	Shrinkage increases visibility of tear seam
VOC	Medium	Lowest	High	High	High = > 100
Fog	Acceptable	Acceptable	High	Acceptable	Acceptable = ~ 125 µg/gram
Process window	Narrow	Wide	--	--	
Scratch & mar resistance	Good	Unknown	Very good	Very good	

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2011

Car Model:	Audi E8
Part:	Instrument Panel Skin Slush Molded
Raw Material Resin:	Kraton
Compound:	Laprene S formulated by SO.F.TER
Fabricator:	Peguform
Features:	Halogen free, pthalate 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

Source: Robert Eller Associates LLC 2010

Technology

Two major stakeholders: Inteva and Kraton

- **Inteva**
  - **Tier one manufacturer of automotive interiors**
  - **Has US patent on SEBS slush molded skin technology (2004)**
  - **Licensed A. Schulman to produce compounds**
  - **Has at least one vehicle model in production**
  - **Seeking licensees**
- **Kraton**
  - **SRC resin/compound supplier**
  - **Launched SEBS slush compounds with S.O.F.T.E.R. in 2010 Commercial on Audi E8**
  - **Uses proprietary resin for compound taking advantage of Kraton's skill and knowledge of molecular tailing the SEBS resin structure**
- **Other suppliers**
  - **Reportedly at least two other compounders working in this space**

Medical

Bio TPEs

- Driving forces:
  - Emotive from the consumer perspective
  - Sustainability from the manufacturer
- Applications
  - Driven by marketing to consumers/consumer oriented products (both disposable and durable goods)
  - Footwear
- Definitions
  - Renewable or Sustainable Compounds
    - Produced from renewable raw material sources that are sustainable from plant or animal base
  - Bio-degradable
    - Produced from renewable raw material sources that are sustainable from plant or animal base
    - compostable
    - can be either synthetic or bio-based
    - how effective is in debate
    - impact on recycle stream also under debate

Feedstock Sources for Polymer Matrices and Elastomers

Non-Renewable

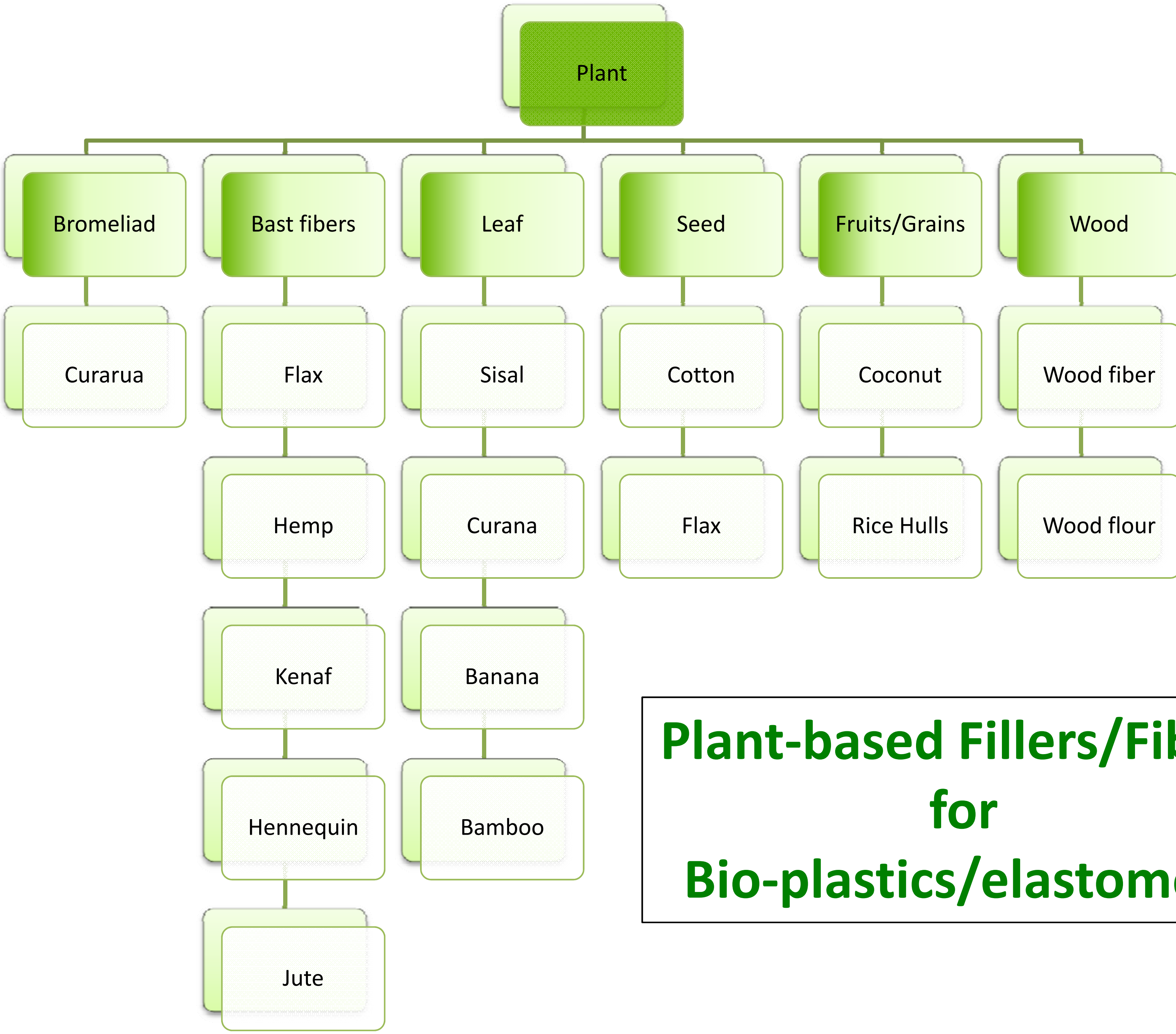
- Petroleum
- Coal

Renewable

- Corn
- Castor Bean
- Starch
- Sugar
- Algae
- Yeasts

Non-Petroleum Feedstock Activity

Feedstock Source	Status and Participants
Coal	Shenhua/Dow in China: Plant under construction
Corn	PLA, polyols (COPE,TPU) Materials in production
Castor Bean	COPA In production
Starch	Teknor Apex In production
Sugar	Braskem (in production for PE) Dow Mitsui JV (Project Crystal) (pilot plant)
Algae	Algenol (Dow) Solarzyme (Dow) Synthetic Genomics (ExxonMobil) All in Pilot Plant stage
Yeasts	Amyris (Kraton) In R&D phase



Plant-based Fillers/Fibers for Bio-plastics/elastomers

Oils

- **Petroleum based oils have better thermal stability and are typically more effective than plant based oils**
- **Petroleum based oils are typically less expensive**
- **Plant based oils**
  - **Epoxidized soy bean oil**
  - **Castor oil**
  - **Sorbitol**
  - **Glycols**
  - **Natural oil polyols**

TPE Compounds based on Renewable Raw Materials

ELASTOMER FAMILY	RENEWABLE/SUSTAINABLE RESOURCE	MARKET DRIVER	PRODUCERS	RENEWABLE CONTENT (%)	HARDNESS RANGE
COPA	Polyamide based on castor oil	Footwear	Arkema Evonik	25-94	35-72 Shore D
COPE/TPEE	Polyols derived from plants (corn)		DuPont DSM	20-60	35-55 Shore D
TPU	Polyols derived from plants (corn)	Footwear	Merquinsa Bayer API GLS	20-70	70 Shore A to 55 Shore D
SBC	Plant based oils		GLS API CTS	20-80	22-85 Shore A

Source: Robert Eller Associates LLC 2010

Biodegradable Thermoplastic Elastomers

- **API has introduced the first biodegradable thermoplastic elastomer: Apinat**
- **Based on TPU and aliphatic copolyester**
- **Two series of biodegradable, one from**
  - **synthetic raw materials**
  - **renewable raw materials (polyols derived from plant (mainly corn))**
- **Softness grades from 55 Shore A to 78 Shore D**
- **What's next: Lactide based copolymers from Arkema?**

Source: Robert Eller Associates LLC 2010

Summary

- PVC substitution is finally occurring
  - Wire and Cable is happening now
  - Automotive skins is in development stages
  - Medical is still needing the strong driver for critical mass
- Bio-elastomers/polymers
  - Lot of R&D and development activity, particularly on the matrix side
  - Select consumer driven markets, still a niche play
  - Where does bio-degradable fit
- Next emerging issue
  - Carbon footprint: already a factor in Europe

Source: Robert Eller Associates LLC 2010

Thank You!

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