Plastics in Automotive Applications

presented by:

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Dr Trevor J. Hutley has international technical and management experience in the global plastics industry; in research [R&D], product development, technical service, and application, market and business development. He is a specialist in polymer materials, additives, formulation, structure-property relationships, and applications. Dr Trevor has been an independent polymer consultant, and Member of the PCN, for 21 years.
Outline

• ‘The Product Lifecycle’ webinar Series by the PCN

• Markets and Applications for Plastics

• Scope: Plastics in Cars

• Drivers and Trends for Plastics in Cars

• Examples of Plastics in Cars

• Cutting edge: Plastics in Cars

Acknowledgements
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Acknowledgements
“The Product Lifecycle” Series of Webinars

presented by:

The Plastics Consultancy Network [PCN] is a professional network of some of the most experienced independent polymer consultants in the world
BPF / PCN “The Product Lifecycle” Series

“The Product Lifecycle” Series of Webinars provides a brief introduction to many of the topics that are critical to understanding the development of plastics products; not lifecycle in these terms:

but the life from a polymer material to a plastic product........

Think rather of the polymer industry value chain
Polymer Industry Value Chain

- **Polymerisation**
- **Formulation and Compounding**
- **Polymer Processing**
- **Applications**
- **Customer**
- **End of Life**

**Influences on Plastic Part Performance:**
- **Material**
  - Polymer, Additives and Modifiers, Compounding Routes, Particle size and shape
- **Design**
  - Material Selection, Shape, Costing
- **Processing**
  - Rheology, Flow, Pressure, Temperature, Orientation

**Increasing value**

Dr. Trevor J. Hutley - 12:00 Wednesday 14 April 2021
Phases of the Lifecycle of a Product:

- Materials
- Design
- Manufacturing
- Applications
- End-of-life
- Managing
Plastics in Automotive Applications

The automotive industry is a major growth market for polymers, with a global consumption that is forecast to soon reach 20 million tons with a value of around $50 billion. This “Lunch & Learn” Webinar provides an introductory overview of this application sector. The focus is on plastics materials in cars. Examples of the automotive applications of plastics provide clear demonstrations of the many benefits of plastics materials, and the value that they create.

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Introduction

A Growth Market

There about 1.35bn vehicles on the roads of the world. In 2020, 56m cars were sold. The automotive industry has been a major growth market for polymers for about 60 years. In 1993, the global market was over 4 million tons with a value over $7,500 million. This global consumption is forecast to soon reach 20 million tons, with a value of around $50 billion.

Purpose:
This “Lunch & Learn” Webinar provides an introductory overview of this application sector.

Scope:
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More than 9 billion tons of plastic have been made since the 1950s.
DRIVERS for growth:

- demographics
- progress of society
- geographical shift
- **material substitution** & technological progress
- market & application opportunities
- carbohydrate *versus* hydrocarbon
MARKETS for PLASTICS

- packaging: 39.6%
- automotive: 9.6%
- aerospace
- consumer
- industrial
- E/E electrical & electronic
- building & construction: 20.4%
- sport & leisure
- medical

Europe

- Europe: 39.6%
- Europe: 20.4%
- Other regions: 9.6%
AUTOMOTIVE MARKET for PLASTICS

• Exterior
  door panels, roofs, sun-roof frames, floors, wings, back panels, bonnets, mud flaps, bumpers, door handles, mirror housings, underbody shields

• Interior
  primarily in decorative, safety, noise, vibration, and harshness applications for the interior parts of the vehicle, including the cockpit systems (instrument panels [IPs], structural portions of IPs, and dashmats), headliners, seat systems, soft and hard trim (door trim and pillars), interior door handles, gloveboxes, and packaging trays, steering wheels, door handles, and mirror housings, airbags, airbag doors (covers)

• Powertrain
  Under the bonnet (AIM, thermostat housing, charge air coolers, engine covers), fuel systems, fuel tank

• external and internal lighting systems
• glazing
Features of Plastics

- low cost
- self-coloured
- can be tailored
- insulating
- durable
- ease of assembly
- transparent
- tough
- integration: part & function consolidation
- low density
- corrosion resistance
- easily shaped
- recyclable
- chemical resistance
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Acknowledgements
• Polymers in Cars

- Adhesives
  - Structural adhesives
  - Sealants

- Fibres
  - Carpets
  - Airbags
  - Polyester seat belts

- Elastomers
  - Tires
  - Hoses
  - Seals
  - Foam

- Plastics
  - Bumpers
  - Radiator end-tanks
  - Technical parts
  - Trim
  - Lighting
  - Infotainment
  - Body panels
  - Air-bag covers
  - Wheel covers
  - Wire insulation

- Paint
  - Paint
  - Coatings
8. CLASSIFICATION BY ENGINEERING PERFORMANCE

THERMOPLASTICS

- PP
- PE
- PVC
- PS
- ABS
- SMA
- SAN

150°C
- POM
- sPS
- PA
- PBT
- COPE
- PET

100°C
- PP
- PE
- PVC
- PS
- ABS
- SMA
- SAN

crystalline
- amorphous

- ultra-high-performance polymers
- high-performance polymers
- engineering polymers
- commodity polymers

Classifications of Polymers

1. Source (where do they come from...?)
2. Type of Polymerization
3. Technological Use
4. Microstructure
5. Architecture
6. Processing Characteristics
7. Chemistry of Composition
8. Engineering Performance
2000+ parts in plastics
Polymers in automotive

ThermoPLASTICS in cars

- A plastic that can be:
  - Melt processed to a certain shape, and can later be re-melted

- Elastomers in automotive
- Polyurethane foams in automotive
- Textiles
- Adhesives in automotive
- Composite materials in automotive

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polyurethane foam
car tires
complex!
- 200 raw materials

• natural rubber
• synthetic rubber
• carbon black
• polyester fibre
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The TENSION between functionality and the environment & economy

For every 10% reduction in vehicle mass, an increase in fuel economy of 6-7% may be achieved.
Dynamics of the Automotive Space

ACCESS

**AUTONOMY**
Advanced driver-assist safety technologies and other technological breakthroughs are helping to gradually relieve human drivers from controlling passenger vehicles.

**CONNECTIVITY**
Future vehicles will offer greater levels of connectivity and communications, driven not only by in-vehicle comfort and convenience but also by safety considerations.

**CIRCULARITY**
Principles of a circular economy emphasize recovering materials at the end of their usable life, refurbishing and repairing materials to extend product lifecycles, and remanufacturing and reusing them in new products.

**ELECTRIFICATION**
Electric vehicle (EV) sales are accelerating and projected to represent between 30% and 50% of worldwide vehicle sales by 2040, up from just 1% of worldwide vehicle sales in 2016.

**SHARED MOBILITY**
Adoption of ridesharing has grown from 15% of U.S. consumers having used ridesharing in 2015 to as many as 43% of U.S. consumers in 2018, helping to reduce travel costs and environmental impact of passenger vehicles.

**SUSTAINABILITY**
Automakers are working to achieve sustainable automotive design that reduces environmental impacts and improves the efficiency of products throughout their lifecycle.

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Dynamics of the Automotive Space

- Convergence of IT & Auto Industries
- Improved Battery Technology
- Proliferation of Artificial Intelligence
- Growing Global Environmental Concerns
- Rise in Automotive Buying Populations in Growing Economies
- Increasingly Urban Populations
- Emergence of Alternatives to Personal Vehicles
- Implementation of Fuel Economy Standards Encouraging Automotive Lightweigting
- Modernization of Regulations and Standards to Enable Self-Driving Cars

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Plastics in Automotive Applications
Milburn Wagon Company 1918

top speed of 30 mph and a range of 100 miles on a charge
Transformative technological, cultural, economic and environmental megatrends are converging to reshape “personal mobility,” creating a demand for new material solutions that plastics and polymer materials can provide.

Automotive plastics - a roadmap

ACCESS

Advanced plastics and polymer composites offer an unparalleled combination of properties that are essential to achieving the opportunities outlined in the ACCESS framework.

The ways these materials can already help the automotive industry capture the opportunities in the ACCESS framework and shape the personal mobility revolution:

- Safely add sensors, electronics, and batteries to vehicles
- Offset added weight from additional features
- Enable design and seamless integration of high-value electronic content
- Support a re-imagination of vehicle interiors
- Help modernize transportation infrastructure
- Promote sustainable design and supply chain

Pliastronics, a technology used to integrate electronic circuits into moulded plastic parts right from the design phase

All manufacturers’ efforts are focused on developing increasingly connected vehicles and making all their models electric.

Electroactive polymers

Polymers that can change shape when subjected to a stimulus, most often an electrical stimulus. This is the principle of piezoelectricity. Various families of polymers fall under this category: ionic electroactive polymers, liquid-crystal polymers, ferroelectric polymers such as polyvinylidene fluoride (PVDF).

Use these materials to Revolutionise acoustic speaker systems in vehicles by doing away with traditional speakers. The aim is to both improve sound quality and reduce their weight. In high-end vehicles, sound systems can weigh up to several dozen kilograms.
Automotive plastics - a roadmap [CONTINUED]

2020 TREND: Hygiene and Health

anti-microbial plastic surfaces  self-cleaning  fragrances  anti-odour

54% of consumers are interested in having their next personal vehicle equipped with an antimicrobial coating

• UV-C lights could be embedded inside air-filtration systems to clean air while cars are in use

• they could also be installed in dome fixtures or headliners to clean steering wheels, seats, and controls when the vehicle is unoccupied

“Polymers remain the materials of the future for our industry”
Gérard Liraut, Polymer Expert Leader for the GROUP RENAULT
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Dashboard
PP, ABS, PC

Glass Interlayer
(PVB)

Interior Trim
(PP, ABS, PVC, PET)

Panoramic Roof
(PC)

Upholstery (PP, PVC, PUR)

Body (reinforced epoxy,
PPO/PPE Alloys)

Wheel House
Radiator Support
(Phthalic acid resin)

Door Handles
(PA, ABS, PC/ABS)

Lighting
(PC, PMMA, ABS, PBT)

Instrument Panel
(PC/ABS, ABS)

Bumper
(PP, ABS, PC/PBT)

Fuel System
(HDPE, PA, PBT, POM)

Seating
(PUR, PP, ABS, PA)

Under the Hood
(PA, PP, PBT)
(car) radiator end tanks in nylon

parts integration and cost reduction, weight reduction, and equal or better performance

nylon 6:6

nylon 6:10
(self-locking) cable ties in nylon 66

- an established $250m application but still growing at 8% per annum
- rapidly injection-moulded in up to 100-cavity moulds
bumpers & body panels

Porsche Carrera 4 [1988]

Material Substitution

RRIM thermoset → Bexloy V polyester

- toughness
- CLTE
- flow
- surface

→ PP polypropylene
air intake manifolds

another Material Substitution story …..

- aluminium

→ • plastic (glass fibre reinforced nylon 66) air-intake manifold
  - 25% weight savings
  - 15% cost savings
  - 3-5% improvement in power

  processes: lost-core moulding; welded components; die slide injection (DSI)

→ • plastic (glass fibre reinforced polypropylene) air-intake manifold
  - 15% weight savings
  - better acoustics
  - less energy in moulding (no drying, lower $T_{melt}$)
oil pan

pedal block

door mirror

thermostat housing
laminated windscreens

SAFETY

In 1981, laminated glass with a total thickness of 6 mm superseded tempered glass for windscreen applications.

Now, a 4 mm windscreen is configured with a 1.8 mm outer pane and a 1.4 mm inner pane with a 0.76 mm PVB interlayer.

4.5 → 4mm asymmetric glass windscreen is tougher, with acoustic PVB reducing road noise by 5dB (class difference) and a weight saving of 1.3kg
Lighting
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Local Motors was one of the first to 3-D print - in about 40h - an electric car, called Strati, which is made with carbon-fiber-reinforced plastics (CFRP)
350-bar conformable hydrogen tank technology

CONFORMABLE TANK TECHNOLOGY

thermoplastic elastomer tube - flexibility, permeation barrier

Liner — Thermoplastic elastomer for flexibility and permeation barrier

Reinforcement — Woven synthetic fiber for pressure containment

Noble Gas Systems

The future of gas storage and delivery is Noble
Acknowledgements

This presentation has used data, insights, images, graphics, infographics from a variety of sources, and I am grateful to all of the original authors for the availability of this valuable information on the world-wide web, which I have used freely for these educational purposes, without any permission ....

plasticsmakeitpossible.com

plastics.americanchemistry.com/Automotive/

www.automotiveplastics.com

book: 2009 Engineering Plastics and Plastic Composites in Automotive Applications - Dr Kalyan Sehanobish

Summary

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Plastics in Automotive Applications

After this “Lunch & Learn” Webinar, delegates will understand where polymer materials are used in cars. With a focus on plastics applications, delegates will learn about how the intrinsic properties of plastics materials create value-in-use. Examples will show how plastics replace earlier materials; how lighter cars are achieved; how plastics enable greater functionality, how plastics simplify construction and assembly, and thereby reduce cost, how their processability provides optimum use of space. Suggestions are given of how this sector might change due to the fast growth of electric vehicles, autonomous driving, and the call for sustainability.

Polymers in Wire & Cable Applications

After this “Lunch & Learn” Webinar, delegates will have the big-picture of the E/E [electrical and electronic] and wire and cable sectors; how it is sub-divided, the drivers, the polymer materials and the required properties, and the terminology used in this industry. They will understand the key polymer materials used for insulation, and how these polymers are typically formulated and modified to achieve certain properties and performance for wire and cable construction.