Systematic Integration of Bio-materials in Automotive Interiors

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Systematic integration of bio-materials in automotive Interiors

Content

- Institut für Textiltechnik, RWTH Aachen
- Sustainability issues in the automotive industry
- Textiles in Automotive Industry
- Application of renewable raw materials
- Developments
  - Composites with natural fibres + biopolymers
  - Weaving of biopolymer fibres

RWTH Campus: a novel cooperation between industry and university

- Biggest technology campus in Europe
- Establishment of high-tech companies in 15 different clusters
- Exchange of research results, staff, other resources
- approx. 2 bill. € investments until 2020
- approx. 10,000 jobs in research & development

Institut für Textiltechnik, RWTH Aachen

Our main topics are our interfaces to

- Social necessities and global mega trends
- Leading themes of the high-tech industry
- Leading themes of the EU-research policy

Mobility

Building & living

Health

Energy & environment

Information & communication

Production | **Materials** | **Qualification**

Sustainability issues in the automotive industry

Relevant EU Directives

- End of Life Vehicle Directive 2000 in EU:
  - 95% of a vehicle should be recovered
  - 85% of a vehicle should be recycled
- Waste management directive 2008: heirarchy of waste
  - reuse, recycling, energy recovery, disposal

Source: Green living

Textiles in Automobile Industry

Current Situation

- Up to 30 kg textile per car
- 2/3rd volume – automotive interiors
- Popular fibres
  - PP, PES
  - Glass, Natural fibres (NF‘)
- Popular structures
  - Nonwovens
  - Wovens
  - reinforced composites

Examples of applications

Source: Audi A8

Application of renewable raw materials

Natural fibres in composite applications

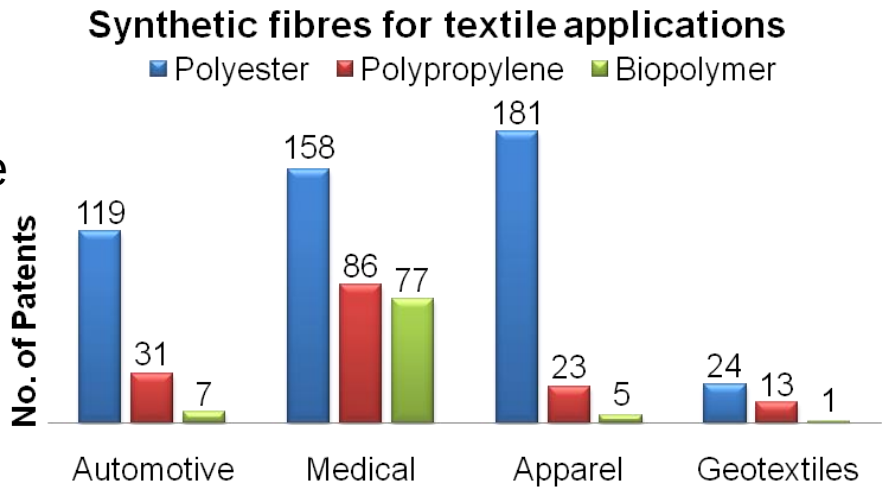
- ✓ Specific strength comparable to glass fibre
- ✓ Low density
- ✓ Low cost
- ✓ Easier to recycle
- ✓ Negative CO_2 emissions
- × Composites with natural fibres as reinforcements are partly bio-based
- × Poor adhesion with thermoplastic matrix

Application of natural fibres

Application of renewable raw materials

Polylactic acid (PLA)

- Thermoplastic – recyclable / biodegradable
- 60% lesser greenhouse gases as PP
- Range of melting temperature
- Challenges
  - Reduce raw material price
  - Improve process ability and achieve stable quality
  - Transfer of technology to the industry – Consumer acceptance
- Approach
  - Development of process technologies
  - Broaden application range



Source: Patent study in ITA, 2010

Natural fibres composite for automotive interiors

Current Situation

- 96 % of all hemp composites in Germany used in automotive interiors (~5 kg / car)
- The volume of renewable raw materials is limited to 40 %
- Current approach – Replace fossil based materials with renewable fibres
  - Cost and resource inefficiency
  - Low technical performance of new products
- Current research focuses on
  - Improving the fiber-matrix interphase
  - Development of demonstrators
  - Automation of the manufacturing process

There is <u>no method with systematic guidelines</u> for replacing fossil based materials with renewable raw materials

Natural fibres composite for automotive interiors

Project: NatureWins (2011 – 2012)

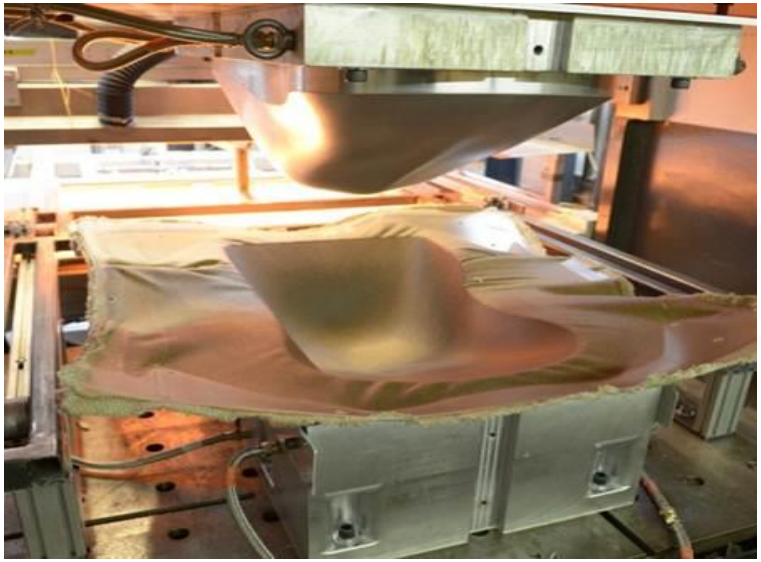
- Objective
  - Development of bio-based composites from 100 % renewable raw materials
- Approach
  - Development of processing technologies for the production of hybrid-yarns and hybrid-nonwovens

Flax-PLA composites

Natural fibres composite for automotive interiors

Project: NatureWins (2011 – 2012)

- Results
  - Biocomposites from long natural fibres (flax, hemp) and thermoplastic biopolymers were developed
  - Mechanical properties comparable with current products in the automotive industry
  - Development of a car seat as functional demonstrator

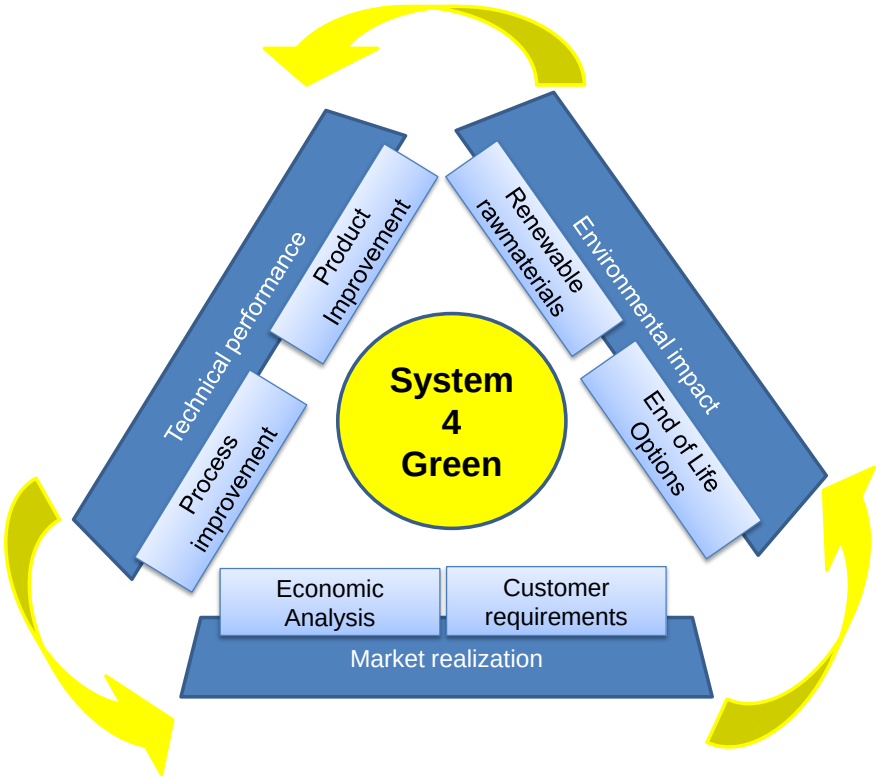


Car seat demonstrator develop from flax-PLA composites

Natural fibres composite for automotive interiors

Project: System4Green (2015 – 2016)

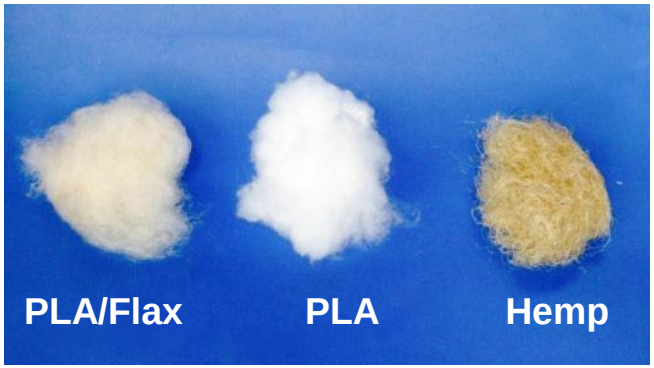
- Motivation
  - Knowledge based Selection of Materials for the Development of Sustainable Products
- Objective
  - Develop the System4Green method for fibre-reinforced composites for
    - replacing conventional fossil-based products with up to 100 % renewable raw materials
    - Efficient development of products from renewable raw materials
  - The method will be implemented on 2 case studies in this project



Natural fibres composite for automotive interiors

Materials

Fibre	PLA	PP	Flax	Hemp
Density [g/cm^3]	1,25	0,91	1,40	1,48
Fineness [dtex]	7,2	7,6	3,9	-
Staple length [mm]	64	50	140	40 - 100
Tensile Strength [MPa]	330	750	720	-



Natural fibres composite for automotive interiors

Nonwoven technologies for the production of bio-composites

Process chain

- Conversion of PLA filaments into staple fibres
- Blending of PLA fibres with natural fibres
- Web formation
- Web consolidation

Process Optimization

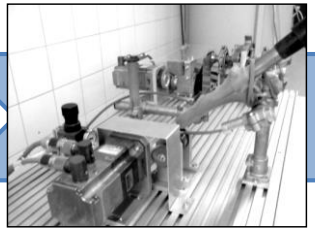
- Type of Blending
- Needle parameters

Development of Composites

- Compression moulding
- Benchmarking

Natural fibres composite for automotive interiors

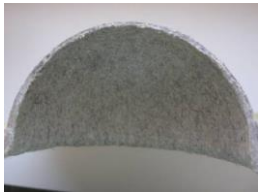
Process chain for the developments of bio-composites



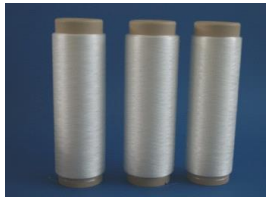
Staple fibre cutter

Air laying

Needle punching



Biocomposites



PLA filaments

Product

PLA staple fibres

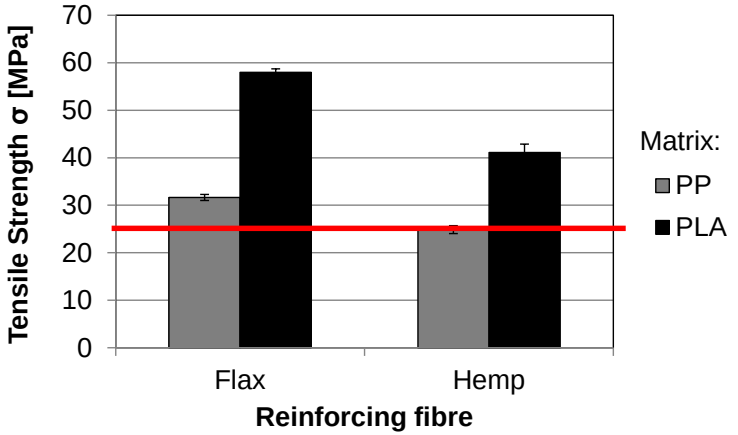
Airlaid webs

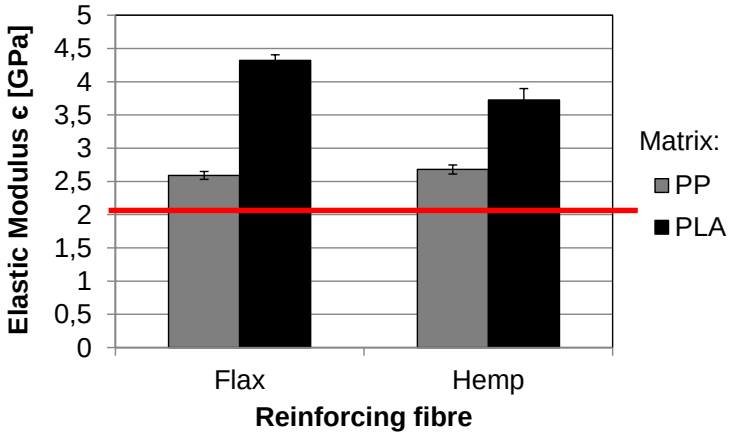
Needlepunched nonwovens

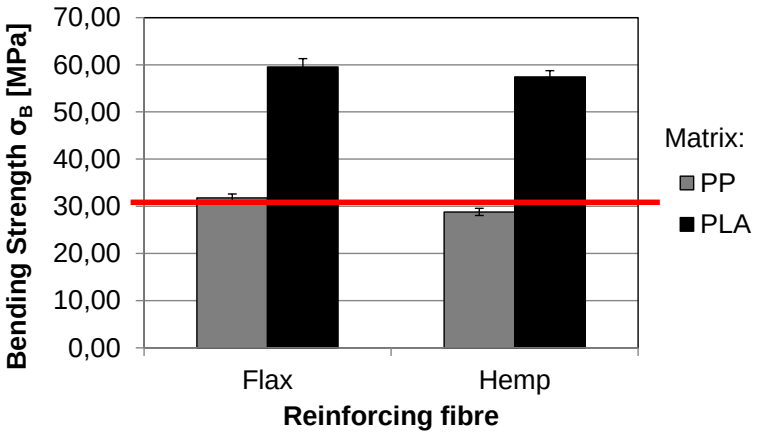
Natural fibres composite for automotive interiors

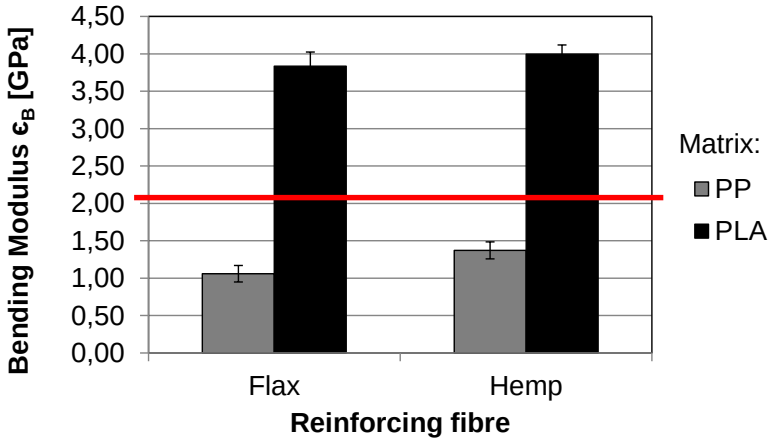
Benchmarking – NF-PP v/s NF-PLA

Requirements from automotive suppliers



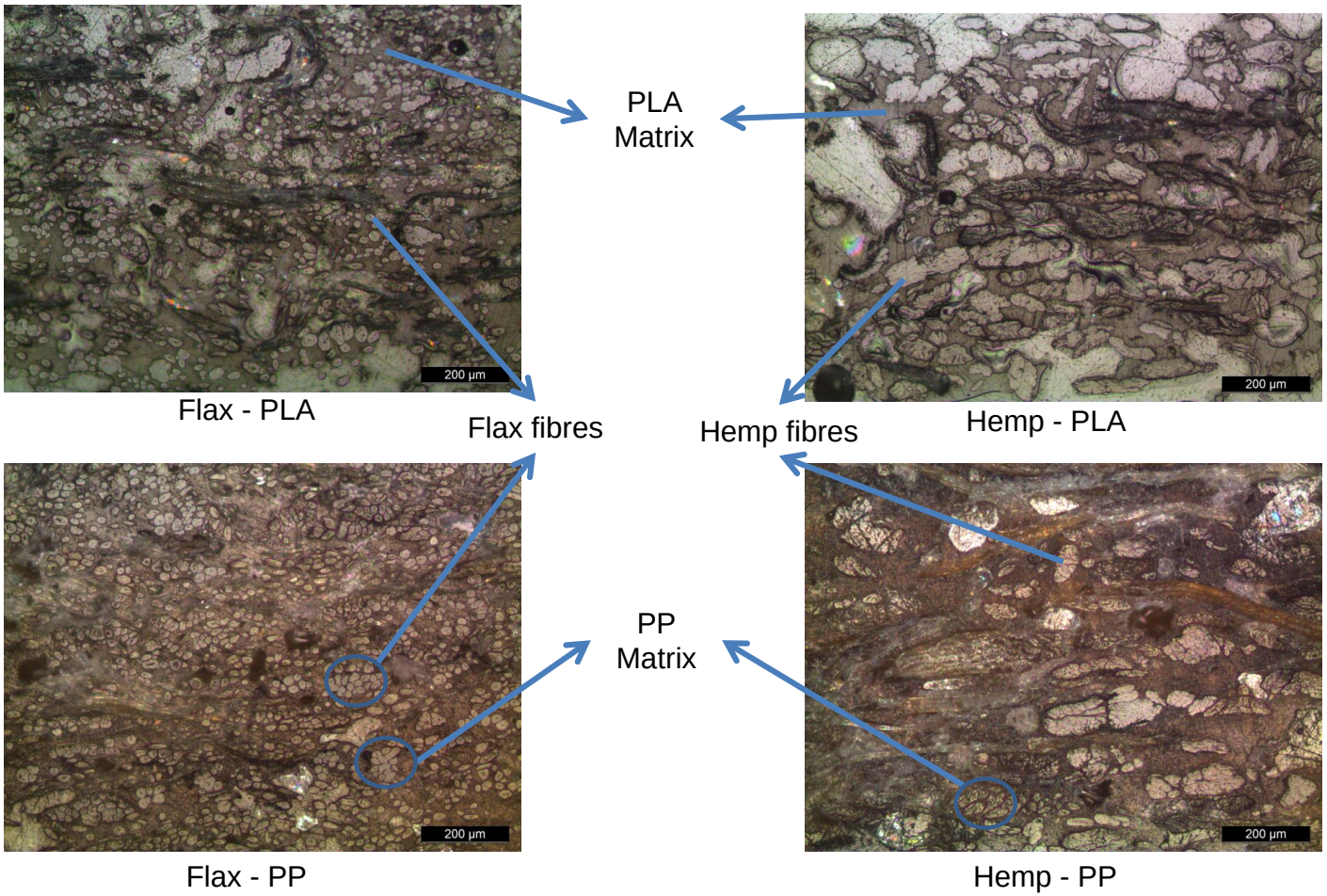






Natural fibres composite for automotive interiors

Benchmarking – NF-PP v/s NF-PLA



Natural fibres composite for automotive interiors

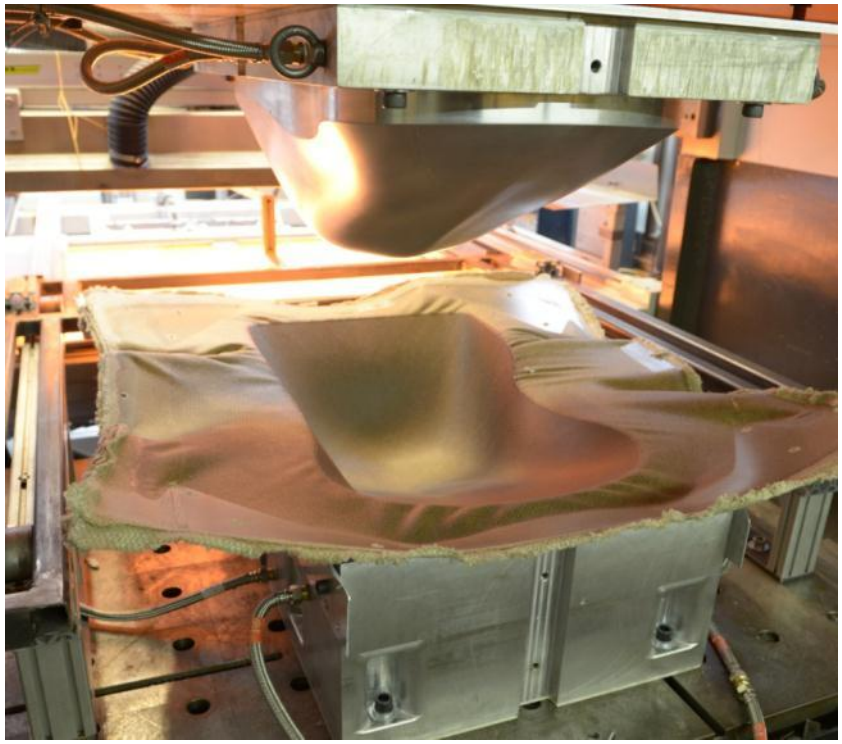
Summary

- Bio-composites developed from 100 % renewable raw materials
- Bio-composites developed are feasible for application in automotive interiors with regards to their mechanical performance.
- Choice of matrix material had a strong influence on the performance of the composites
- PLA composites exhibiting better properties compared to the PP composites

Natural fibres composite for automotive interiors

Future work

- Benchmarking the composites for other performance requirements of the automotive industry
  e.g. fire retardence, emissions
- Environmental and economic analysis of the composites
- Development of demonstrators in collaboration with industry partners in real-time conditions



Production of car seat from biocomposites

Weaving of biopolymer fibres

Project: BioFibroCar (2013 – 2015)

- Objective
  - Development of textiles for automotive interiors made from renewable and eco-friendly bio-polymers
- Approach
  - New functionalised yarns from biopolymers
  - New additives for anti-microbial and anti-odor properties
  - New PLA compounds with improved properties for application in automotive interiors
  - New textiles from PLA for the automotive interiors

Weaving of biopolymer fibres

Materials

Material	PES	PLA-PHB (control)	Stereo-complex PLA	Black stereo-complex PLA
Tm [°C]	250-260	130	220	220
Fineness [dtex]	660	660	650	650
Tenacity [cN/tex]	4,0-5,5	2,53	3,23	3,23
Elongation [%]	25-30	28	23	31,5

Weaving of biopolymer fibres

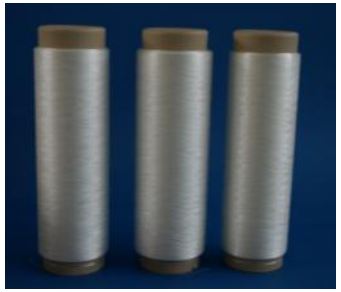
Process chain for weaving of PLA filaments

Filaments:
- PLA-PHB
- Stereocomplex PLA
- PLA with additives

Process
- Weaving Preparation
- Weaving

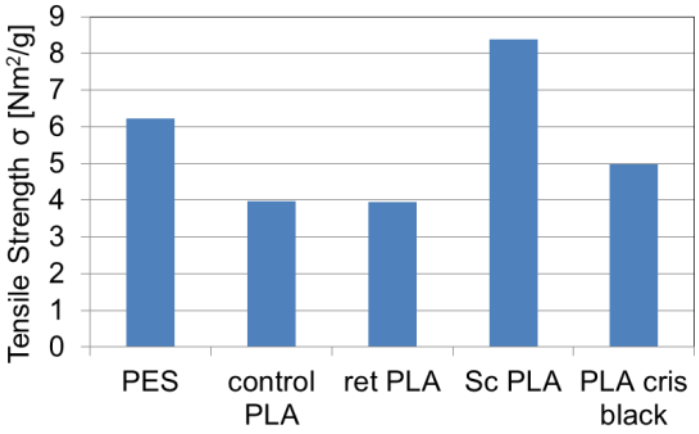
Parameters
- Creel
- Sectional warping
- Narrow
- Broad
- Industry loom

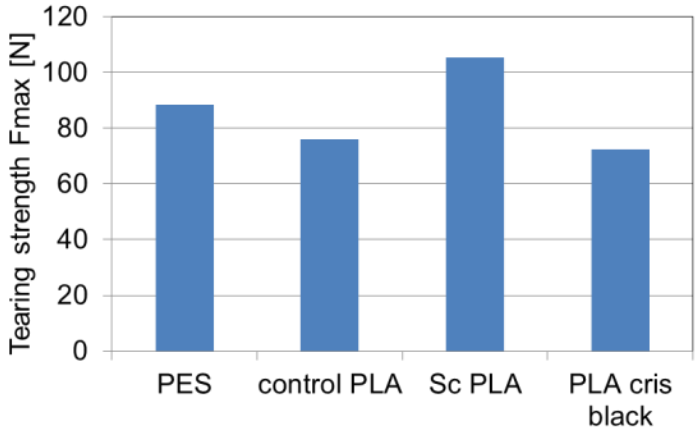
Evaluation
- Filament Strength
- Elongation
- Areal weight
- Thickness
- E. Modulus
- Flammability
- Permeability
- Abrasion
- Weavability
- Colour fastness

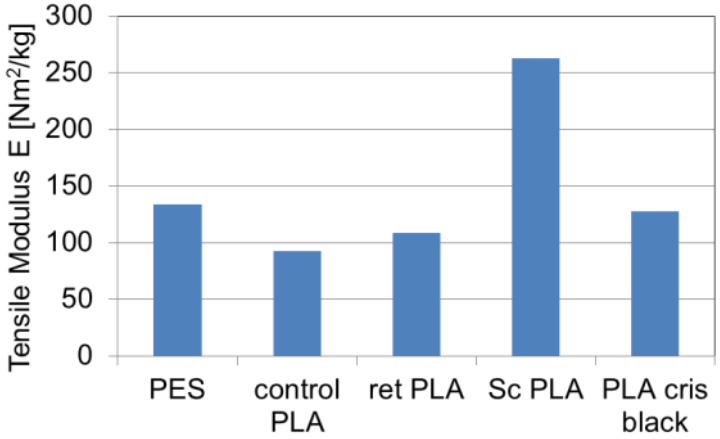


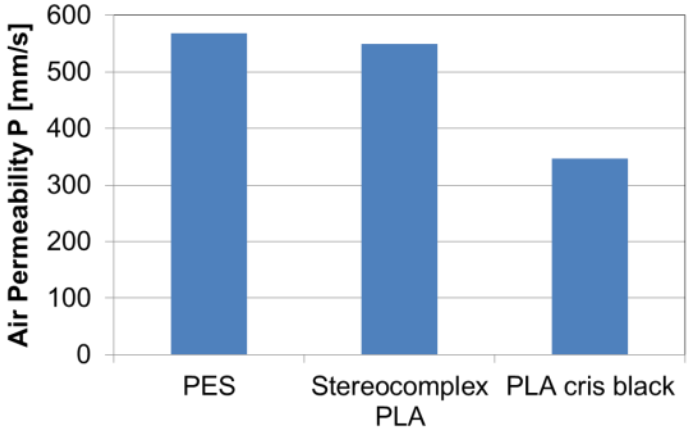
Weaving of biopolymer fibres

Benchmarking









- PES: polyester
- control PLA: PLA + 2% PHB
- ret PLA: reticulated PLA
- Sc PLA: stereocomplex PLA
- PLA cris back: PLA + talc + black

Weaving of biopolymer fibres

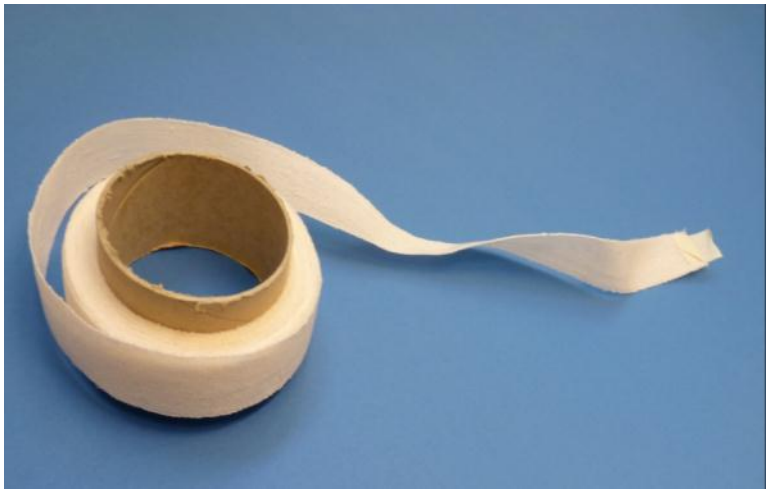
Benchmarking

Test	Norm	Requirement	Sc-PLA	PLA + talc
Flammability	e.g. MVSS 302 (Motor Vehicle Safety Standards used by Volvo)	< 102 (mm / min)	0 mm / min	0 mm/min
Pilling	DIN EN ISO 12945-2 (modified Martindale)	Grade >=4 at 4000 load cycles	5	4-5
Abrasion resistance	DIN EN ISO 12947-2 (Martindale with 12 KPa load)	>= 5000 load cycles	19000 load cycles	19000 load cycles
Colour behaviour	DIN EN ISO 105-B06	>= Grade 7	8	8
Greyscale	DIN EN ISO 105-B06	>= Grade 3-4	5	5

Weaving of biopolymer fibres

Conclusions

- Weaving of 100 % PLA-PHB fabrics
  - comparable to weaving PES yarns in terms of processability and end breaks
- Benchmarking with polyester reference fabrics currently used as seat covers in automotive industry
  - The mechanical performance of the stereocomplex PLA superior to the reference polyester fabrics.
  - PLA fabrics have a potential for application in the automotive industry as seat cover fabrics



Thank you
for your kind attention

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