DEUTSCHE INSTITUTE FÜR TEXTIL+FASERFORSCHUNG

Future technologies for the functionalization of textile materials

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IFAI Expo, Orlando, USA, October 2019

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German Institutes of Textile and Fiber Research

- Europe's largest textile research center
- Founded in 1921, foundation under public law
- 3 research centers, 1 production company (ITVP)
- Application oriented research from molecule to product on 25,000 m²
- Research with industrial pilot facilities, focus on technical textiles and life sciences
- Connected to University of Stuttgart and Reutlingen University by 3 chairs and 2 professorships

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German Institutes of Textile and Fiber Research

Key figures 2018

- Employees: approx. 300
- Turnover: approx. 27 Mio. € (12 Mio. € public, 15 Mio. € industry)
- Industry: (without ITVP)
  31% Baden-Württemberg
  51% national
  18% international
  49% small and medium-sized enterprises

Application oriented research from molecule to product

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German Institutes of Textile and Fiber Research

Research fields


High Performance Fibers and Yarns


Smart Textiles


Functionalized Textiles and Finishing


Medical Technologies


Lightweight Design and Fiber Composites


Textile 4.0

Application fields

Architecture and Construction
Health and Care
Mobility
Energy and Environment
Production Technologies
Clothing and Home Textiles

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Overview

- Bio-Textiles: Fibres and coatings with renewable resources
- Coatings with finest fibres
- Smart Textiles: printed sensors, thick protection layers
- Digital printing
- Water and energy saving finishing technologies

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Definition Biopolymers

- A biopolymer:
  - synthesized from biogenic sources
    or
    is biodegradable

This includes:
- petroelum based products which are biodegradeable
- Polymers from natural molecules which are not biodegradable


Castor oil plant Quelle: Wikipedia (Robodoc)

- Compostable (EN 13432):
  - in a composting plant:
    degradation within 90 days up to 90%
  - no toxic substances

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Challenges for the use of biopolymers

- High costs compared to petroleum based fibres and polymers
- Changed processability compared to established standard materials
- Transfer of economic process technologies into industry
- Achiving technical specifications for the applications

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Biobased polyamides and polyesters for fibres

Product	Chemical characteristic	% biobased
Polylactide (PLA)	Polyester	100%
Polyhydroxybutyrate (PHB)		100%
Polytrimethyleneterphthalate (PTT)		30%
Polyethylenefuranoate (PEF)		100%
PA 11 , PA 12 / PA 12	Polyamide	100% / 0%
PA 10.10		100%
PA 6.10		60%
PA 6.12		66%
PA 4.10 , PA 5.10		100%
PA 5.6		45%
PA 4.6		40%

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Overview polymer properties

Product	Selected properties compared to standard polymers	Biobased
Polylactide (PLA)	Comparison to PET • bioderadeable • Higher water vapor transport • Lower density • Less smoke development/ higher LOI • Much lower melting point • Lower tear strength	100% Fermentation of starch
PA 6.10	Comparison to PA 6 / PA 6.6 • Lower density • Lower water uptake • Higher hydrolytic stability • Lower melting point • Lower tear strength • Lower abrasion resistance	60% Cleavage/Oxidation of Castor oil/ Sebacinic acid

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Fluorfree Hydrophobicizers

- Meanwhile high product variety
- Diverse chemical basis:
  - Waxes / paraffin eg Ecoperl 4, CHT, D
  - Silicone waxes eg ECOPERL HC, CHT, D
  - Dendrimers eg RUCO-DRY ECO PLUS, Rudolf Chemie, D
  - Polyurethane / alkyl urethane eg Zelan R3, Huntsman, D
  - Copolymer Acrylates / Paraffin eg Smartrepel Hydro PM, Archroma, D
- Improved washing performance
- Good water repellence
- No oil rejection
- Partially bio-based

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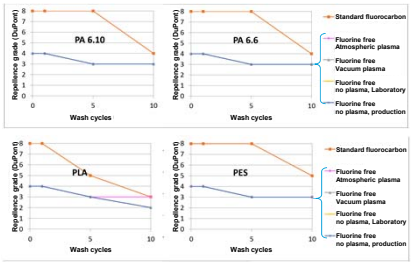
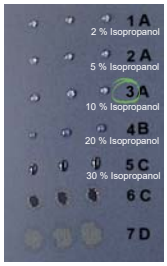
Water repellence and Washing fastness – DuPont





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Summary

- Biopolymers PA 6.10 and Polylactide were investigated for outer fabrics
- Aim was an effective and durable fluorine free impregnation
- PA 6.10 and PLA are more hydrophobic than the fibre polymers PA 6.6 or PET
- Plasma activation accelerates the finishing process (faster liquor pick-up)
- Effect level and durability turned out to be good but relatively independent on plasma treatment
- Finishings on PLA-samples were less durable with regard to washing
- Spray rating of fluorine free impregnations after washings partially higher than standard fluoro carbon

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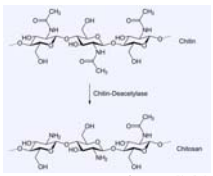
Chitin and Chitosan: Renewable resource in large quantities

10^6 bis 10^7 Tonnen pro Jahr

Source: www.wikipedia.de

Main source of Chitin:
- Bowls of shrimp
- Crustaceans

Under construction:
- maggot production in Europe



Source: www.wikipedia.de

Production of chitosan from chitin:
N-deacetylation
- caustic soda (alkaline process)
- encymatically

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Chitosan in textile industry: potential application areas

Sizing agent:
- high weaving efficiency
- low consumption
- supports coloring
- product available

As a water repellent:
- chemically modified
- in development for good wash resistance

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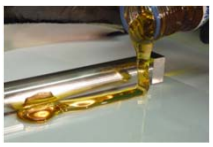
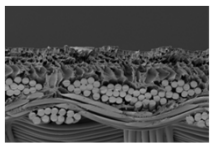
New process technologie: Ionic liquids





Future:

Ionic liquids as solvents for biogenic polymers:
Elimination of chemical modification

for:
- Cellulose
- Chitin
- Fibres and coatings

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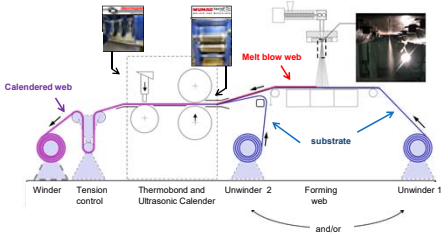
Coating with fibres: Melt Blow



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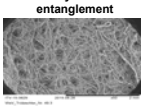
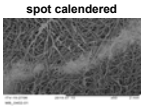
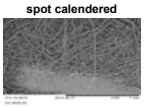
Consolidation of melt blow webs – Hydroentanglement vs. thermobond vs. ultrasonic calendering

Hydro-entanglement	Thermobond spot calendered	Ultrasonic spot calendered
		
▪ Keeps web flexible ▪ Increases web strength significantly ▪ Increases ultimate elongation strongly ▪ Weak areas gets weaker ▪ Cohesion depends on structure of the carrier	▪ Influences adjacent fibres	▪ Sensitive to unevenness
	▪ Increases web strength ▪ Elongation less improved ▪ Cohesion depends on thermal properties of the carrier	

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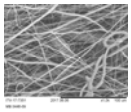
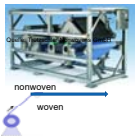
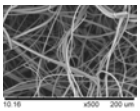
Breathable membranes from nonwovens

- fluorfree
- base: Polypropylen



PP-Meltblown – 20 g/m²
Average fibre diameter ca. 0,5 µm





PP-Meltblown – waterentangled

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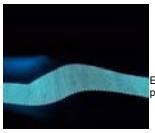
Smart Textiles – E-Textiles

Challenges for the functionalisation:

- Electrical conductivity on flexible textiles
- Connecting soft conductive fibers to hard electronics
- Local acting processes necessary
- lifetime of active elements (limited applications and economic use)

Sensor shirt for determination of vital parameters for protection of firefighters



Electroluminescent printed structures

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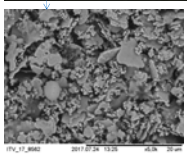
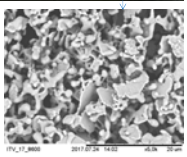
Flexible electrically conductive contacting: laser sintering of metal dispersions

Determination of limit values

Not treated coating





Frequency: 100 kHz
Laserpower: 2 W
Speed: 200 mm/s
Line distance: 0,025 mm

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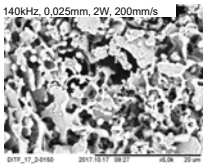
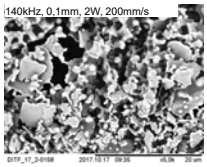
Laser sintering of metal dispersions: degree of sintering

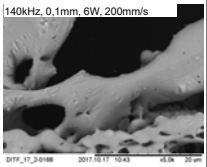
140kHz, 0,025mm, 2W, 200mm/s



140kHz, 0,1mm, 2W, 200mm/s



140kHz, 0,1mm, 6W, 200mm/s



Analysis room Laser:

- Frequency: 20-140 kHz
- Line distance: 0,025-0,1 mm
- power: 2-6 W
- speed: 200 mm/s-7000 mm/s

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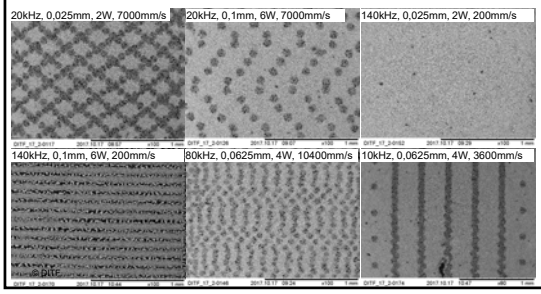
Laser sintering of metal dispersions: Homogenity of samples



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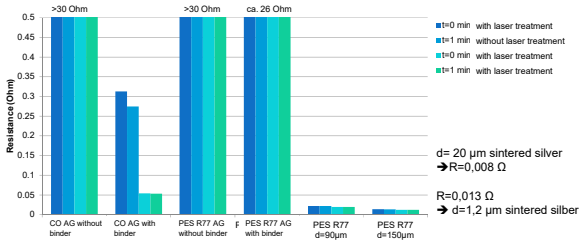
Laser sintering of metal dispersions: Influence fibre, binder, size of metal particles



d= 20 µm sintered silver
➔R=0,008 Ω

R=0,013 Ω
➔ d=1,2 µm sintered silber

© DITF Laser treatment: 200 mm/s, 2 W, 140 kHz, 0,025 mm line distance

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High barriers: Life time of Smart Textiles limited

Water and oxygen lead to electronic

Function elements for premature power loss through

- Corrosion
- Chemical changes
- Structural changes

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source: DITF Yearly Report, S-Gard

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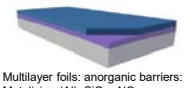
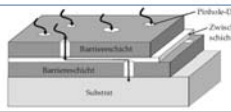
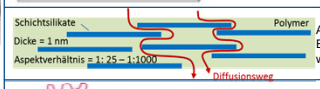
High barriers: State of the art



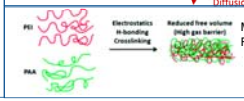
Multilayer foils: anorganic barriers: Metalising (Al), SiOx, AlOx



Multilayercoatings & foils: combination multiple Barriere layers O_2-barrier + H_2O-barrier



Additive: Extension way of diffusion



Multilayer / Polyelectrolyte: Reduction free volume

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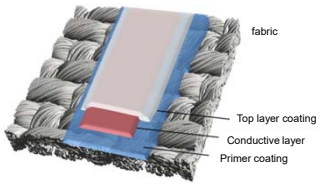
High barrier: solution coating of conducting layer

1. Coating system

- Dispersion with compounding of phyllosilicates

2. Application

- Screen printing



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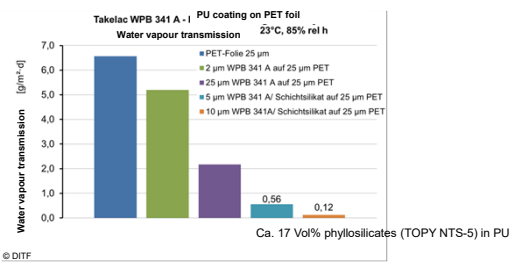
Takelac WPB 341 (PU)- coating with phyllosilicates



Ca. 17 Vol% phyllosilicates (TOPY NTS-5) in PU

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Digital / localised functionalisation

- State of the art: local functionalisations mainly through the textile construction and make up
- Localized functionalization can improve the products
  - water repellency
  - Soil Release
  - Antimicrobial
  - Handle
  - Friction
  - abrasion resistance
  - Electric conductivity

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Digital / localised functionalisation

- Users: People with special requirements
- Clothing: shoes, orthoses

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Digital application technologies in finishing

- Viscosity: 50-500 mPa·s
- Output per nozzle: 3...35 g/min
- Application: 200...1000g/ m²
- Resolution: 50/100 dpi
- Point size: 0,5/0,25 mm
- Point density: 4.000.000 /m² 16.000.000/m²

- Pressure nozzles: adjust on viscosity (inks, binder systems)
- Upscaling: Increasing the number of print heads
- Flexible: several storage tanks, quick change
- Pattern change: intimate, without set-up times
- Sustainable: hardly any residual fleetsDruckdüsen: abstimmen auf

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Demonstration: localised hydrophobicity

Bright regions: wetted by water
Dark regions: water repellent / dry

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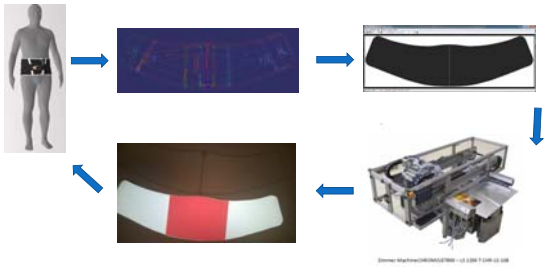
Digital finishing:
finishing is part of integrated process chain



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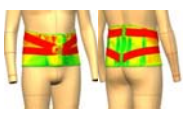
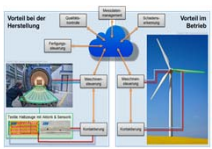
Textil 4.0:
Networking of specific customer requirements into production



Today

Individualised products, produced by Big Data and optimized processes



Future

Networked process monitoring with sensors in the textile base material

Vision

Dynamic, adaptive, self-organized and learning textile processes and materials

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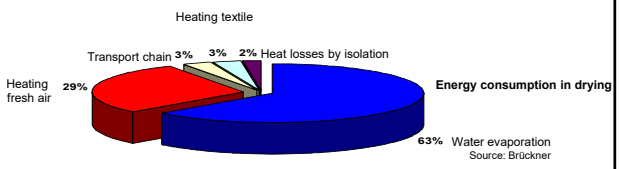
Energy consumption in textile finishing



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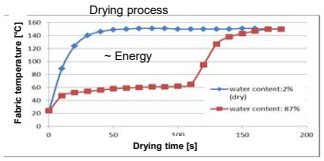
Wasser evaporation dominated energy consumption



specific heat capacity water: 4,2 kJ/kg·K
20°C ⇨ 70°C : ca. 200 kJ/kg
specific evaporotion capacity water: 2257 kJ/kg

Water evaporation needs ca. 10x more energy than heating up water

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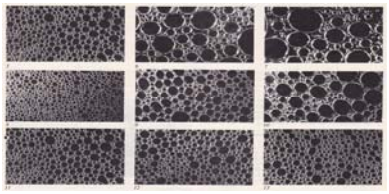
Foam application

- Replace water by air!!
- Air reduces liqour viscosity
- Conventional application methods
- Energy reduction analog water reuction



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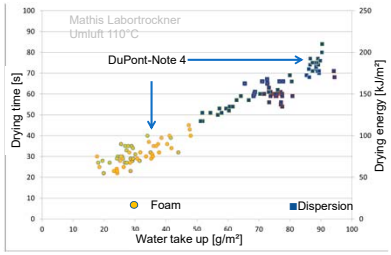
Hydrophobisation



Polyester fabric 164 g/m²

Liqour pick up 10% 30% 50% 60%

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Acknowledgement

Thanks to funding

Thanks to partners in the different cooperation projects

Gefördert durch:

Bundesministerium für Wirtschaft und Technologie

Bundesministerium für Bildung und Forschung

aufgrund eines Beschlusses des Deutschen Bundestages.

ZIM

AiF Projekt GmbH

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Thanks for your attention!

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