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Department for Agrobiotechnology

Natural-fibre materials: From Ideas, to Products, to Markets

Prof. Dr. Rupert Wimmer

Institute for Natural Materials Technology

IFA Tulln, Universitaet fuer Bodenkultur Vienna

What you can expect...



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“**A keynote** is delivered to set the **underlying tone** and summarize the **core message** or **most important revelation** of the event.”

My **personal view** on developments, based on my professional experiences in academia and industry .



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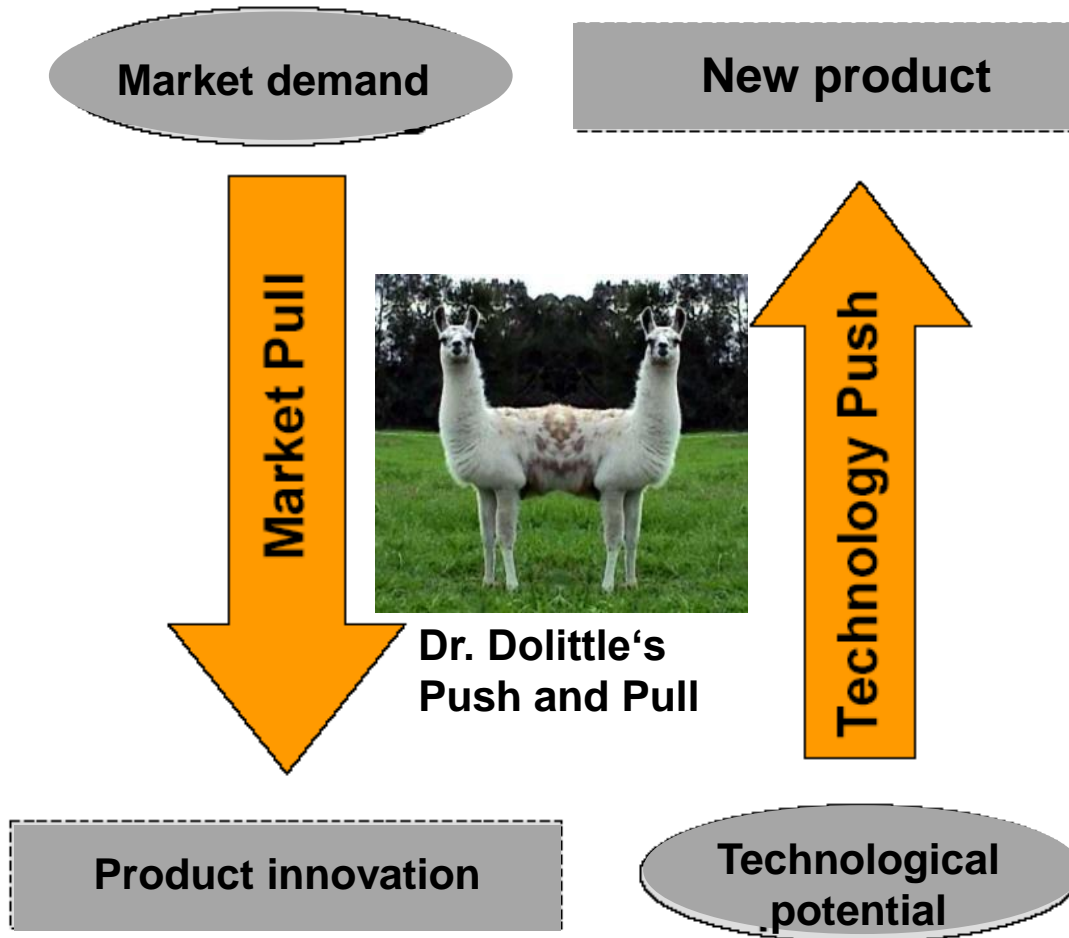
Ideas.....



How is innovation happening?



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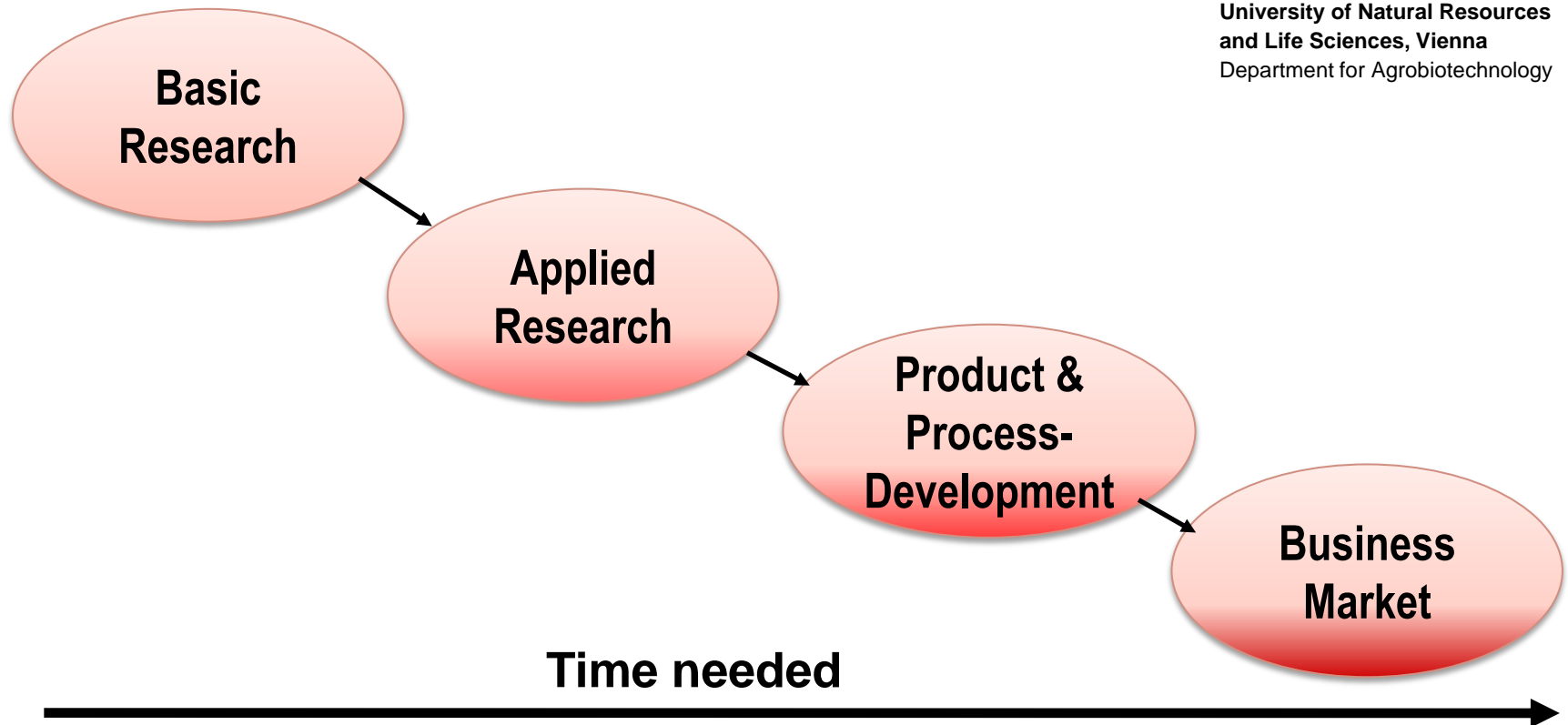


Starting point for each innovation is either a *technology push* or an existing *market pull*.

Classical innovation chain



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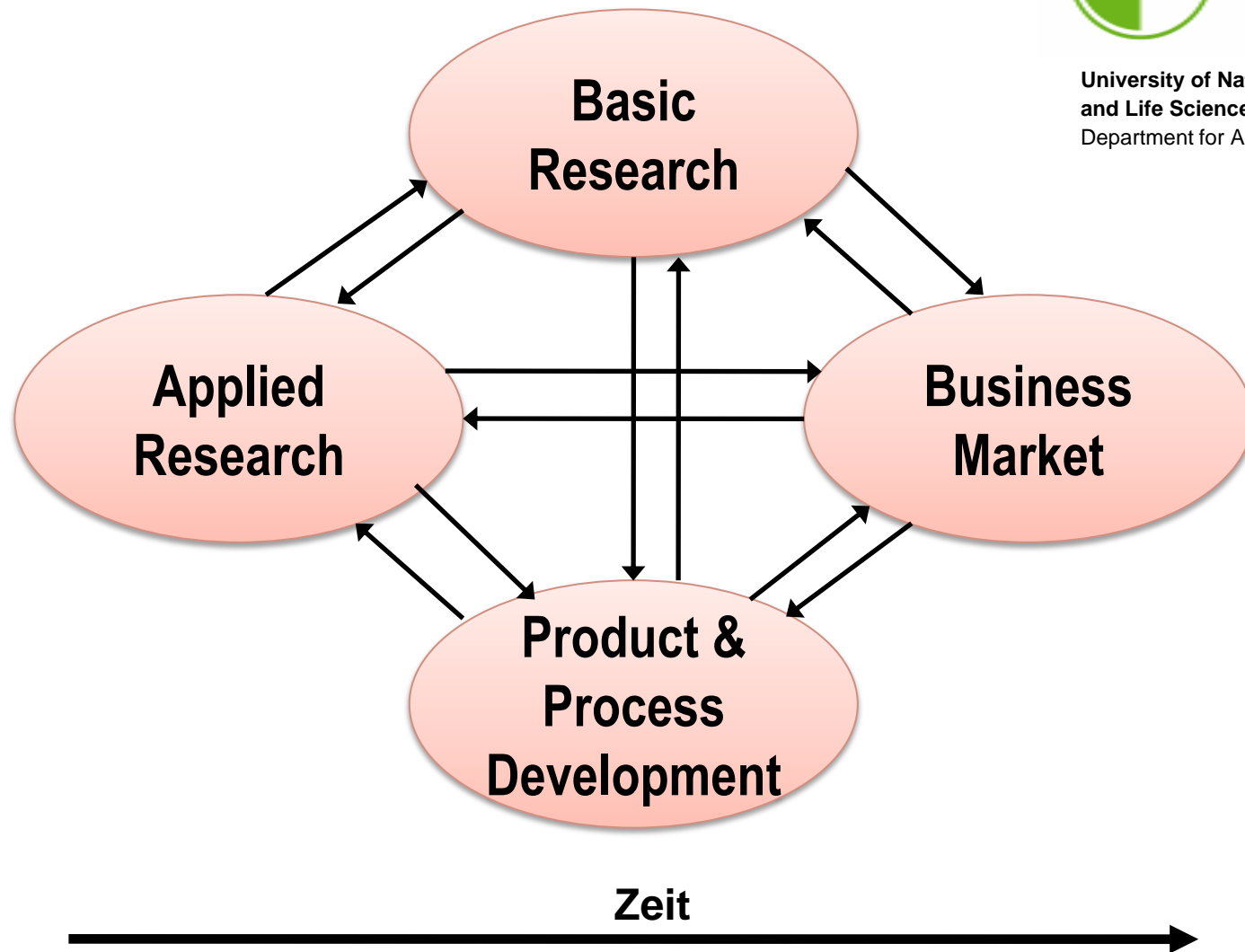


Company's R&D activities are utilizing results from basic and applied research

Integrated “Key-Technology” Concept



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Future fields for innovations



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Automotive industry, -supplier

1. Aktive Sicherheit, aktive Lichtsysteme und Fahrerassistenzsysteme
2. Neue Antriebstechnologien, Verbrauchs- und Emissionsreduktion
3. Elektrik/Elektronik
4. **Light weight, new materials**
5. Neue Fertigungstechnologien

Maschining, Processing

1. Neue Fertigungstechnologien
2. Elektrik, Elektronik und Automatisierungstechnik
3. **New materials**
4. Wirkungsgradsteigerung, neue Energiequellen, Emissions- und Verbrauchsreduktion
5. Mikro- und Nanotechnologie

Constructive engineering, buildings

1. Verbesserte Bedienung und Komfort
2. Neue Energiequellen, Emissions- und Verbrauchsreduktion
3. **New process technology**
4. **New Materials**
5. Systemlösungen

Chemical industry, raw materials

1. Biotechnologische Herstellverfahren
2. **New surface applications**
3. Direktverfahren und Anlagenautomation
4. **Functional Cellulose Fibers**
5. **Nanotechnology**

Based on 300 industry expert views from Germany and Austria

Quelle: Arthur D. Little Innovation Excellence Studie 2004

Where to find ideas?



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Added Value

LT / HA ↔ Fine Chemicals

- Dyestuff, Cosmetics
- Pharmacy, Spices
- (Edible Oils and Fats)

HT / HA ↔ Biocascading

- **Fibers**
- Specialities for Niche Markets

Technology

LT / LA ↔ Bulk Production

- Energy from Biomass
- Sugar / starch
- Oil / Fatty acids

HT / LA ↔ Bulk Production

- **Pulp and paper**
- **Panels/boards**
- Insulation materials

LT = Low Tech HT = High Tech LA = Low Added Value HA = High Added Value



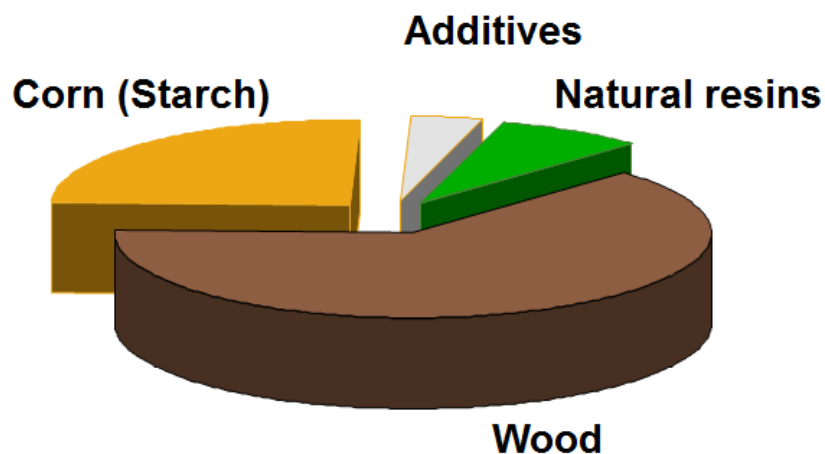
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A key idea: The FASAL material



- **Faser (Fiber)**
- **Zerealien (Cereals)**
- **Extrusion**

fasal[®]

FASAL = wood + starch + resins





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Fasal and Fasalex

- Wood particles
- Corn
- Natural resins
- Biol. Additives

Extrusion

Compounded granulates

Injection molding

Profile Extrusion



FASAL-
injection molding

FASALEX-
Profiles

History



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- 1987 First extruder
- 1989 „Fasalex“ first application for patent
- 1990 Extrudable particle board
- 1991 „Styropor“, mold, gypsum patent, “Ökopur“
- 1993 Injection molding started, Fasal
- 1996 Natwood (solid wood modification)
- 2001 Prosin (protein and resin)
- 2009 biopolymer processing (PLA, PHB)
- 2010 Paper-Plastic-Composites (PPC)
- 2012 Sustainable biomaterials group

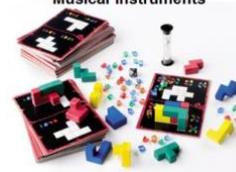
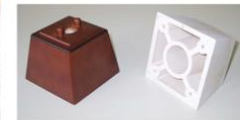


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to products.....



Musical instruments

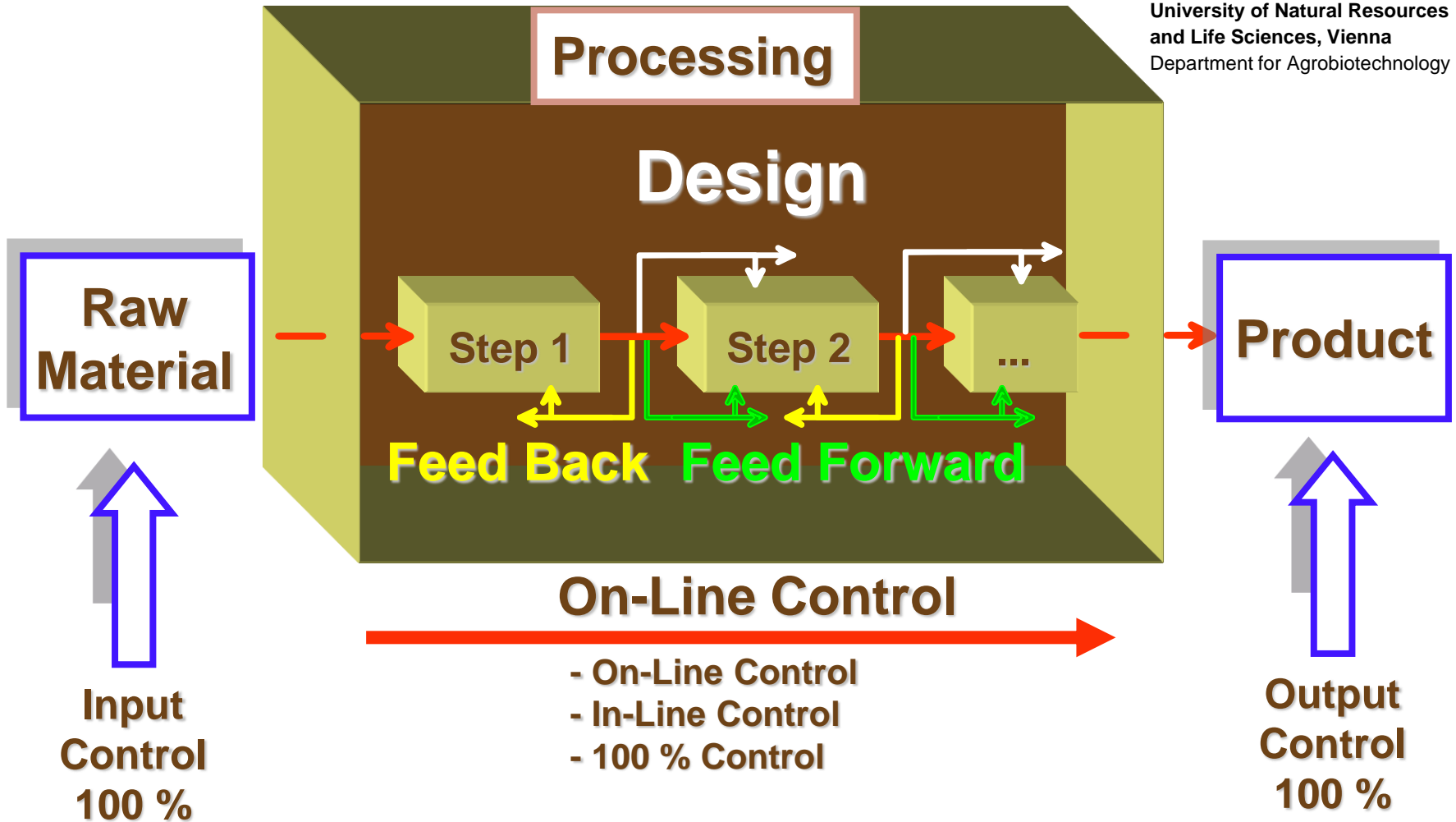


through *process* and *product* design



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Product Functionality Design through process optimization *and* product design



“Re” - Design criteria



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- Renew/Redesign
- Reduce
- Reuse / Recycle
- Remove
- Renewable
- Resize

- **Functionalities**
- Raw material management
- Biodegradeable
- **Product safety**
- **Environmental friendly**
- Energy efficient

Product and Process Design



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- Product Functionality
 - Low weight (not really new)
 - Low emissions (“better air” products / panels)
 - mold resistance (non toxic)
 - Electrically / thermally conducting
 -
- Process Development & Design
 - Expensive processes – little knowledge
 - Advanced sensor technology
 - Process modeling

Sensor technology - Experimental Design



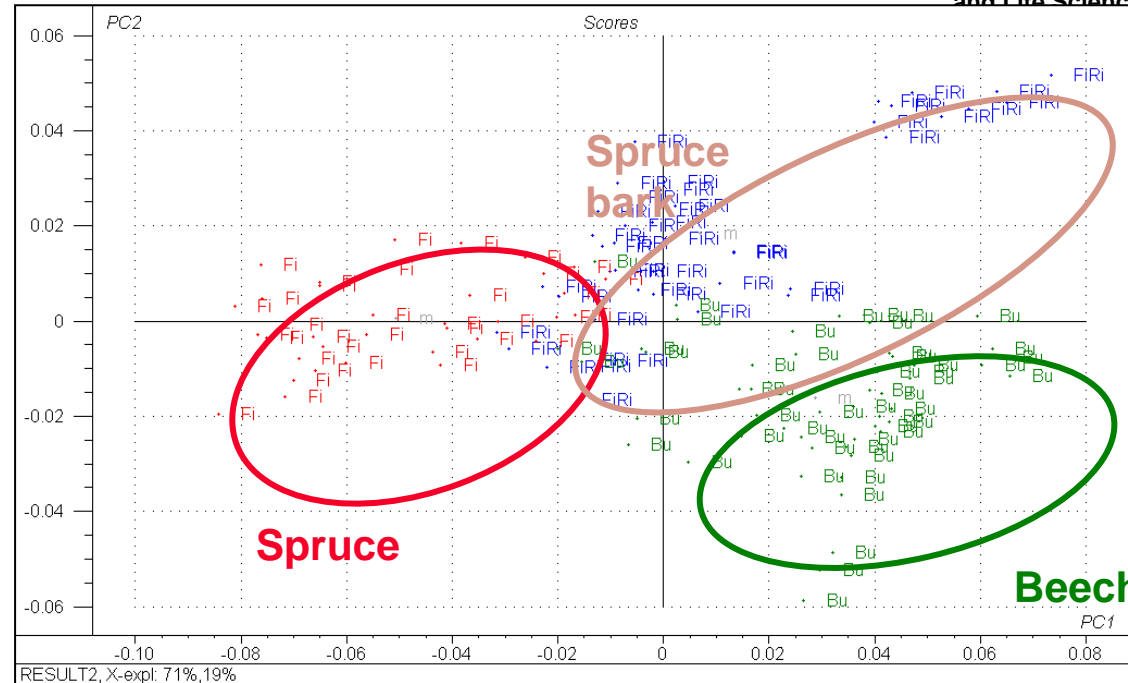
Online trial



Lab trial

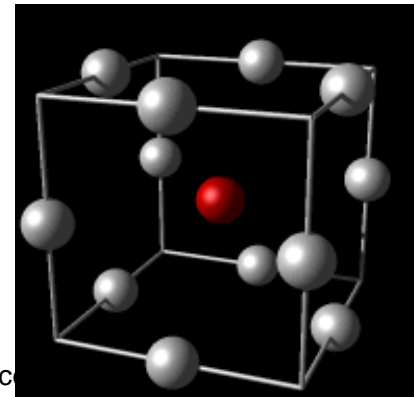
On-line UV-Vis-NIR-Raman spectroscopy

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PCA – species mixture for hardboards

based on DOE (Design of Experiment)



Mixture design with natural fibres



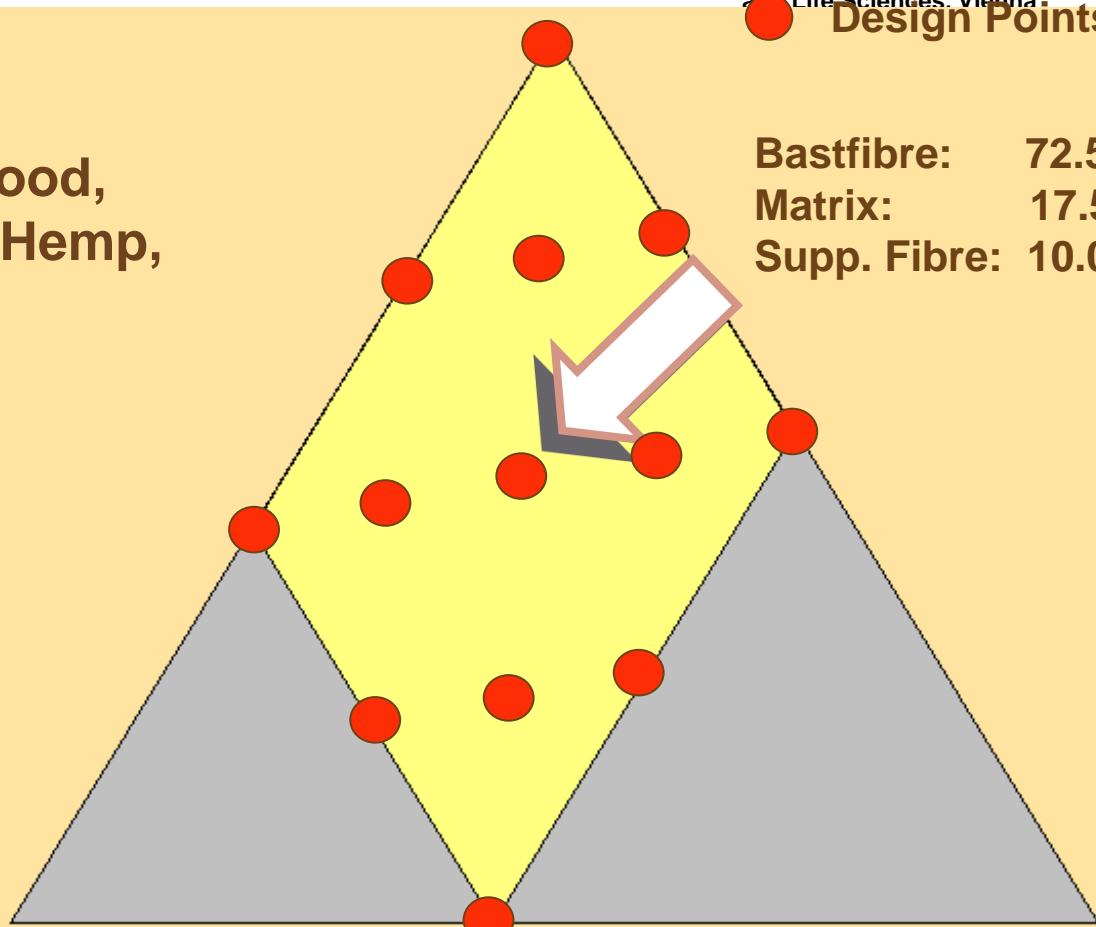
e. g. wood,
kenaf, Hemp,
Flax

Bast/wood fiber

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● Design Points

Bastfibre: 72.5 %
Matrix: 17.5 %
Supp. Fibre: 10.0 %



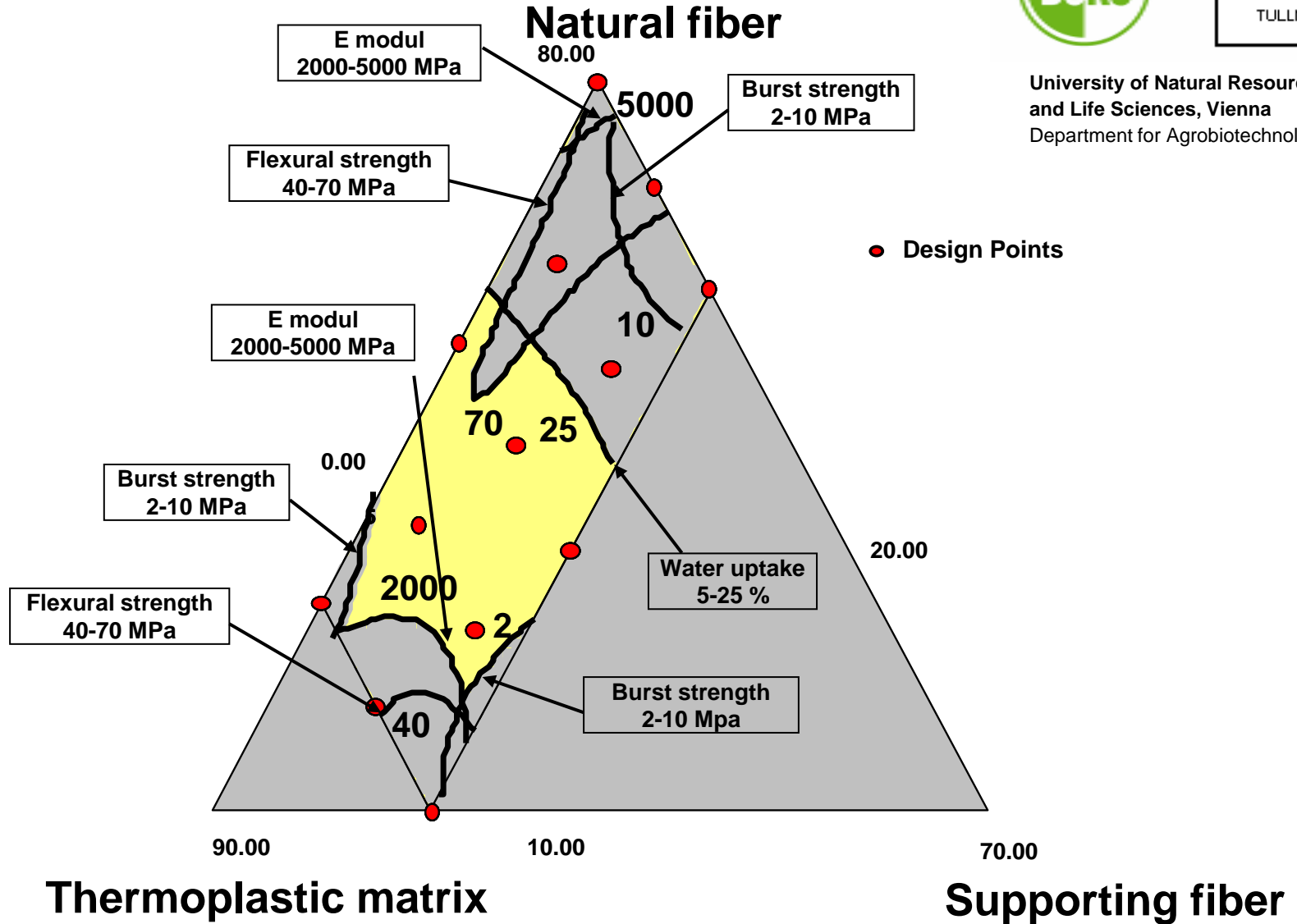
Matrix

Supporting Fiber

Superimposed mixture design plot



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...different natural fibers used

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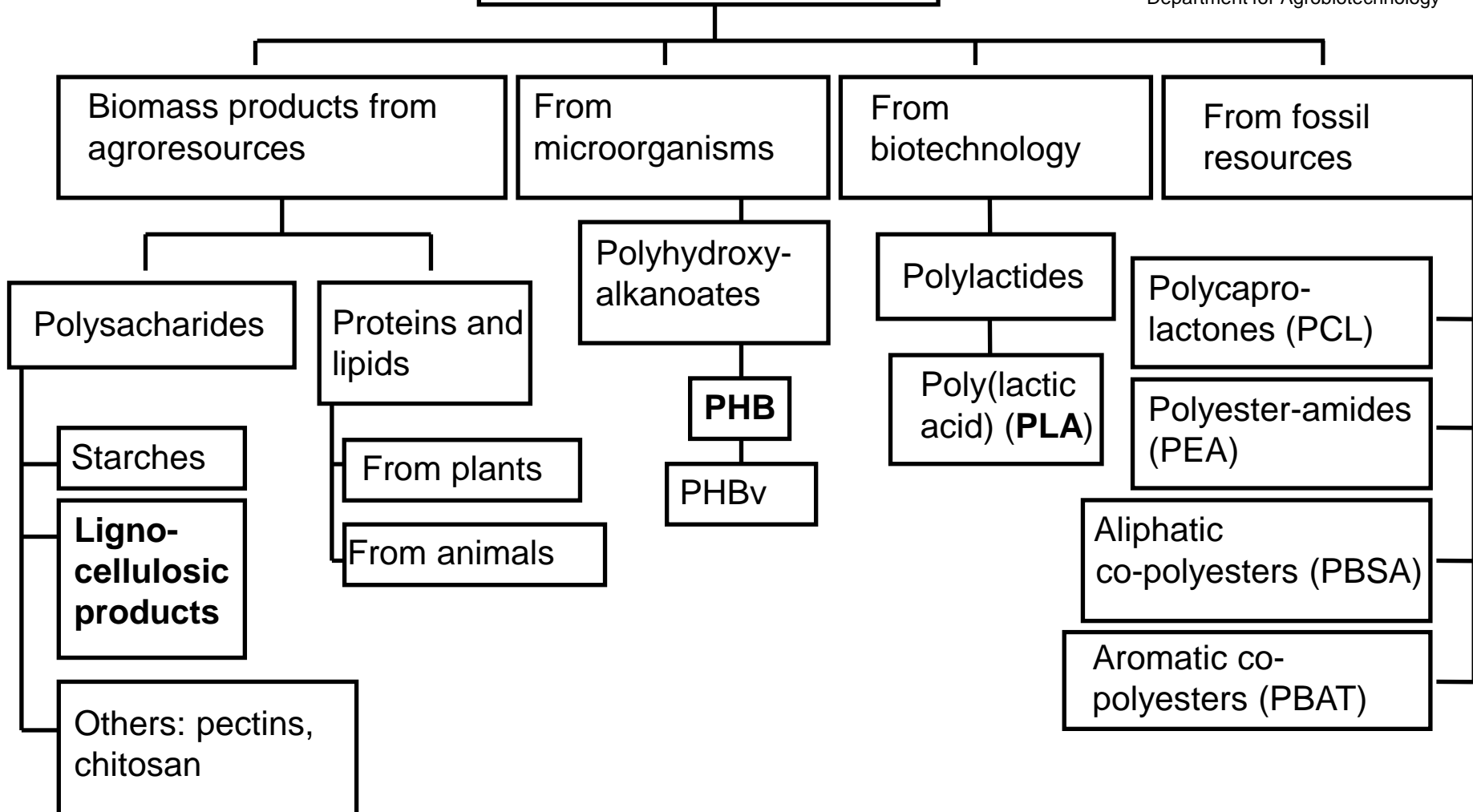
wood, coir, hemp, flax, sisal, straw, reed, bamboo, rice husks, bagasse

....and polymer matrices



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Biodegradable polymers



Extrusion technology



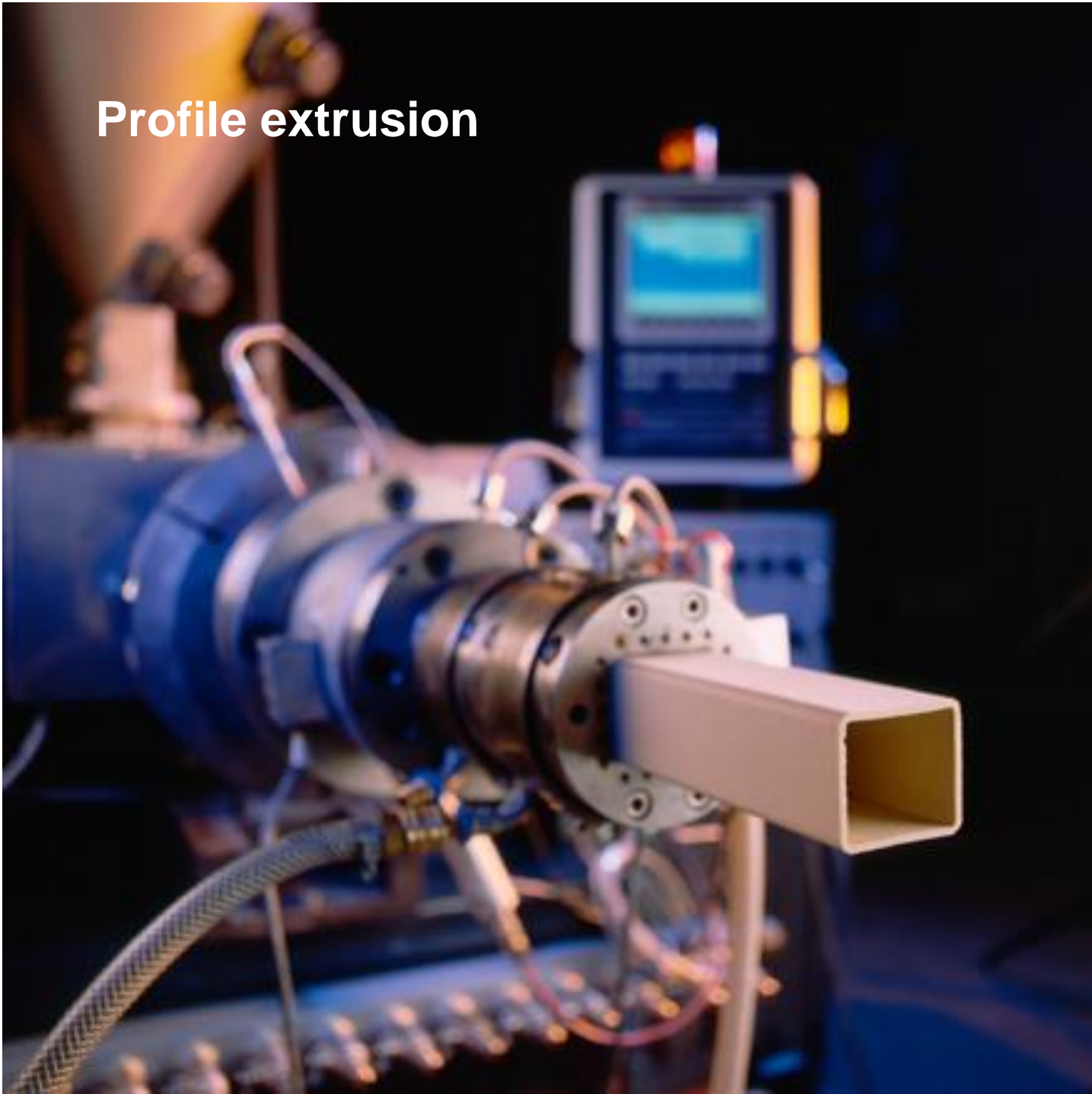
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Conical co-rotating NCT 55 extruder



Maschinen und Anlagenbau Schulz GmbH

Profile extrusion



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Injection molding technology



Engel ES 330/80 HL



Non-Woven



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Air-lay spike system for fibre fleeces



Fleeces from waste materials



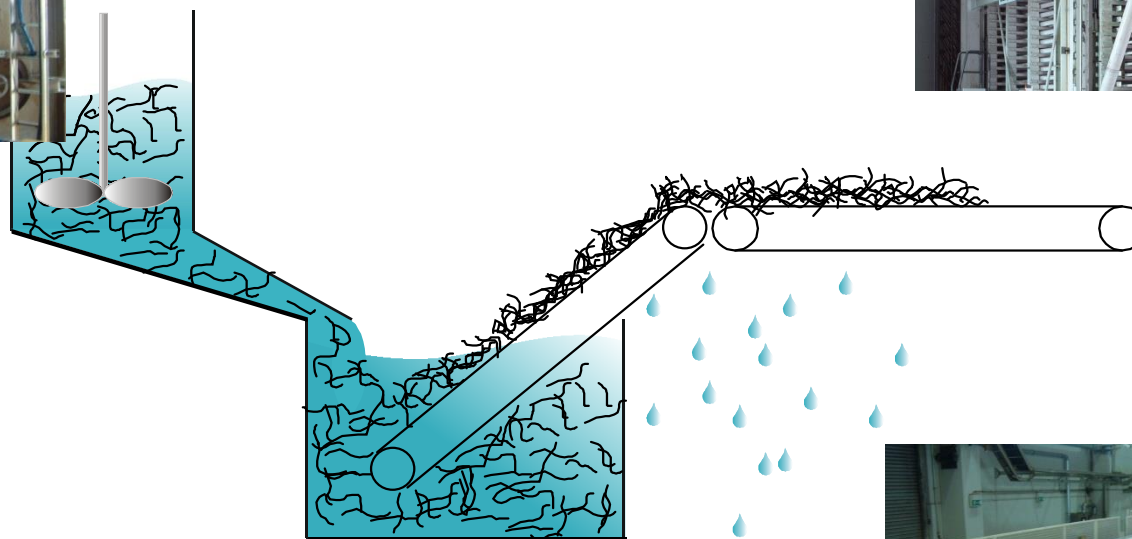
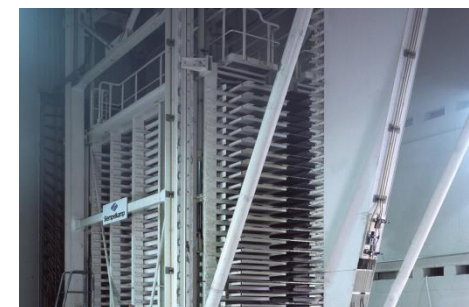
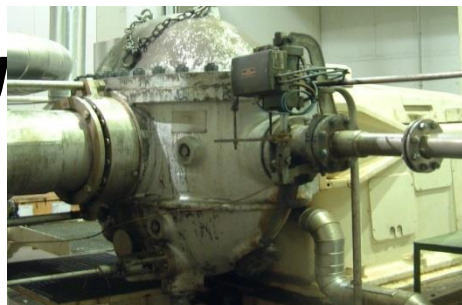
Mechanical entanglement

Expert knowledge in processing



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Wet-laid processing

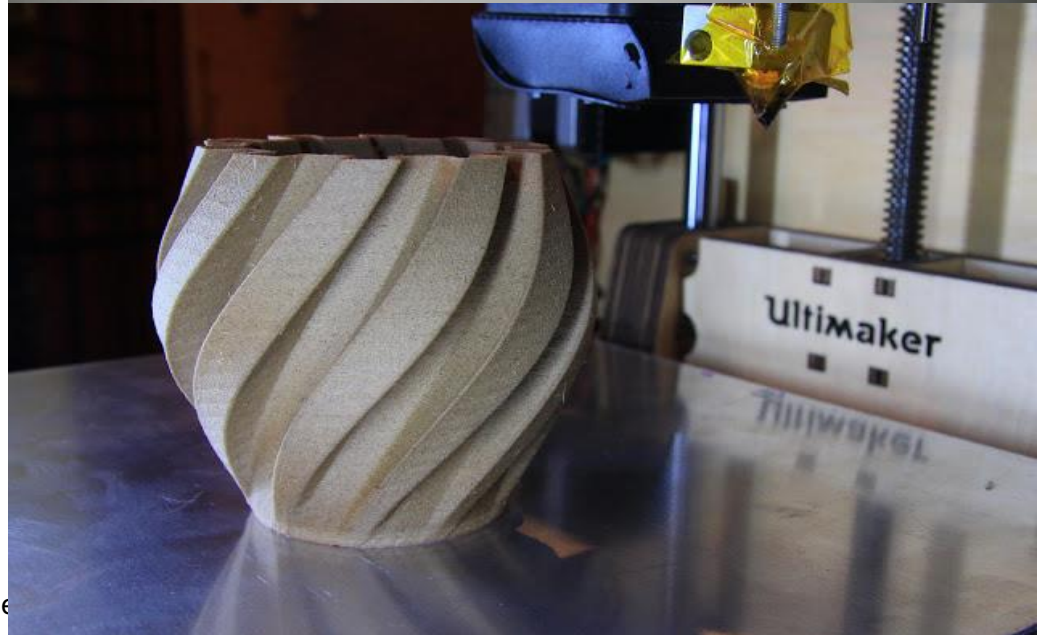


Printing wood - its possible!

Even with treering- like structures



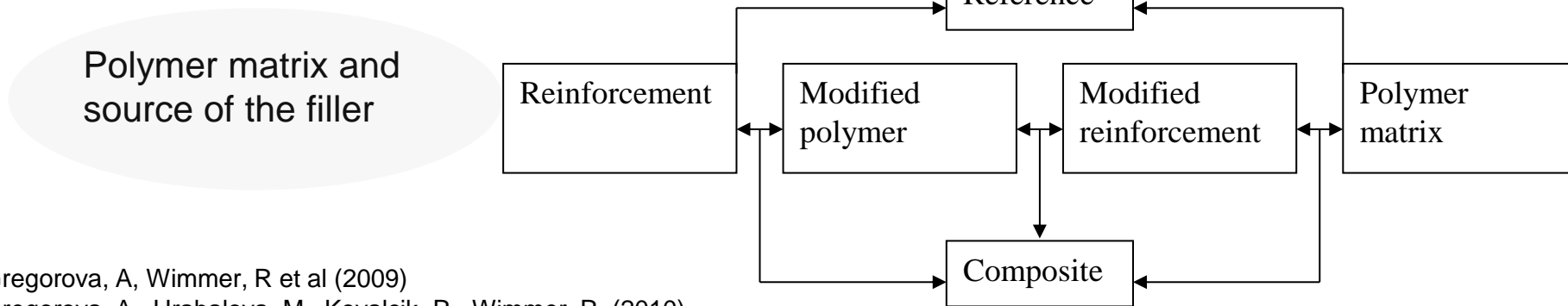
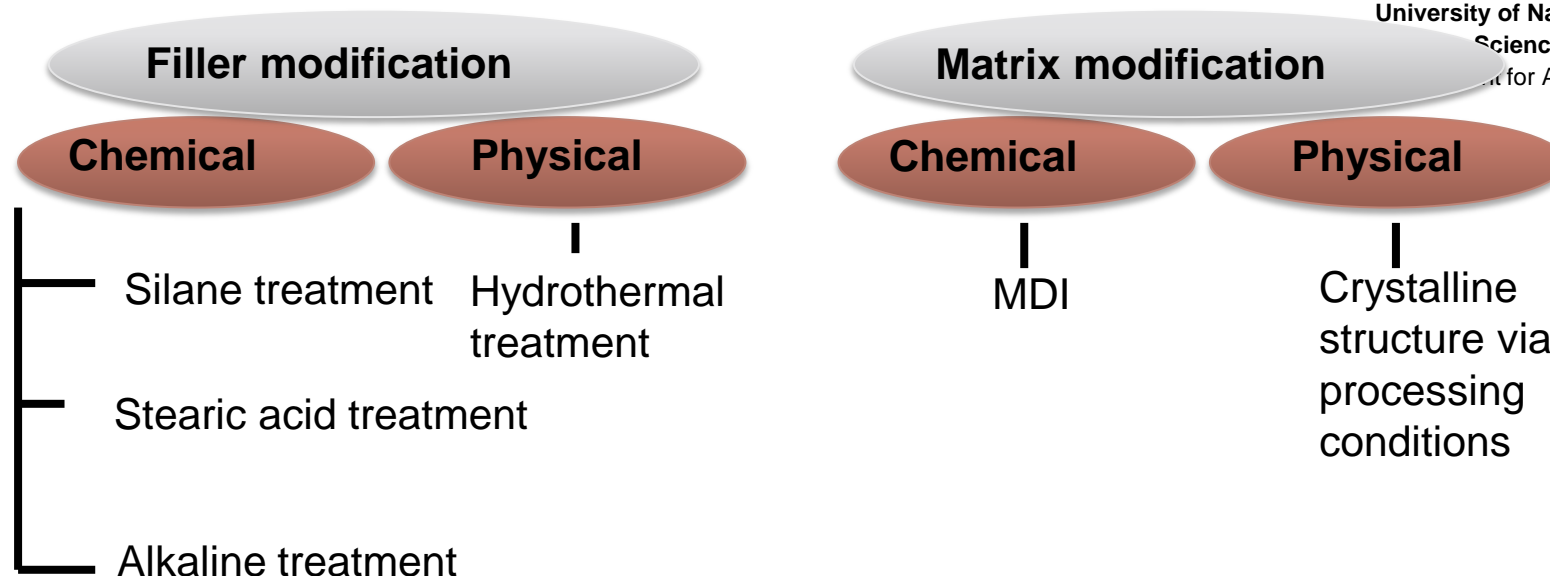
The new type of
„Wood-Polymer-
Composite“?



Improving composite performance



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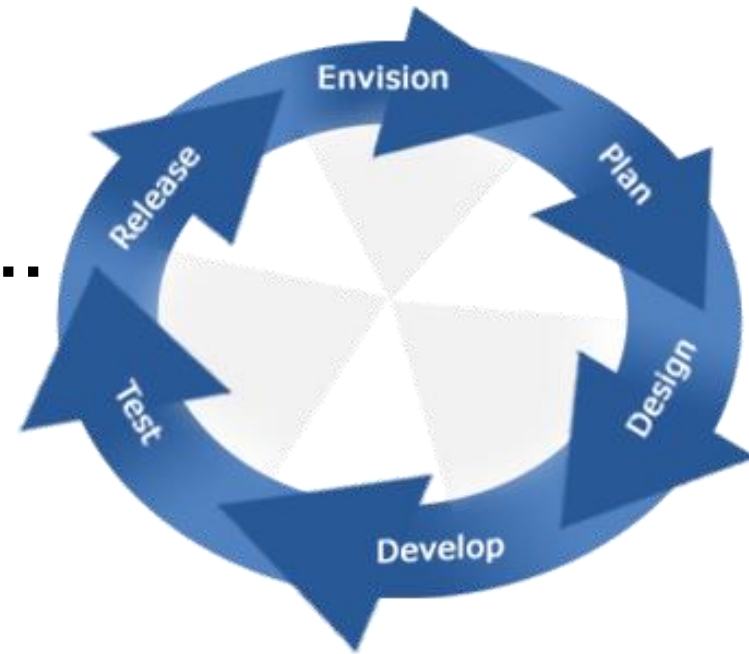


Gregorova, A, Wimmer, R et al (2009)
 Gregorova, A., Hrabalova, M., Kovalcik, R., Wimmer, R. (2010)
 Hrabalova, M. Gregorova, A., Wimmer, R..... (2010)
 and others....



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Product developments ... (examples)



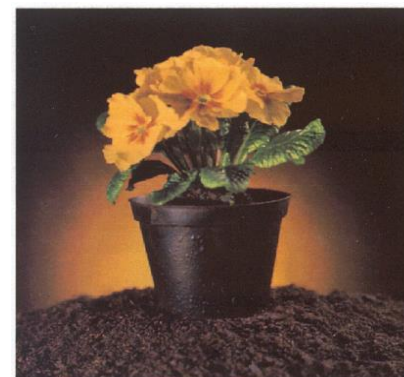


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1995 – product examples



Some still
on the market!



1991

Foamed bio-materials (protein-based, wood)

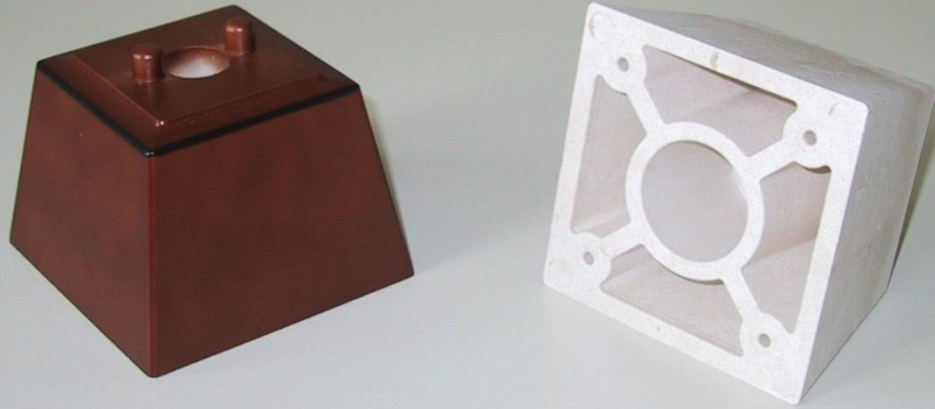


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Breakthrough
still anticipated !

Product examples



- **Fasal 465**
- PS, wood, corn
- Tensile strength [MPa] 24,3
- Flexure strength [MPa] 47,4
- Swelling [%] 1,2
- Impact pending [kJ/m²] 6,1
- Tensile stretch [%] 0,65
- Density [g/cm³] 1,23

- Paintable, polishable



- **Fasal-Prosin 293/6**
- PP, wood, proteins and natural resins

- Tensile strength [MPa] 26,6
- Flexural strength [MPa] 49,6
- Swelling [%] 0,2
- Impact pending [kJ/m²] 3,49
- Tensile stretch [%] 0,90
- Density [g/cm³] 1,19

- Not paintable, dye

Product examples



- **Fasal 621/1**
- PP, wood, corn, natural resins
- Tensile strength [MPa] 19,4
- Flexural strength [MPa] 34,9
- Swelling [%] 0,0
- Impact pending [kJ/m²] 6,05
- Tensile stretch [%] 1,5
- Density [g/cm³] 1,14
- Not paintable, dye



I Resources
ienna
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- **Fasal-Prosin 293/17**
- Biopolymer, wood, protein, natural resins
- Tensile strength[MPa] 11,9
- Flexural strength [MPa] 19,3
- Swelling [%] 0,9
- Impact pending [kJ/m²] 9,92
- Tensile stretch [%] 3,28
- Density [g/cm³] 1,33
- paintable, dye biodeteriable

Materials from Wastes / residual products

9 billion tons of domestic waste / a worldwide plus industrial waste....

What to do with all the rubbish ?

Why not making products out of it?



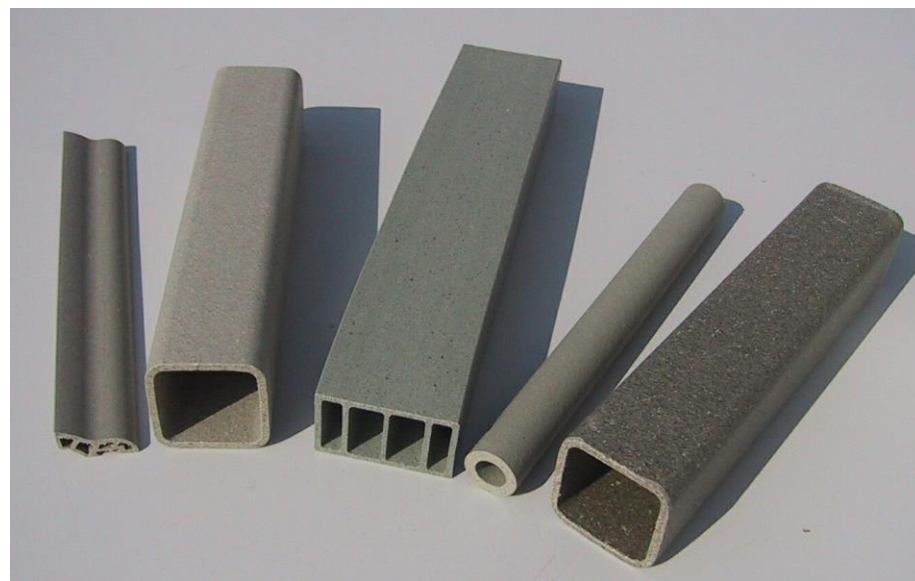
different waste paper types





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De-Inking Paper Sludge → Extruded Products



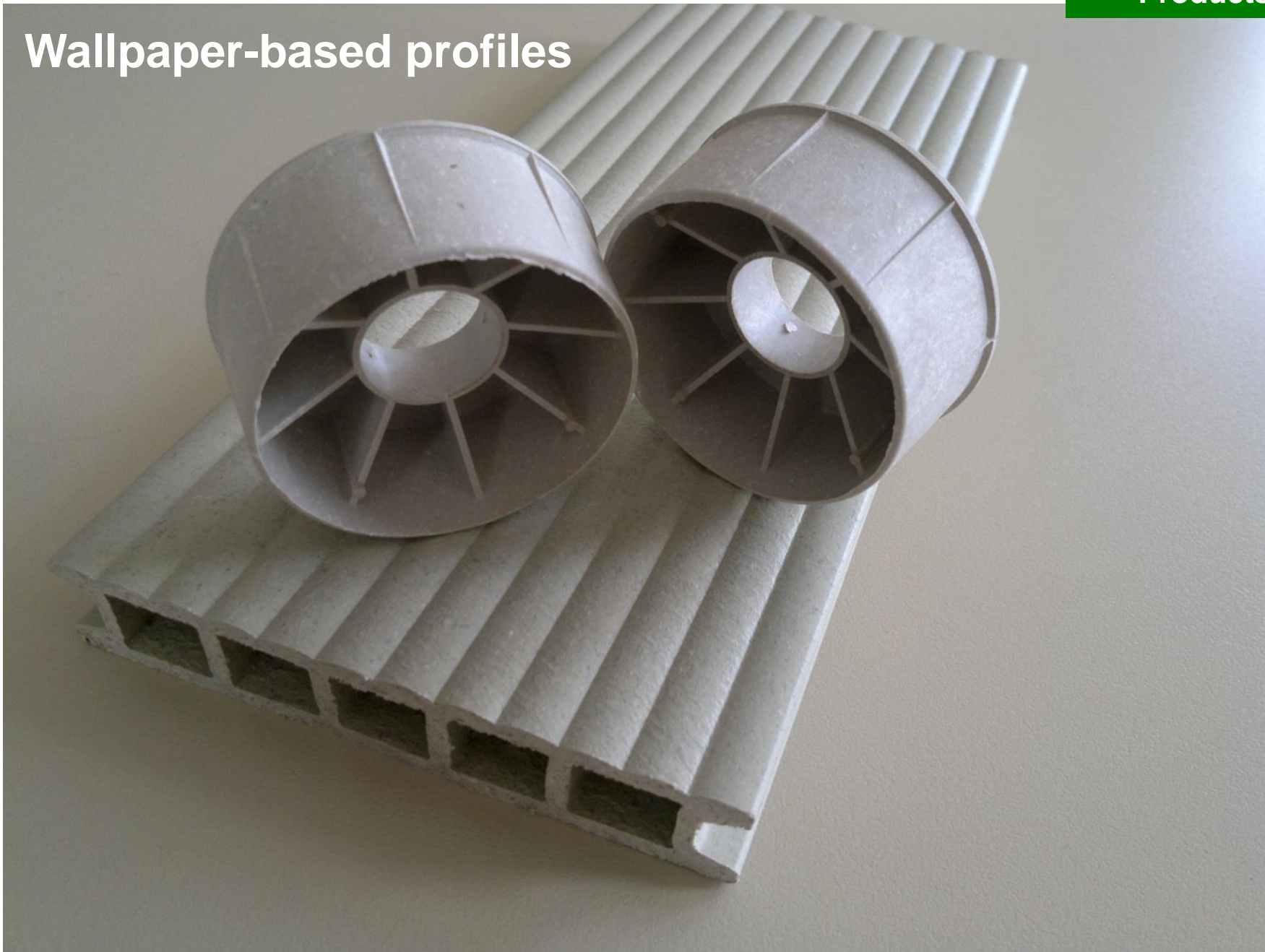
~ 70 % inorganic
~25% cellulose

Innovative materials from waste

- Beverage Cardboard
- Cardboard
- Kraft paper
- Leaflet paper
- Poster paper
- Wallpaper
- Yoghurt Beaker
- Laminated paper
- De-Inking paper sludge



Wallpaper-based profiles



Poster paper-based profiles



- Wallpaper-based profiles
- Beverage-cardboards (tetrapak)
- Yoghurt-beaker waste materials





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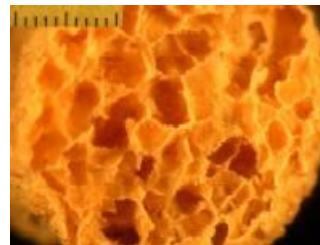
Mechanical properties

Composites with PP as a matrix (50%)

Wood Poster paper Tetra Pak

Flexural strength	45	24	35	[MPa]
Flexural E-modulus	3820	1810	2240	[MPa]
Impact strength	5,6	8	13	[kJ/m²]
Water absorption after 24h	1,5	2,2	1,6	[%]
Water boiling test 2h	3,4	2,6	2,3	[%]

Foamed Products



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Foamed Granules Die-diameter 2 - 3 mm



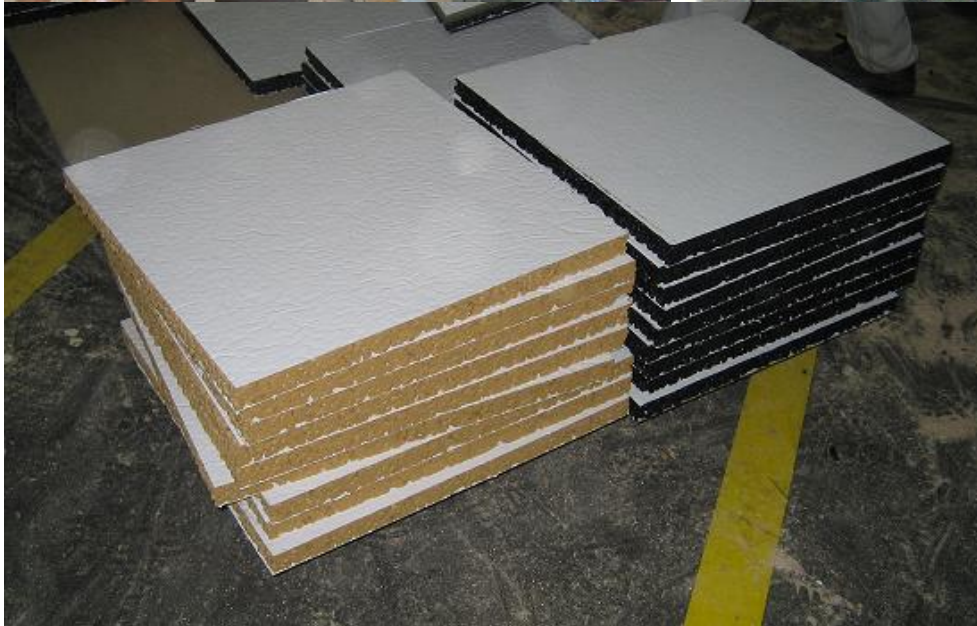
Extruder CM 45 Food



Foamed Products – natural materials and waste



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Non-Woven based wood-fiber materials



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Today:
Up to 15 kg NFRC / car



Non-Woven based wood-fiber materials



Cargo area panels for trailers

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wood / annual plant non-woven resin-impregnated panel



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and markets.....



FASAL: Why competitive ?



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- **extrudable / injectable wood**
- **wood-like haptic and look**
- **properties similiar to wood**
- **renewable**
- **low quality wood used**
- **no /low waste**
- **alternative materials (hemp, flax, straw...)**
- **high strength, MOE; good hardness, density**
- **low swelling**
- **easy to color, paintable, polishable**
- **glueable withough further treatment**

FASAL – why competitive? (cont.)



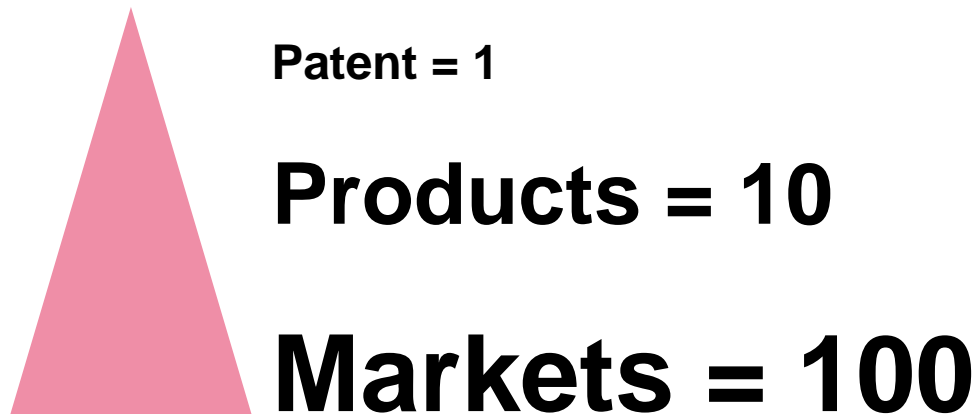
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- **shape stability at higher temperature, no softening**
- **little thermal shrinkage, no excess pressure needed**
- **good acoustic properties**
- **low flammable (class B2)**
- **no splintering**
- **biodeterable**
- **quick loss of integrity with water**
- **recycible (up to 20% added to virgin material)**
- **low cost:**
 - > **Fasal: € 1,05-2,00/kg**
 - > **Fasalex: € 0,59-0,67/kg**
- **patented**



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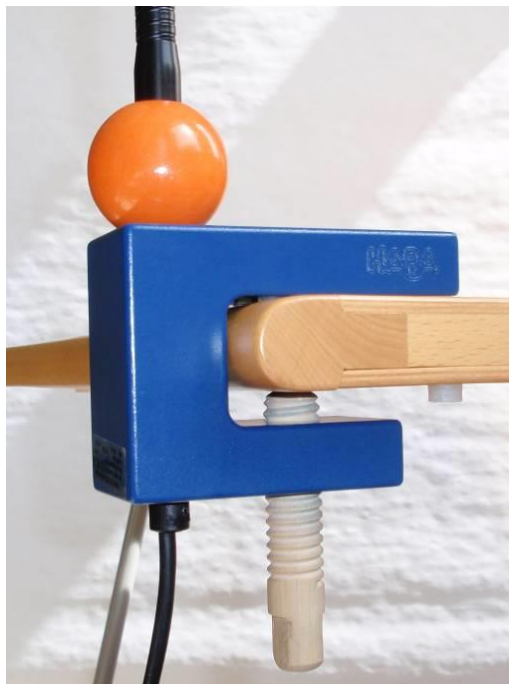
An Inventer can be enthusiastic.....



fasal[®]

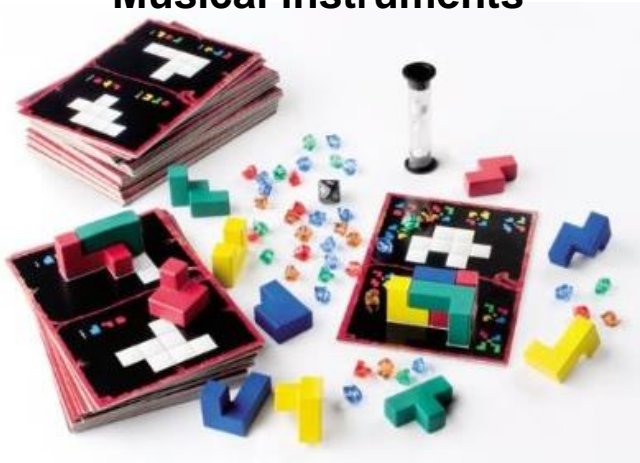
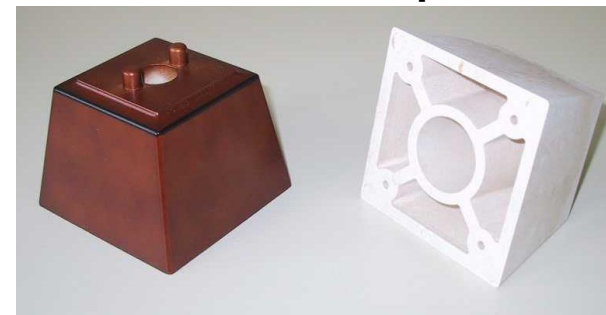


Musical instruments



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Furniture parts



20.06.2013

toys

Toys...growing market for bio-based materials

**Toys**
go green

MATERIAL

Bio-Baumwolle, zertifiziertes Holz,
recycelter Kunststoff – hier dreht sich alles
um umweltfreundliche Materialien.

Organic cotton, certified wood, recycled
plastic – here everything is geared to
environment-friendly materials.

**Toys**
go green

MATERIAL

**Toys**
go green

VERPACKUNG PACKAGING

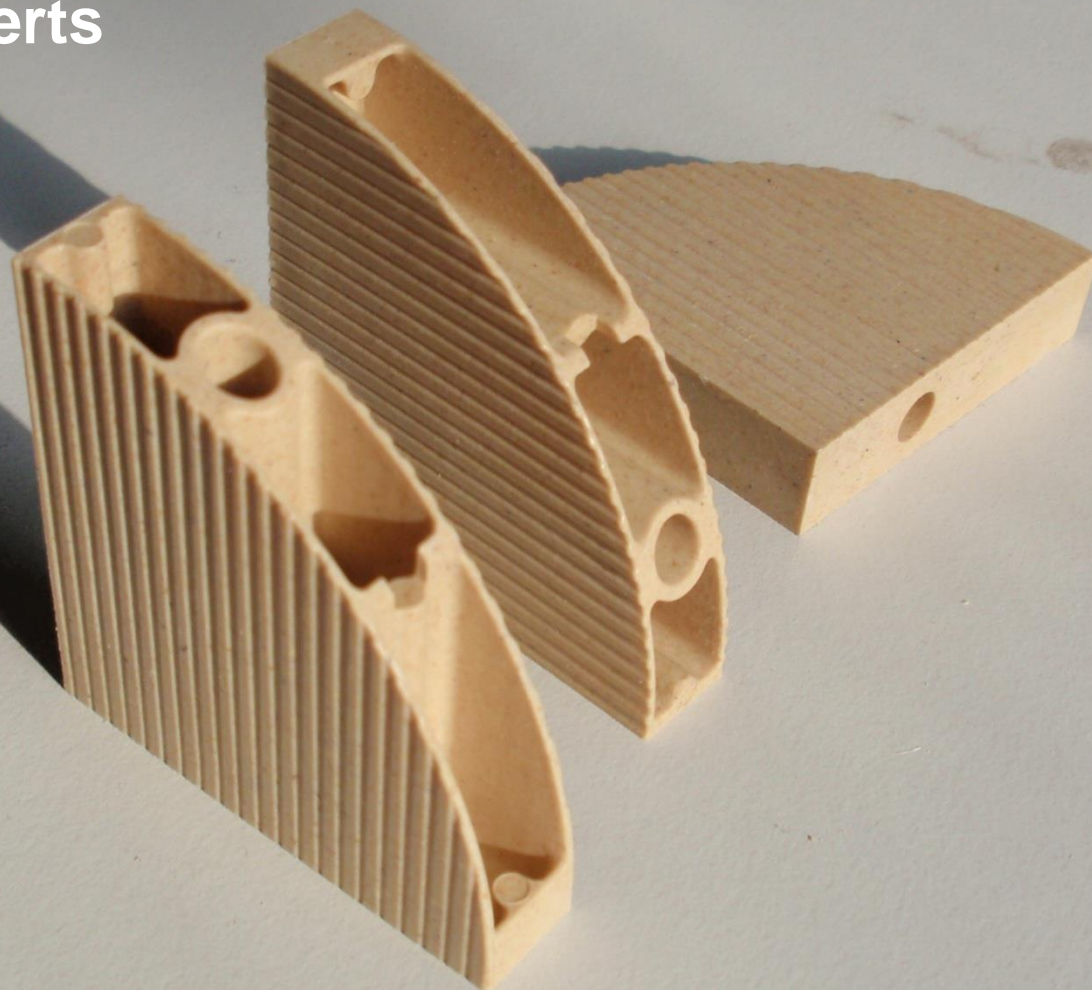
Bestück ab 7.30 Uhr
Anklisten ab 7.30 Uhr







Furniture-Inserts



Hangers

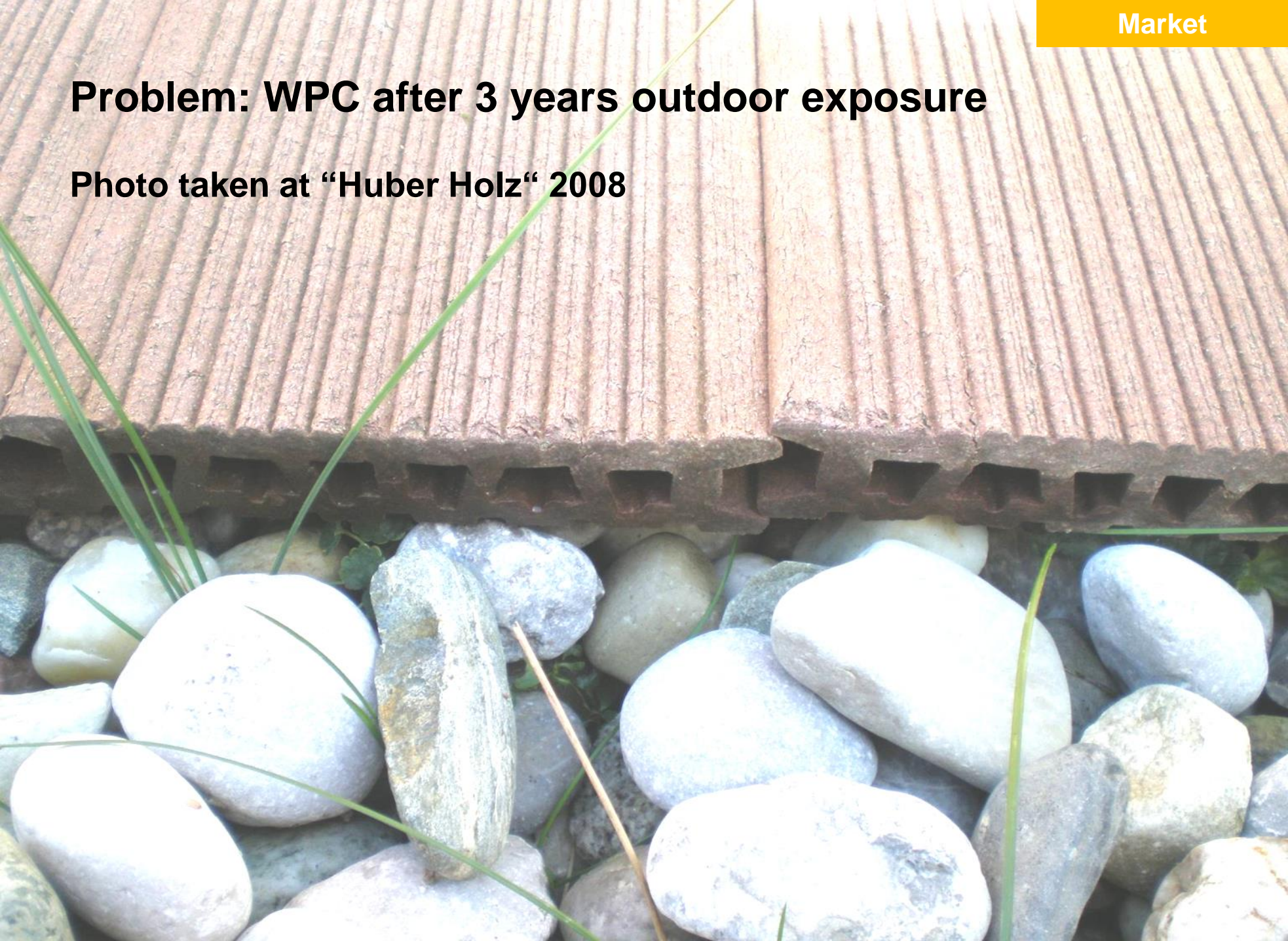


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Problem: WPC after 3 years outdoor exposure

Photo taken at “Huber Holz“ 2008





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Finding more durable WPC

Wood

Natural

Lignin & resin in the matrix

- thermal instable
- brittleness by resin
- silicate causes abrasion

- greying

Paper

Chemical treated

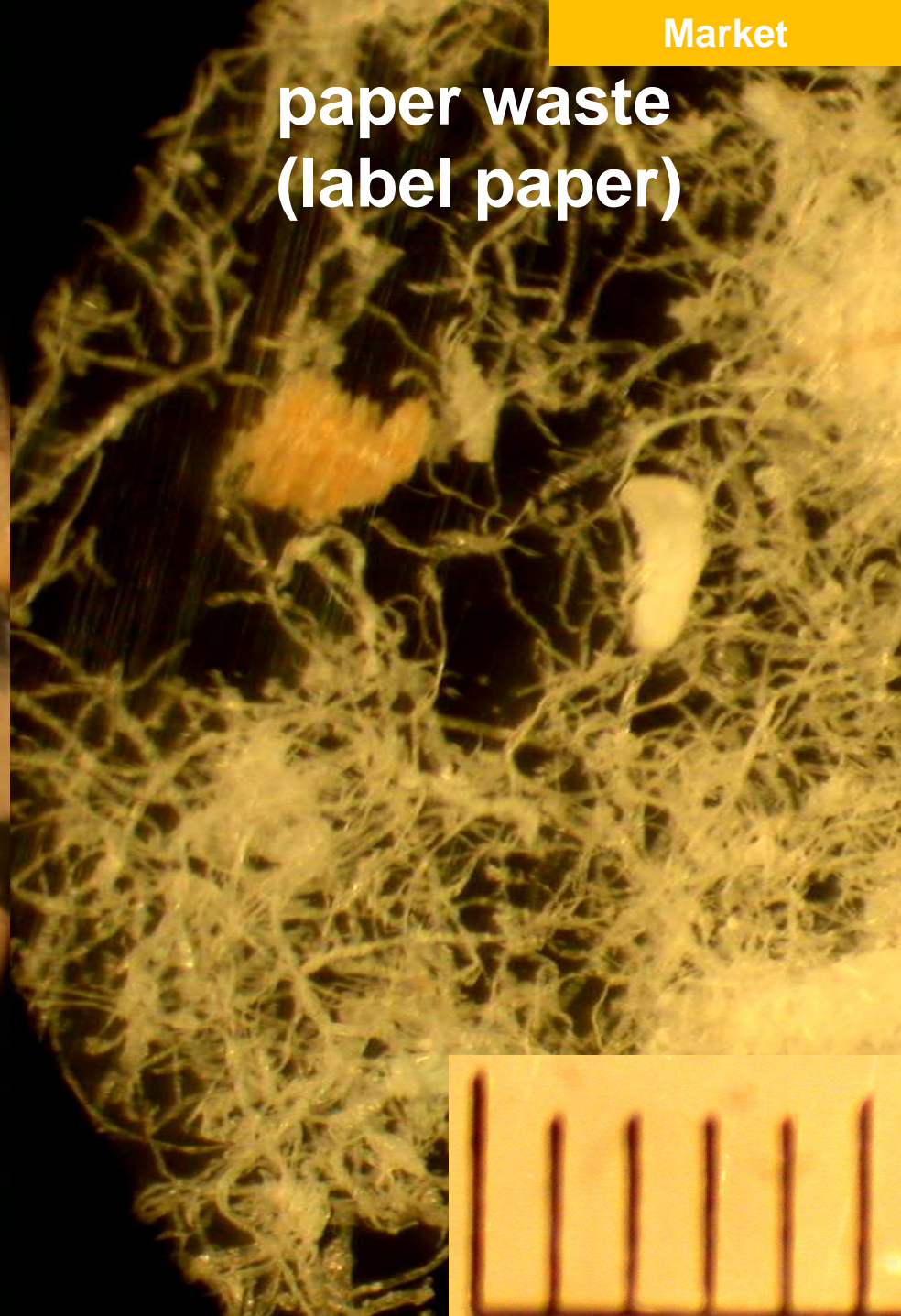
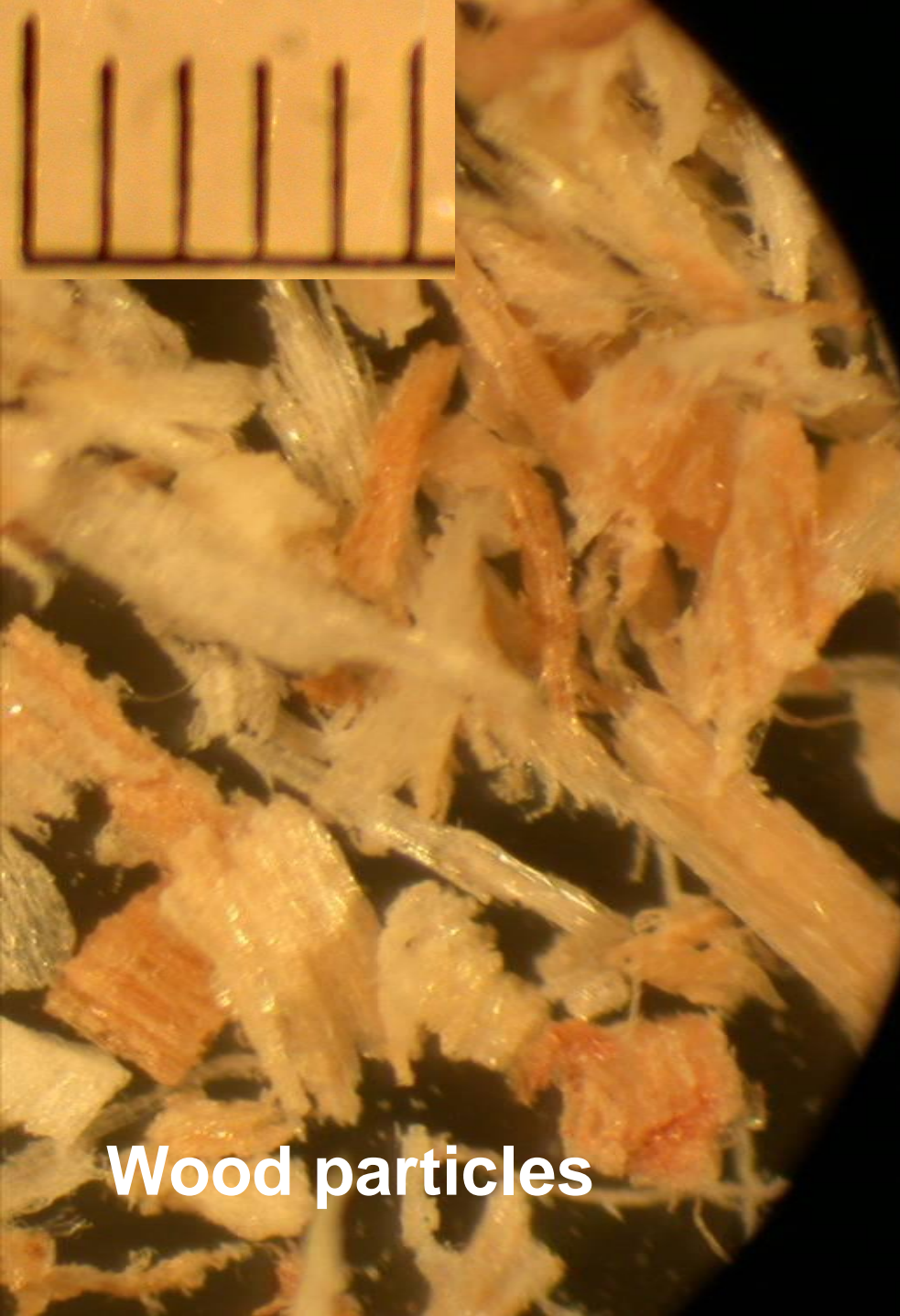
Nearly **no lignin** and resin

- higher processing temperature
- flexible adjustment of properties
- **higher lifetime at processing units**

- **UV - stable**

paper waste
(label paper)

Wood particles





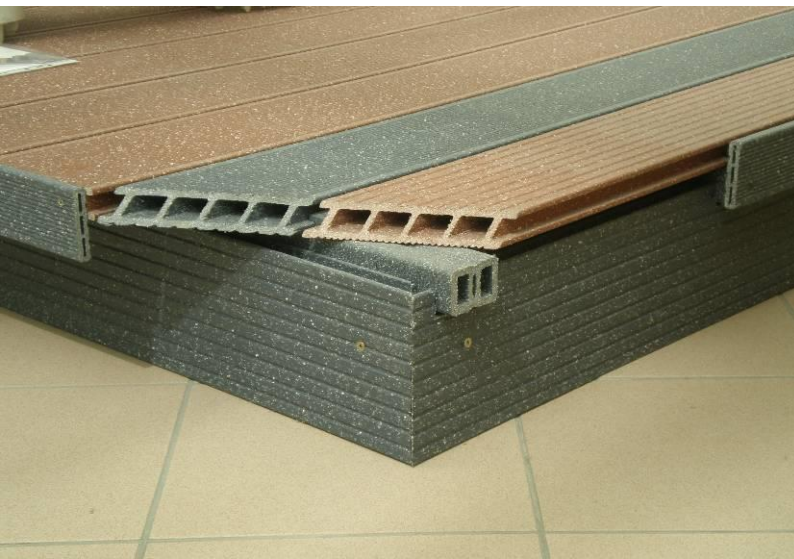
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Research project 2005 - 2009 UPM-Kymmene Cooperation, FI

Product now on the market: **UPM ProFi Deck**

using label-paper from industrial processes,
non-recyclable paper is converted to a high-value product !

Deckings



UPM

Fair in Milano





Based on R&D results...a company invests



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Consequences on „wood“ education



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- Classical wood science & technology education is not enough
- To meet future innovation and market demands, competences are needed in:
 - Polymer Chemistry
 - Knowledge on biopolymers, plant-based chemicals, extractives, resins, additives
 - Polymer Engineering and Processing
 - Non-woven technology



Core messages from this keynote

What is needed ?



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- In Research: bio-inspired materials / bionics, nano (?), fiber and matrix modification, wood-refinery.
- Technology: Knowledge-based production, newly developed or adopted technologies, new products with new materials or/and new processes.
- Education: new teaching profiles and contents.

A photograph of a forest with sunlight filtering through the trees, creating a bright, glowing effect in the center. The text is overlaid on this image.

Thank you for your attention !!

Like to acknowledge.....

Norbert Mundigler

Eva Sykacek, Josef Hintenberger,

Hannes Frech, Wolfgang, Schlager,

Thorsten Bätge, Christian Weichhart

Andrea Ganz, Rudolf Kessler