CELEBRATING 70 Years
Ideas that work

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Developing plant fibre-based products for industrial sectors

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CSIR
Port Elizabeth

Driving Post-Mining Industrial Development through Fibrous Multi-Product Value Chains
May 24th, 2018

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- Overview of CSIR
- Plant Fibre based R & D projects
- Results and Conclusions
- Collaborations
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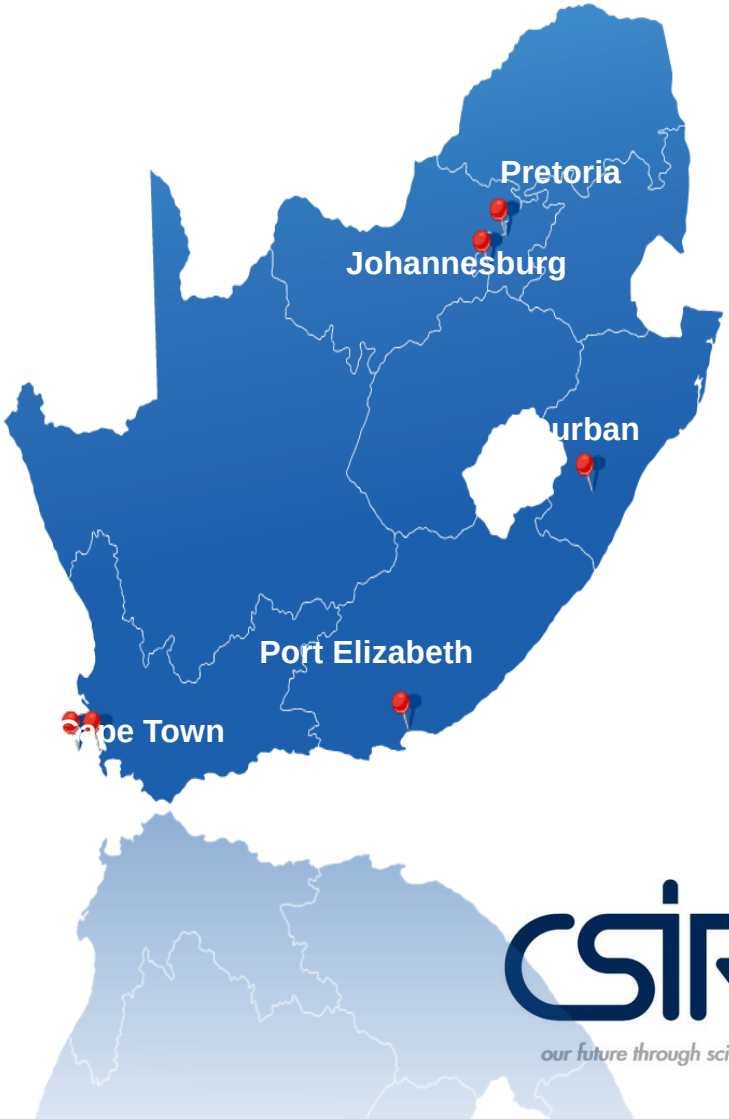
Council of Scientific and Industrial Research (CSIR)

Our core values are EPIC and they are the driving force behind our ability to conduct cutting-edge research and technological innovation to improve the quality of life of South Africans. The CSIR pursues Excellence, celebrates People, personifies Integrity, and welcomes Collaboration.



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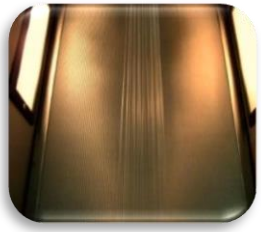
R & D focus in bio-based materials at Polymers and Composites division

ADVANCED COMPOSITES / MATERIALS

BIO-BASED MATERIALS

- BIOCOMPOSITES
- BIOPOLYMERS
- BIONANOCOMPOSITES
- BIO-BASED FLAME RETARDANTS
- BIO-BASED COATINGS





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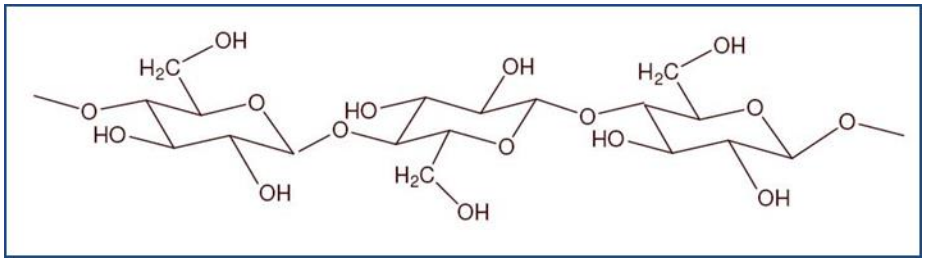
Why Natural Fibres ?

- High specific strength
- Low cost
- Weight Reduction (minimize up to 30%)
- Positive environmental impact
- Non-abrasive and non-hazardous
- Safer crash behaviour and good acoustic properties
- Worldwide availability

Maya Jacob John and Sabu Thomas , Carbohydrate Polymers 71, 3, 343-364, 2008

Challenges in natural fibre composites

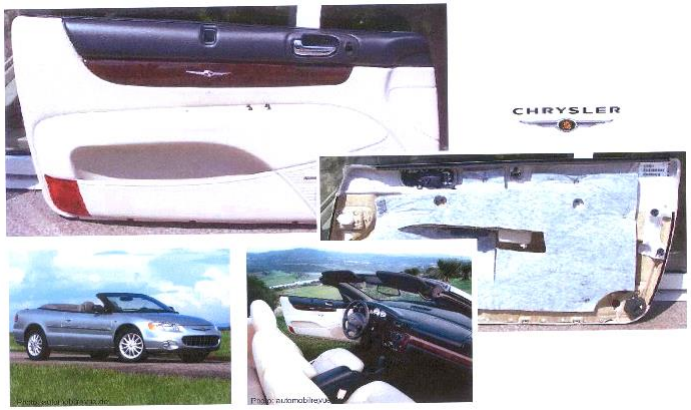
- Hydrophilic nature of natural fibre
- Processing problems with high temperature plastics

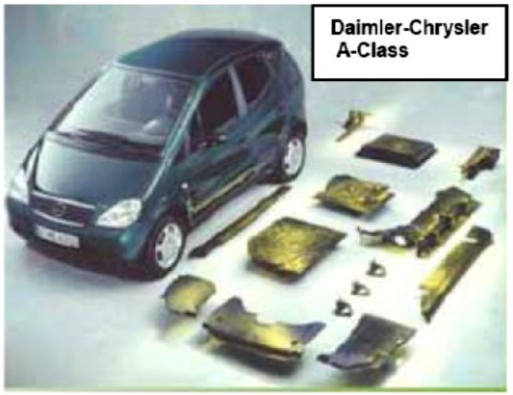


Maya Jacob John, Rajesh D. Anandjiwala., Composites Part A 40, 442–448, 2009

Applications of Natural Fibre Composites

VOLVO C70





Natural fibres in South Africa

- World's third largest bio-diverse country
- Indigenous fibres (wild silk)
- Wool fibres (cashmere and mohair)

Nonwoven Technology

- Needle punching
- Hydro-entanglement
- Chemical bonding
  - Advantages
    - Aspect ratio
    - Strength and flexibility

Nonwoven Line at CSIR

Project 1 : Aerospace

- Project in collaboration with AIRBUS
- Development of natural fibre reinforced composites for secondary structures in cabin and cargo areas in aircrafts
- Phase 1 Thermoset matrix
- Phase 2 Bio-based polymer matrix

Panel from woven flax fabric and thermoset resin

Key Criteria in Aircraft Performance

- Lighter
- Faster
- Environmental Friendly

Main Challenges

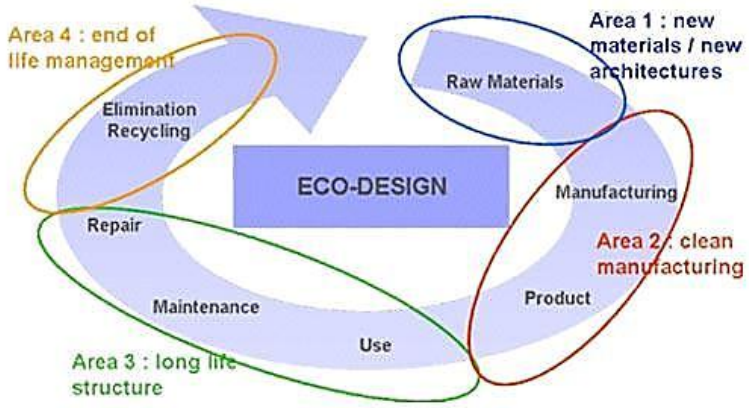
- Maintain balance between strength and flame, smoke and toxicity standards as required by Federal Aviation Administration (FAA) and AIRBUS

- Maintain weight as required by AIRBUS

Why bio-based materials in aerospace?

- Energy and environmental concerns
- Lightweight – an overriding consideration in transportation sector
- Escalating cost of petroleum derived materials and depleting resources
- European Union's 'Clean Sky' Initiative

- REACH Regulations
- Importance of ‘carbohydrate economy’ realisation on economic potential of renewable resources



Aircraft Requirements

- Flame, Smoke, Toxicity Standards
  - Cone calorimeter
- Mechanical Requirements
  - 4-point bending test
  - Peel test
- Weight

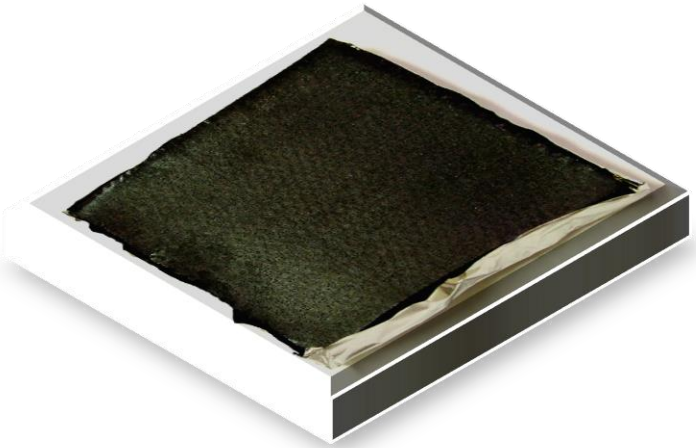
EXTREME CONDITIONS OVER A LONG PRODUCT LIFE

Surface of panels after cone calorimeter testing

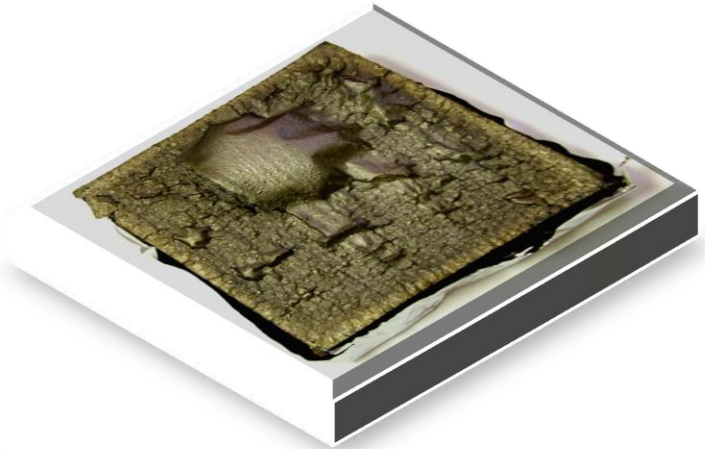
Panel from woven flax fabric thermoset resin

Flame retardant panel No flame retardant

Surface of panels after cone calorimetric testing



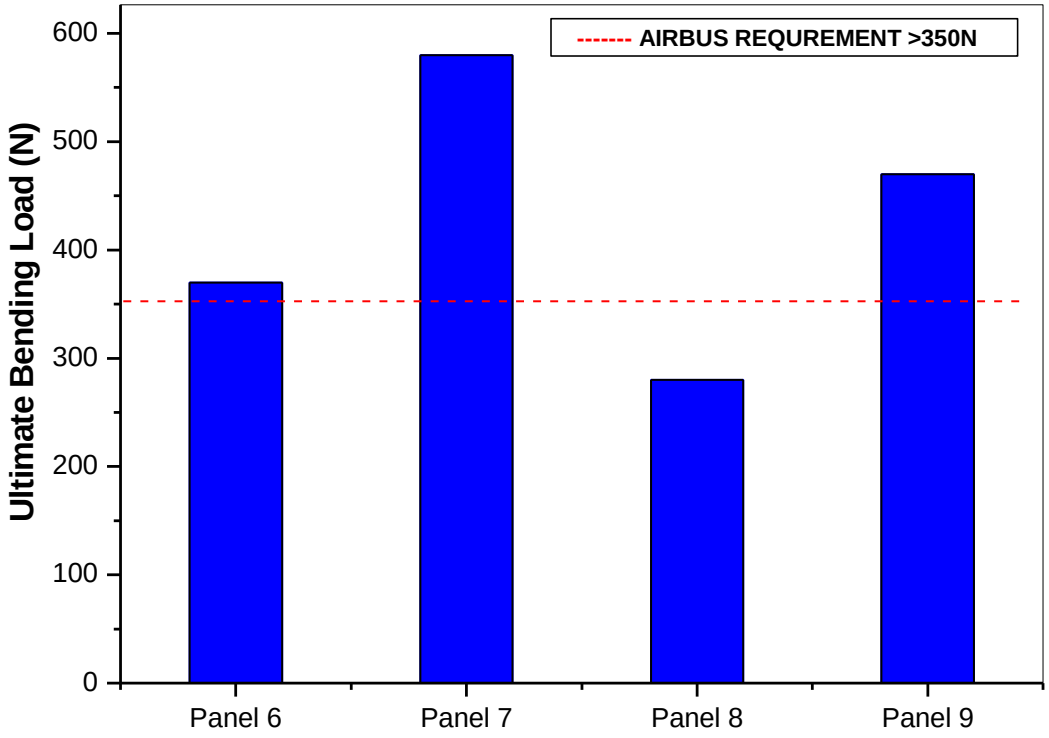
Panels with FR

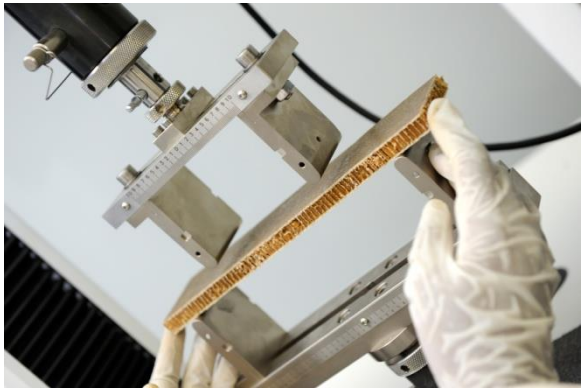


Panels with FR coating

Panels with FR coating

Flexural testing, AIRBUS, Bremen





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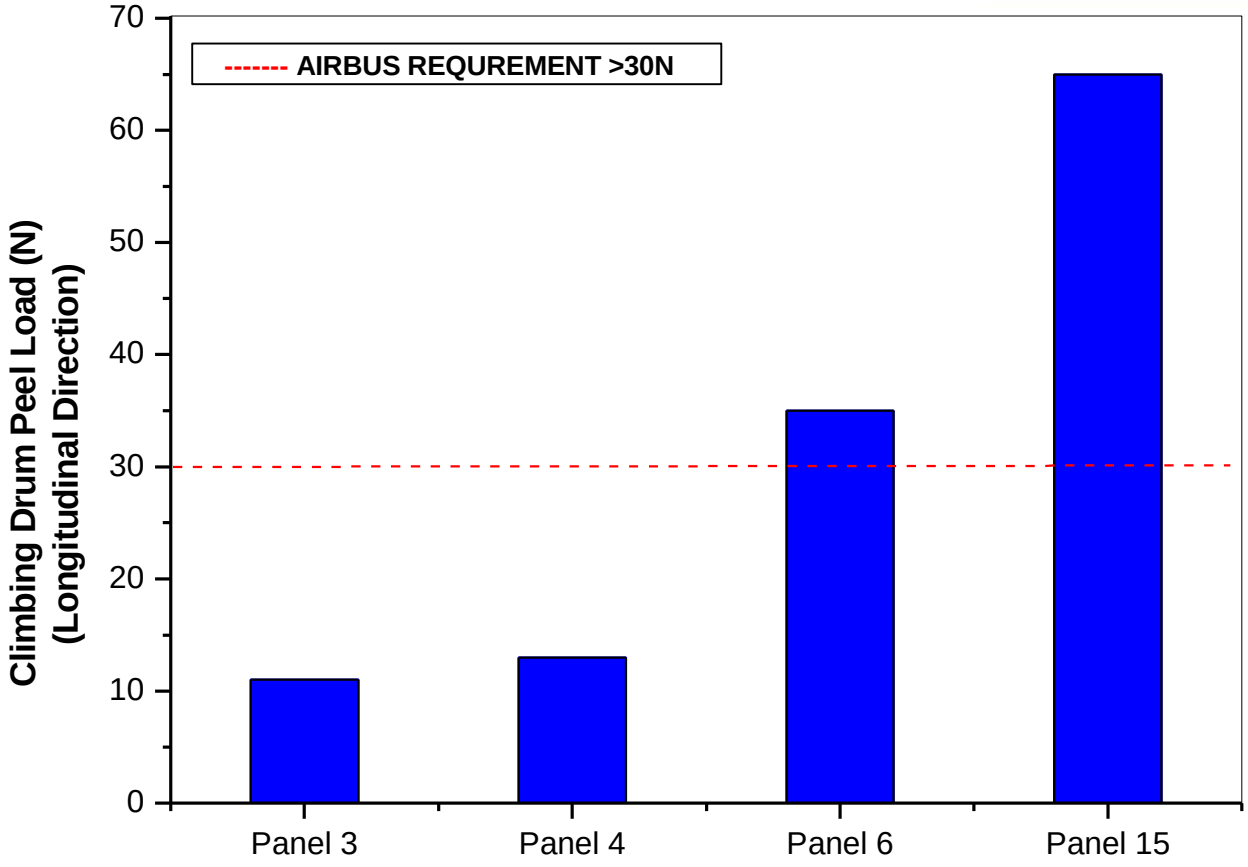
Peel test, AIRBUS, Bremen



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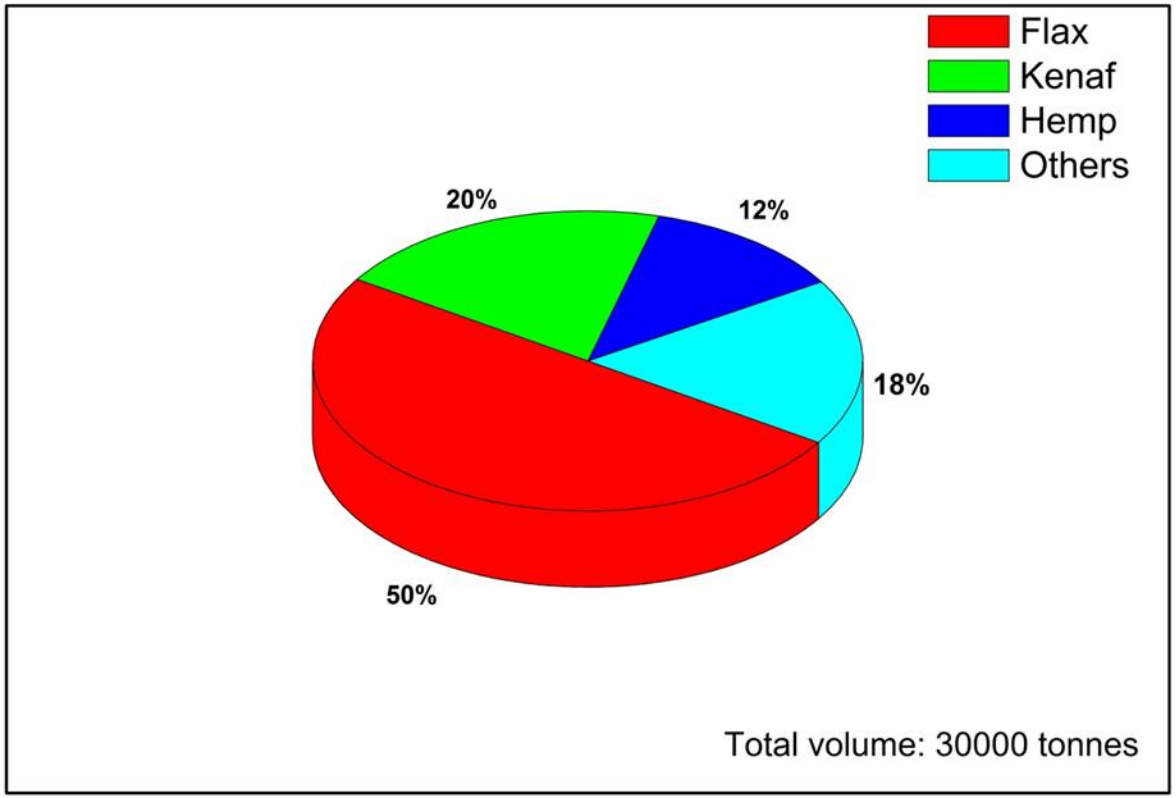
Conclusions

- Natural fibre based sandwich composites –promising materials in aerospace applications
- Flame retardant treatment successful in complying with FAA requirements
- Establishment of fire testing facility at CSIR

WO2013/084023 R. Anandjiwala, S. Chapple, M. John, H-J Schelling, M Doecker, B. Schoke, "A Flame-proofed Artefact and a Method of Manufacture Thereof" (2013).
US 9,796,167 R. Anandjiwala, S. Chapple, M. John, H-J Schelling, M Doecker, B. Schoke, "Flame Retardant Bio-based panels (2017)

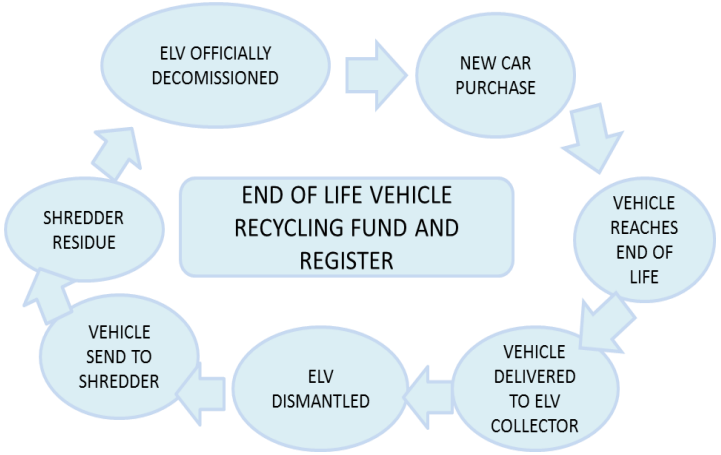
Natural Fibres in European Automotive Industry 2012



Dammer L. et al. Market Developments of and Opportunities for biobased products and chemicals. Dec 2013

Legislations

- Waste generated in transport sector : 8-9 million tonnes /year
- End of life vehicle directive – regulates the environmentally friendly disposal of end-of-life vehicles (ELVs) for the re-use, recycling and recovery of vehicles and their components.
- EU - ELV directive – 95% reusable and recyclable by 2015
- Japan – ELV directive – 95% reusable and recyclable



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Fuel economy

US

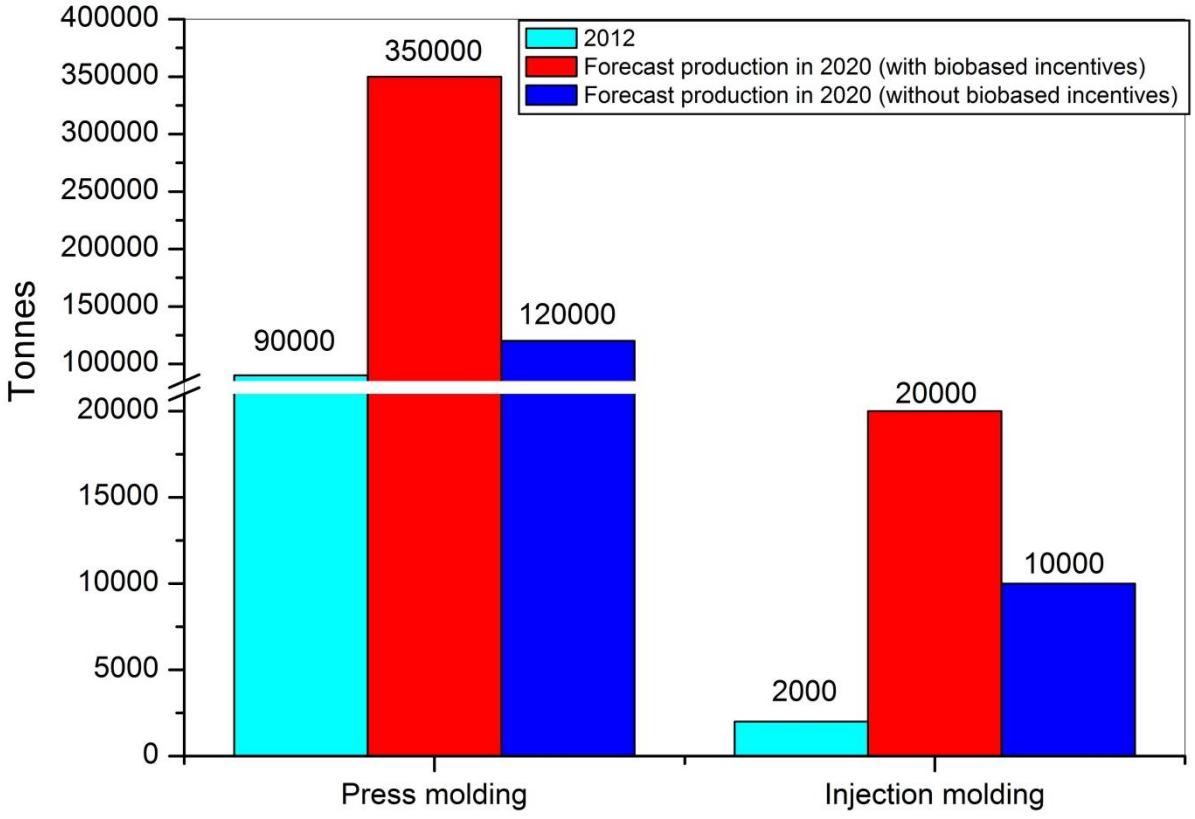
- Legislations relating to fuel economy of cars where each manufacturer has to comply with corporate fuel economy standards (CAFE standards)
- Avg fuel economy by 2025 - 22.5 km/litre

EU

CO_2 emissions values

- 2015 - 130g/km
- 2020 - 95g/km

Production of natural fibre composites for automotive in 2012 and forecast in 2020

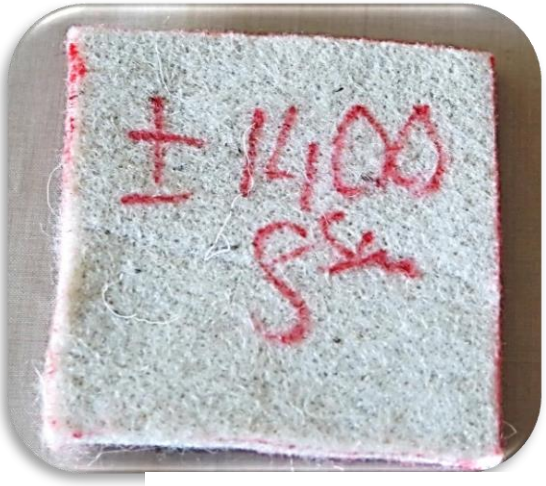


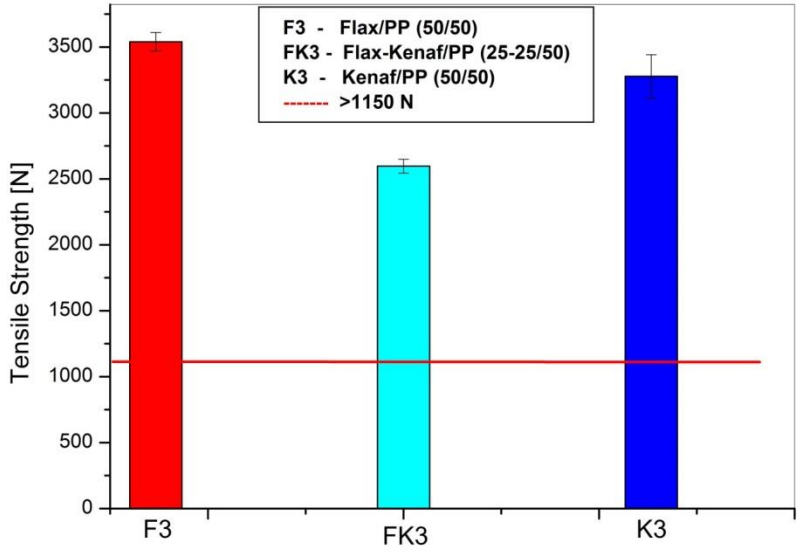
WPC/NFC Market Study 2014-19; www.bio-based.eu/markets

Project 2: Interior trim structures

- Develop natural fibre based composites for use as interior trim structures in transport sector
- Automotive sector – Contributes to R 3.4 bn to SA's GDP
- Local content 35-40 %
- APDP program - Increase local content to 70%

Mechanical testing





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Project 3: Beneficiation of post-harvest agricultural residues

- Develop value added biobased products from agricultural waste residues - maize stalks and sugarcane bagasse

- Benefits of agrowaste
  - Abundantly available
  - Renewable feedstock for the production of novel bio-based products
  - No competition with food crops

South African Scenario

Maize

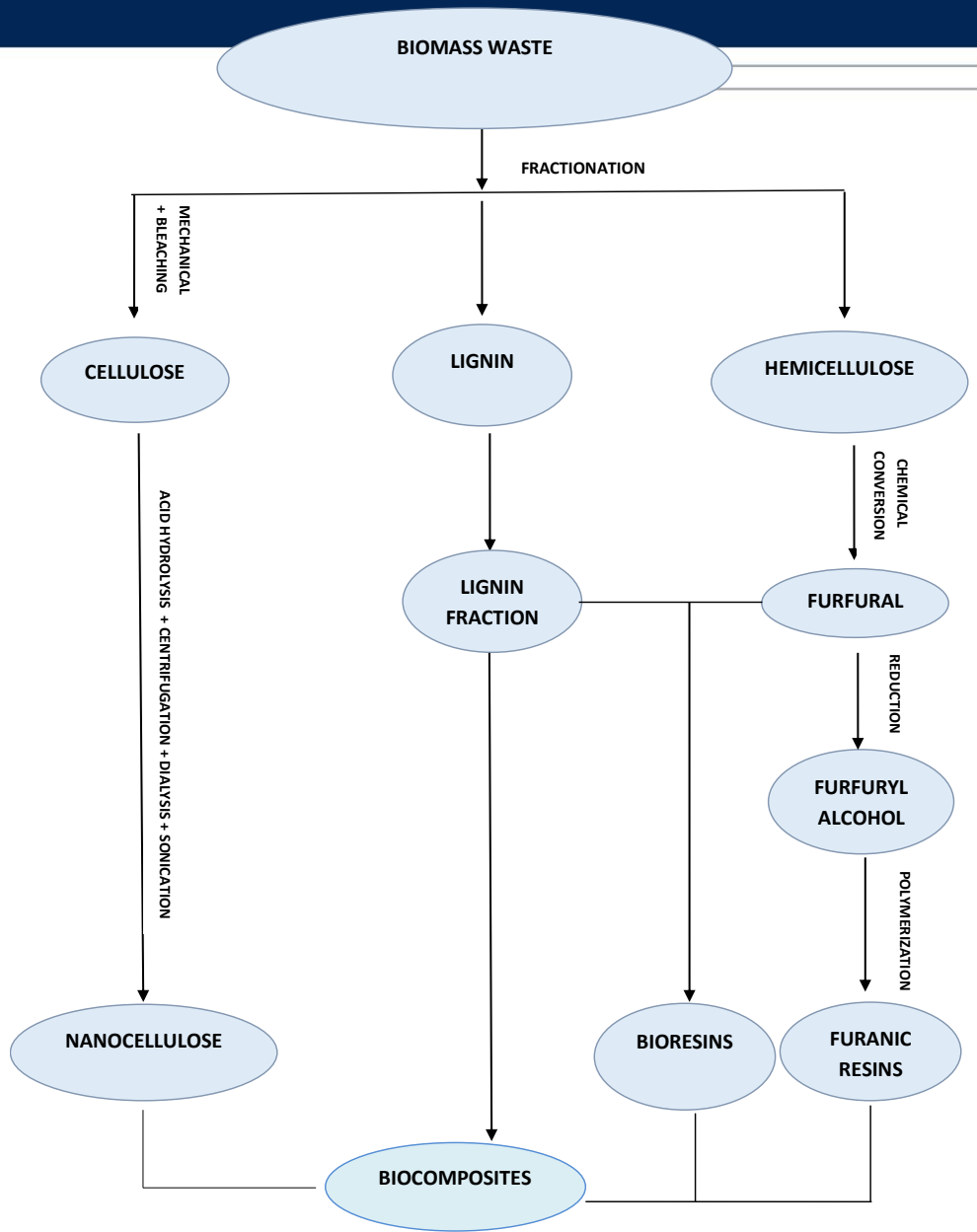
- South African maize industry largest in Africa
- Annual production is ~ 8 million tonnes in 3 million hectares of land
- Waste comprises of cobs, leaves and stalks

Sugar cane

- 14 sugarcane milling companies
- Bagasse – Fibrous waste ~ 3 tons / 10 ton of crushed sugarcane

www.biomass pellet and www.gy research groups

Lignocellulose to Bio-based Products



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Cellulose nanopaper

Collaborating partner: Lulea University of Technology Sweden

Samples	Tensile strength (MPa)	Tensile modulus (GPa)	Strain at break (%)
Micropaper	3.28 ± 0.27	0.2295 ± 0.057	1.57 ± 0.058
Nanopapers prepared from CNCs	32.77 ± 1.7	4.325 ± 1.4	1.6 ± 0.46
Nanopapers prepared from CNFs	95.56 ± 2.7	8.759 ± 0.79	2.325 ± 0.25

- High strength and modulus
- Transparent
- Applications in packaging

A Mtibe, Linganiso L., M John, Mathew A.P, Oksman K.,Carbohydrate Polymers 118 1-8 2015

Bionanocomposites
Nanocellulose – Polyfurfuryl alcohol

Furfuryl alcohol → P-toluene sulfonic acid → Acidified FA → 2% CNW → Acidified FA +CNW mixture → 50° C/5 days, 100° C/1 h, 160° C/1 h → **PFA composite**

- Highly thermally stable
- Flame retardant
- Applications in automotive and aerospace sector

Asanda Mtibe, Yanga Mandlevu, Linda Z. Linganiso , and Rajesh D. Anandjiwala, J. of Biobased Materials and Bioenergy, 9, 1-9, 2015

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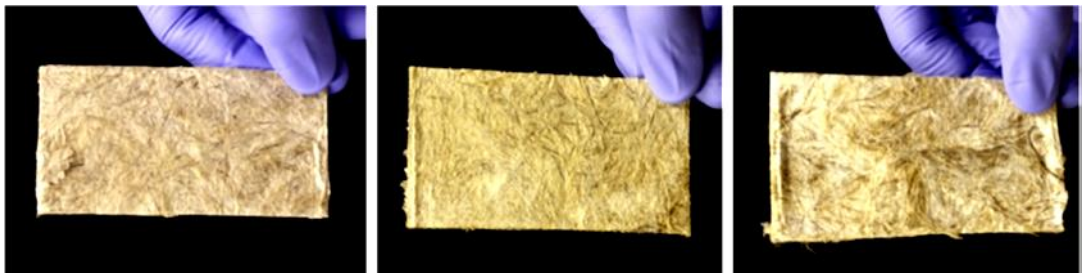
Nanocellulose binders

- Collaborating partner: University of Vienna, Austria
- Coating of natural fibre nonwovens with nanocellulose suspension
- Nanocellulose forms network throughout natural fibres



Hemicellulose based products for packaging applications

- Xylan blends with natural biopolymers
- Solvent casting
- Xylan-alginate films

Xylan-alginate films

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New Scientist 1997

“Cars that grow on trees”
S.Hill

Eindhoven University, 2018

“World’s first circular car – NOAH”

Collaborating Institutes/Programs

- University of Vienna
- Lulea University of Technology, Sweden
- Stockholm University, Sweden
- Mahatma Gandhi University, India
- Universite of Lille, France
- ICT Fraunhofer, Germany
- COST MP1105 – Sustainable flame retardants
- COST FP1405 – Active and intelligent fibre based packaging
- COST FP1306 – Valorisation of lignocellulosic biomass

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- Department of Science and Technology (DST), South Africa
- National Research Foundation (NRF)
- AMTS (Advanced Manufacturing Technology Strategy)
- Nonwovens and Composites Research Group, CSIR
- DST Waste RDI program

Thank you

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