The Use of Natural Fibers in the Automotive Sector: The Case for Volkswagen of Brazil

Salvador, Bahia, May 28

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RESIDUALL

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HOMAGE TO Wilson Andrade

- In 2018, we organized ISNaPol – International Symposium on Natural Polyemers, a very technical event covering natural polymers and fibers.
- Mr Wilson,should receive our homage but could not attend it due to the truck drivers strike!
- Why we choose him: NOBODY IN BRAZIL and maybe in the world, MADE MORE FOR NATURAL FIBERS, promoting fibers technically and commercially!

My life respect and friendship Wilson

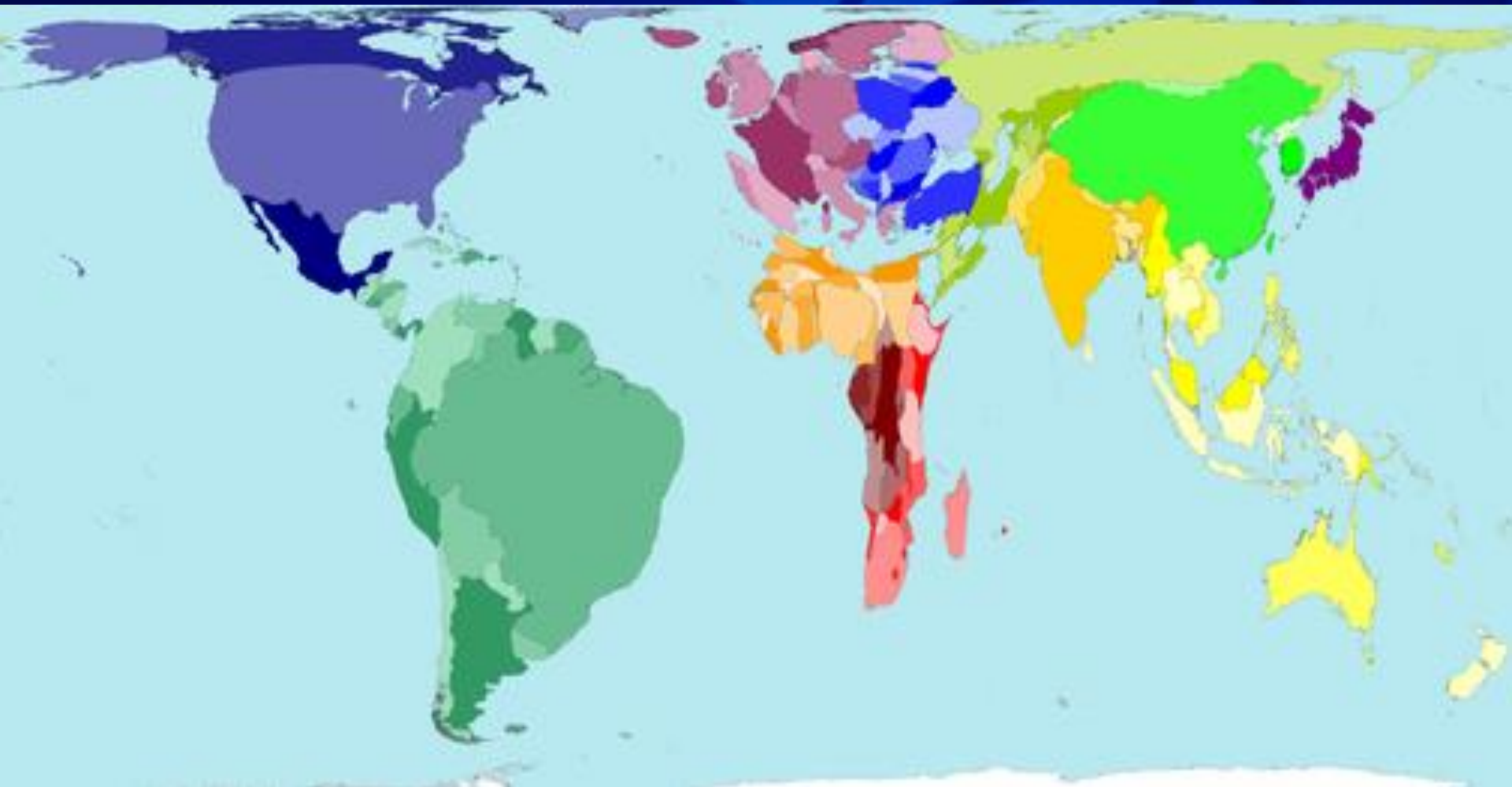
Research Areas at RESIDUALL

- In Vitro cultivation of crop fibers
- Agriwastes and agrofibers residues – full utilization
- Bioenergy from agriwastes and MSW
- Natural Polymers Composites
- Nanocomposites
- Biorefinery (energy and chemical feedstocks)
- Composting
- Recycling of polymers

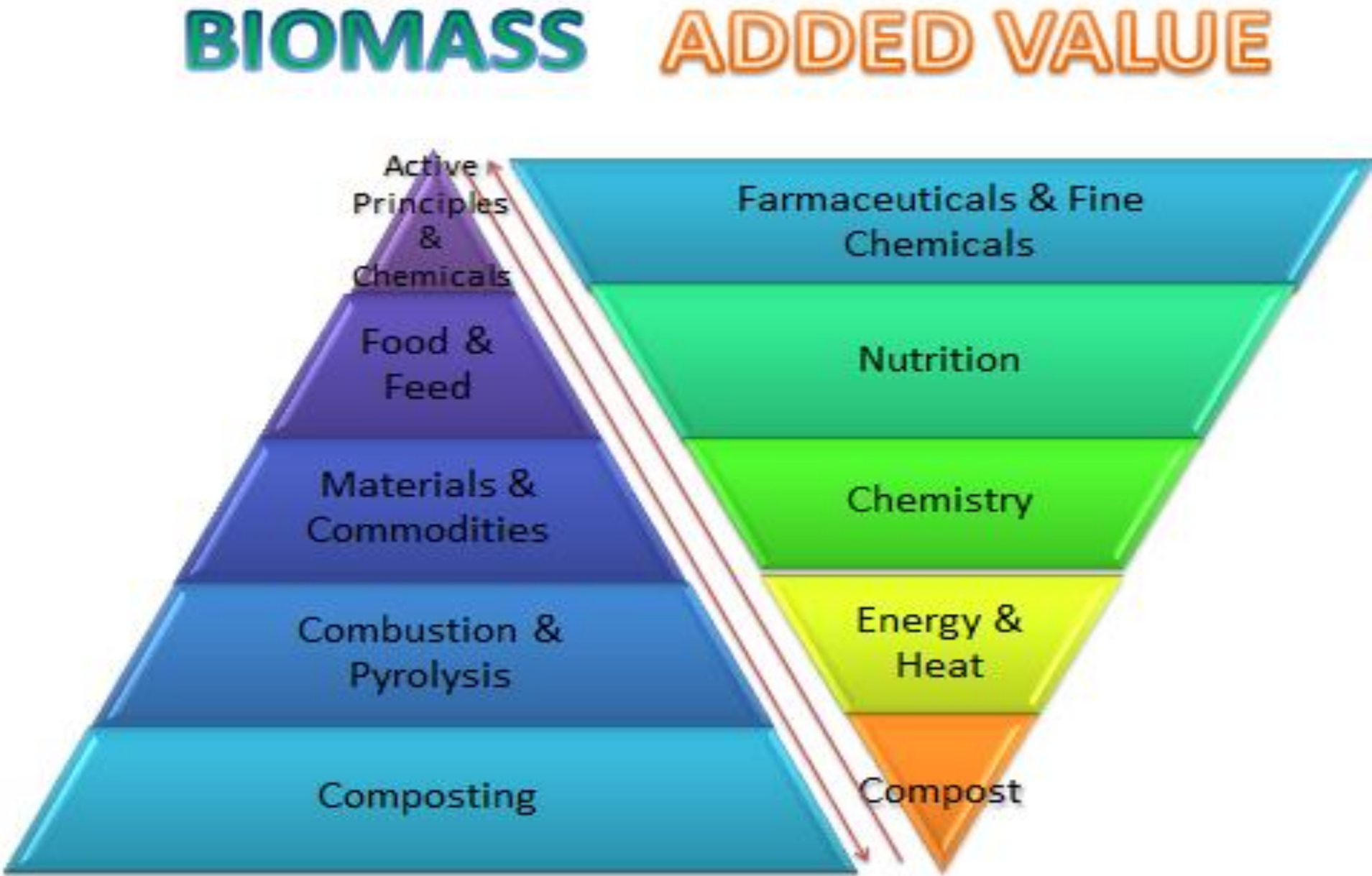
Laboratory Philosophy

- Do not use resources that compete with food
- Full use of agricultural, industrial and urban residues
- Enhancement of the agricultural chain
- Materials and feedstock prior direct burning
- Development of innovative technologies in partnership with private companies through the UNESP Foundation (technology transfer contracts)

Biocapacity



The Pyramid Value Concept for the Biomass Utilization



Added Value Products

- Coffee sachet for the *expresso* machine: multiply the commodity price by 25 times
- T-shirts for the Super bowl: Retail price 9.94; cotton price 0.24
- Gasoline: Retail price: 2.05; commodity price 1.44
- Coffee cup: Retail price: 2.45; commodity price 0.03
- Chicken legs: Retail price: 2.99; commodity price 1.69
- Beer: Retail price: 0.83 bottle; commodity price 0.01
- Beef: Retail price: 4.49; commodity price 0.33
- Corn: Retail price: 2.50; commodity price 0.06

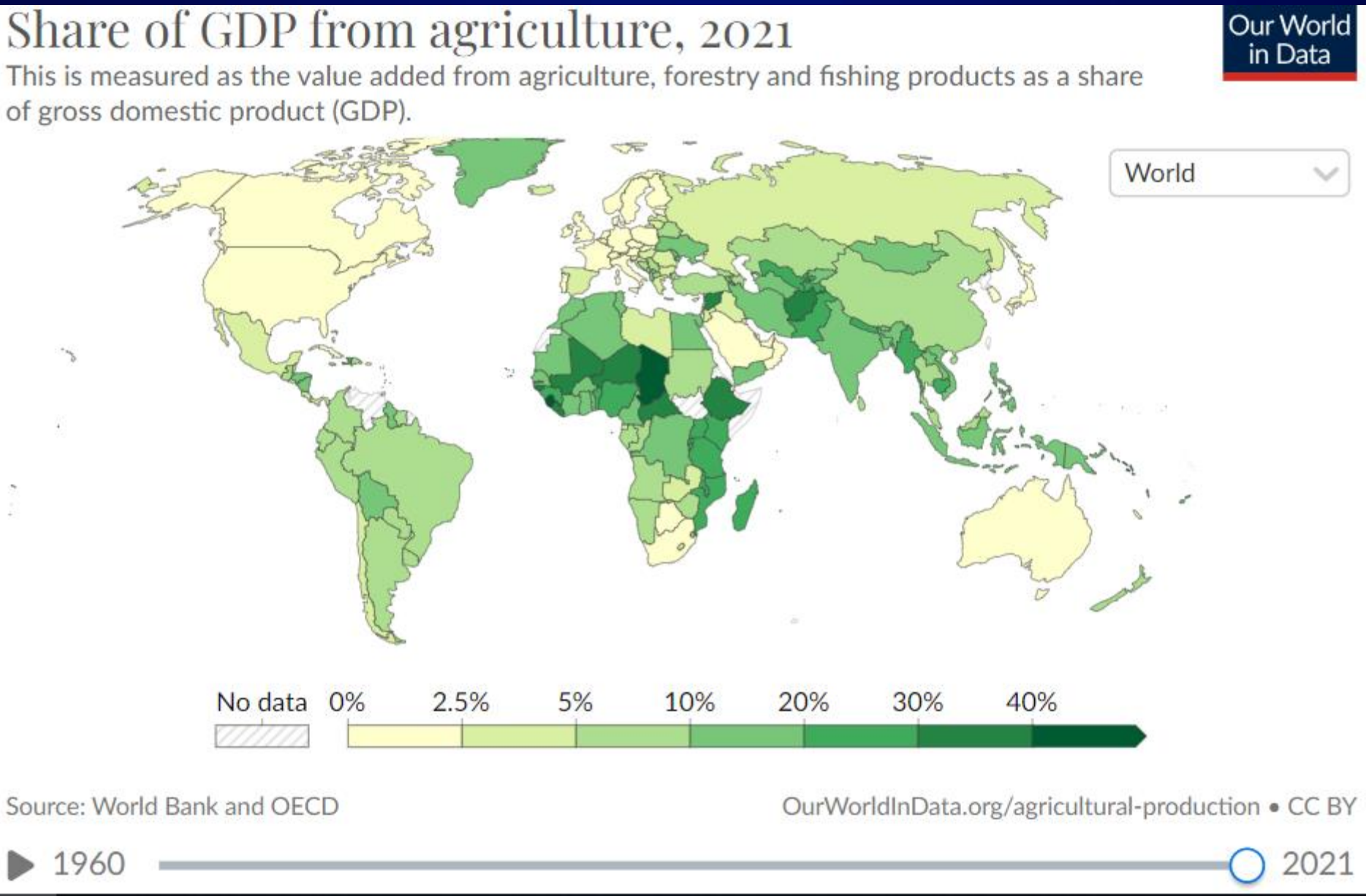
Patents Granted in Brazil for Biobased Processes/Products

KEY WORDS	# Pat.	KEY WORDS	# Pat.
Biomaterials	35	Green PP	35
Biopolymers	49	Green PE	978
Bioplastics	3	WPC	1
Biorefinery	7	Wood plastic	142
Polyol	18	Green composite	110
PHB	5	Renewable composite	1935
PHA	14	Lignocellulosics composites	104

Patents Granted in Brazil for Biobased Processes/Products

KEY WORDS	# Pat.	KEY WORDS	# Pat.
Vegetable fibers composites	305	Extractives	4
Bioprocesses	1	Nanocellulose	11
Green chemistry	53	Nanocrystal	1
Rubber	2111	Natural Fibers	57
Cellulose	1188	Renewable Resources	10
Lignin	10	Biofuel	69
Hemicellulose	31	Bioenergy	6

The Dutch Disease – De industrialization



Objectives of Applied Research

- Rejects – something useless, which unique destination is final disposal
- Residues – everything that serves for a productive process
- By-Product – something that is valuable to the main business, although at minor scale
- Co-Product – something of value compatible to the main business activity
- Product – main activity for a business

Circular Economy

- Use of agriwastes and food waste aiming the production of biobased feedstock, energy or materials;
- Densify the producing chain of a agricultural crop;
- Reduce the environmental impacts of the conventional biomass conversion processes through new products or new uses for existing products.

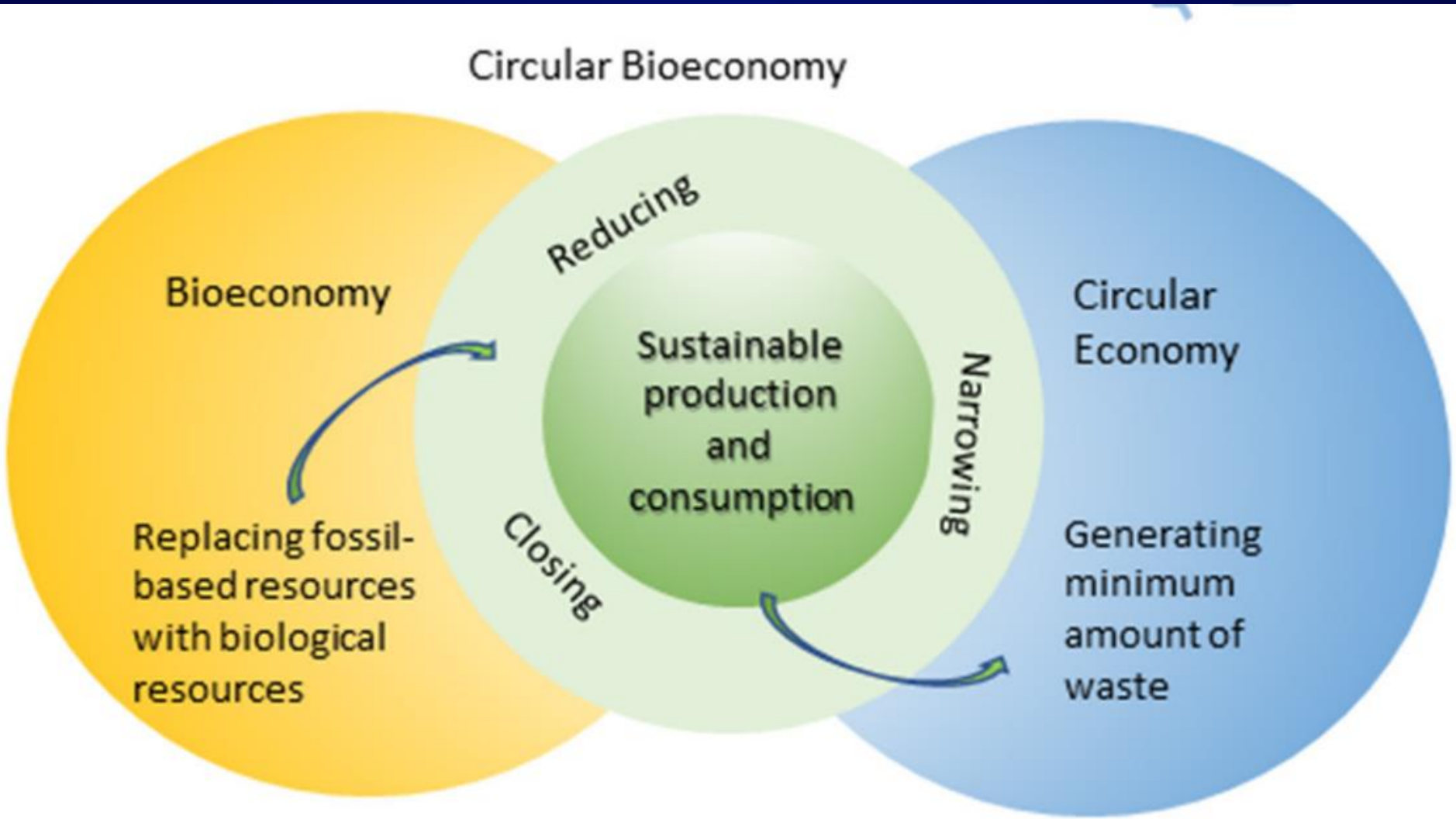
Circular and Bio-Economy Concepts

Circular Economy

- Intrinsic recycling and feedback loops;
- Applies to the whole economy;
- Adding value to waste materials

Bio-economy

- Can be both linear and circular;
- Only bio-based products and systems;
- Reliant on the primary sectors;
- Emphasis on adding value to raw materials with strong knowledge and technical development.


Circular Bioeconomy
Bioeconomy
Reducing
Sustainable production and consumption
Narrowing
Circular Economy
Closing
Replacing fossil-based resources with biological resources
Generating minimum amount of waste

Route Towards a Biobased Economy

- One of the greatest global challenges of the 21st Century in times of climate change will be to sustain a growing world population both with sufficient foodstuffs and with renewable commodities – as industrial raw materials and for energy production.

Global Strategy Bioeconomy - 2030

Circular Biobased Economy

- Using non-food biomass
- Agricultural and forest residues and waste materials
- Algae based biomass
- Aquatic weeds biomass (*Eichhornia*)
- Use of all the components of various crop plants
- Cascading and coupling of raw material use
- Biomass Cascade Approach
- Development of the biorefinery

Alternatives – The treshold is oil at US$80 barrel

Global Strategy Bioeconomy for 2030

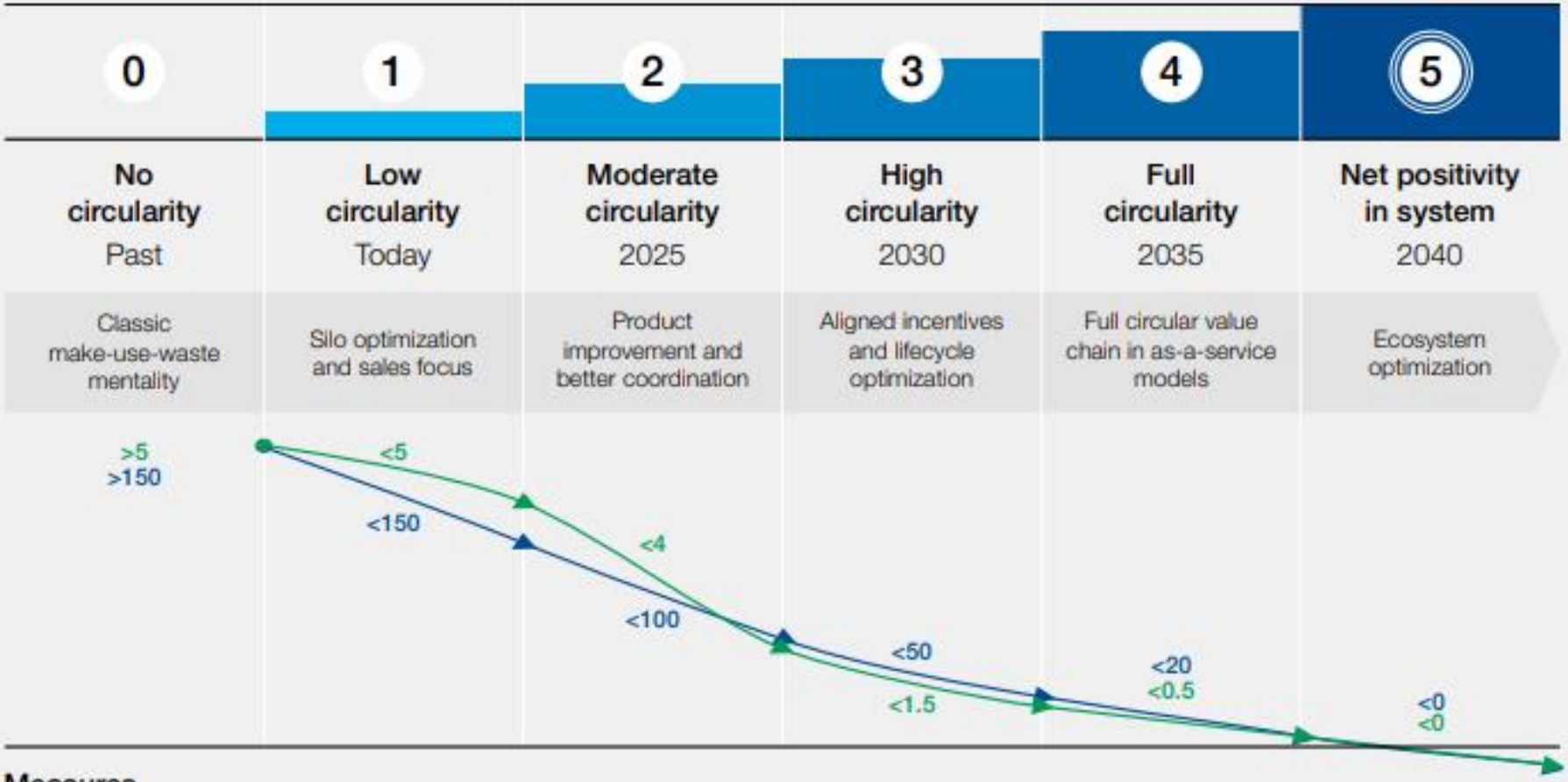
Circular Biobased Economy

- Using non-food biomass
- Agricultural and forest residues and waste materials (MDF, HDF, Green Coconut, Rice husk, MUCILAGE, peels, etc.)
- Algae based biomass
- Aquatic weeds biomass (*Eichhornia*)
- Use of all the components of various crop plants
- Cascading and coupling of raw material use
- Biomass Cascade Approach
- Development of the biorefinery alternatives

Circular Cars Initiative, May, 18 2022

- . The circular economy approach enables automotive companies to increase revenues per vehicle by 15-20 times the sales price and significantly improve profitability by maximizing lifetime performance

Levels of circularity



Measures

Carbon efficiency

Lifecycle CO_2e emissions (g)

Passenger km

Aligning the car with greenhouse gas budgets for mobility in a 1.5-degree scenario

Resource efficiency

Non-circular resource consumption (g)

Passenger km

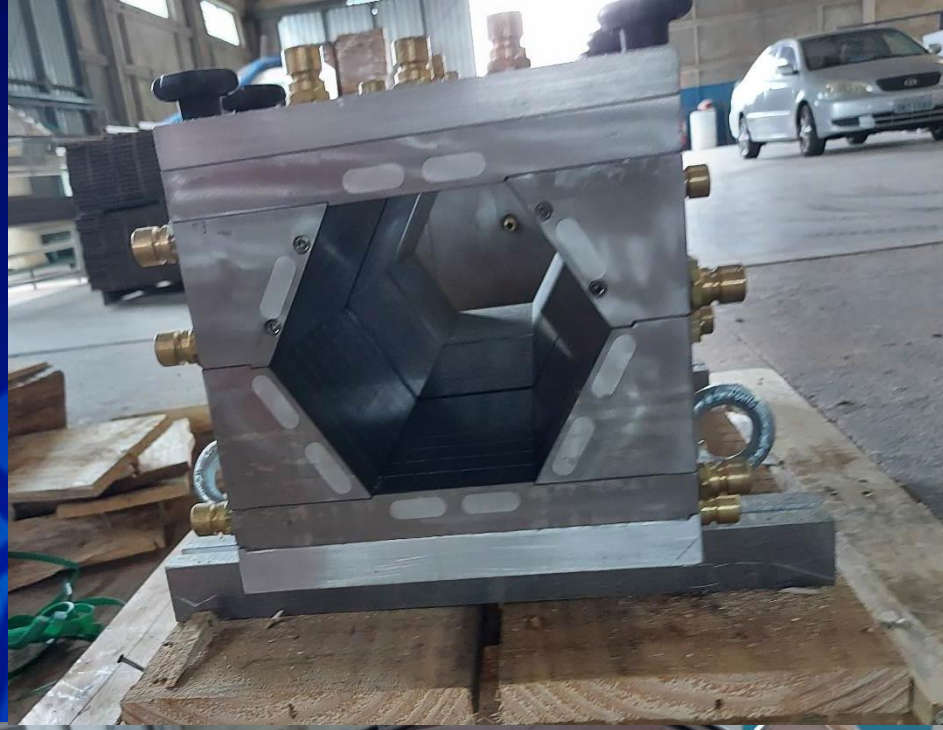
Maximizing the value from resource consumption

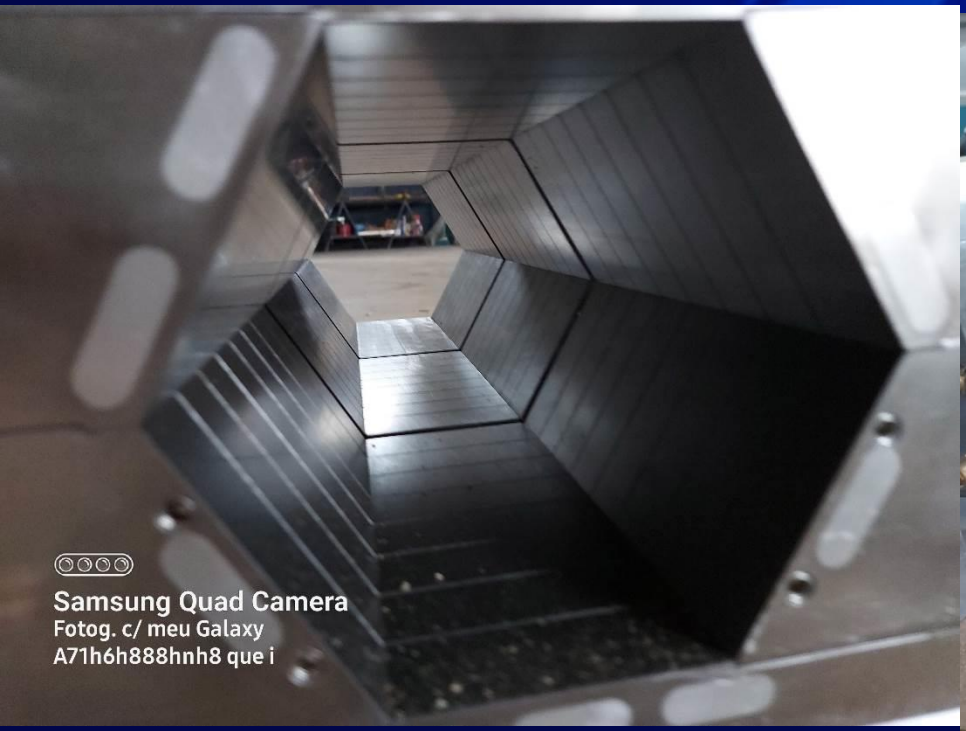
Transformation pathways and corresponding circularity initiatives

Use of Biochar Wastes Into Composites

Eko-Teck Ltda
Botucatu, Brazil

Eko-Tech Botucatu

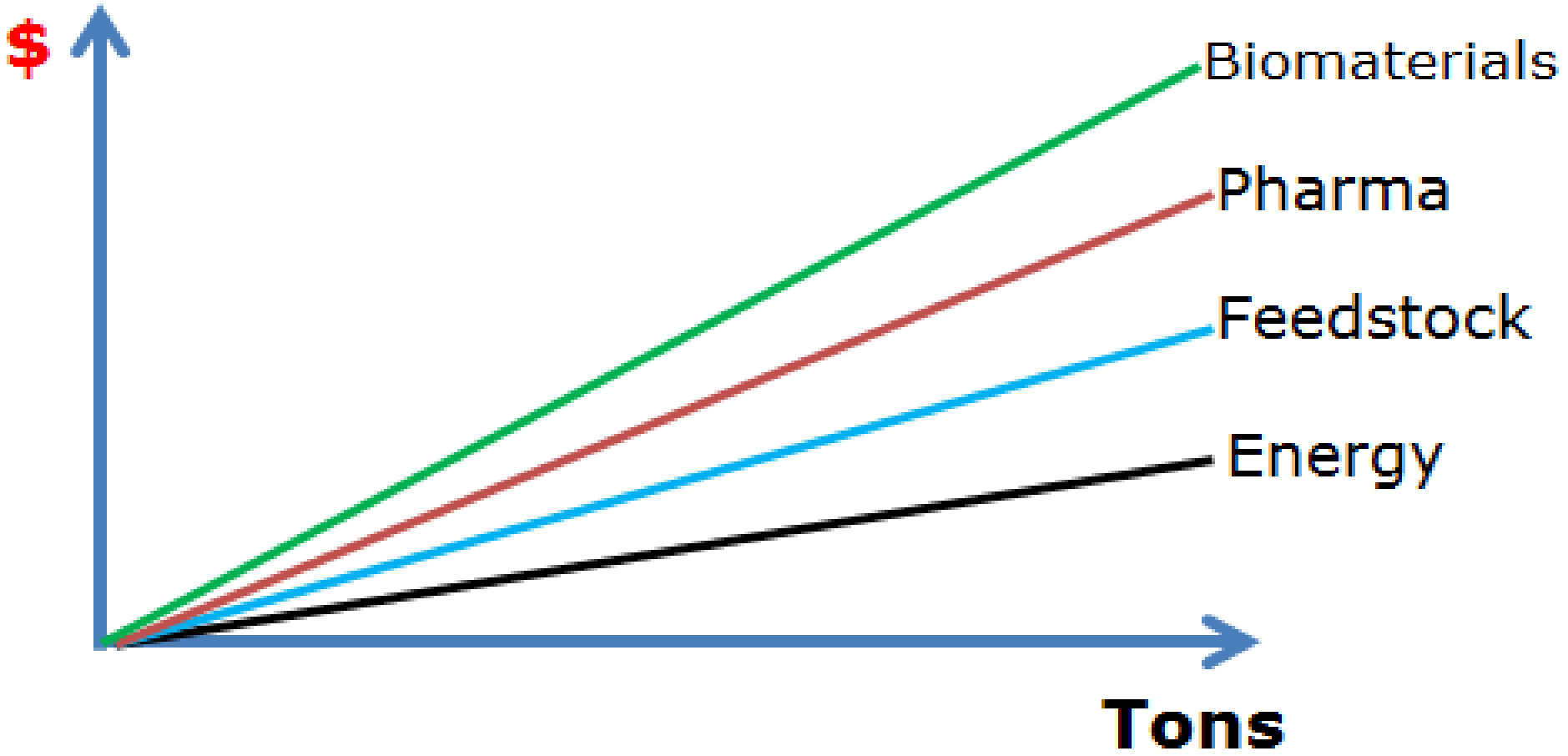




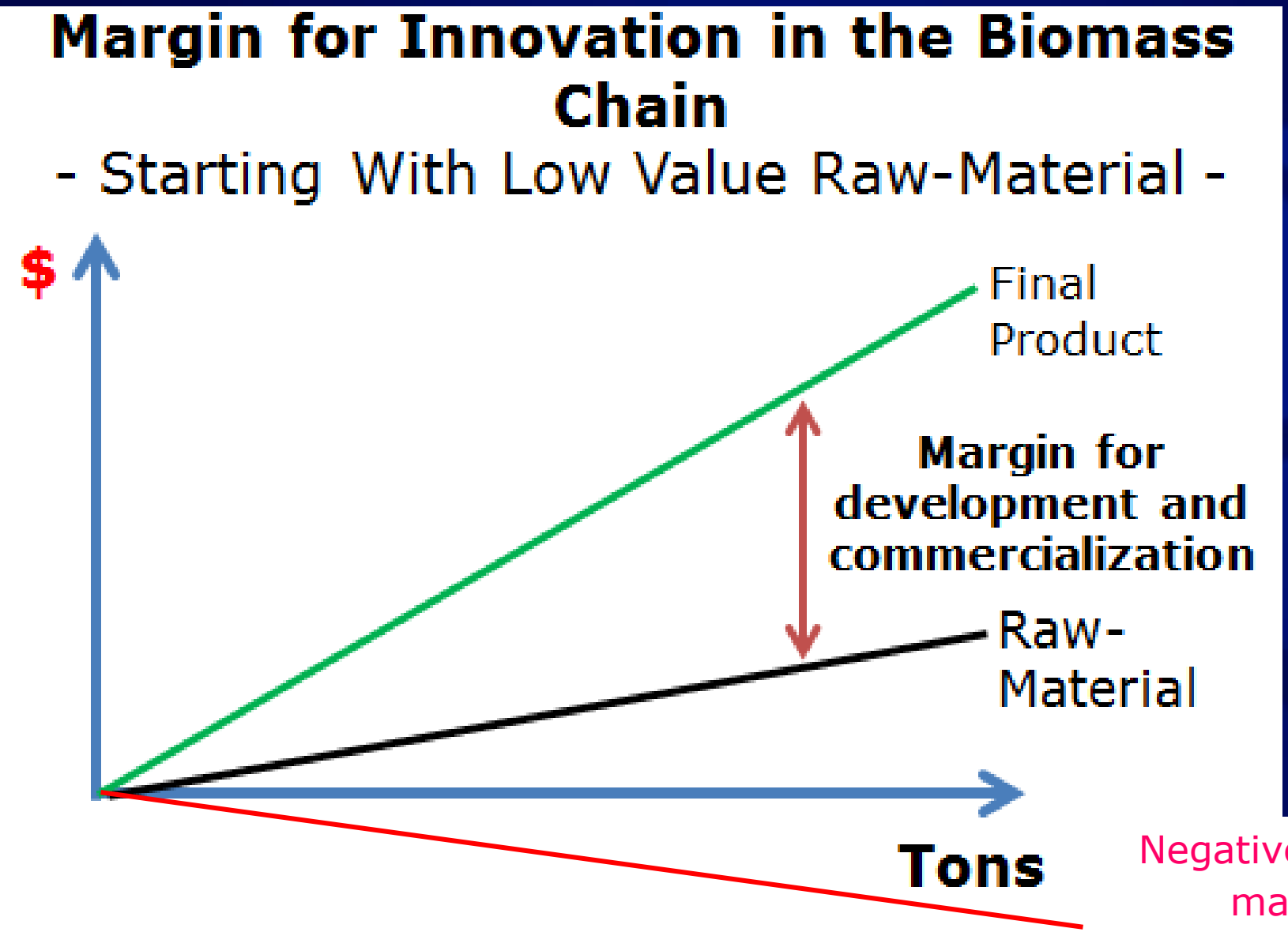
WPC Decks Made of Residues in PVC Matrix

The Relation Between Raw Material and Final Product Cost

Adding Value in the Biomass Chain



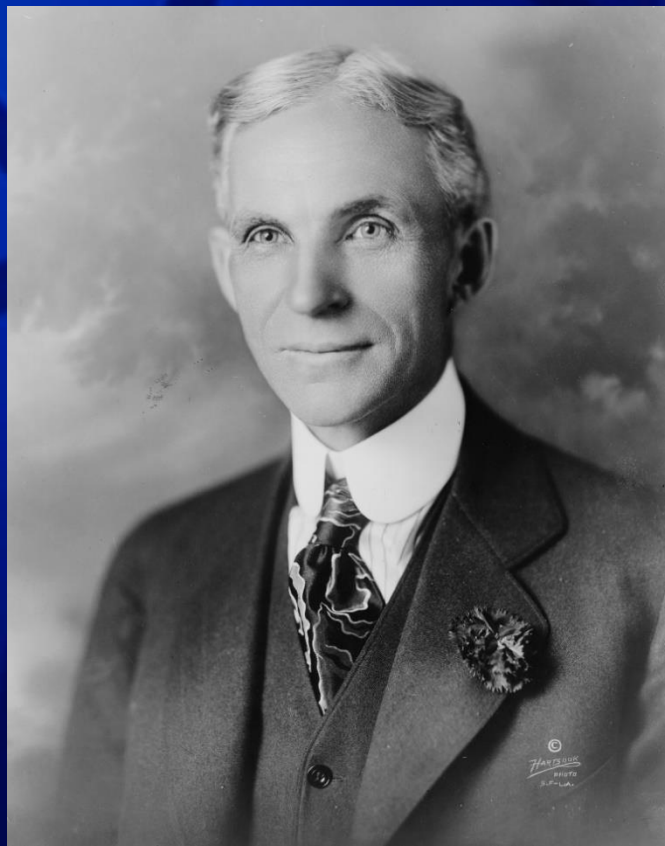
Use of Low Cost Raw-Material Can Be An Advantage For A Biobased Product



Natural Fibers: Oportunity for ALL!

"The most environmentally friendly thing you can do for a vehicle that burns fuel is to make it lighter."

"They (automobiles) will be lighter and many of them will be made of plastics from agricultural products".



Henry Ford, from an article written by James Schweinehart published in The Detroit News of July, 30rd, 1942.

Natural Fibers

Lignocellulosic natural fibres are an excellent raw materials for production of wide range of composites for different applications.

The interest in using natural fiber such as different plant fiber as reinforcement in polymers increased during last years.

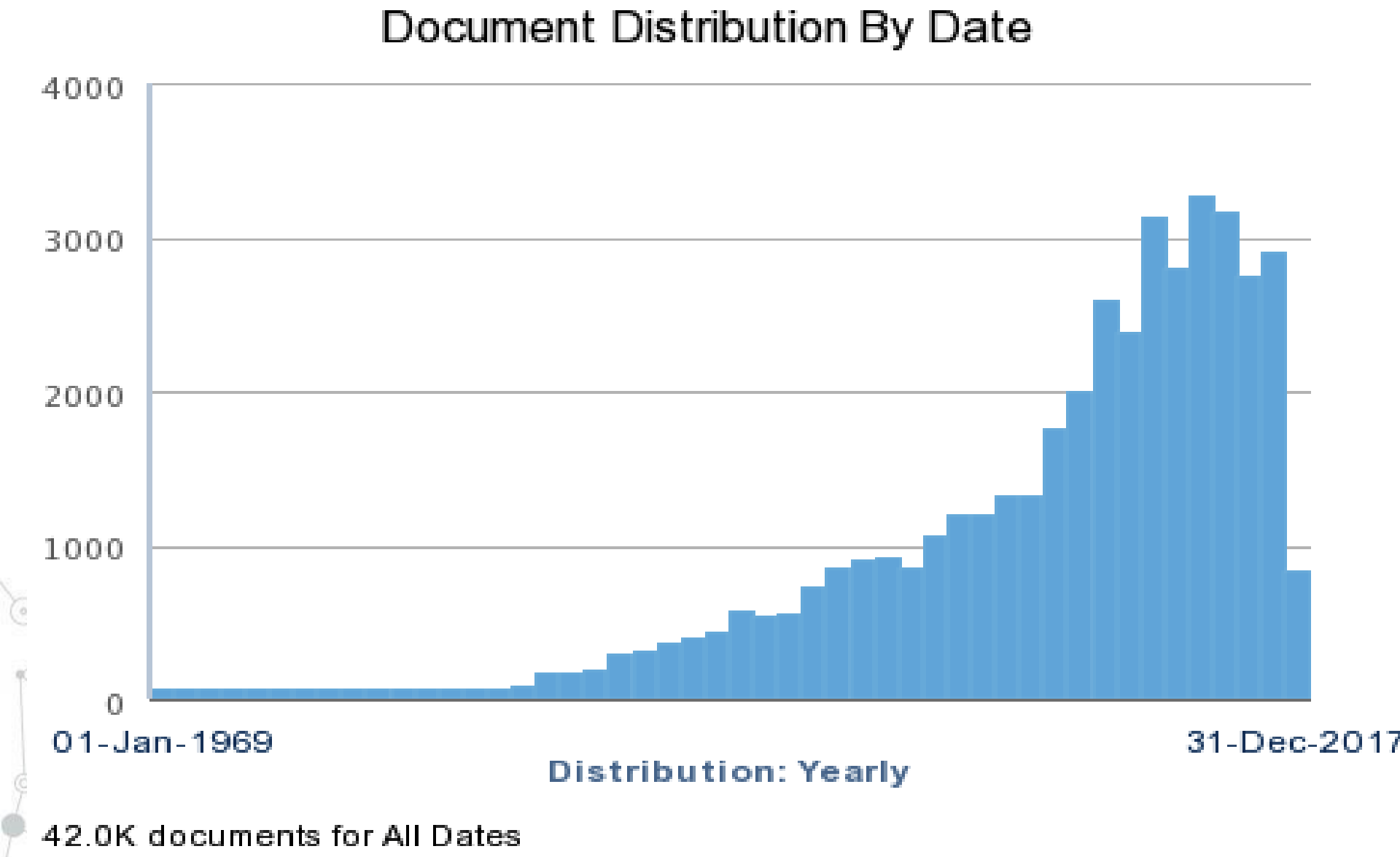



Natural Fibers in South America

Brazil is the biggest producer and consumer

- Abaca – Ecuador
- Fique – Colombia
- Totora – Peru/Bolivia
- Flax – Argentina (?)
- Embira – Brazil
- Caroá – Brazil
- Bamboo - Brazil
- Phormium (imbira) - Brazil
- Curaua – Brazil, Venezuela
- Kurowa - Guiana
- Sugar cane bagasse and leaves
- Pineapple (Brazil)
- Sisal – Brazil, Cuba, Haiti México
- Buriti, Carnauba, Babacu, and Tucum – NE of Brazil
- Malva & Jute – Brazil
- Coir – Brazil
- Banana – Brazil
- Hemp – Chile
- Taboa (Typha) - Brazil
- Piteira – Brazil and Ecuador
- Tagua – Ecuador
- Jarina – Brazil (Vegetable ivory)
- Piaçava – Bahia, Brazil
- Aguapé (Water Hyacinth)

Natural Fibers – Media Coverage



Summary of Natural Fibers Brazil (By Percentage in the World)

COUNTRY	PUBLICATIONS	INVESTMENT
Brazil	6.752	3.032
Germany	5.556	0.791
Australia	1.246	?
TOTAL	**13.554**	**4.023**

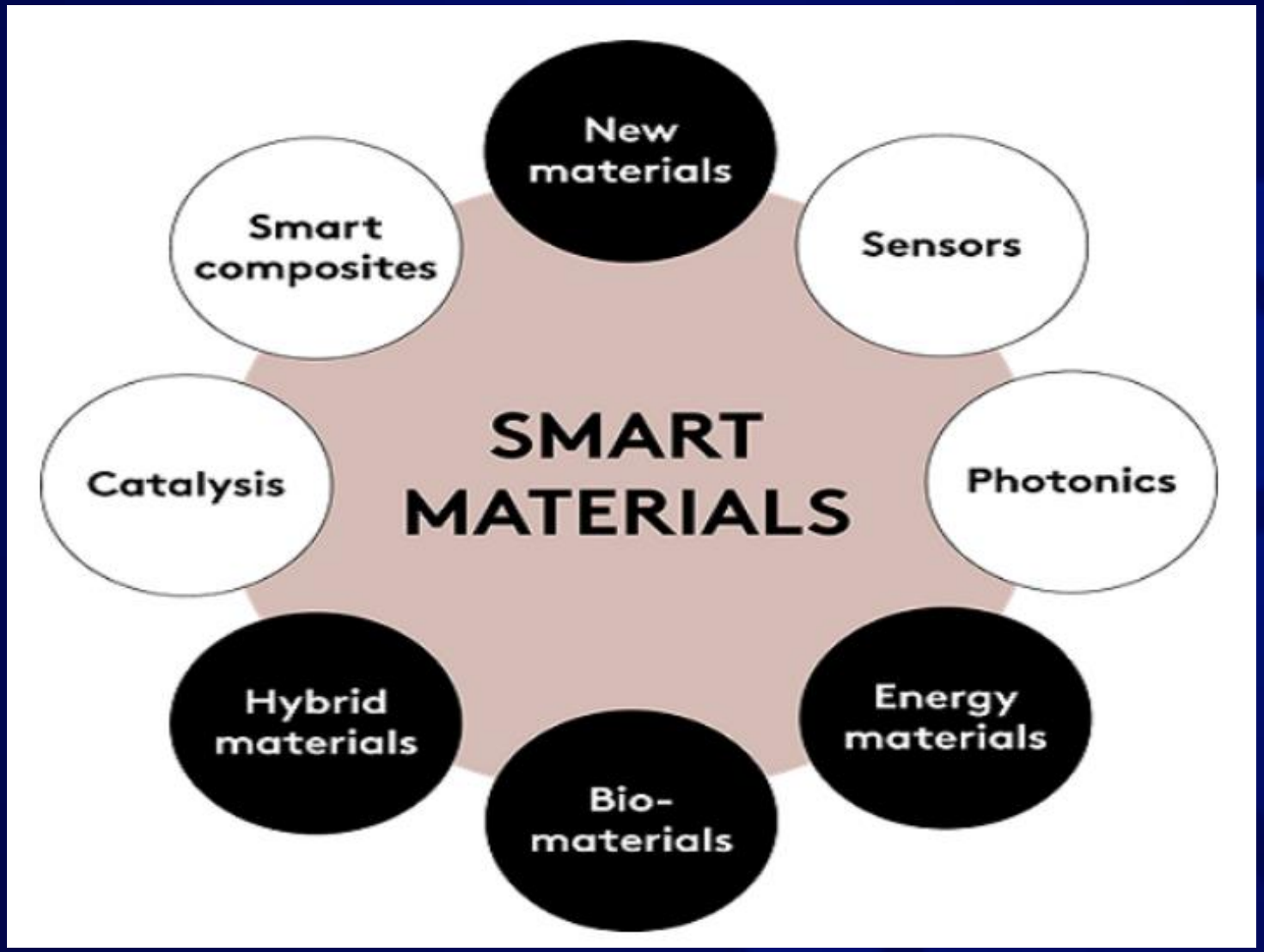
Green Chemistry and Sustainability
From Waste to Wealth

Why not Biogenics Smart Materials?

There Will be No Difference Between Waste, Energy and Materials (Biobased Materials)

Smart Materials Advantages

- They can be used in different types of industries. Some of the most popular smart materials have heat-resistant, self-curing and self-assembling properties.
- Smart materials manufacturing is an example of how the circular economy can be used to produce sustainable products and materials.
- These materials are designed to be durable, efficient and resilient, making them ideal for making products that can be effectively reused or manufactured.


SMART MATERIALS
New materials
Sensors
Photonics
Energy materials
Bio-materials
Hybrid materials
Catalysis
Smart composites

Why to Use Natural Fibers

- The use of natural fibers incorporated into the polymer results in a general improvement in the properties of the material.
- The incorporation of natural fibers results in a lighter material.
- The resulting product is more environmentally friendly.
- The use of the biocomposite implies a general reduction in the use of synthetic polymers.
- Cars lighter have a lower carbon fooprint, safer, easier to drive, higher load capacity, etc….

Volkswagen –UNESP Contract

Way To Zero strategy to neutralize carbon emissions by 2050. The replacement of mineral components for natural will allow a reduction of about 80% of carbon emissions in the production process. In addition, the weight of the vehicle's plastic parts will decrease by approximately 10%, which also means a reduction in the amount of CO_2 emitted into the

The Volkswagen Case

Considered options from the beginning:

- Jute
- Coir
- Sisal
- Bamboo
- Eucalyptus
  - **AGRIWASTES**

Improvements to Specific Properties of The Material

- Fire retardants
- Compatibilizers
- Density
- Plasticisers agent
- Anti UV
- Impact modifier
- Pigments
- Odourless

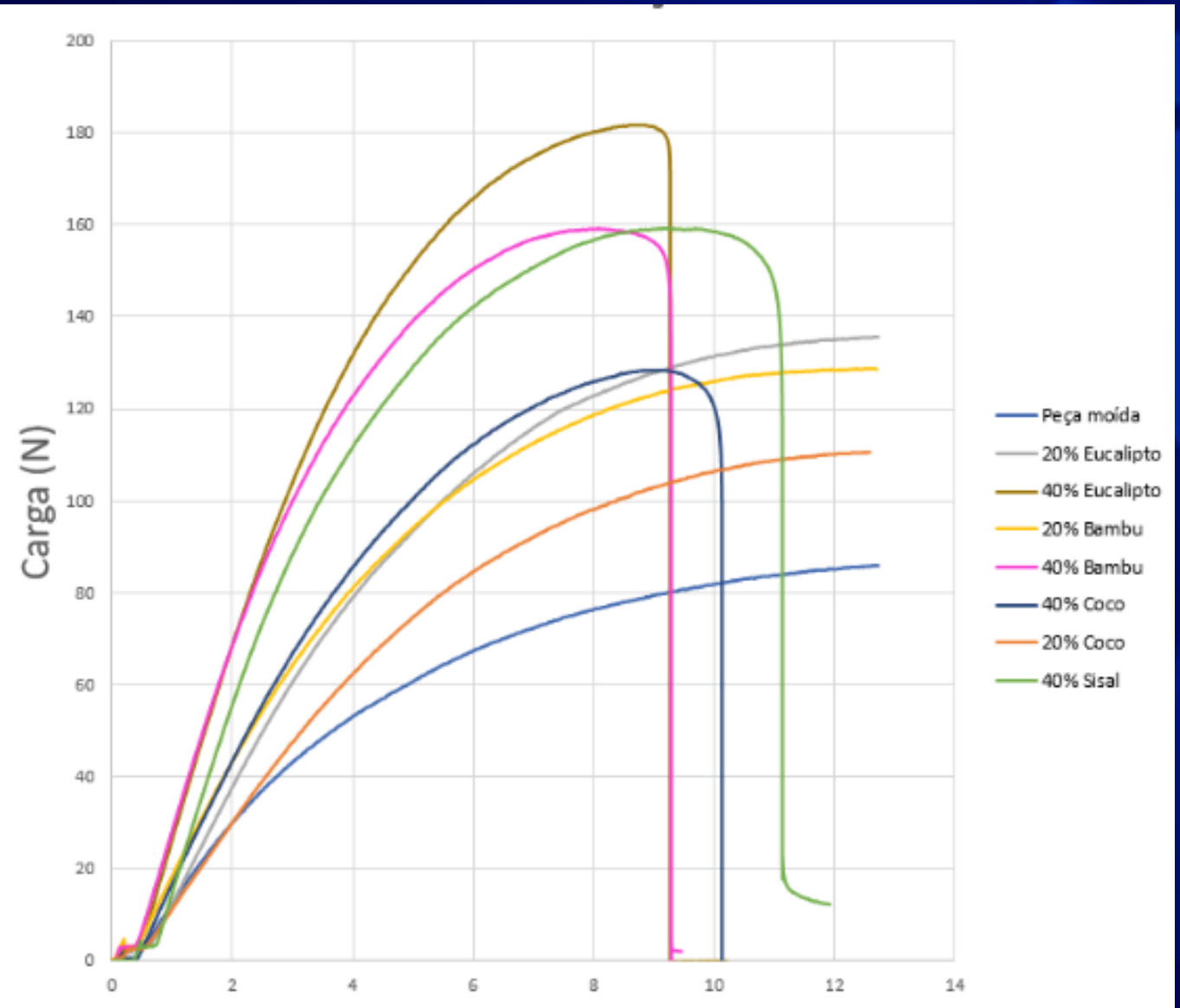
Methodology

- Material preparation (cleaning, drying, granulometric analysis)
- Homogeneization
- Grinding
- Extrusion of pellets
- Injection molding
- Mechanical, physical and chemical testing
- Data analysis
- Technology transfer to tier 1

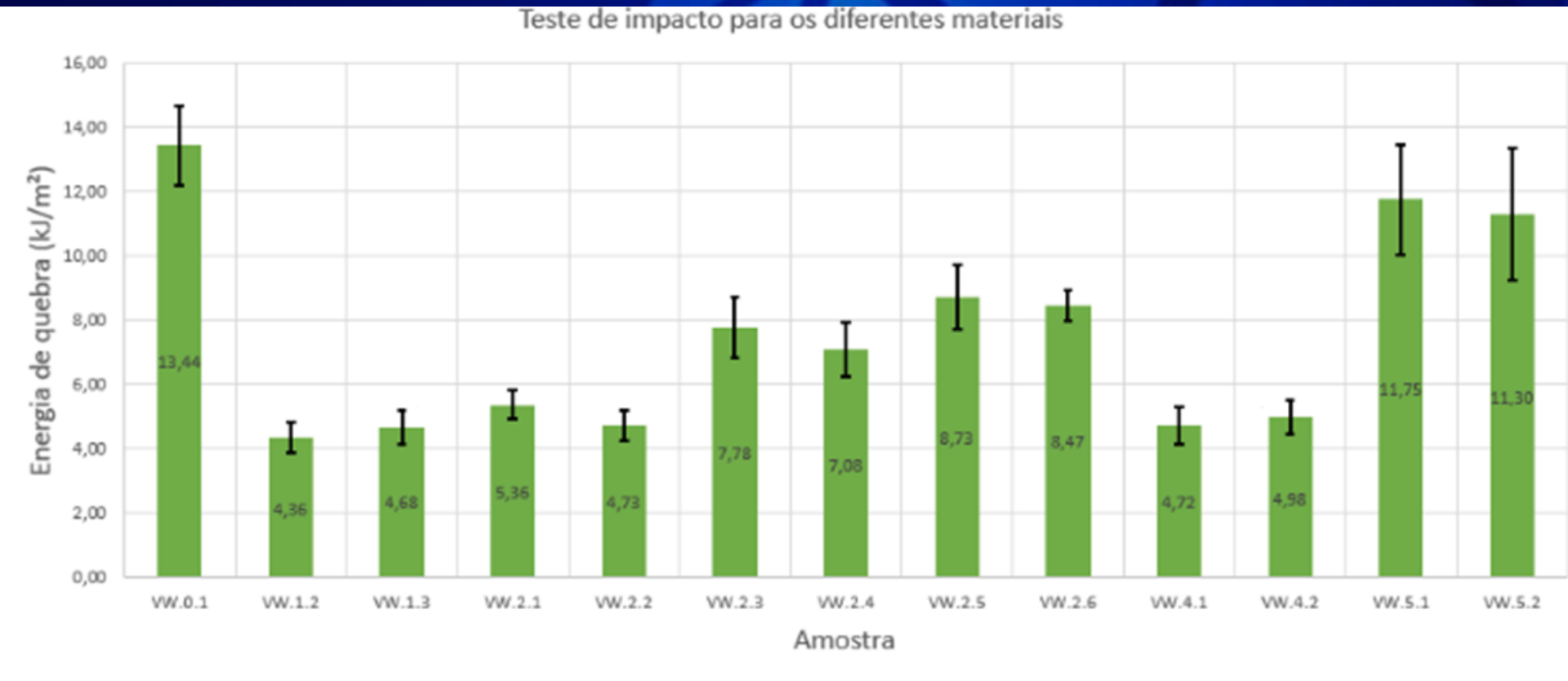
Experimental Design

MATERIAL	CONCENTRATION (%)
PP co-polymer with talc	100 - REFERENCE
Jute	20 & 40
Coir	20 & 40
Sisal	20 & 40
Bamboo	20 & 40
Eucalyptus	20 & 40

Flexural Properties for Green Carbon Composites for VW

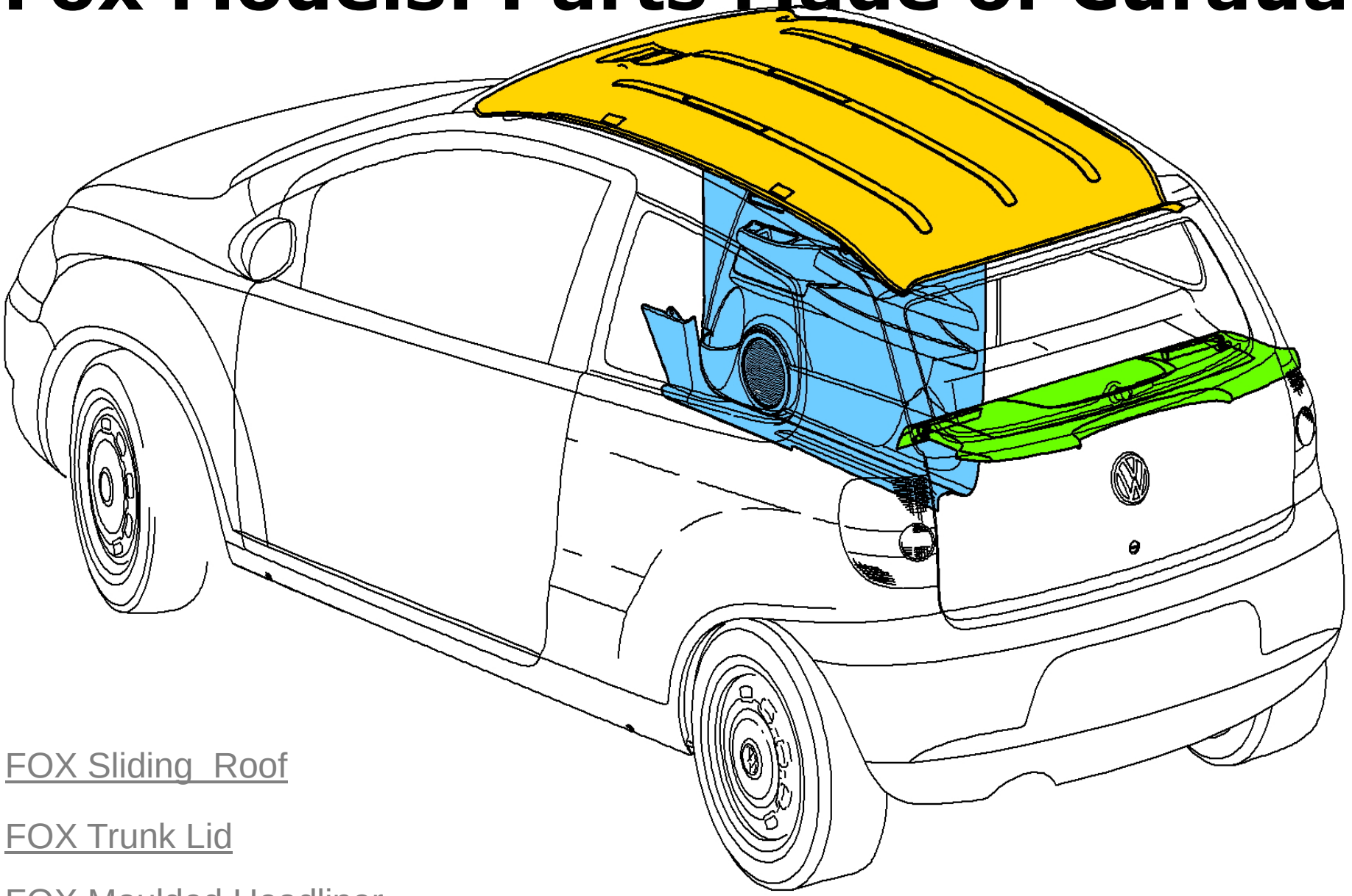


Green Carbon Composites for VW



Trabant – Made of Cotton

Fox Models: Parts Made of Curaua



FOX Sliding Roof

FOX Trunk Lid

FOX Moulded Headliner

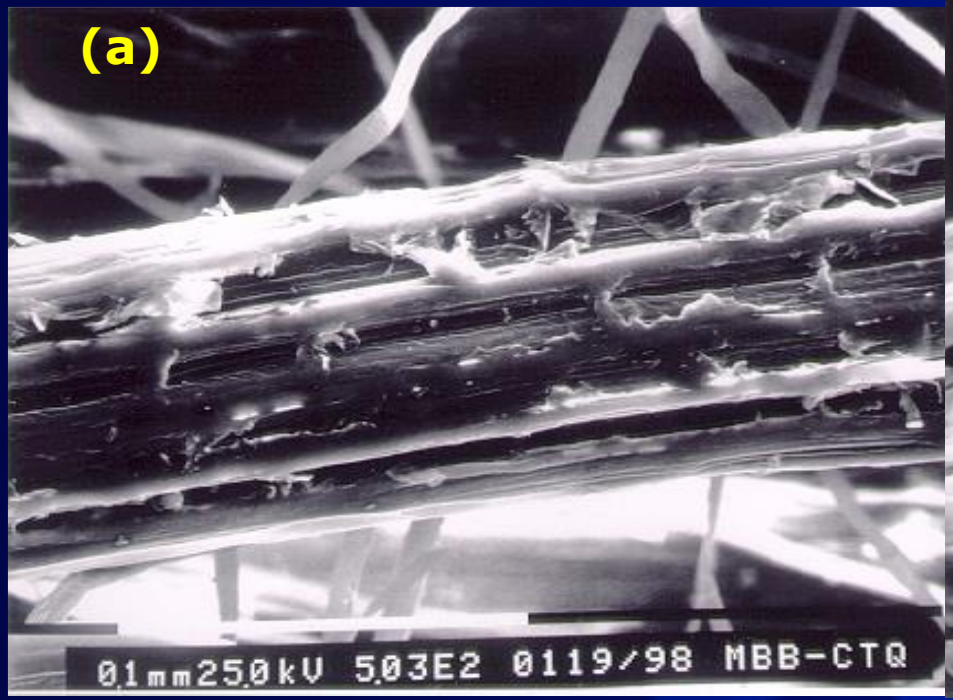
Carrier: 50/50 Curauá Fiber + Polymeric

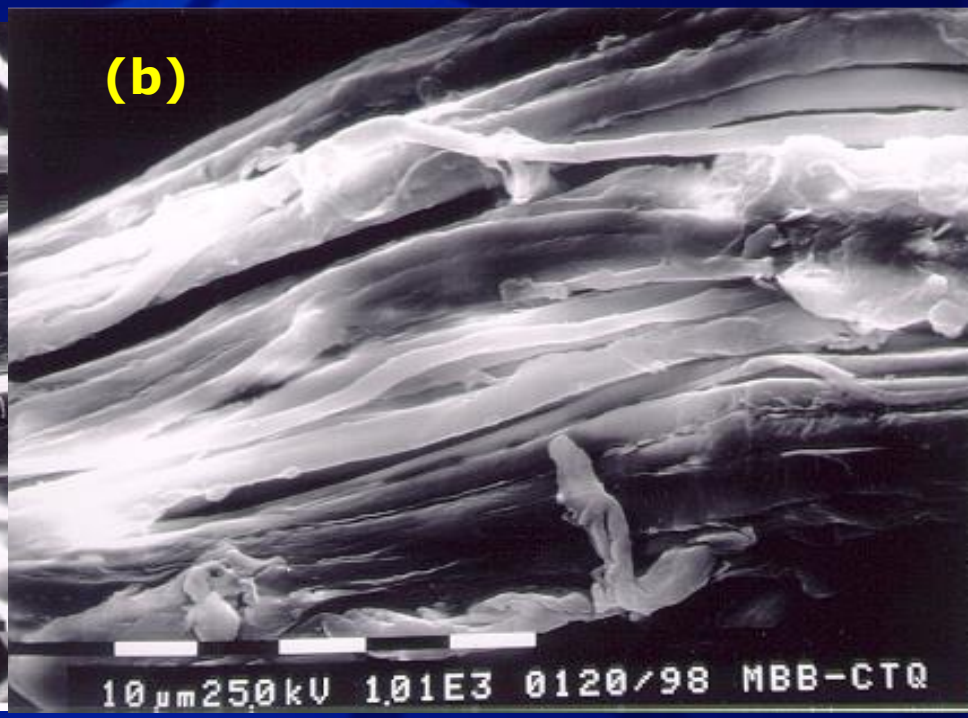

CGE
VISITANTES

Door Opener - Mercedes Benz Truck

Gloves Compartment VW Gol – Injection Molding

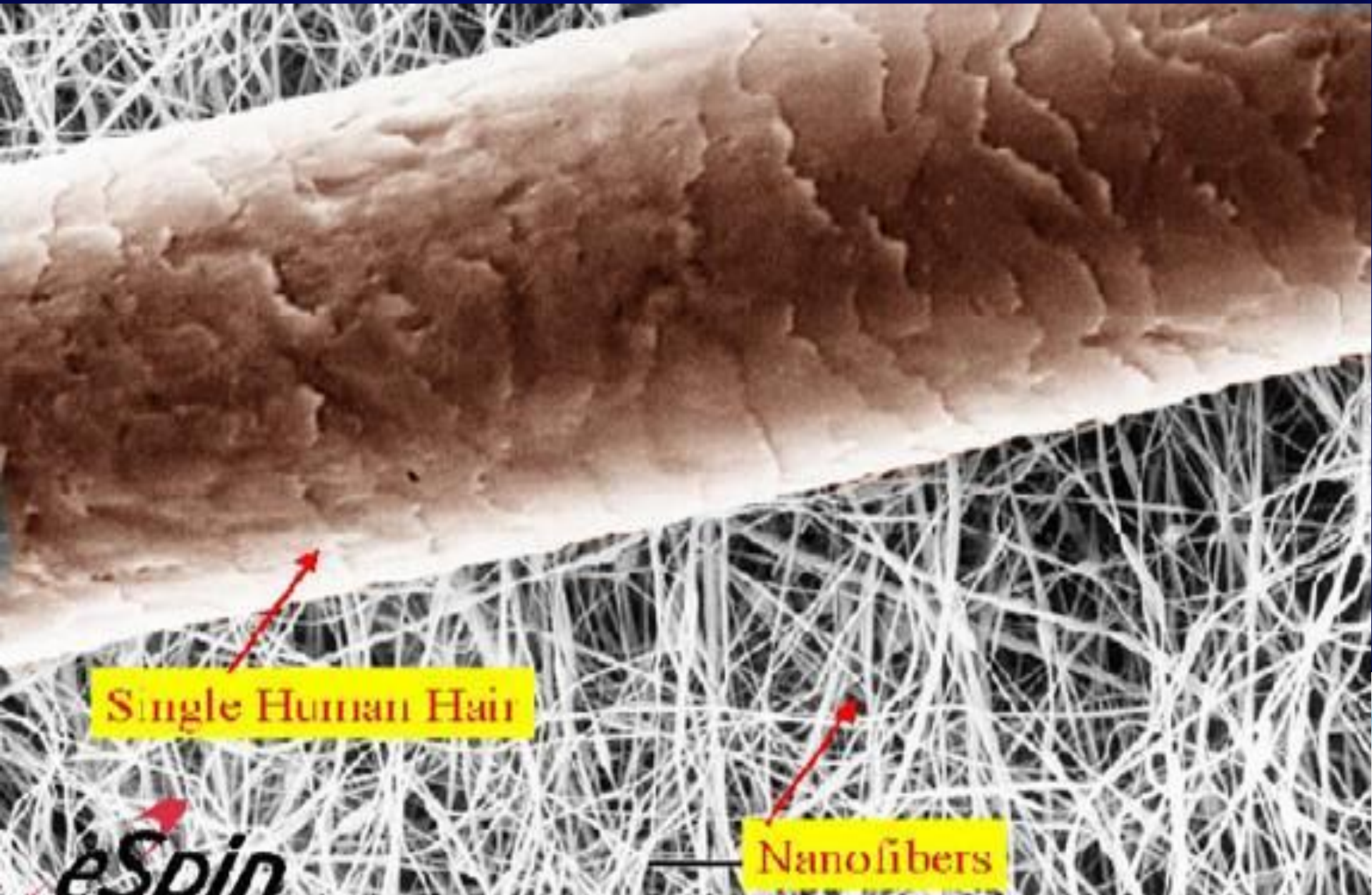
Effect of the Processing Over the Fibers – Damage!!!



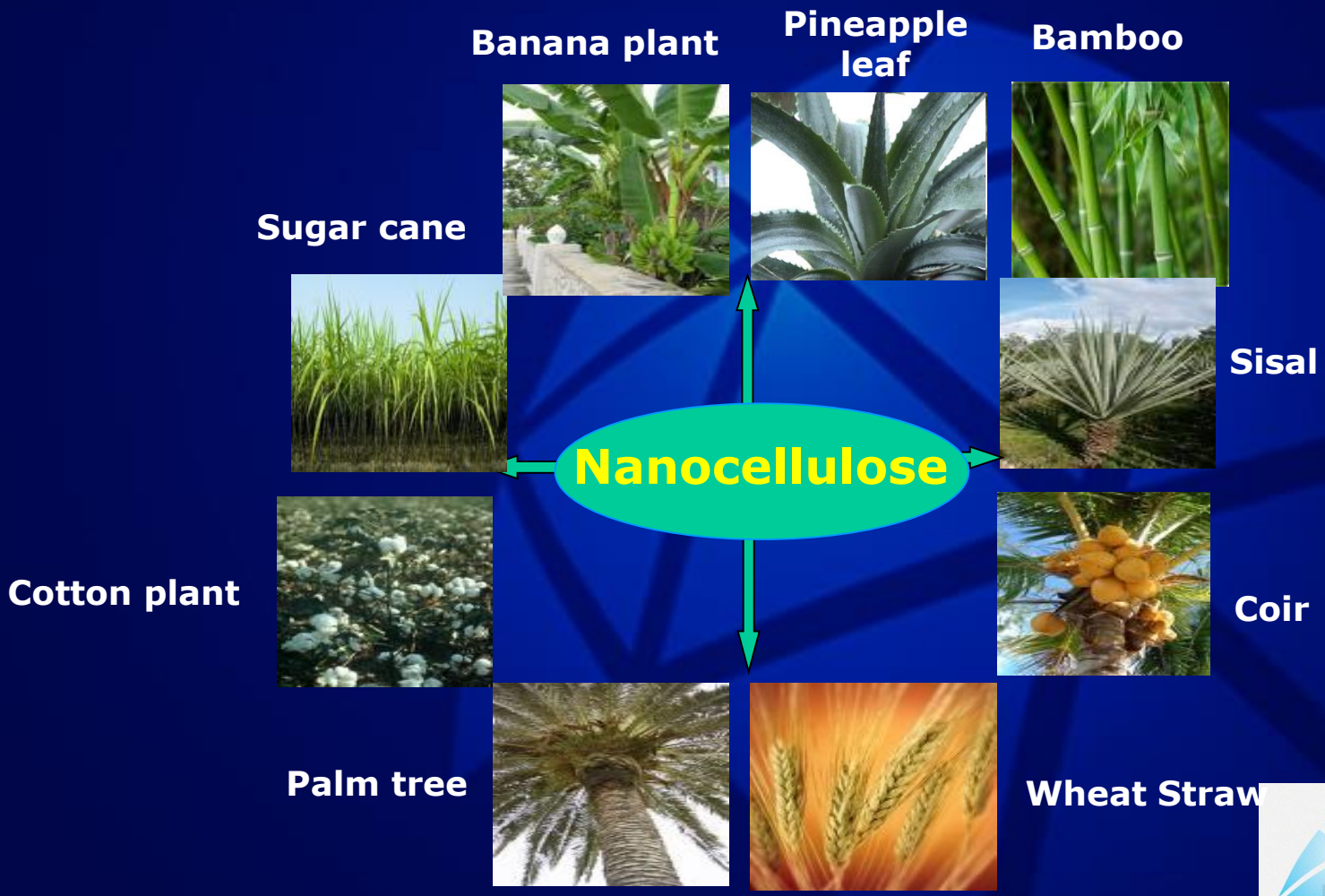


SEM of curauá fiber:
a) prior to processing (fabric manufacturing) and
b) after processing.
The damage caused to the fiber is clear

Nanofiber Scale



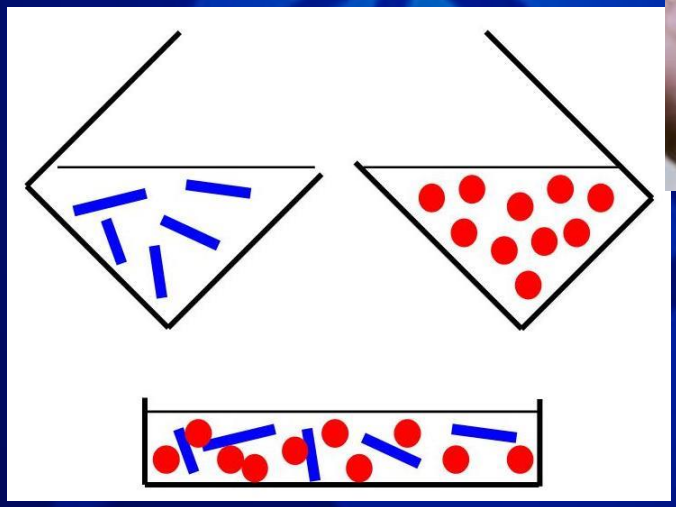
Sources of Nanocellulose



Phormium Nanocellulose

Processing of Nanocomposites

Alternative = use of a polymer hydrophilic (latex)



Water evaporation (T>Tg) → **Particle coalescence** → **Nanocomposite casting film**

Film → **Grinding** → **Extrusion** → **Injection Molding**

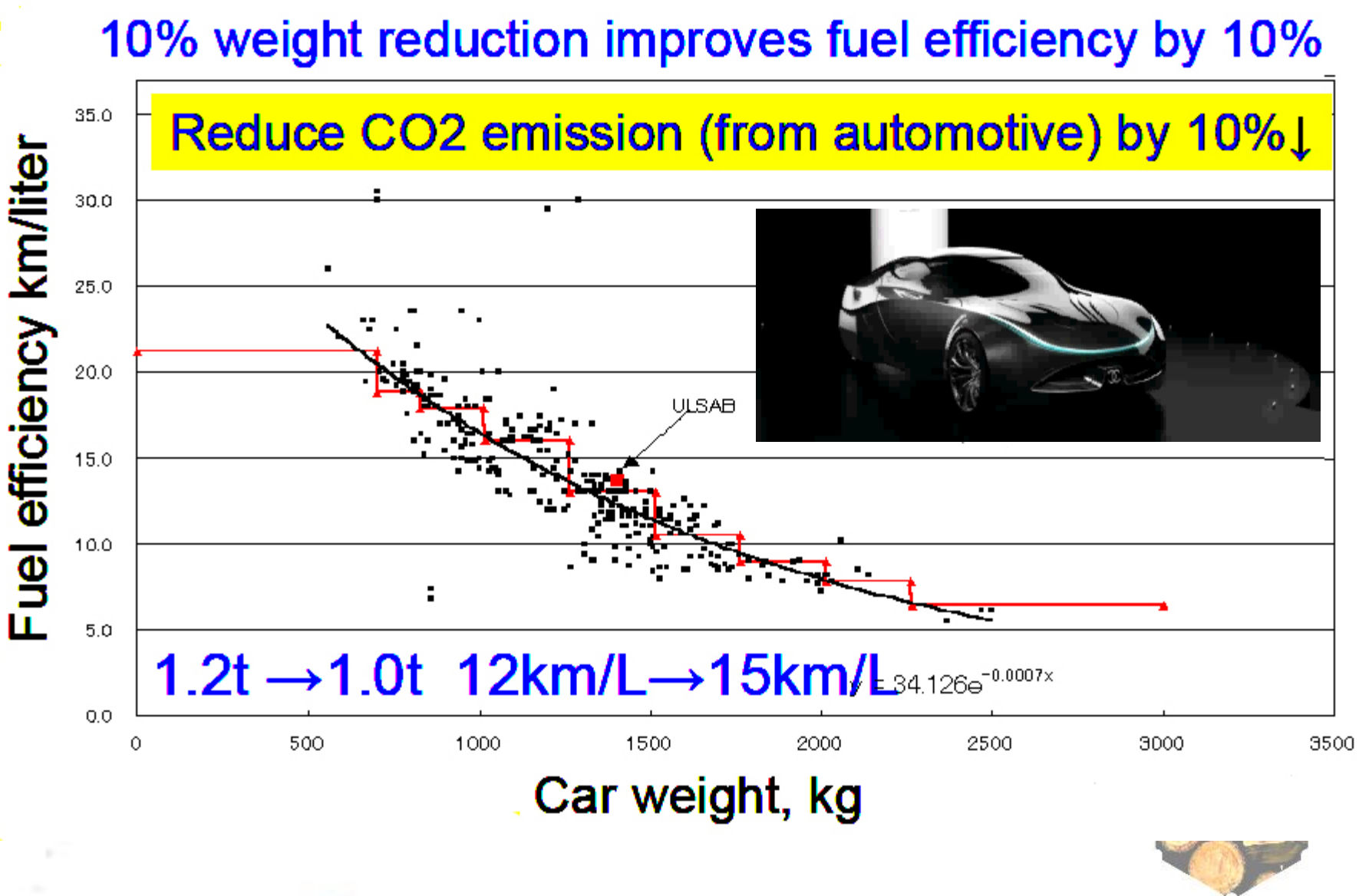
Fruity coupes… Pineapples and bananas for more fuel-efficient cars

Industry Leaders Magazine

The rise of "Green Plastic"

These completely renewable fruit-based plastic fibres can be almost as stiff as Kevlar, according to Alcides Leao, lead scientist of the Sao Paulo team developing the plastic. However, their major point of difference lies in the fact that these nano-cellulose fibers would be made from source materials that are completely biodegradable and renewable.

The Reduction of Body Weight Improves Fuel-efficiency



Advantages

- Lighter
  - 30% less than current materials
- Biodegradable
- Low energy to manufacture
- Excellent energy absorption
- Replace current plastics and even steels
- Non-Toxic

Future Application of Cellulose Nanocomposites

300kg reduction of automobile body weight

improves fuel consumption by 20%

Future Ford

Green Nanocomposite Interior Parts

Future Mercedes-Benz E-Class

Nanocellulose Reinforced Windows

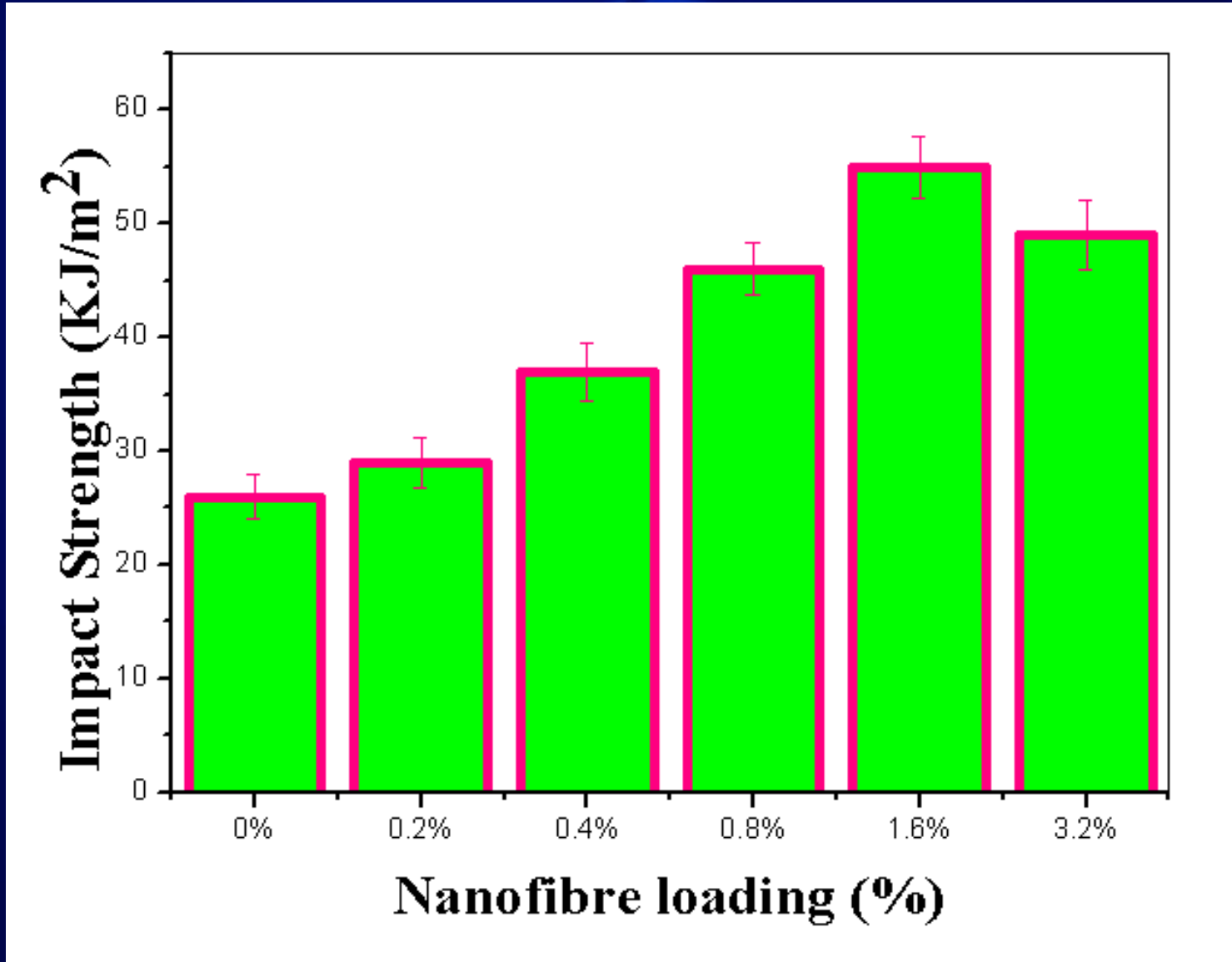
Nanocellulose Reinforced Body

Challenge: Green Nanocomposites for Automotive Parts

- Reduction of CO_2 emission - Green

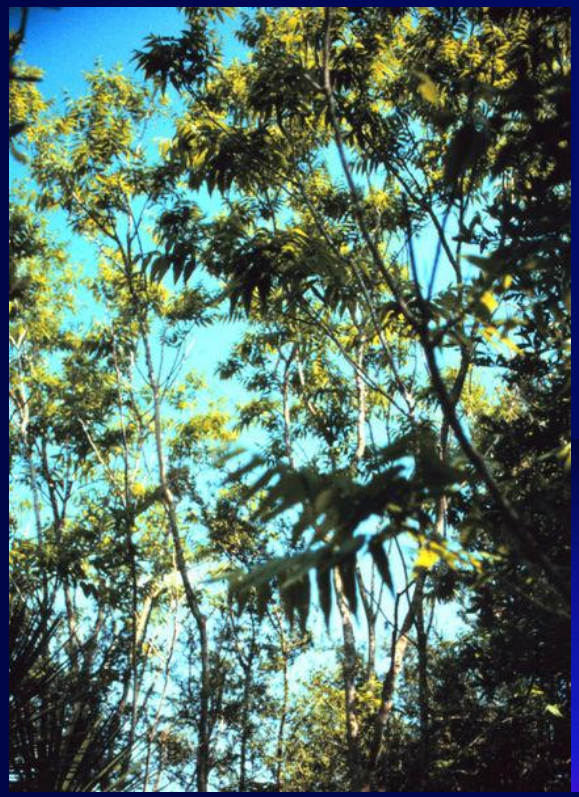
Average weight : 1200 kg

Mechanical Properties of Nanocellulose-PP Nanocomposites



Natural Surfactant (Saponin)

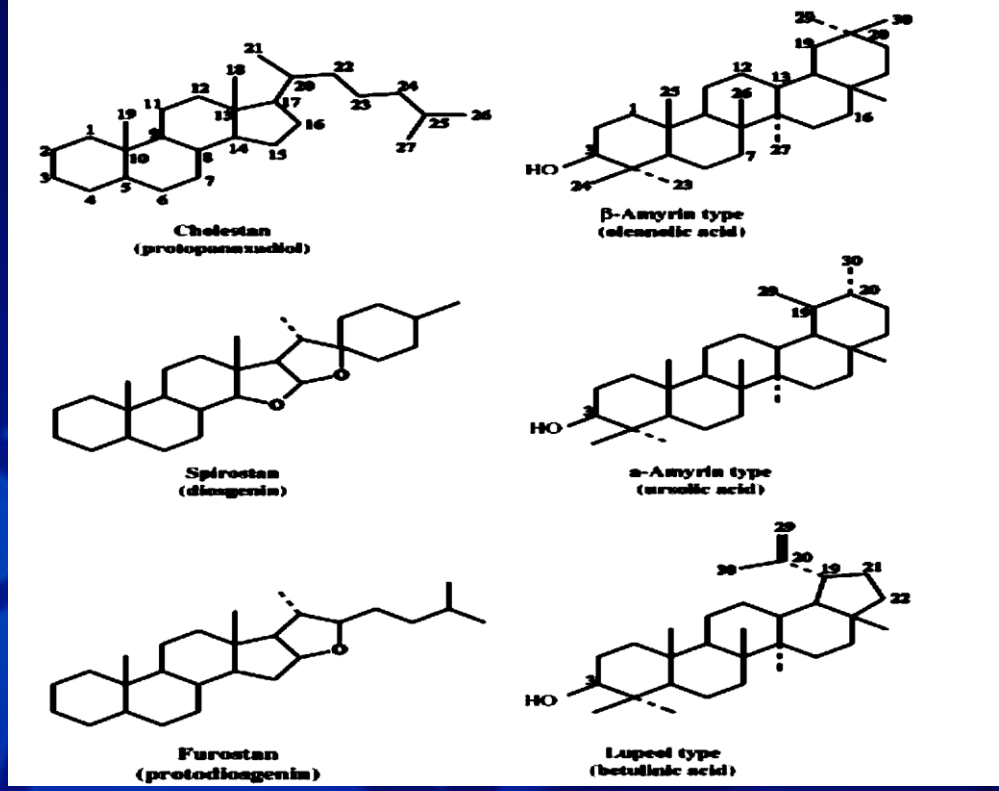
Sisal has and more valuable than fibers



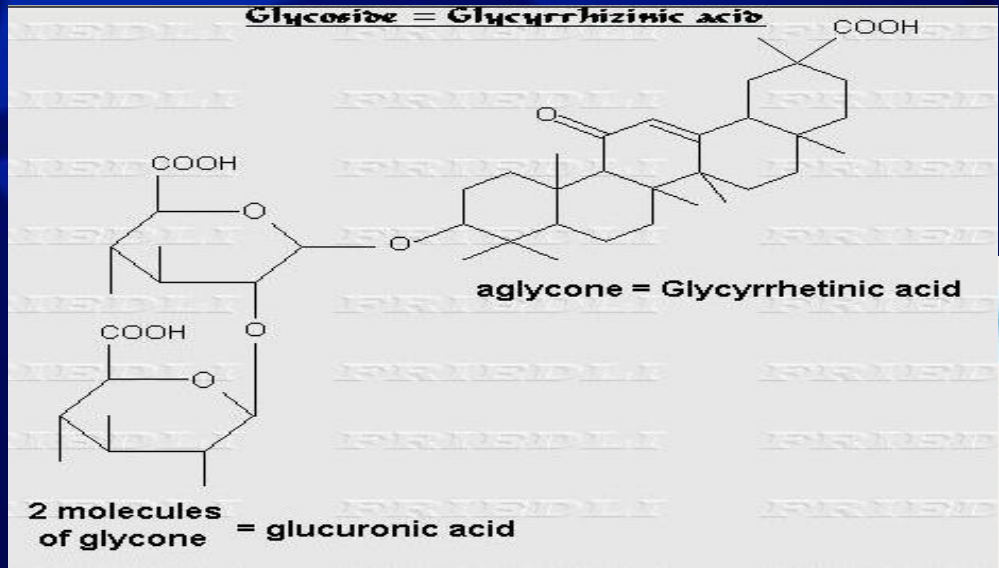
Sapindus mukorossi

Soapnut Tree

Saponins are complex molecules consisting of non-sugar aglycone coupled to sugar chain (glycosidic) units



Basic sapogenin skeletons—steroidal (left column) and triterpene (right column)



.	Natural fibres used in the study	Recommended Applications
	Flax plant fiber	Vehicle bonnet
	Jute, coir, kenaf, flax, abaca, sisal, hemp	Automobile application
	Caryota fiber	Automotive components
	Leucas Aspera	Brake pads
	Azadirachta indica	Automobile application
	Flax	Automobile hood
	Banana fibers with leather	Automobile application
	Areca sheath	Automobile dashboard panel
	Jute fibers	Frontal bonnet of a vehicle
	Pineapple and cassava flour	Automotive interior parts
	Flax fiber	Vehicle bonnet
	Calotropis Procera	Automobile interiors, and sports equipment
	Coconut flower cover fiber	Automobile application
	Glass fibre with hemp fibre	Automobile application
	Kenaf fibres	Automobile components such as dash boards, door inter and underfloor components
	Abaca fibre	Automobile application
	Palm sheath and sugarcane bagasse fibres	Vehicle dashboard applications
	Demostachya Bipinnata Fibers	Automotive component applications
	Milkweed, kusha grass, sisal, banana, and hay fibres	Automobile application
	Sisal/kenaf fiber	Automobile application


Curaua in
Consortium
with
Eucalyptus

Curauá Fabrics Fashion Show at ISNAPol 2000

Conclusions

1. Design: Not only the product but also the entire life cycle must be designed to optimize resource recovery and reuse.
2. Scale: Adequate quantities of used cars must be available to justify investments in recycling infrastructure.
3. Policy: Regulations must prohibit inappropriate disposal, establish appropriate incentives and enable manufacturers to recycle both their own as well as competitors' products.
4. Collection: It must be possible to integrate the collection of the used product through the same channels and partners as the distribution of new ones.
5. Cost: Economically and environmentally preferable technology must enable the cost-effective recovery and reuse of materials.
6. Continuous improvement: The ability to identify, monitor and adjust for issues and opportunities that can impede or unlock value is necessary.

Auto Industry in the Future

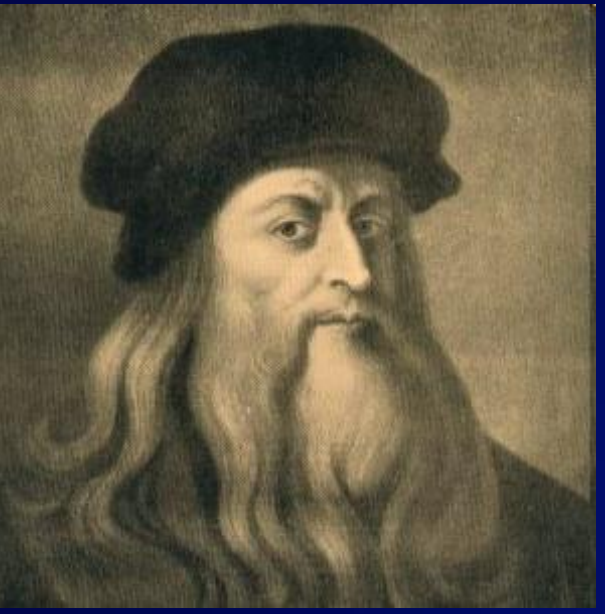
- The car parts made of natural fibers and other biopolymers are the best alternatives, since they can match the sustainability requirements in the agriculture, fibers processing and recyclability for end-of-life vehicles.
- The use of biobased materials to replace fossil-based ones and redesign of materials to sustain reusing and recycling are options for the natural fibers in the automotive industry contributing to an earlier transition to a bioeconomy. The car parts made of natural fibers and other biopolymers are the future.

Auto Industry in the Future

- The car of the future may soon be stronger and more environmentally friendly because body shell materials will be ‘grown’, reducing reliance on unsustainable traditional materials as a way of promoting sustainable development. Science and technology will provide it.

Acknowledgments

- CNPq – National Council for Research – Brazil
- FAPESP – São Paulo Research Support Agency
- CAPES/Print Internationalization Program



Life is pretty simple:You do some stuff. Most Fails. Some Works. You do more what works. If it works big, others quickly copy it.Then you do something else. The trick is the doing something else

Leonardo da Vinci