Hybrid Natural Fibre Composite for Injection Molded Semi-Structural Auto-Parts

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Non-Food Agro-Materials Research Road Map

- Macro, Micro and Nano-Fibre Isolation, Transformation
- Plant Molecular Engineering
- Bio-plastics and Agro-plant fibre Bio-composite Manufacturing
- Computational Modelling of Biocomposite Performance & Standardization

Non-Food Agro-Research Program Road Map

Engineering Unit Operations

Structural bio-fibre and Bio-Plastics

- Separation
- Isolation
- Purification
- Catalysis
- Extraction
- Identification
- Membrane
- Enzyme

Explored Plants and Root Crops

Plant / Root Fibers

Bast Fibers	Leaf Fibers	Seed Fibers	Fruit Fibers	Root Fibers
Flax	Agaves	Cotton	Coconut	Turnip
Hemp	e.g. sisal	Kapok	Cashew	Sugar Beet
Wheat	curaua		shell	Rutabaga
Soy	Banana			Potato
Corn				?????

Fibre & Nano-fiber Source in Plant Stem

Inside structure of Agrofiber

Nano-tissues (Source of Bioplastics?)

Ultrathin Stem Fiber

PART 1

Plants to Structural Fibres

- Plantation & Harvesting
- Retting
- Fibre Opening
- Fibre Transformation

Structural Plant Fibre Production

- Plantation & Harvesting

Research Needs

- Seed Selectivity
- Enhance Cellulose Content
- Improve Fibre Consistency
- Prevent Fibre Damage

UofT

Structural Plant Fibre Production

- Retting

- Process to remove pectin and enhance bast fibre separation without degrading cellulose

Approach:

- Field Retting
- Water Retting
- Fungal Retting
- Enzymatic Retting

Retting of Wheat Straw with Microbial Strain

Water retted

Selective Strain effectively removed pectin and bleached straw

Wheat straw

Enzyme retted

(9 strains and 12 Fungi)

Bleached Straw

Retting of Corn Straw with Microbial Strain and Enzymatic Conversion of Corn Cobs

Corn cob

Mechanical grinding

Fungal treatment & experiment in process

Fungal treatment 15 days

Characterization under experiment

Corn stalks

Structural Plant Fibre Production

➢Fibre Opening

➢Mechanical Process
(Long & short technical fibers)

➢Refiner Process
(Short reinforcing fiber)

➢Chemical Process
(Short structural fiber)

➢Cryogenic Process
(Structural Nano bio-fibre)

1) Long and Short Technical Fibres

➢Mechanical Process

Cutting bales

Metering and cutting straw

Opening Straw by breaker

Screened Technical fibers

Clean long fibers

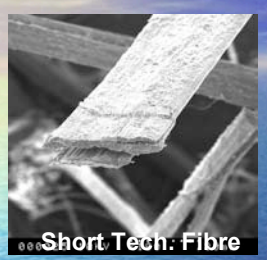
Screening and Karding

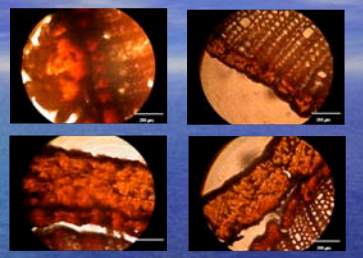
Source: Institute of Agricultural Engineering Bornim, www.atb-potsdam.de

Technical Grade Plant Fiber Strength Performance after Mechanical Processing

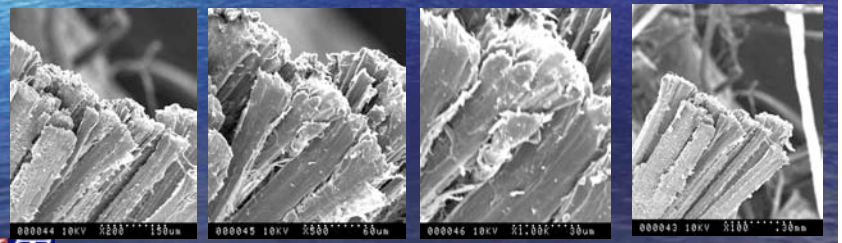
Fiber	Length	Density (Kg/m^3)	Modulus (GPa)	Specific Modulus
Hemp	20-50	1.5	28	19
Kenaf	20-50	1.5	22	15
Jute	500-700	1.5	26-52	17-35
Glass	Cont.	2.6	72	28

Transformative Research from Semi-structural to Structural Plant Fibre



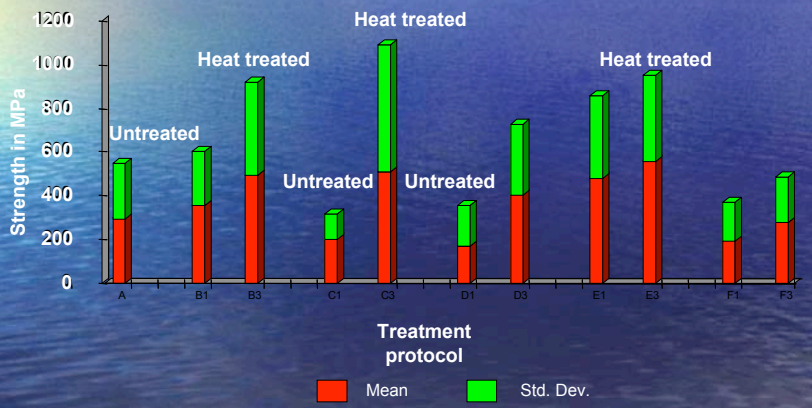


- Fibre opening by high pressure heat treatment



Transformative Research from Semi-structural to Structural Plant Fibre

Strength of Heat-treated Hemp Fibre



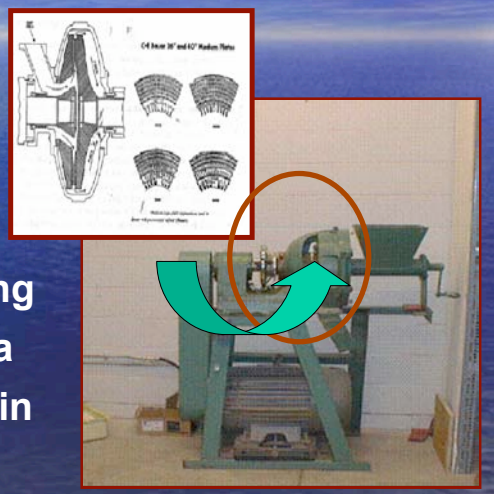
2) Short Reinforcing Fiber

- Refiner Process

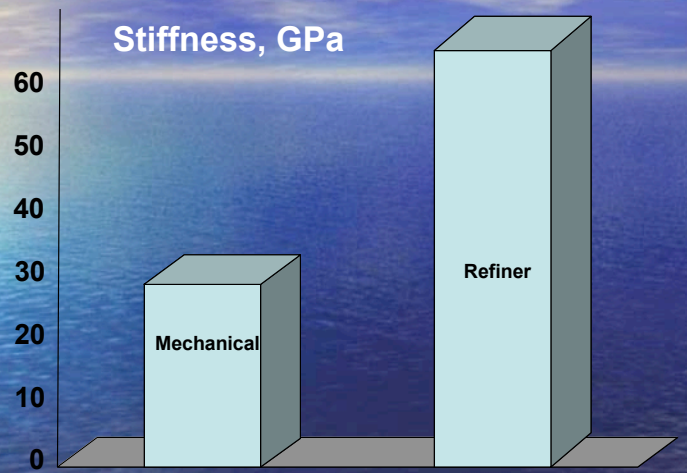
Feedstock:

Soy, Wheat, Corn, Flax, Wood & Hemp Straw

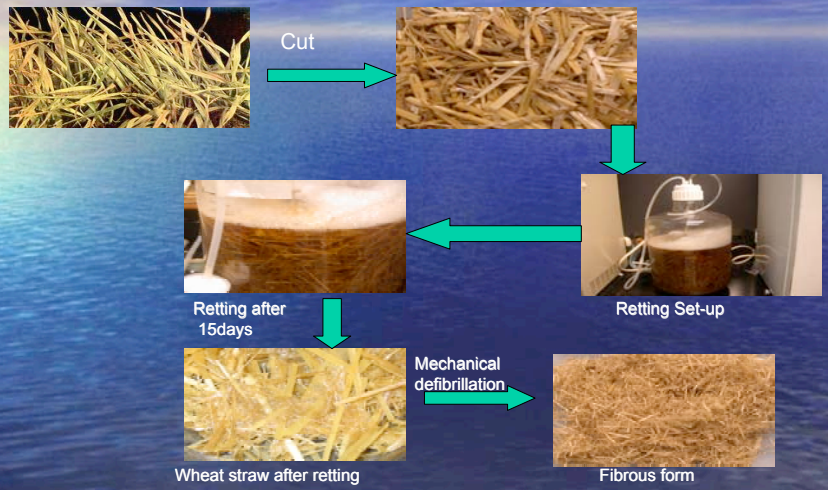
- 6 inch cut
- high shear refining
- 30-100 micron dia
- 0.5 mm to 10 cm in length



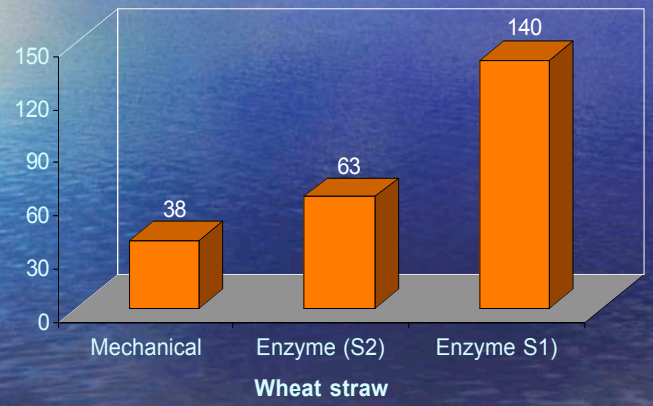
Flax Straw to Reinforcing Plant Fibre



Transformation of Technical Fiber to Structural Fibre: Enzymatic Process Example: Wheat Straw



Transformative Research from Technical to Semi-structural Plant Fibre



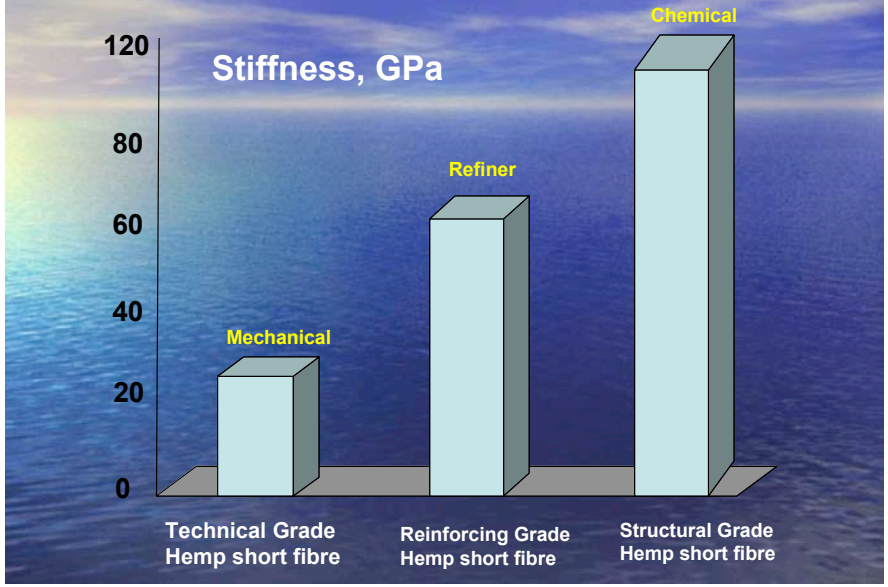
3) Short Structural Fiber
➢Chemical Process

Feedstock:

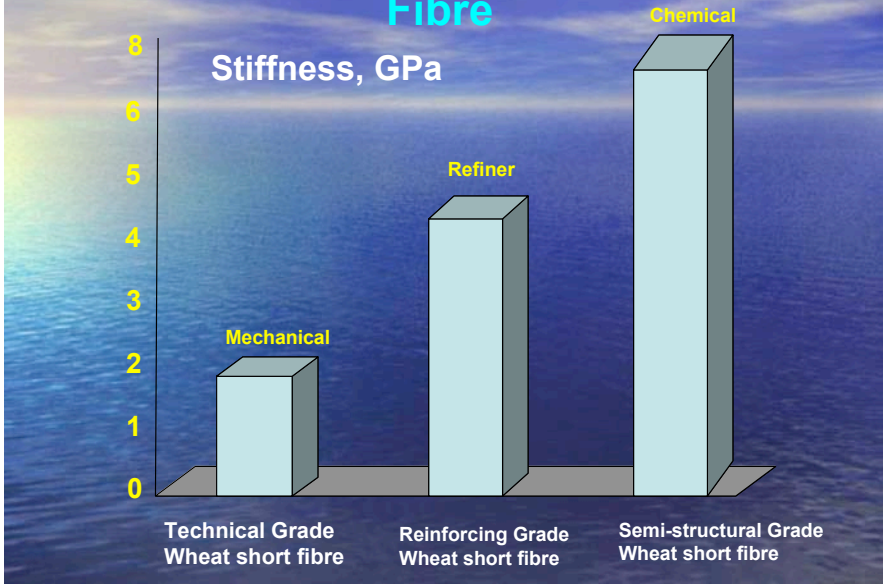
Soy, Wheat, Corn, wood, Flax & Hemp Chopped Straw

- ➢2-4 inch cut
- ➢De-lignification (NaOH)
- ➢20-60 micron dia
- ➢ 2 mm to 20 cm in length

Hemp Bast to Structural Plant Fibre



Wheat Straw to Semi-structural Plant Fibre



Structural Short Fiber Production Process

semi final products

Harvested Wheat Straw

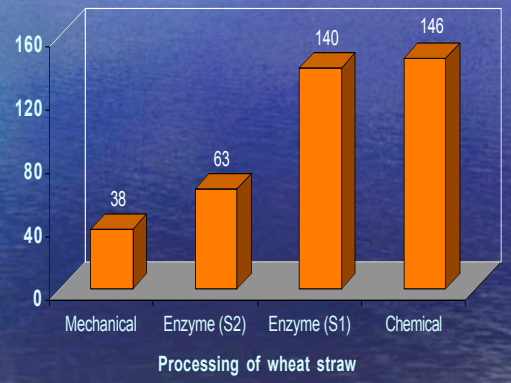
Chopped Wheat Straw

OMAF-Funded

(Milling) (Defibrilation) (Enzyme Retting) (Alkali Cooking)

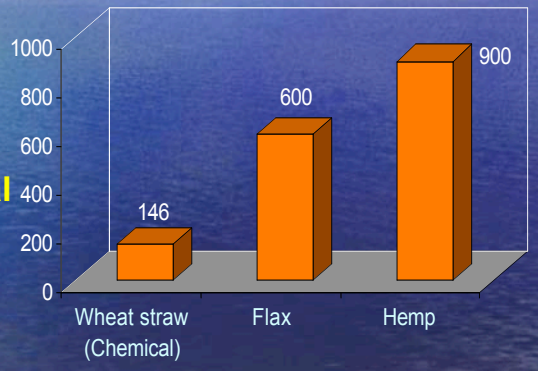
Transformation of Wheat Fibers

Enzymatic Retting Enhances Fibre Performance



Performance of Wheat Fibers

Retted Wheat Straw Produces Semi-structural Grade not Structural Ones

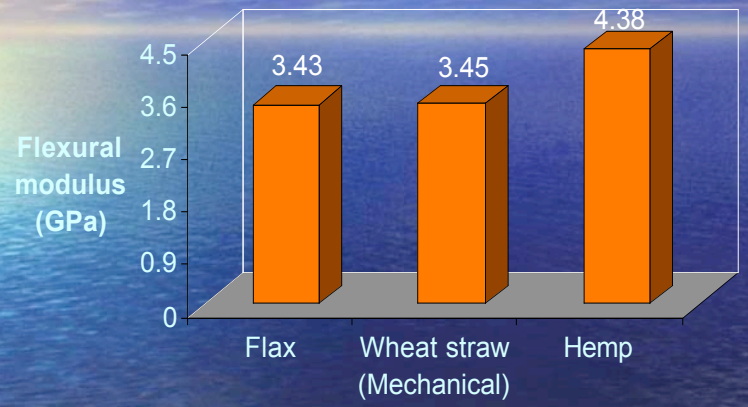


Summary

Section I

Research Advancement in Developing Structural Properties of Technical Grade Plant and Root Fibres Demonstrate Tremendous Future Promise for Engineered Applications of Biofibres

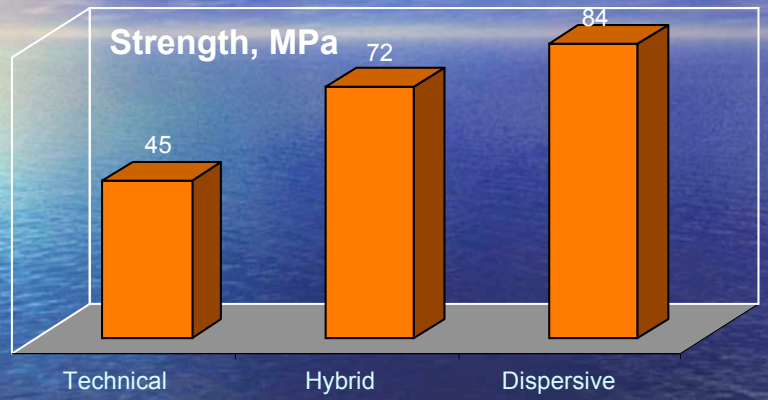
Injection Molded Semi-Structural Properties with Plant Fibres



PP composites with wheat straw, hemp & flax

OMAF-Funded

Injection Molded Recyclable Structural Properties with Plant Fibres

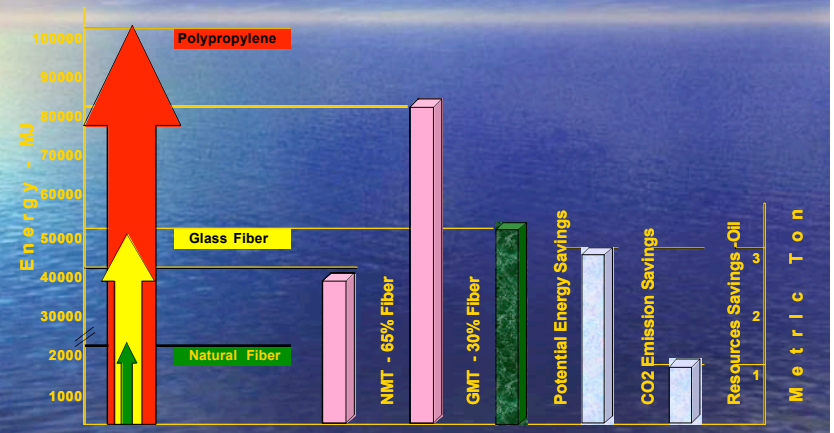


US Patent Pending

PP composites

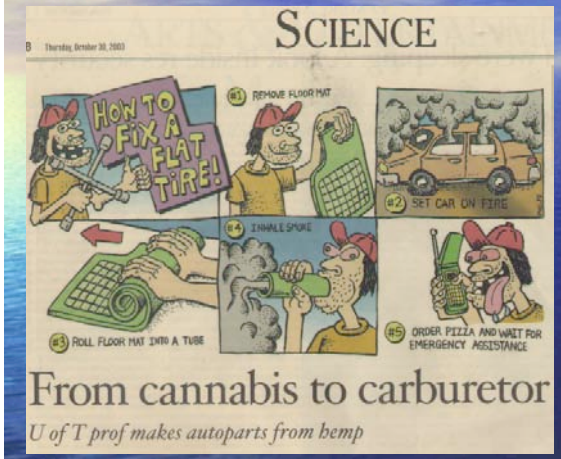
Environmental Benefits

Energy and GHG Emissions Savings



Sources: T. Corbiere-Nicollier "Life Cycle Assessment of Biofibers replacing Glass Fibers as Reinforcement in Plastics", Resources, Conservation and Recycling, 33 (2001), 267-287.

Our Life and Environment with Plants


SCIENCE

From cannabis to carburetor

U of T prof makes autoparts from hemp

Plant Have to Become "High Tech Product Image"

Effective Communication of Research and Technological Success Stories to the Society is the Key to Achieve This Goal!!!

Acknowledgement

NCE- Auto 21, Canada

Ontario Ministry of Agriculture & Food (OMAF)

Atofina

Hempline