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Lower cost, lower weight and greener polypropylene biocomposites for automotive applications

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ICAUTO C 2016
International Conference on Automotive Composites
September 21 to 23, 2016 • Lisbon • Portugal

**LOWER-COST, LIGHTER AND GREENER
POLYPROPYLENE BIOCOMPOUNDS
FOR AUTOMOTIVE APPLICATIONS**

Mihaela Mihaj, Karen Stoeffler

*Polymer Bioproducts Team
Automotive & Surface Transportation
National Research Council Canada*



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PRESENTATION OUTLINE

- **About National Research Council Canada**
- **NRC's green vision**
- **Materials, processes and characterization**
- **Bio-based PP compounds:**
 - **Lower-cost biocomposites**
 - **Lighter biocomposites**
 - **Greener bioblends and biocomposites**
- **Summary**

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About NRC:

- Government of Canada's premier Research & Technology Organization
- Over 3,550 full-time employees
- Provides a broad array of technical and R&D services to the industry
- Supports innovation finance for SME via Industrial Research Assistant Program (IRAP)

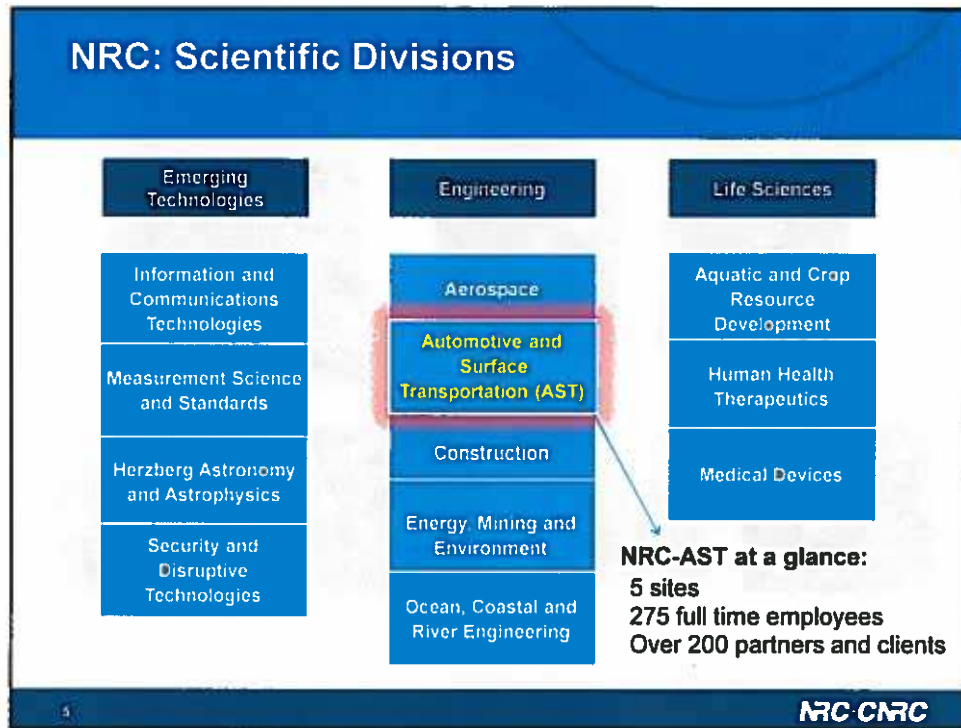
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National Research Council Canada: A Research & Technology Organization

- Mission-oriented provides innovation services to companies, organizations and governments (R&D projects, technical services, consortiums, Industrial Research Assistance Program)
- Bridges gap between early stage R&D and technology deployment
- Builds economic competitiveness and improving quality of life



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NRC: Automotive and Surface Transportation Market Driven Programs



Lightweighting



Vehicle Propulsion Technologies



Composites and Plastics for Transportation



Advanced Manufacturing



Design Systems



Rail Vehicle Track Optimization







Fleet Forward 2020

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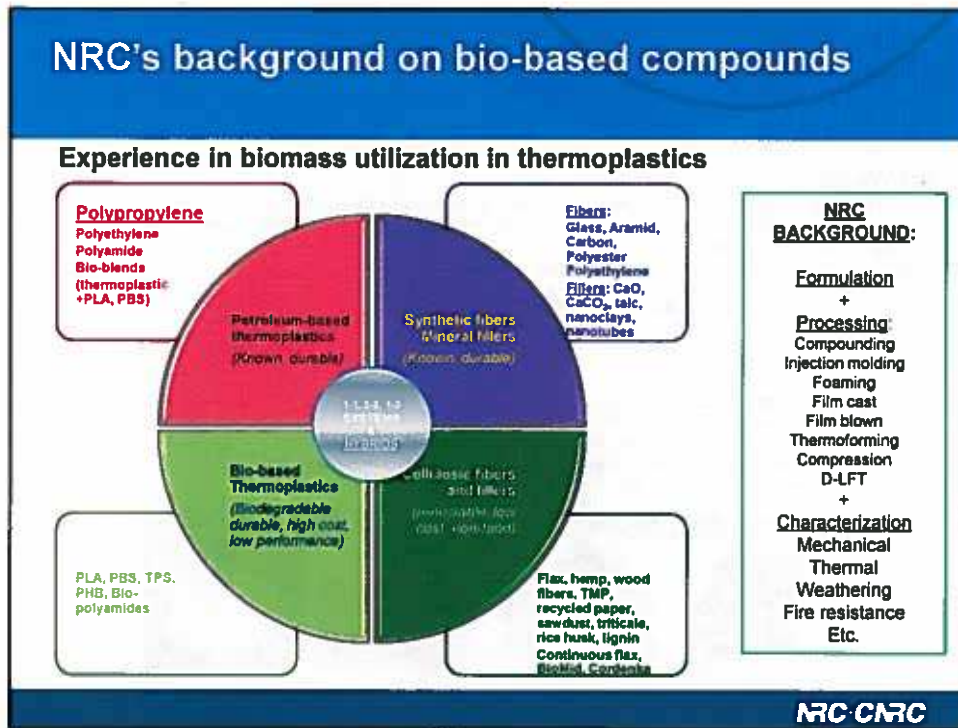
NRC: Biomaterials for automotive applications Value Proposition

Stronger, tougher thermoplastic / biofiber materials for lighter, lower-cost and eco-friendly applications:

- Forestry and agricultural cellulosic fibers;
- Sustainable biomaterials;
- Cellulosic biofiber contents up to 50%;
- **Weight reduction up to 25%;**
- Reduction in material costs, energy cost = **Cost savings;**
- Custom made formulations to meet industry requirements.

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- ## NRC's green vision for PP
- Focus on replacement of PP filled with minerals and PP-glass fiber composites by PP bio-compounds;
 - The substitution of petroleum-based PP compounds and PP composites by biocomposites containing cellulosic fibers can allow weight and cost reductions;
 - The use of injection foaming process allows to further reduce the weight and the cost of the parts;
 - The substitution of a part of PP by a bioplastic is a way to increase renewable content.
- NRC offers solutions for novel PP biocomposites and bioblends which:**

 - Could be cost competitive, greener and lighter;
 - Could have equivalent or higher performance compared at conventional materials.
- NRC CNRC**

Materials

Polymers:

- PP: Pro-fax 6323 general purpose homopolymer from Lyondell Basell for injection molding applications.
- PLA: 8302D amorphous grade from Nature Works, was selected as bio-sourced minor phase;
- Coupling agents were used;
- Commercial PP grades used for comparison purposes were:
 - PP 20 % talc – Accutech 20L & PP 40% talc – Accutech 40L
 - PP 20 % GF – Polifil GFPP-20 & PP 40% GF – Polifil GFPP-40

Fibers:

- Cellulosic fibers contents: up to 40 wt. %
- Short flax fibers: was supplied by Schweitzer Mauduit Canada;
- Thermo-mechanical pulp (TMP) fibers: was supplied by SEC Papier Masson WB;
- Wood fibers (WF) in the form of dices (WoodForce) were supplied by Sonae Industria;
- Short glass fibers (GF), 3 cm in length, were a commercial grade;



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Processing & Characterization

Compounding line:



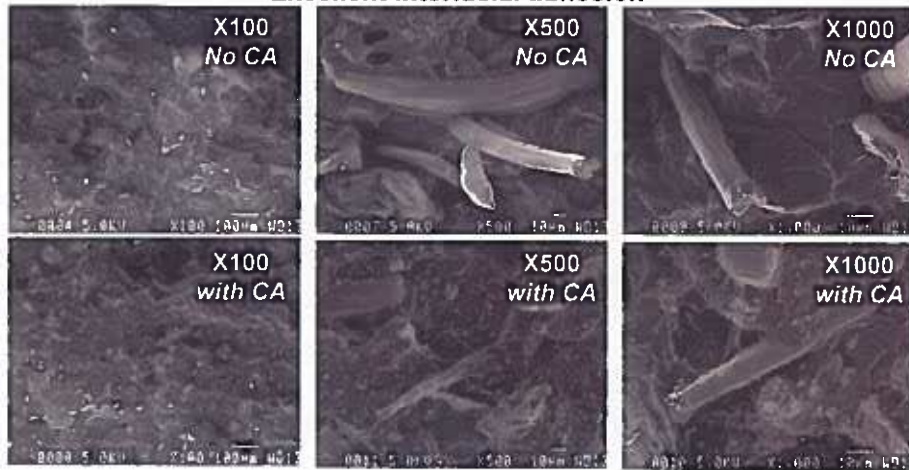
Testing

- Morphology: Scanning Electron Microscopy (SEM)
- Tensile properties (TS, TM, e%) - ASTM D638
- Impact strength (IS_{200}) - ASTM D256
- Heat Deflection Temperature (HDT) - ASTM D648

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Lower-cost PP biocomposites Partial replacement of PP by cellulosic fibers

Excellent interfacial adhesion

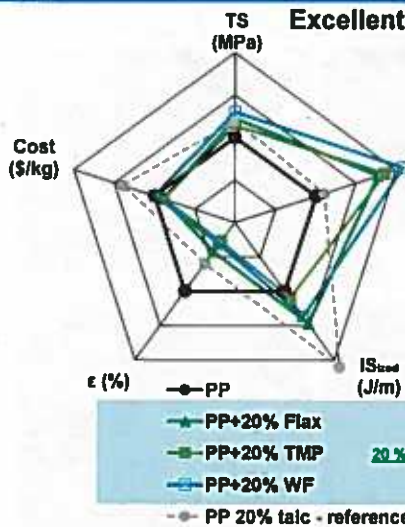


Morphology of PP/20%flax biocomposites without and with coupling agent

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Lower-cost PP biocomposites Partial replacement of PP by cellulosic fibers

Excellent tensile properties



Approximate prices (\$/kg) on the market :

PP (\$/kg)	Co-PP (\$/kg)	Flax (\$/kg)	TMP (\$/kg)	WF (\$/kg)	PP / 20% talc (\$/kg)	PP / 20% GF (\$/kg)
1.8	1.8	1.0	0.3	1.5	2.5	1.3

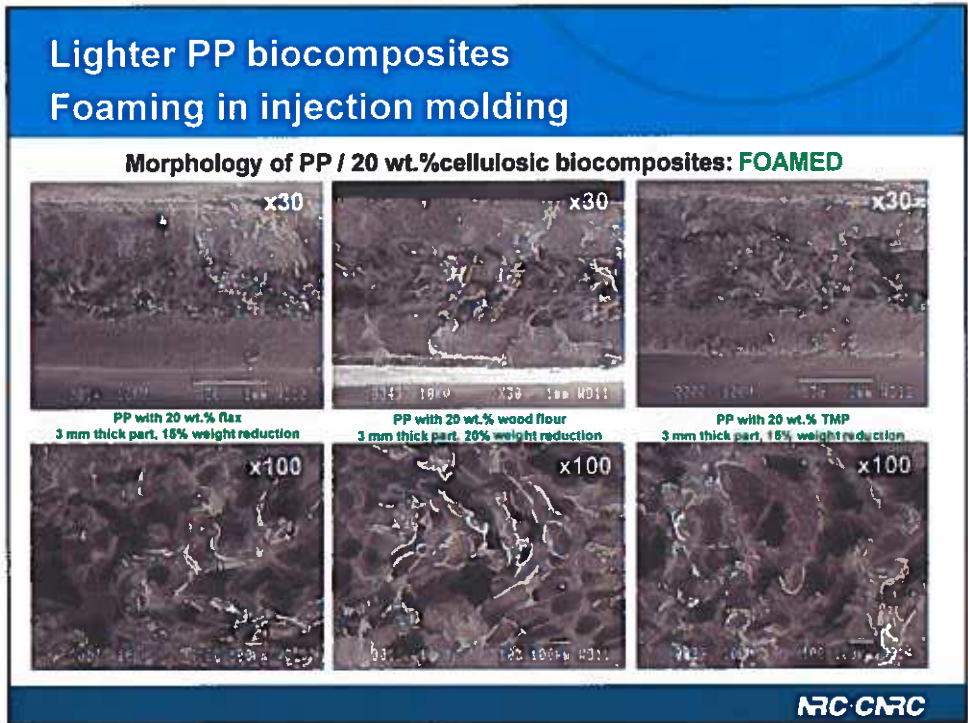
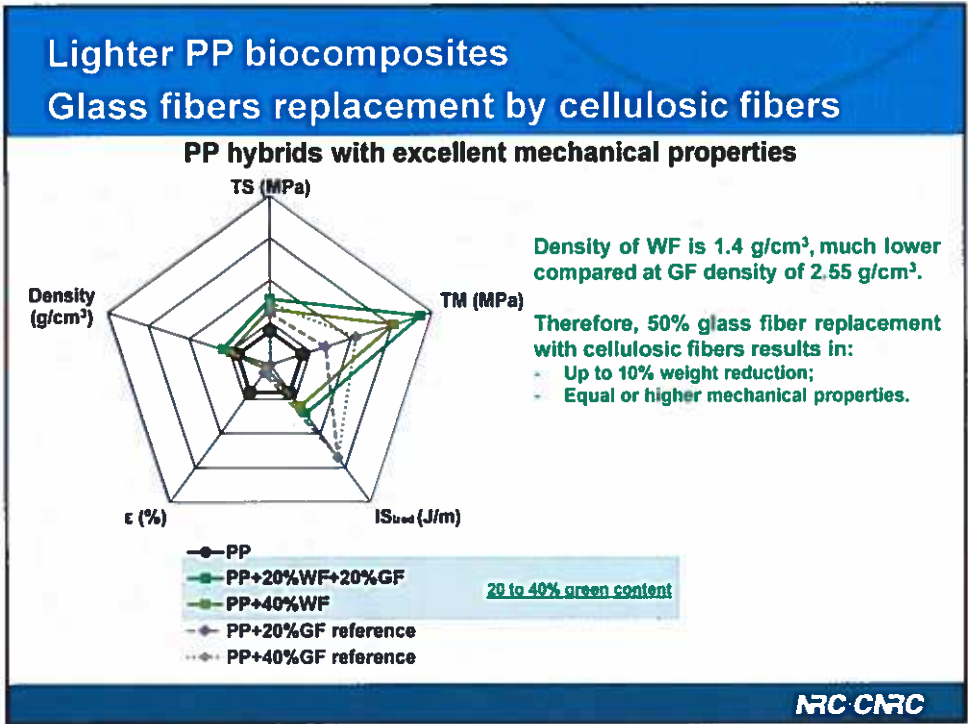
TM (MPa)

Cost reduction

	20 wt.% Cellulosic content		40 wt.%	
	Cost (\$/kg)	Cost reduction (%)	Cost (\$/kg)	Cost reduction (%)
PP / Flax	1.6	9.0	1.4	18.0
PP / TMP	1.6	17.0	1.3	33.4
PP / WF	1.8	3.4	1.7	6.8

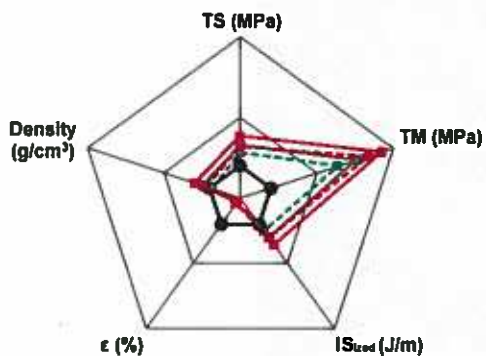
When replacing up to 40% of the matrix by cellulosic fibers:
 > Mechanical properties are comparable with the references or higher;
 > The cost is reduced by 3 up to 33% due to lower price of the cellulosics comparing to the price of PP.

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Lighter PP biocomposites Foaming in injection molding

Excellent properties of foamed PP biocomposites



- PP
- PP+40%WF unfoamed
- PP+40%WF foamed
- PP+20%WF+20%GF unfoamed
- PP+20%WF+20%GF foamed

Replacing up to 40 wt.% of PP by cellulosic fibers results in a 10-30 % cost reduction.

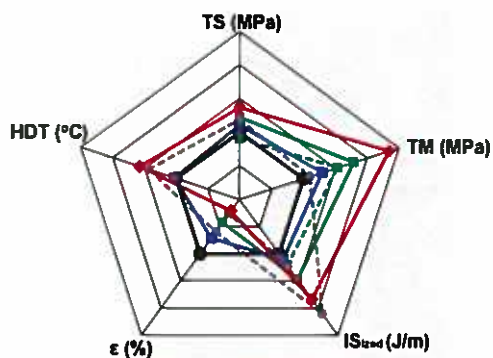
When these biocomposites are further foamed in injection molding the weight reduction could be up to 25 %. This translates into up to 25 % supplementary cost reduction.

20 to 40% green content

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Greener PP/PLA : Bioblends and biocomposites

Properties of PP/PLA bioblends and PP/PLA biocomposites



- PP
- PP+20%WF unfoamed
- PP+20%WF foamed
- PP+30%PLA
- PP+30%PLA+20%WF
- PP 20%taic reference

HDT increased from 80°C to 126°C for PP/PLA/20 wt.% WF, that is higher comparing to PP/20% talc (115°C)



20 - 50% green content

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NRC demonstrators based on Polyolefins biocomposites



Polyolefins / PLA /
cellulosics: injected
parts

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NRC demonstrators based on Polyolefins biocomposites: C-pillar cover

PP / wood flour (20 wt.%) prototype as a replacement for mineral filled PP:



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CRIBE

Alberta
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NRC demonstrators based on Polyolefins biocomposites



**Recycled Polyolefins / 10-50% cellulotics:
thermoformed sheets for trim and molding applications**

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NRC demonstrators based on Polyolefins biocomposites



- **Recycled Polyolefin / cellulotics: extruded foamed profiles.**
- **Up to 25% weight reduction compared to unfoamed profiles.**
- **Applications: decking, door and window profiles, others...**

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NRC demonstrators based on Polyolefins biocomposites



**Polyolefins / cellulosics biocomposites:
Sidings obtained in extrusion and extrusion foaming**

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Summary

- NRC biocomposites based on PP and PP/PLA are:
 - Equivalent in terms of mechanical and thermal properties to conventional PP-based materials currently used by automotive industry;
 - Lower-cost due to a content up to 50 wt.% of renewable resources;
 - Lighter due to:
 - Partial or complete replacement of glass fibers by cellulosic fibers;
 - Foaming in injection molding;
 - Greener when a bioplastic replaces a part of the PP matrix.
- We also developed:
 - PE and PE/PLA based biocomposites with cost and weight reductions;
 - PA6 and PA6/PLA based biocomposites with cost and weight reductions;
 - ABS and ABS/PLA based biocomposites with cost and weight reductions;
 - PP, ABS and PA6 based biocomposites with continuous cellulosic fibers by D-LFT process.
- Those **lower-cost, lighter and greener biocomposites** could replace the petroleum compounds and composites in automotive applications.

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Thank you!

Scientific and technical contributions

- Karon Stoeffler, research officer & team leader
- Mehel Chikhal, technical officer / injection molding
- Florence Perrin, technical officer / morphology
- Yves Simard, technical officer / compounding
- Manon Bourde, technical officer / mechanical testing



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