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Sustainable polymer products for transportation and manufacturing

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July 25th, 2018.



Outline

- **Who are we?**
- **Context and strategy**
- **Sustainable polymer products at NRC**

  The lignocellulosic platform:
  - Cellulosic biocomposites: a mature technology
  - The lignin roadmap

  Bioplastics from industrial waste:
  - Using poultry feathers as a feedstock?
  - PHA from industrial waste

- **Conclusions and perspectives**



About NRC

- Government of Canada's premier **Research & Technology Organization**
- Over **3,700** full-time employees
- Bridges the gap between early stage R&D and technology deployment
- Provides a broad array of **technical and R&D services** to the industry

NRC: Already 102 years old!



- **4 scientific divisions:**
  - Life sciences
  - Emerging technologies
  - Engineering
  - **Transportation and manufacturing**
    - **•Automotive and surface transportation**
    - •Aerospace

- **Over 1,000 clients:**
  - Technical & testing services, Research services
  - 1-on-1 projects, multi-partner projects, consortia
  - IP terms determined on a case-by-case basis
  - Projects at any stage of the R&D pipeline are welcome

Polymers & Bioproducts at NRC: Vision & Research Themes

Develop innovative yet sustainable polymer products for tomorrow's industry



Eco-Responsible Materials

Biorefining

Bioplastics

Biocomposites

Clean processes and technologies



Innovative Materials and Processes

Functional and smart materials

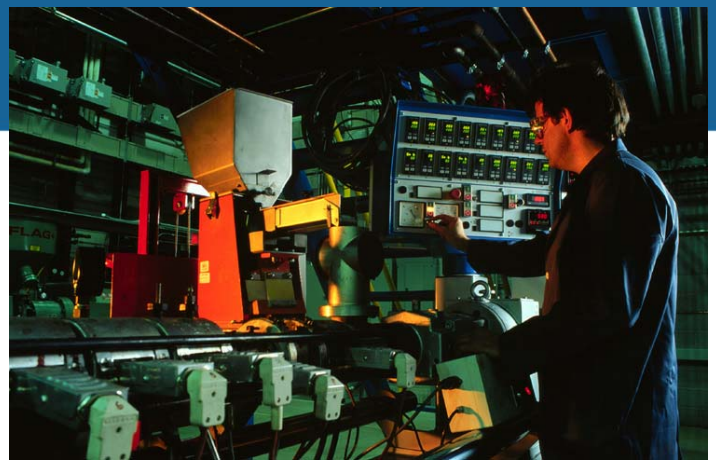
Lightweight composites

Accelerating materials development through AI

Large Scale Processing



Polymer Processing



Extrusion

- Semi-industrial scale twin-screw extruders (Ø11 mm – Ø34 mm)
- Semi-industrial scale twin-screw extruder with physical foaming capability (Ø50 mm)
- Large scale twin-screw extruder with D-LFT capability (Ø70 mm)



Injection-molding

- Semi-industrial scale presses (34t, 150t w/ co-injection capability, 250t)

Film & sheet

- Blown film lines, 5 materials, 5 extruders (Ø20 mm & Ø100 mm)
- Cast film (monolayer, 5-layer w/ coating capability)
- Biaxial stretcher
- Thermoforming

Composites processing

Forming-stamping

- 1,250 ton press, 2 m daylight
- 1,1 m x 1,3 m platens size
- Heated/cooled smooth platens (425°C)
- T-slotted platens
- IR oven (PEEK capability) for forming-stamping
- Small scale capabilities also available



Direct Long Fibre Thermoplastic (D-LFT)

- Twin screw extrusion, Ø70 mm
- >100kg/h
- 2,500 ton press
- Small scale capabilities also available for formulation



Liquid moulding processes

- Resin infusion / Light-RTM
- RTM / HP-RTM



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Properties & Performance assessment



Microstructure and chemistry

- Preparation: microtomy, ultramicrotomy, polishing
- OM
- SEM, TEM, AFM
- WAXD
- FTIR, UV

Rheological properties

- Capillary rheometer
- Constant stress/strain rheometers
- Elongational rheometers



Thermal properties

- DSC, TGA, TMA, DMA, HDT

Mechanical properties

- Tensile, flexural, impact
- Fatigue

Flame Smoke & Toxicity

- Flame spread
- Smoke density
- Analysis of combution gases



Others

- Permeability (O_2, H_2O)
- Accelerated weathering
- Biodegradability

Sustainable Polymer Products: Context

- **A global challenge:**
  - Global production: 280 Mt/yr
  - Packaging: 40%
  - Global recycling rate: 10%
  - Ocean waste plastic: 9 Mt/yr

June 2018



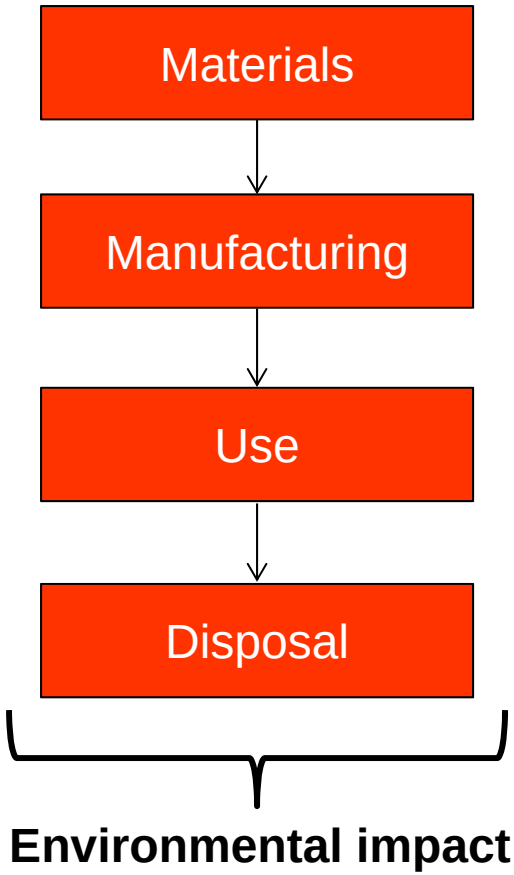


- **G7 Ocean Plastics Charter:**
  - Sustainable design, production and after-use markets
  - Collection, management and infrastructure
  - Sustainable lifestyles and education
  - Research, innovation and new technologies
  - Coastal and shoreline action



Sustainable Polymer Products: Strategy

- **A life cycle analysis (LCA) standing point:**



☑ **Low environmental impact materials**

☑ Energy efficient manufacturing processes

☑ **Lightweight materials**

☑ Energy efficient motors

Fuel consumption (2025: 54.5 mpg)

☑ **End-of-life scenario**



Sustainable Polymer Products:
Using Residues as a Feedstock



Residues

Biochemicals

Biomonomers

Biopolymers

Natural reinforcements

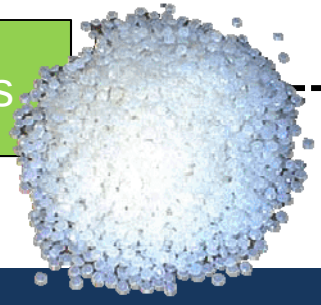
Petro-polymers

Biocomposites

Cost
Weight
Sustainability









The Lignocellulosic Platform:
Cellulosic Biocomposites: A Mature Technology

- **Over 15 years experience in:**
  - Cellulosic reinforcements selection
  - Surface modification
  - Formulation and compatibilization
  - Processing



The Lignocellulosic Platform:
Cellulosic Biocomposites: A Mature Technology

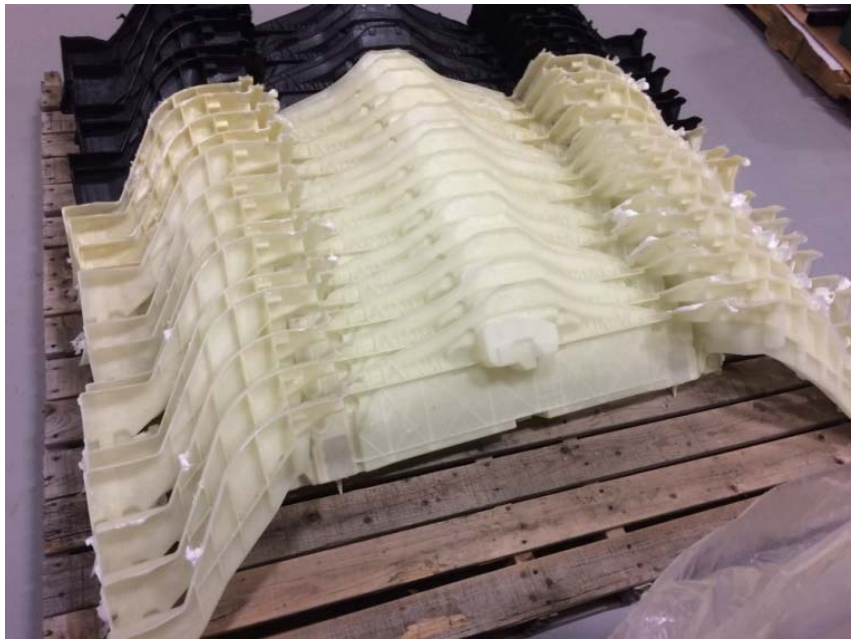
- **Lightweight automotive components:**

Instrument panel
injection-molded part



Weight reduction 10 -20%

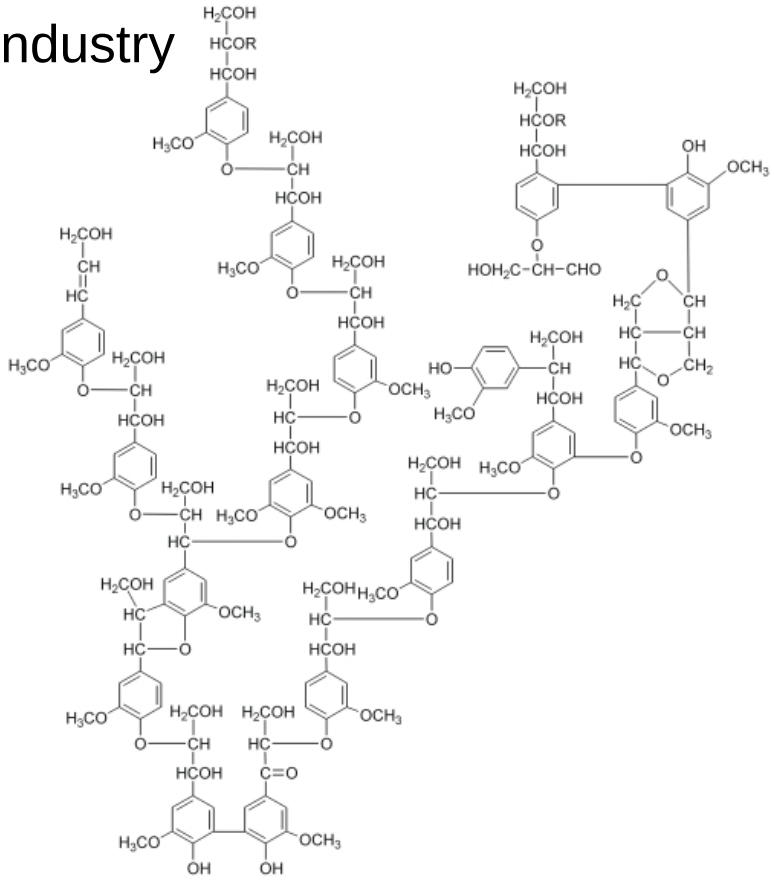
Front end carrier
By D-LFT / Compression molding



Proof of concept established

The Lignocellulosic Platform:
The Lignin Roadmap

- **The second most abundant natural polymer:**
  - By-product from the pulp and paper industry
  - Aromatic natural polyol
  - Currently landfilled or incinerated



- **What if… we could use lignin to make new polymer products?**
  - ✓ Valorization
  - ✓ Bio-based polymer products
  - ✓ Potentially low cost products



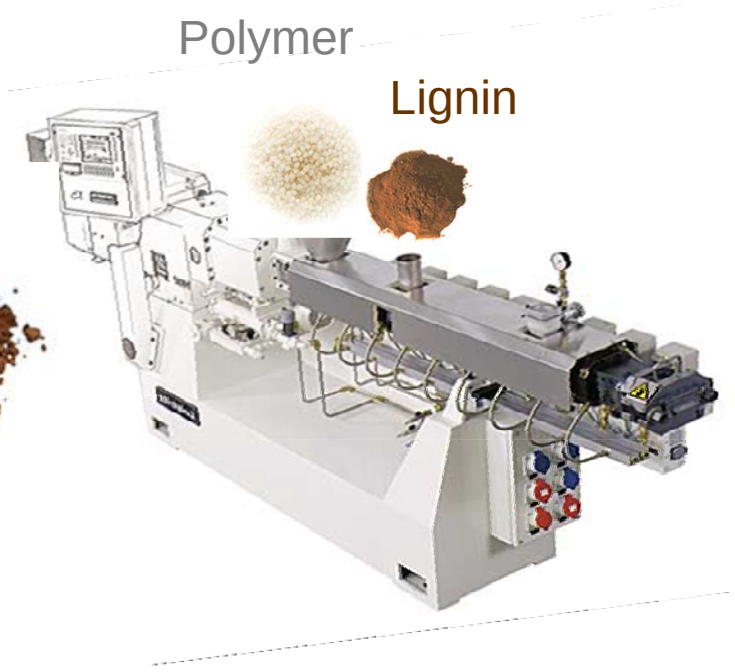
The Lignocellulosic Platform:
The Lignin Roadmap

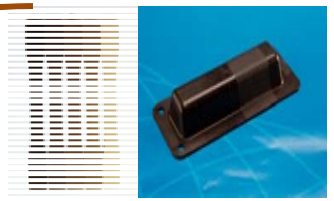
- **Over 10 years of R&D:**
  - With industrial partners
  - Towards commercial applications







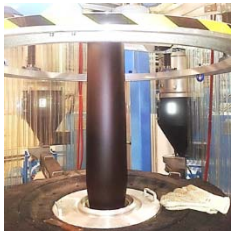




Molded parts



Extruded profiles



Extruded films



Extruded foams



PU foams

The Lignocellulosic Platform:
The Lignin Roadmap

- **Polyurethane flexible foams:**
  - Bio-based polyols from vegetable oils (soybean oil, castor oil, etc.)
  - Chemical modification of the oil required to introduce –OH functions
  - Lower mechanical properties as conventional polyols

  Example: Ford's BioSeat™





«Ford currently has soy-foam seats in more than 15 million vehicles on the road, which has reduced petroleum usage by more than 15 million pounds.»
Ford, Sustainability Report 2014-2015.

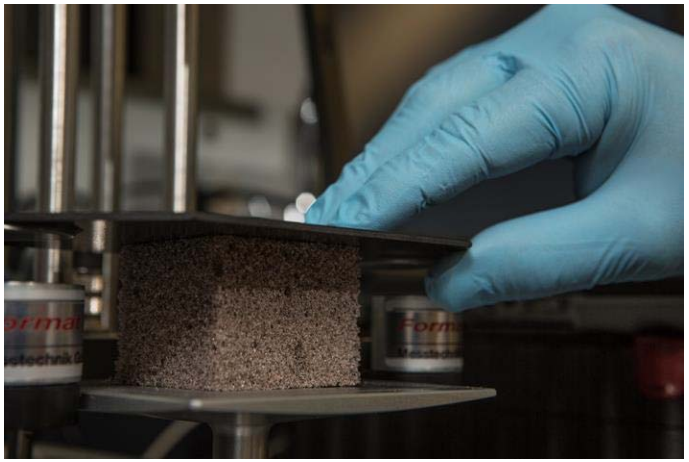
- **NRC's approach:**
  - Use lignin as a natural polyol to replace up to 20% of the polyol

The Lignocellulosic Platform:
The Lignin Roadmap

- **Polyurethane flexible foams based on lignin:**
  - Selection of the appropriate type of lignin
  - Production of the ligno-polyol
  - Control of the solubility, rheology and reactivity of the ligno-polyol
  - Formulation of the biofoam
  - Evaluation of the foaming ability and the performance of the biofoam







Bioplastics From Residual Waste:
Using Poultry Feathers as a Feedstock?

- **An interesting biopolymer source:**
  - Global poultry feather waste: 5 Mt/yr
  - Contains 90% of keratin, a natural polymer
  - Currently landfilled



- **What if… we could synthesize new polymer products from feather waste?**

Keratin feestock → Keratin extraction → Plastic products

Process needs to be:
- Economically viable
- Environmentally friendly





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Bioplastics From Industrial Waste:
Using Poultry Feathers as a Feedstock?

- **Working together:**
  - Multi-partner project built around the value chain
  - Medium term (3 yrs) and long term (5 yrs) objectives
  - Potential benefits:
    - ✓ Waste valorization
    - ✓ Low cost and environmentally friendly products
  - Status: Currently seeking for industrial and research partners. Target date: December 2018.

Keratin feedstock → Keratin extraction → Plastic products











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Bioplastics From Industrial Waste:
PHA From Organic Waste

- **Polyhydroxyalcanoate (PHA):**
  - Produced naturally by fermentation
  - Biodegradable
  - High production cost
    (feedstock, extraction, purification)



- **Creating low cost PHA products:**
  - A multi-partner project built around the value chain:
    - ✓ Use organic waste from the pulp and paper industry as a feedstock
    - ✓ Optimize fermentation and extraction processes
    - ✓ Formulate adequate bioplastics

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PLASTIQUES MOORE Technologies d'injection

Bioplastics From Industrial Waste:
PHA From Organic Waste

Injection-molded products



Extruded sheets & Thermoforming



3D printing filament



BOSK BIOPRODUCTS



Conclusions & Perspectives

- **NRC is actively working towards sustainable manufacturing:**
  - Bio-based materials
  - Lightweight materials
  - Clean processes and technologies
  - End-of-life options

- **NRC can help you develop your next generation products:**
  - Technical & testing services, Research services
  - 1-on-1 projects, multi-partner projects, consortia
  - IP terms determined on a case-by-case basis
  - Projects at any stage of the R&D pipeline are welcome



Thank you !

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