Cellulosic Materials at Alberta Innovates-Technology Futures

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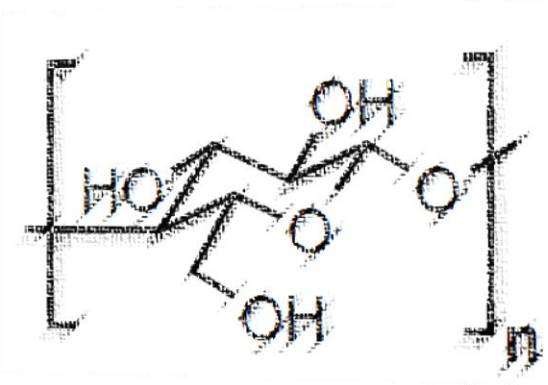
Freedom To Create. Spirit To Achieve.

Areas of Interest

- Focus on polysaccharide technologies
  - Extraction of wood or agricultural biomass
  - Polysaccharide modification
  - Properties
    - physical
    - mechanical
    - chemical



- Application development
  - Water soluble cellulose polymers for oil recovery
  - Modified polysaccharides for biomedical
  - Suspensions of nanocrystalline cellulose (NCC)

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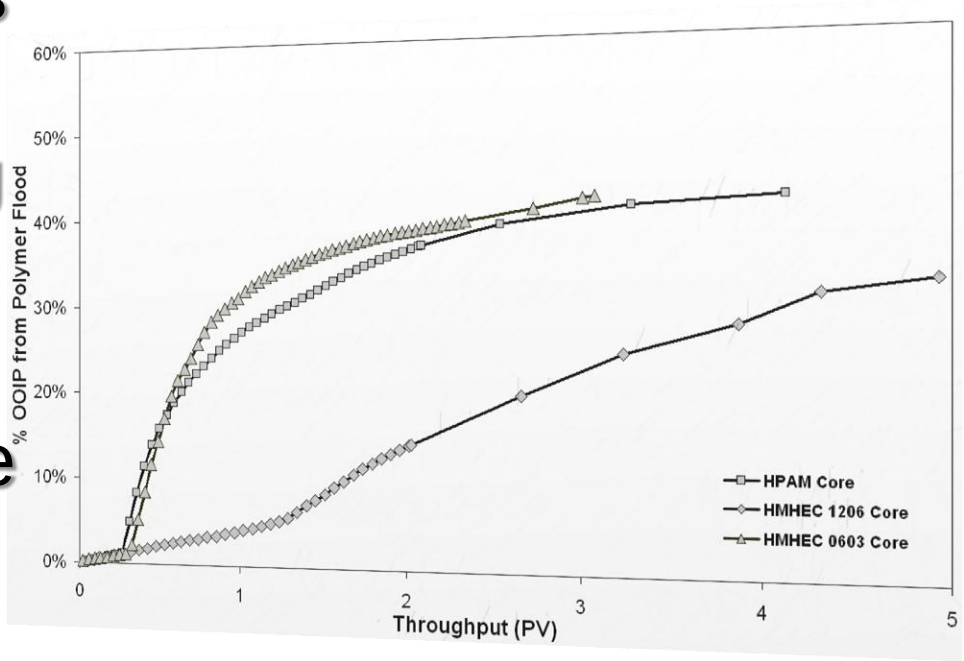
Enhanced Oil Recovery

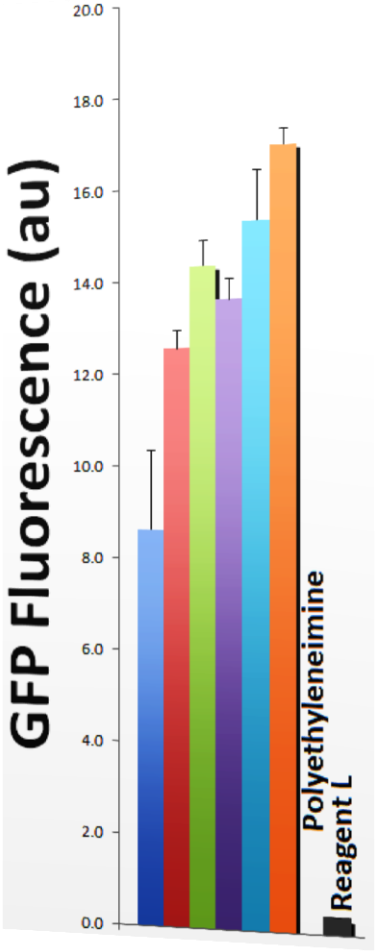
- Coreflood experiments show oil recovery comparable to existing commercial polymers
- Unique benefit: excellent salt tolerance



Bai, Jiang; Boluk, Yaman M.; Hawkins, Blaine F.; Jost, Robert; Wassmuth, Fred; Zhao, Liyan. *Waterflooding Method for Secondary Hydrocarbon Recovery.* Canadian Patent #2,684,230, International Application #WO 2011/050445 A1.

Transfection and Gene Therapy

- Better transfection efficiencies than commercial reagents
- Unique benefit: low toxicity
- Works on both plant and mammalian cells



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Boluk, Yaman M.; Jost, Robert W.; Uludag, Hasan. *Polyamine-Containing Polymers and Methods of Synthesis and Use.* US patent application #20110251265.

Nanocrystalline Cellulose (NCC)

- A highly crystalline particle of cellulose derived from chemical wood pulp
- Prepared by using strong acid to hydrolyze amorphous regions of the cellulose

Concentrated NCC suspension in water

Dried NCC powder

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Types of Nanocellulose

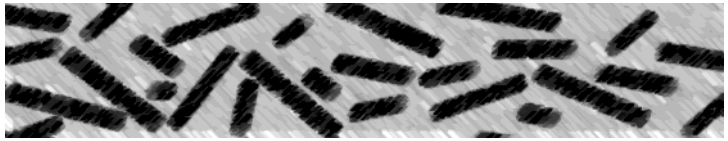
Nanocellulose

Micro/nanofibrillated cellulose
Bacterial cellulose
Cellulose nanofibrils
Nanosized/Nanoscale fibers

Larger aspect ratios

Nanocrystalline cellulose (NCC)
Cellulose nanocrystals (CNC)
Cellulose microcrystals
Cellulose whiskers Cellulose crystallites Nanosized cellulose

Highly crystalline



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Genesis of NCC

- Sulfite pulp treated with 2.5 N (11%) sulfuric acid
- Particle dimensions 46 X 7.3 nm

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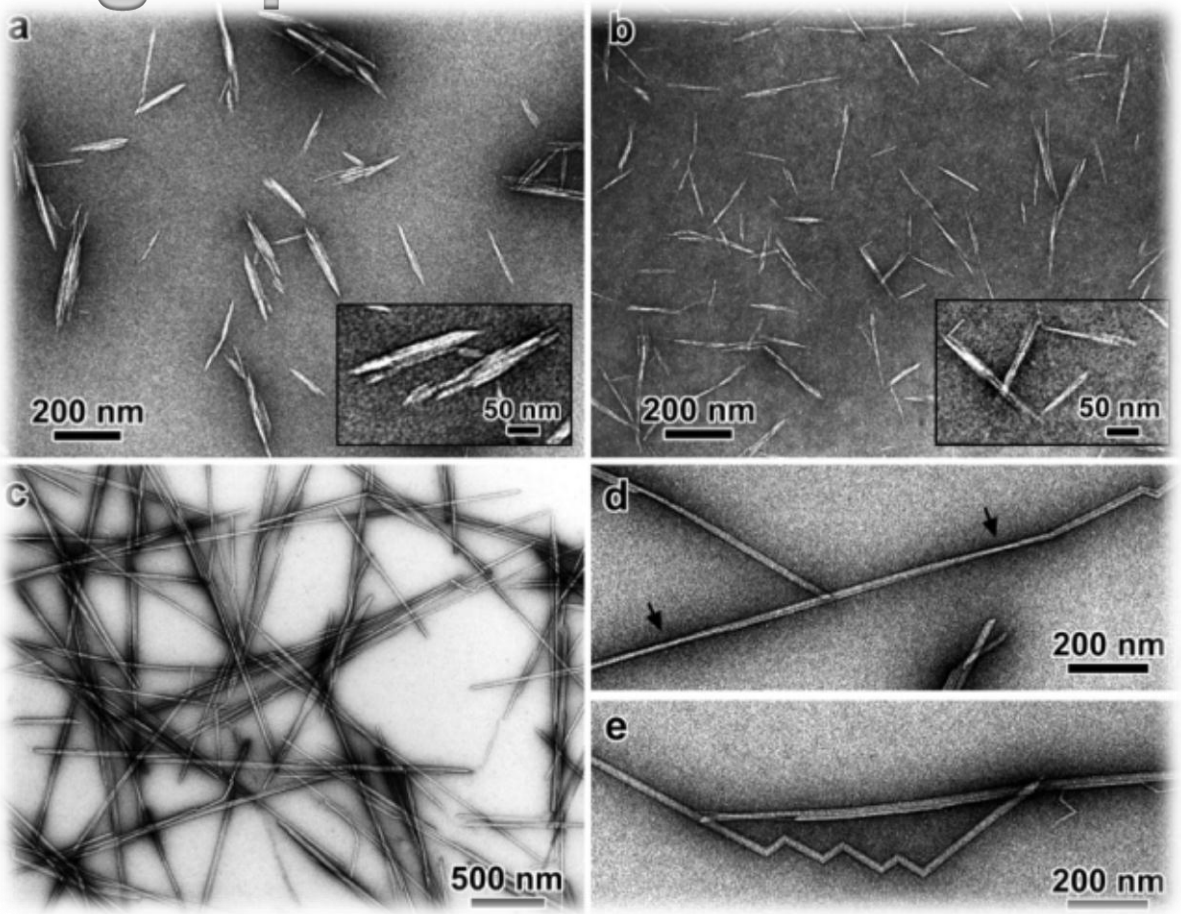
Ranby, B. G. *Faraday Soc.* **1951**, 11, 158−164.

Transmission Electron Micrographs of Various NCCs

Cotton

Avicel (MCC)



Tunicin

Tunicin

Tunicin

Elazzouzi-Hafraoui, S.; Nishiyama, Y.; Putaux, J.-L.; Heux, L.; Dubreuil, F.; Rochas, C. *Biomacromolecules* **2008**, 9, 57−65.

Typical NCC Preparation Methods

- Temp: 45−70°C
- Sulfuric acid concentration: 64%
- Cellulose concentration: 10%
- Time: 30−60 minutes
- Purification: centrifugation, filtration/dialysis, and drying

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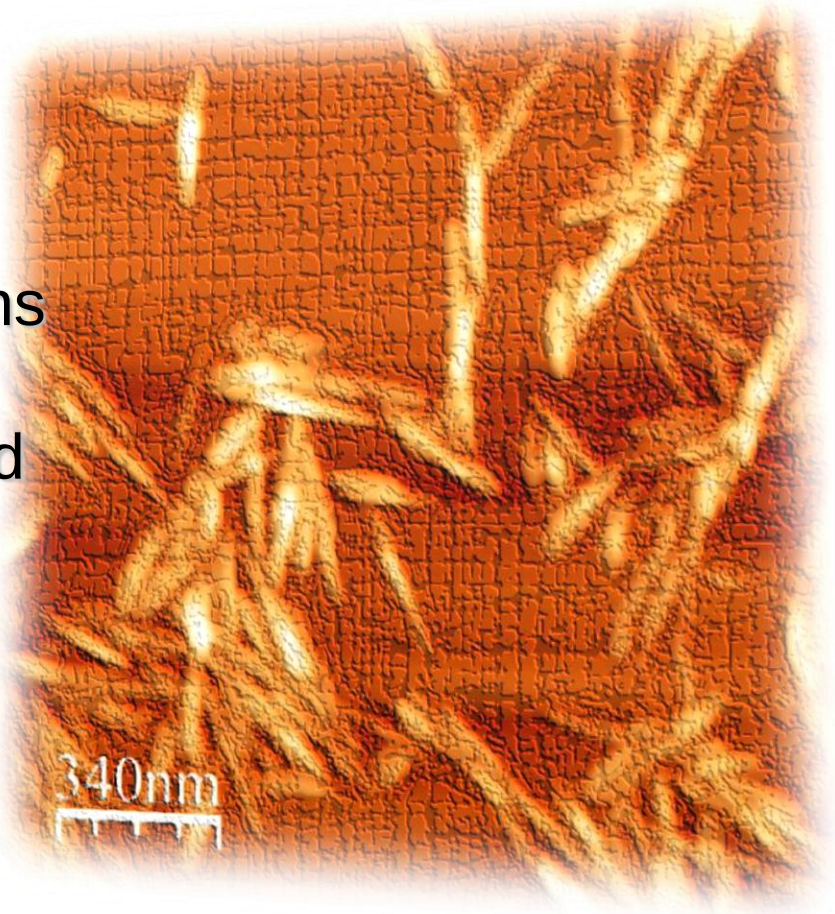
NCC Unique Properties

- Size: 10 nm X 200 nm rods
- Crystallinity: >80%
- Can form stable dispersions from dry state
- Liquid crystalline suspensions in water
- Suspensions can be oriented with an electric or magnetic field
- High strength, roughly 1/10 that of carbon nanotubes
- Biodegradable



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NCC Pilot Plants

FPInnovations; Pointe-Claire, Quebec
CelluForce; Windsor, Quebec
USDA Forest Products Laboratory; Madison, Wisconsin
Alberta Innovates-Technology Futures; Edmonton, Alberta

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AITF NCC Project

- Three year, $5.5 million project funded by federal and provincial governments
- Objectives:
  - Build a pilot plant capable of producing up to 100 kg NCC per week
  - Gain NCC scale-up production knowledge
  - Identify applications with sufficient volumes to justify a commercial facility
  - Construct a commercial NCC facility in Alberta

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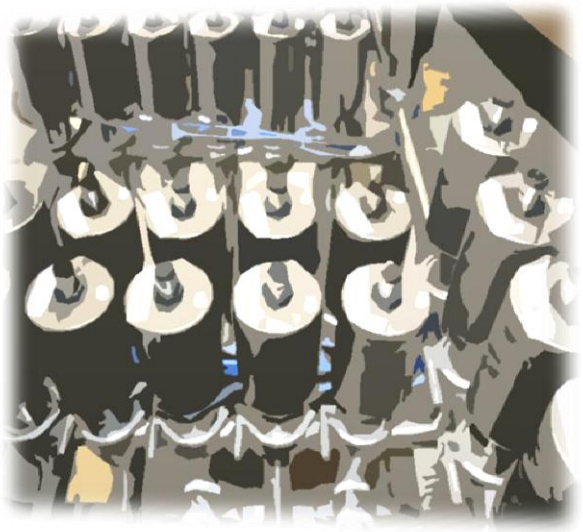
AITF Current Focus

- Nanocrystalline cellulose pilot facility
  - design
  - construction
  - equipment installation
  - commissioning



- Work closely with University of Alberta, National Institute of Nanotechnology, and industrial partners such as Alberta Pacific Forest Industries Inc. to advance NCC scale-up and application development

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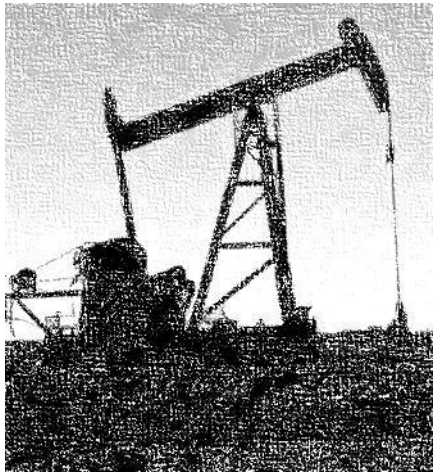
AITF NCC Application Focus

- Green chemical for energy sector
  - stimulation chemicals
  - enhanced oil recovery chemicals
  - drilling fluids
- Use of NCC-water suspensions
  - rheology control
  - address NCC limitations



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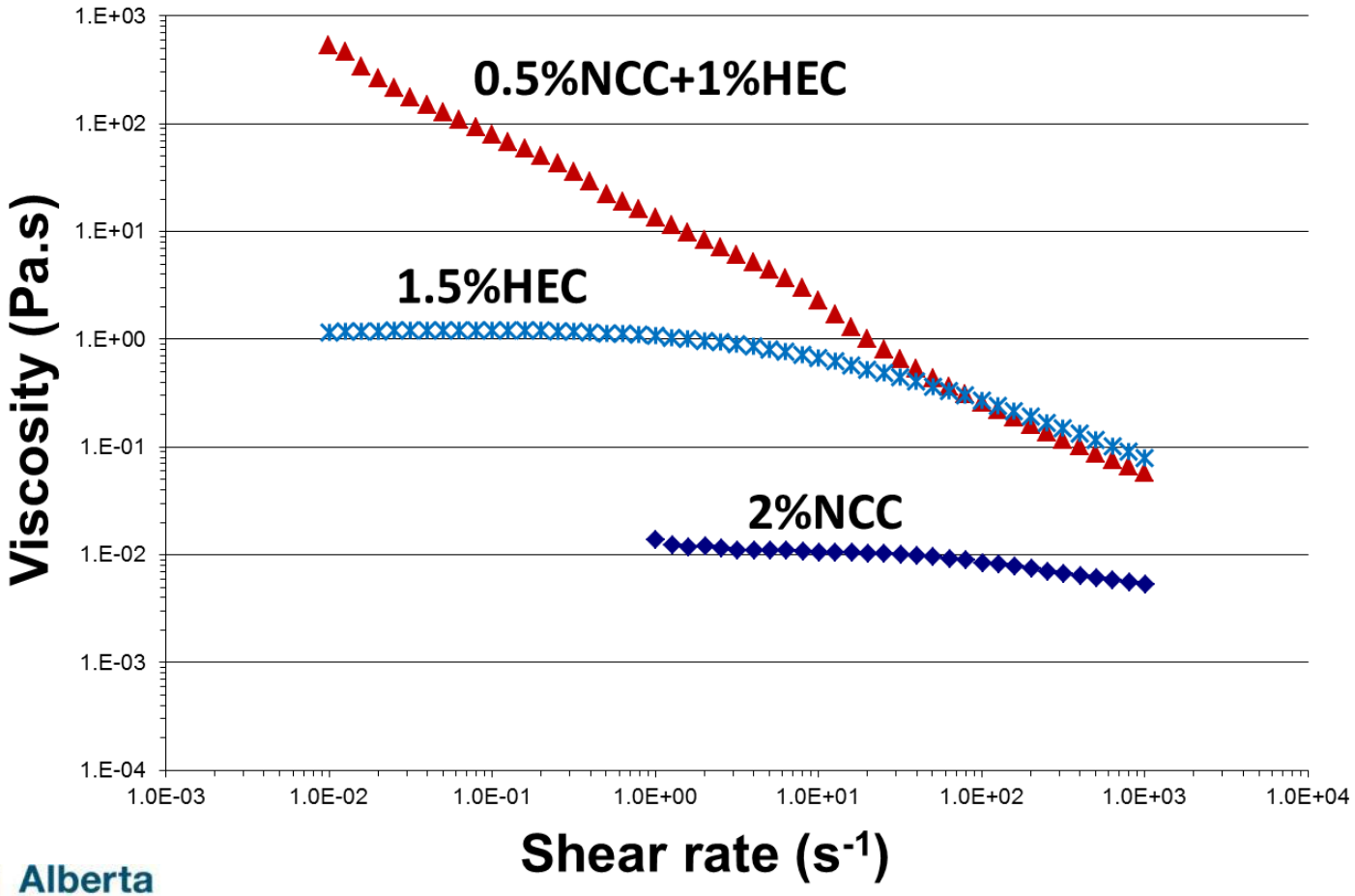
AITF NCC Co-thickening Technology



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Boluk, Yaman; Zhao, Liyan. *Aircraft Anti-Icing Fluids Formulated with Nanocrystalline Cellulose* US Patent# 8,105,430.

AITF's Value Proposition

- Feedstock production and processing expertise
- Utility experience with viscosity control
- Western Canadian industry focused
- Goals:
  - forest industry
    - increase competitiveness
    - demonstration/commercial NCC facility
  - energy industry
    - increase extraction efficiency
    - decrease environmental effects

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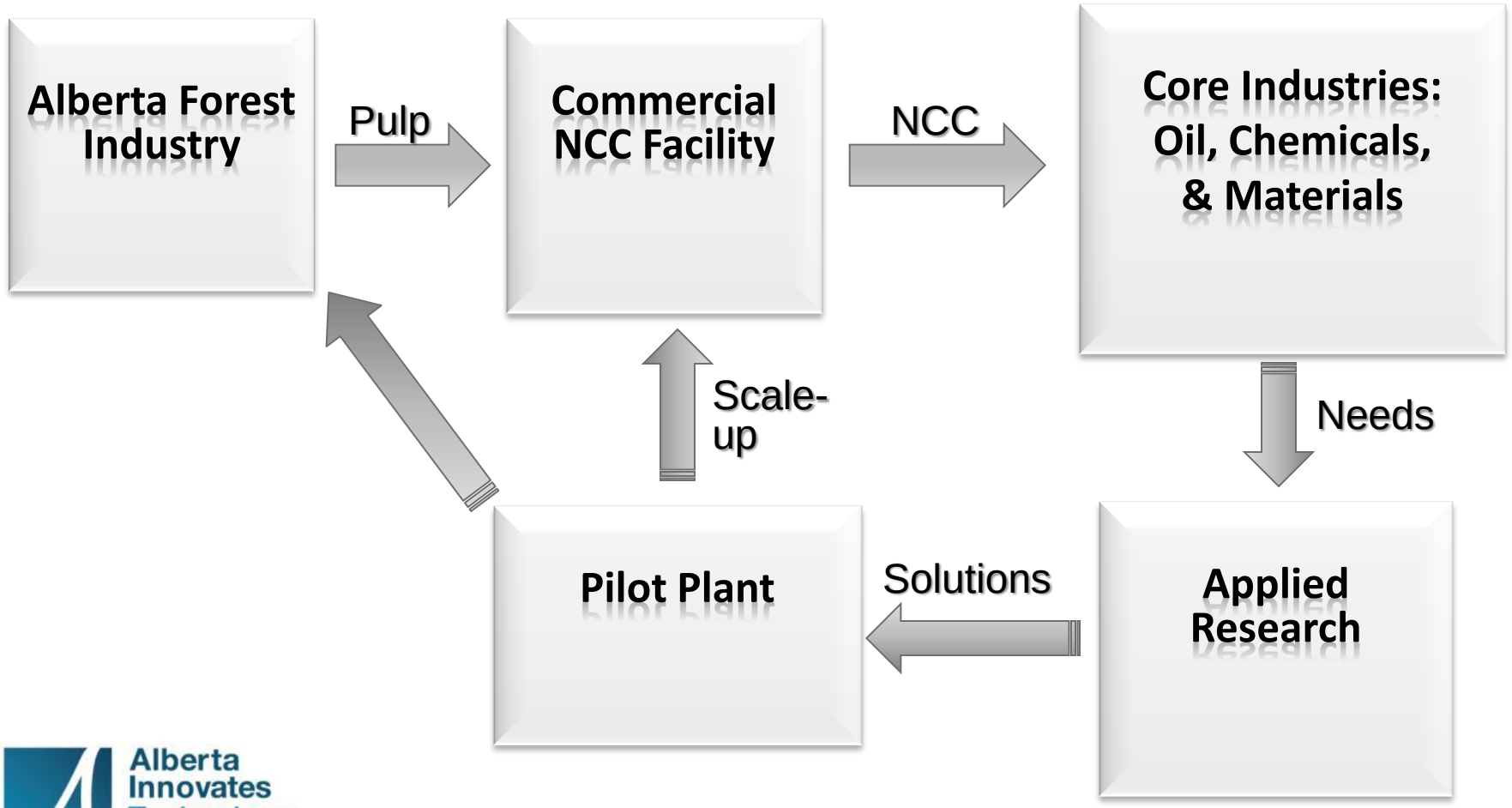
Conclusions and Outlook



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