Carbon Fibre Grand Challenge
Phase I Webinar

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Bryan Helfenbaum, Executive Director – Advanced Hydrocarbons

February 11, 2020
AGENDA

• Housekeeping
• Alberta Innovates Background
• Bitumen Beyond Combustion
• Asphaltenes & Their Properties
• Grand Challenge Objectives & Program Details
• Application Process
• Evaluation Criteria
• FAQs
• Q&A
Housekeeping

1. Please mute your Microphones.

2. If you are joining by phone, please enter your Conference ID when prompted and then mute your phone to avoid echo.

3. Questions about connecting to the webinar can be sent by email to:
   • Steve Wlasichuk—Steven.Wlasichuk@albertainnovates.ca
   • Or contact our Helpdesk at: 1-877-225-0099
Housekeeping – Submitting Questions (via Skype)

1. Click on the message box located at the bottom corner
2. Type in the message you would like to send
3. Click on the blue and white arrow to send message
Alberta Innovates At A Glance

• Largest provincial R&I agency in Canada ($180M/year)
• Innovation strategy and programs
• Provide technical expertise, entrepreneurial advice
• Provide funding to advance innovation

Business Lines
• Clean Resources
• Health Innovation
• Investments + Emerging Tech

Storied History of Supporting Innovation
• Oilsands (BPU, BBC)
• Materials (MARIOS)
• Wood Products (OSB)
• Artificial Intelligence / Machine Learning (Amii)
• Agriculture (CAAIN)

Subsidiaries

C-FER
A SUBSIDIARY OF ALBERTA INNOVATES

InnoTech
A SUBSIDIARY OF ALBERTA INNOVATES
ALBERTA RESEARCH AND INNOVATION FRAMEWORK (ARIF) | 2030 TARGETS

ENERGY AND GHG MITIGATION
- 45% reduction in methane emissions by 2025
- 30% electricity from renewables
- 50% per bbl decrease in fresh water use and GHG emissions
- 25% increase in value of oil and gas exports

ENVIRONMENT AND CLIMATE ADAPTATION
- 30% increase in water efficiency and safe, secure water
- 20% reduction in landscape disturbance and accelerated reclamation

EMERGING TECHNOLOGIES
- 25% Revenue increase in cleantech
- $40B Alberta’s manufacturing output
- $20B Alberta’s digital economy

BIOINDUSTRIAL
- 50% reduction in waste to produce new products
- $3B drive investment into advanced bio-products, fuels and bio-energy
- Biodiversity maintained or enhanced

ALBERTA INNOVATES
Clean Resources Program Areas

- Advanced Hydrocarbons
- Clean Technology
- Environmental Innovation
- Smart Agriculture and Food
- Bio-Industrial Materials
- Alberta Prion Research Institute

Support to ERA
- Strategic Advice
- Project Adjudication
- Project Advisory
Diversity, Equity, Inclusivity

• We believe the Alberta Research and Innovation (R&I) ecosystem is stronger and more sustainable when it is broadly representative of the overall diversity of our community.
• We strive to ensure that all interested and qualified parties have an equitable opportunity to participate and contribute to the ecosystem and that our processes are inclusive.
• Historically, there have been a number of groups/populations that have been under-represented in the R&I landscape including:
  • Women entrepreneurs/researchers
  • Indigenous entrepreneurs/researchers
  • Remote/small community entrepreneurs/researchers
  • New immigrant entrepreneurs/researchers
• We encourage ALL entrepreneurs/researchers to apply!
• If you are a first time AI applicant, don’t hesitate to reach out to the program contacts for navigation information.

ALBERTA INNOVATES
BACKGROUND
Alberta Oilsands Bitumen

- Reserves: 180 Billion bbl
- Production: 3 Million bpd

Combustion Products (~90%)

Non-combustion Products (~10%)

- Non-combustion products are produced by refineries (e.g. lubricants, etc.)
Bitumen Beyond Combustion (BBC)

What is BBC?

• BBC involves the conversion of bitumen to non-combustion materials instead of using bitumen as a source for transportation fuels
• Asphaltene, the heaviest component in bitumen, holds the best promise for BBC
• 15 - 20% of the barrel is asphaltenes
• Carbon fiber is identified as a top BBC product
Carbon Fibres: Production from PAN

- Commercial process
- Complex and costly
- Capacity (per train): ~2,000 tonnes per year
Carbon Fibres: Example Production from Asphaltenes

Opportunity for Innovation!

Advantages
• Favourable chemistry
• Low cost supply
• Divert hydrocarbons away from combustion

Challenges
• Stabilization
• Pre-treatment necessary?
• Sulfur and metal content
• Scale-up
• Carbon efficiency & GHGs
• Don’t know what we don’t know
What Are Asphaltenes?

- Solubility fraction of petroleum (including bitumen): insoluble in n-alkanes; soluble in toluene
- Polydisperse complex mixture
  - MW from ~400 to 1,000 Da
  - Wide range of molecular types
    - 78-80 wt % carbon; range of H, S, O, N per molecule
- Glassy solid at room temperature
- Thermoplastic; softening at 120 – 230°C depending on composition and treatment
- NOT petroleum pitch
What Are Asphaltenes?

80-90 wt% bridged structures
Strong aggregation

10-20 wt% island structures
Weak aggregation

Carbon Fibres: Production

<table>
<thead>
<tr>
<th></th>
<th>From PAN &amp; Pitch (Current)</th>
<th>From Asphaltenes (Target)</th>
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<tbody>
<tr>
<td>Cost, US$/kg</td>
<td>18 – 35</td>
<td>&lt; 9</td>
</tr>
<tr>
<td>Global production, tpy(^a)</td>
<td>100,000</td>
<td>400,000(^b)</td>
</tr>
<tr>
<td>Train capacity, tpy(^a)</td>
<td>~2,000</td>
<td>&gt;2,000?</td>
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\(^a\) tonnes per year

\(^b\) requiring app. 100,000 barrels per day of bitumen
## Current Target Characteristics

<table>
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<tr>
<th>Characteristic</th>
<th>Grand Challenge Target</th>
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<tbody>
<tr>
<td>Geometry</td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>7 $\mu$m</td>
</tr>
<tr>
<td>Length</td>
<td>Continuous or 6 mm</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>$&gt;3,000^a$ - $&gt;4,000^b$ MPa</td>
</tr>
<tr>
<td>Modulus</td>
<td>$&gt;250^a$ - $&gt;300^b$ GPa</td>
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\( ^a \) Phase II  \( ^b \) Phase III

![Graph showing tensile strength and modulus](image)
Key Knowledge Gaps: Carbon Fibre Production from Alberta Oilsands Asphaltenes

• **Mesophase Requirement** – mesophase is important in CF production from pitch, but is it required when Alberta Oilsands Asphaltenes are the feedstock?

• **Impact of Sulphur and Metals** – Alberta oilsands asphaltenes have substantial concentrations of sulphur and metals. Their impact on CF production and CF properties is unknown.

• **Scientific Fundamentals** - The chemistry and physics (e.g., rheology, heat, and mass transfer) of CF production from PAN and pitch are fairly well understood, but similar knowledge is missing for feedstocks derived from Alberta oilsands, especially asphaltenes.
Key Knowledge Gaps: Carbon Fibre Production from Alberta Oilsands Asphaltenes

- **Short Carbon Fibres** - process technology for producing short CF (not based on chopping continuous fibres) is missing.

- **Large-Scale Production** - technologies for producing CF at >2,000 tonnes per year per train are missing. Conceptualization and demonstration are needed.

- **Economics, Energy Requirements and Greenhouse Gas Emissions** - The economics, energy requirements, and GHG emissions of CF production processes based on Alberta oil sands asphaltenes need quantification.
GRAND CHALLENGE PROGRAM DETAILS
Objectives

• Greatly accelerate the development of technologies that can convert Alberta oil sands asphaltenes (‘AOA’) into carbon fibre
• Create line of sight to production capacities and costs that would enable rapid uptake of carbon fibre into major existing and new markets
• Advance technologies that will benefit Alberta industry and the province of Alberta
# Grand Challenge Timeline

<table>
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<tr>
<th>Date</th>
<th>Planned Activity</th>
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<tr>
<td>January 2020</td>
<td>Launch of Grand Challenge</td>
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<tr>
<td>January – April 2020</td>
<td>Phase I application process</td>
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<tr>
<td>June – December 2020</td>
<td>Phase I Projects execution</td>
</tr>
<tr>
<td>February – April 2021</td>
<td>Phase II application process</td>
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<tr>
<td>June 2021 – December 2022</td>
<td>Phase II Projects execution</td>
</tr>
<tr>
<td>January – February 2023</td>
<td>Phase III registration</td>
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<tr>
<td>March 2023 – December 2024</td>
<td>Phase III execution</td>
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Phase I – Conceptualization / Proof of Concept

• **Goal**: advance concepts and ideas for manufacturing carbon fibre from AOA while addressing knowledge gaps.

• **Applicant Objective**: conceptualize and potentially test pathways for manufacturing CF from AOA, with a line of sight to development of the manufacturing pathway in Phase II

• **Minimum Outcome**:
  • a concept for a plausible AOA to CF manufacturing process, including expected inputs and outputs that addresses some or all of the knowledge gaps stated in Appendix A.
  • a plan, based on scientific fundamentals or experimental evidence, of how to investigate in Phase II the impact of sulfur and metals in AOA feedstocks on the carbon fibre manufacturing process and end product CF
Phase I – Conceptualization / Proof of Concept

• No strength or modulus targets for asphaltene fibre or carbon fibre produced in Phase I

• **Funding:** a maximum of $50,000 in Canadian dollars (‘CAD’) awarded to successful applicants. A total of $1,000,000 is available

• **Deadline:** April 7, 2020 at 2:00 PM MT (UTC -7:00)
Phase II – Scaling

- **Goal**: consolidate learnings from Phase I to produce carbon fibre from AOA at lab scale, with line of sight to a demonstration plant that can be commercially scaled.

- **Applicant Objective**: produce CF that meets minimum quality specifications using bitumen derived AOA

- **Minimum Outcome**: Carbon fibre production of > 10 grams per day; tensile strength >3,000 MPa and modulus >250 GPa; potential end uses identified and/or validated. For chopped fibres, the target length is 6 mm with 7 µm diameter.

- **Funding**: $500,000 CAD awarded to successful applicants. A total of $5,000,000 is available
Phase III – Demonstration

• **Goal**: achieve pre-commercial demonstration of CF manufacture that enables immediate commercial investment

• **Applicant Objective**: design, development, and demonstration of a pre-commercial CF production process using AOA

• **Minimum Outcomes**: Continuous production of > 10 kg per day; tensile strength >4,000 MPa and modulus >300 GPa; projected commercial cost of CF < US$9 per kg.

• **Funding**: $3,000,000 CAD Grand Prizes awarded to 3 winners (total $9,000,000) as a lump-sum at the end of Phase III
PHASE I APPLICATION
Phase I Application Examples

• Novel approaches to manufacturing continuous carbon fibre that could produce a much greater quantity per train than current technology
• Methods to manufacture short carbon fibre that do not involve chopping continuous fibres
• Methods that utilize existing carbon fibre production technology but are scalable to much larger production capacities
• Methods that blend new (undeveloped) and existing carbon fibre production technologies
Phase I Application

• Applicants **MUST** propose in their application the basis of the concept or idea for carbon fibre production from Alberta Oilsands Asphaltenes that they will develop during Phase I.

• Applications that do not propose an idea or concept for carbon fibre production from asphaltenes will be not be considered.

• Applicants that indicate that the idea or concept will only be generated during Phase I will be not be considered.

• Ideas or concepts do not have to be fully developed in the application – that is the objective of Phase I
Eligibility

Applicants

• Open to technology developers, industry (including small, medium, and large size enterprises), industry associations, research and development (R&D) organizations, post-secondary institutions, not-for-profit organizations, and government research labs.

• Applicants are not required to be based in Alberta but must demonstrate a clear value proposition for the Province
Eligibility

Applicants

• Must have demonstrated expertise with respect to:
  • Applying scientific and engineering fundamentals relevant to the manufacture of carbon fibre
  • Completing scientific or technical laboratory or other small scale practical work on or relevant to carbon fibre production
  • Utilizing results and conclusions from laboratory and other small-scale work to establish the viability and competitiveness of production technologies, such ability to include experience with preparing process flowsheets (with mass and energy information and basic equipment specifications) for purposes of process evaluation and scale-up;
  • Identifying and addressing critical business issues, including CAPEX and OPEX estimates, market characteristics, and environmental and social acceptance;
  • Addressing scientific, technical, business, and environmental challenges and opportunities.
Eligibility

Project Partners (if any)

• Project Partners must satisfy the following criteria:
  • demonstrate the relationship between the Applicant and the Project Partner(s) does not create a conflict of interest;
  • be in good financial standing with Alberta Innovates and its subsidiaries InnoTech Alberta and C-Fer Technologies;
• Other Funding Agencies are considered eligible partners
Eligibility

Project Eligibility

• To qualify for funding, all Projects must
  • be completed by December 31, 2020; and
  • submit to other criteria that Alberta Innovates may develop from time to time.
Feedstock Samples

• Asphaltenes used in Projects funded by the Grand Challenge must be derived from Alberta oilsands bitumen. No exceptions will be made.

• Alberta Innovates can provide samples for those applicants that are unable to source AOA – please indicate on your application form if you require asphaltenes

• If you do not source AOA from Alberta Innovates, you are required to demonstrate the Alberta origin of the asphaltenes and submit a sample to Alberta Innovates for characterization
Application Evaluation Criteria

• The Opportunity
• Proposed Solution
• Project Implementation
• Team
Phase I Application Process

• Online application portal (http://ai.smartsimple.ca)
• One-stage application
• Deadline is April 7, 2020 at 2:00 PM MDT (UTC -7:00)
Online Portal Instructions

• Step 1: Register
• Step 2: Select the correct application (Carbon Fibre Grand Challenge)
• Step 3: Fill out the application
• Step 4: Submit
Online Portal Instructions

- Step 1: Register

Organization Information

- Organization
- Address
- City
- Country
  - Select One
- State / Province
- Postal Code
Online Portal Instructions

• Step 2: Select the correct application (Carbon Fibre Grand Challenge)
Online Portal Instructions

• Step 3: Fill out the application
Online Portal Instructions

• Step 4: Submit

Encouraged to Save Draft frequently!!!!!
<table>
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<tr>
<th>Date</th>
<th>Planned Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 15, 2020</td>
<td>Launch of Grand Challenge</td>
</tr>
<tr>
<td>February 11, 2020</td>
<td>Webinar</td>
</tr>
<tr>
<td>April 7, 2020 at 2:00 PM MST (UTC -7:00)</td>
<td>Close of application submissions</td>
</tr>
<tr>
<td>Late April/Early May 2020</td>
<td>Successful Applicants Notified</td>
</tr>
<tr>
<td>June/July 2020</td>
<td>Phase I Projects begin</td>
</tr>
<tr>
<td>December 31, 2020</td>
<td>Latest completion date for funded projects</td>
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Advice for Preparing a Successful Submission

• Read the Program Guide
• Use clear and concise language
• Define what problem you are trying to solve
• Address each question in the application template and read the question guidance carefully
• Don’t wait until the last day to submit
FAQ’s

• Can projects or funding occur outside the province?
• What are examples of “project partners”?
• What costs are eligible for funding?
• Is there a minimum funding request?
Contact Information

• Dr. Paolo Bomben (CFGC Program Manager), Paolo.Bomben@albertainnovates.ca

• Bryan Helfenbaum, P. Eng. (Chair, BBC Strategic Advisory Committee), Bryan.Helfenbaum@albertainnovates.ca

• Dr. Axel Meisen (Senior Advisor), axel@meisen.ca

• Dr. Murray Gray (Senior Advisor), Murray.Gray@albertainnovates.ca

• Dr. John Zhou (Strategy and Partnership), John.Zhou@albertainnovates.ca
Thank you.