ALBERTA INNOVATES

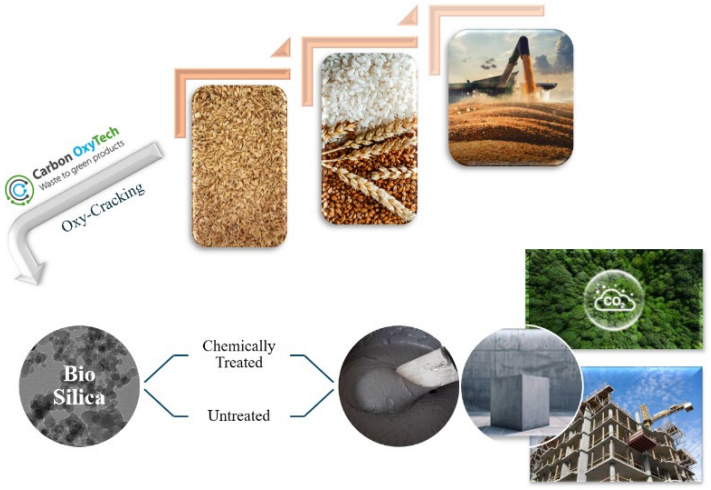
AGRICULTURE AND ENVIRONMENT

BIOINDUSTRIAL AND CIRCULAR INNOVATION

BIOINDUSTRIAL MATERIALS

Low-temperature Extraction of Biosilica from Agricultural Crop Residues for Producing Low-carbon Cement and Concrete

A team of researchers led by Dr. Khoshnazar and Dr. Nassar at the University of Calgary is developing a new biosilica for producing cement and concrete materials with lower greenhouse gas (GHG) emissions. Concrete is by far the most widely used material for construction. However, its production is a large contributor to GHGs, mainly due to cement manufacturing. This research extracts silica-rich components from agricultural crop residues and utilizes the so-produced biosilica in concrete for performance enhancement. The successful completion of the project would result in production of a high-quality biosilica and a protocol for using it in concrete that can be tested for field applications.



FUNDING DETAILS

RECIPIENT:

Dr. Rahil Khoshnazar

University of Calgary

PARTNERS:

Carbon OxyTech Inc., National Research Council

TOTAL BUDGET:

$1,000,000

AI FUNDING:

$500,000

PROJECT DATES:

April 2023 - March 2026

PROJECT TRL:

Start: 3
End: 6

APPLICATION

The biosilica can be used as an addition to or replacement of cement in concrete materials. As it is extracted from agricultural wastes, it can contribute to waste management in the province. Besides, it can enhance the concrete performance, like strength and durability, or enable the use of lower cement content in concrete without compromising its performance. Therefore, it would reduce the carbon footprint of concrete structures and infrastructure over their life cycle.

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PROJECT GOALS

- Optimize extraction of biosilica particles from agricultural crop residues such as wheat and barley.
- Characterize the extracted biosilica and evaluate its suitability for being used in cement-based systems.
- Elucidate the mechanisms of interactions between the biosilica particles and the cement-based systems.
- Test the best performing biosilica particles in a typical concrete mixture and determine the optimum amount based on the compressive strength of concrete.
- Assess the durability and environmental impacts of the concrete mixtures incorporating the biosilica.

BENEFITS TO ALBERTA

- The commercialization of this biosilica can have significant environmental advantages. If an average of 10 wt% of the Portland cement produced in Alberta is replaced by this new biosilica, ~40,000 tonnes/year of GHGs can be eliminated at 25% market penetration. In addition, almost 1 million tonnes/year of Alberta's agricultural crop residues will be utilized.
- The product has the potential to make concrete materials stronger and more durable which is important for the health of the society as it reduces the risk of collapse of structures/infrastructure and associated injuries and fatalities. It also offers more comfort and security to the people using such structures/infrastructure.
- This interdisciplinary research will train a diverse group of highly qualified and skilled personnel who can play entrepreneurship and leadership roles in the cement and concrete industry in Alberta.

5 Publications

6 Students Trained

1 Patent

1-10 Project Job

10-100 Future Jobs

1 New Product/Service

Indirect Project GHGs

1-100 kt/yr Future GHGs Reduced

CURRENT STATUS

APRIL 2025 – In progress

The research team completed the extraction and detailed characterization of the biosilica from different agricultural wastes. The biosilica has been tested in various concentrations in cement paste (mixture of cement and water). About 35% enhancement was observed in the compressive strength of cement pastes incorporating only 1 wt.% of the biosilica that was extracted from wheat wastes. These results are very promising, and the team is testing and optimizing their materials for suitability at larger scale.