Advanced Biological Fermentation Process Development: Cost-reduced cellulosic sugars for biofuels co-produced with high value cellulose nanocrystals

Dawit Beyene[1], Michael Chae[1], Jing Dai[1], Christophe Danumah[2], Frank Tosto[2] and David C. Bressler[1]

BACKGROUND

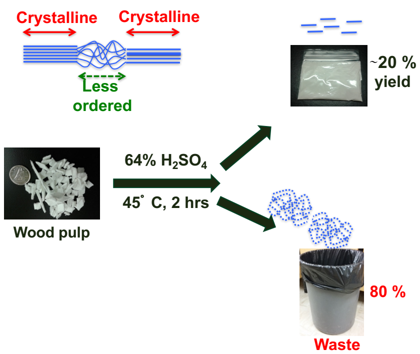
The biofuel industry is currently under pressure due to termination of government subsidies (2017) and low oil price

Utilization of low-cost industry by-product streams can improve economics

Forestry products processing industries such as cellulose nanocrystals (CNC) plants are ideal sources of by-products

CNCs are

- highly crystalline nanoparticles with superior mechanical properties for application in many industries[a]
- isolated by acid hydrolysis of amorphous regions from cellulosic-based feedstock[b]



Sugars are generated from hydrolysis; but cannot be easily recovered from the acid waste stream.

Cellulases are enzymes that can degrade celluloses

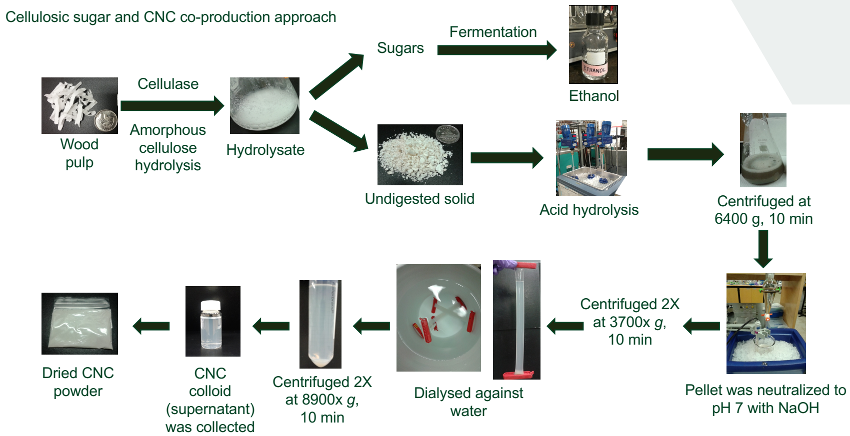
These enzymes can be used to degrade the amorphous cellulose to recover the sugars for fermentation

SHORT-TERM OBJECTIVES

1. Screen cellulases for activities on wood pulp as a cellulosic feedstock
2. Identify effective cellulase enzyme concentration for hydrolysis
3. Generate sugar by-product at different levels of enzymatic degradation
4. Improve the CNC yield from cellulase-treated feedstock by acid hydrolysis
5. Optimize acid hydrolysis conditions for CNC isolation

PROJECT OVERVIEW

Cellulosic sugar and CNC co-production approach



Preliminary results

Table 1. Sugar and CNC yields from cellulase-treated wood pulp

Enzymatic treatment (h)	Glucose yield (wt % substrate)	Xylose yield (wt % substrate)	CNC yield (wt % acid–hydrolyzed feedstock)*	Overall CNC yield (wt % original feedstock)**
0	0	0	10.3 ± 0.1^{a}	10.3 ± 0.1^{ab}
2	21.0 ± 0.6^{a}	6.1 ± 0.2^{a}	16.2 ± 1.5^{b}	12.1 ± 1.0^{a}
4	30.6 ± 1.1^{b}	8.5 ± 0.3^{b}	17.7 ± 0.9^{b}	11.1 ± 0.7^{a}
6	36.6 ± 0.8^{c}	9.8 ± 0.2^{c}	19.2 ± 1.5^{b}	10.3 ± 0.7^{ab}
8	39.9 ± 2.2^{c}	11.1 ± 0.6^{d}	17.3 ± 1.9^{b}	8.8 ± 1.0^{bc}
10	44.2 ± 1.4^{d}	12.1 ± 0.3^{e}	18.4 ± 0.7^{b}	8.3 ± 0.2^{c}

Values within columns that are denoted by non–identical letters (in superscript) are significantly different (Tukey, $p < 0.05$);
*CNC yield from acid hydrolysis of a fixed mass of feedstock; **CNC yield accounting for the mass loss due to enzymatic treatment

THEME OVERVIEW

Biomass

We already know how to create fuels from certain types of biomass, but many other feedstocks can potentially be transformed in a similar manner. In order to identify new viable sources, we must develop more a sophisticated understanding of the technological processes that might be used to convert biomass to fuel, and assess the potential business cases for adopting certain sources that might have other economic uses, or compete with established cash crops. We can also explore the potential for tailor-made fuels for the transportation sector, developed from biological sources.

EXPECTED OUTCOMES

1. Enzymatic treatment of wood pulp will generate low-cost fermentable C5 and C6 sugar stream for the biofuel industry
2. Improvement in acid hydrolysis efficiency from a cellulase-treated feedstock will reduce:
   - Operation costs
   - Reagents and water usages in the upstream and downstream processes for the CNC industry
3. The enzymatically-mediated acid hydrolysis process for the co-production of:
   - CNC
   - Fermentable sugar by-products will be adopted by Alberta Pacific Forestry industries (Al-Pac) at the CNC pilot plant facility at InnoTech Alberta

InnoTech Alberta CNC pilot plant, Mill Woods, Edmonton, Alberta.

EXTERNAL PARTNERS

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6. Novozymes

Affiliation

[1]University of Alberta, Department of Agricultural, Food and Nutritional Science, T6G 2P5, Edmonton, Alberta,

[2]InnoTech Alberta, Biomass Conversions and Processing Technologies, T6N 1E4, Edmonton, Alberta

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[b]Habibi, Y.; Lucia, L. A.; Rojas, O. J. Cellulose Nanocrystals: Chemistry, Self-Assembly, and Applications. *Chem. Rev.* 2010, 110, 3479–3500. DOI: 10.1021/cr900339w.

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