# Advanced Biological Fermentation Process Development: improving the process for cellulosic ethanol production by advanced fermentation strategies

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## BACKGROUND

- Cellulosic ethanol is a biofuel converted from lignocellulose material—the most abundant renewable feedstock on the planet[1]. On a life cycle basis, cellulosic ethanol greatly contributes to the reduction of greenhouse gas emission[2].
- In recent years, technologies have been under extensive development to promote the viable commercialization of cellulosic ethanol. However, the cellulosic ethanol industry, compared to the mature first generation ethanol, is still faced with economic challenges, for instance, high production cost[3].
- As a result, any further major improvements in ethanol productivity will require development of novel fermentation strategies in a cost-effective manner.

Lignocellulose

Cellulosic Ethanol

## SHORT-TERM OBJECTIVES

I. Build up a self-cycling fermentation (SCF) system based on a 5-L capacity bioreactor (Figure 1).

II. Test whether SCF would help improve productivity for ethanol fermentation using simplified synthetic medium.

III. Test whether productivity of cellulosic ethanol could be improved through the newly established SCF system, by feeding the bioreactor with hydrolysate of lignocellulose material, such as wood pulp.

**Figure 1.** 5-L Bioreactor used in this study.

## PROJECT OVERVIEW

### Conventional method to produce cellulosic ethanol—batch fermentation

- Each batch campaign involves lag and stationary phases, where no significant amount of ethanol is produced. Significant downtime is necessary after each fermentation to clean up the reactor and prepare for the next campaign. In addition, seed culture needs to be gradually scaled up to start each fermentation[4].
- As a result, batch fermentation and its associated seed cultivation contribute to high capital and operating costs, accounting for 34% and 33% of the total production costs of cellulosic biofuel, respectively[5].

### Self-cycling fermentation (SCF)

- SCF is a semi-continuous cycling process (Figure 2) that employs the following strategy: once the onset of stationary phase is detected, half of the broth volume is automatically harvested and replaced with fresh medium to initiate the next cycle[6].
- SCF has been shown to increase product yield and/or productivity in many types of microbial cultivation[7-9]. However, to this day, SCF has not been successfully implemented in ethanol production.
- We have proved through proof-of-concept that a cycling strategy could help improve ethanol volumetric productivity (the titer of ethanol produced in a given cycle per corresponding cycle time) by 43.1 ± 11.6% (Figure 3)[10]. Hence, if applied to ethanol production, SCF could help improve productivity by reducing fermentation time and downtime, benefiting the economics of the cellulosic ethanol industry.

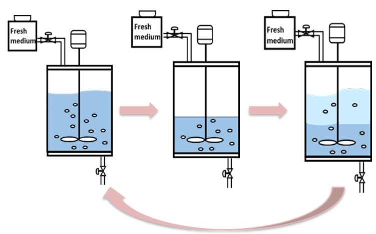


**Figure 2.** Self-cycling fermentation process.

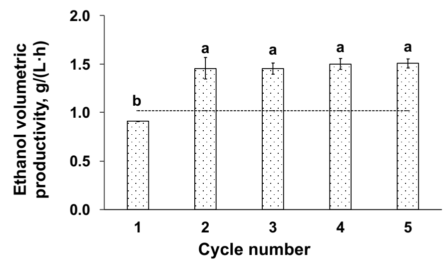


**Figure 3.** Ethanol volumetric productivity in experiments mimicking SCF.

The horizontal solid line represents the mean values obtained in batch studies. Error bars represent standard deviation of triplicate experiments. Means that do not share the same letter are statistically different (95% confidence level, Tukey).

## 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

I. A self-cycling fermentation system specifically for ethanol production will be established (Figure 4).

II. Self-cycling fermentation could help significantly improve ethanol productivity, compared to conventional batch operation.

III. Productivity of cellulosic ethanol would be significantly improved through integrating wood pulp hydrolysate with self-cycling fermentation.

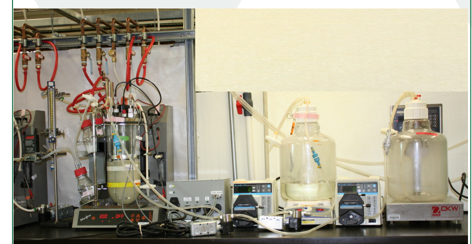

**Figure 4.** The experimental setup of the self-cycling fermentation system used in this study.

## EXTERNAL PARTNERS & REFERENCES

**External Partners**:
Novozymes; InnoTech Alberta; Alberta-Pacific Forest Industries Inc.; BioFuelNet Canada; Biorefining Conversions Network; Natural Sciences and Engineering Research Council.

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