Organosolv pretreatment produces an inhibitor free hydrolysate with superior fermentability at high-solids loadings

Poster

CV

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INDUSTRIAL BIOTECHNOLOGY

Key numbers

7.5 billion

Primary energy consumption as coal, oil, natural gas (**non-renewable**) **86%**

~ 4500 Mt

Crude petroleum oil extracted annually

fuels **~ 4000 Mt**

materials **~ 400 Mt**

World energy needs **~ 600 EJ** (10^{18})

Total energy in crude oil extracted **~ 200 EJ**

A tree weighs **~ 10 t**

Cellulose per tree dry mass **~ 1 t**

Trees on Earth **3 trillion**

Ethanol yield per tonne of cellulose (*via* fermentation) **~ 0.5 t**

World ethanol production **78 Mt**

Potential for fuel ethanol with 1% of the trees **12 000 Mt**

Cost of enzymes **US¢ 2 – 10 per L of ethanol**

Cellulosic ethanol plants under operation **<10**

Introduction

Surely, in times such as now — *a swelling population, an urban lifestyle, and increased economic growth* — the sustainable production of fuels and chemicals from non-petrochemical feedstock is a move, a prudent one indeed.

The omnipresence and abundance of lignocellulosic biomass verily make a renewable feedstock. However, *pretreatment* is warranted to split open its inner structure, for the enzymes to act, and release the sugar monomers. This process releases obnoxious chemicals that pose problems in fermentation, concomitantly decreasing the product yields.

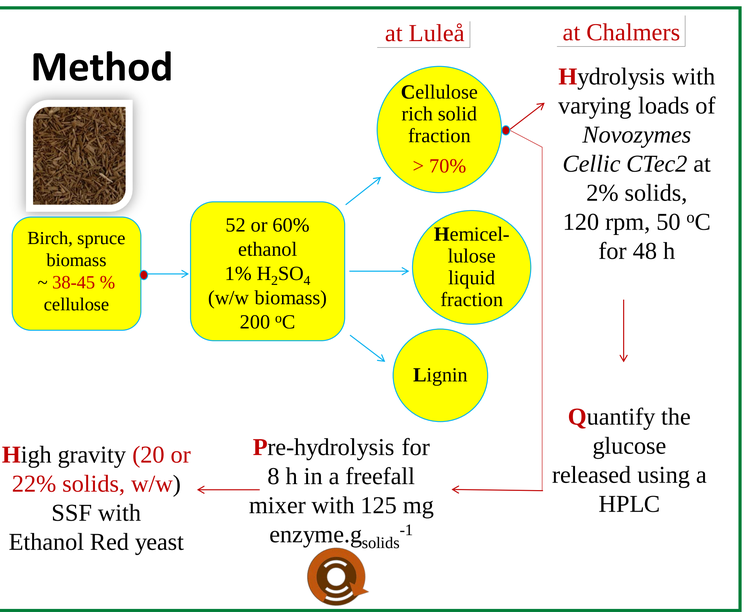
In a paradigm shift, we resorted to *Organosolv* – OS – pretreatment, proposed as early as 1931 for efficient delignification; OS yields three distinct and neat streams: cellulose, hemicellulose & lignin; the solid fraction is devoid of inhibitors – furans, phenolics or weak acids – that are normally produced during conventional pretreatment processes.

We developed a hybrid process that combines the conventional *organosolv* cooking with explosive decompression of the cooking mixture at the end of the pretreatment period on birch and spruce and performed simultaneous saccharification and fermentation – SSF – at >20% solids loading.

Objective

To demonstrate the potential of *organosolv* pretreatment for high gravity cellulosic ethanol fermentation.

Method



Literature cited

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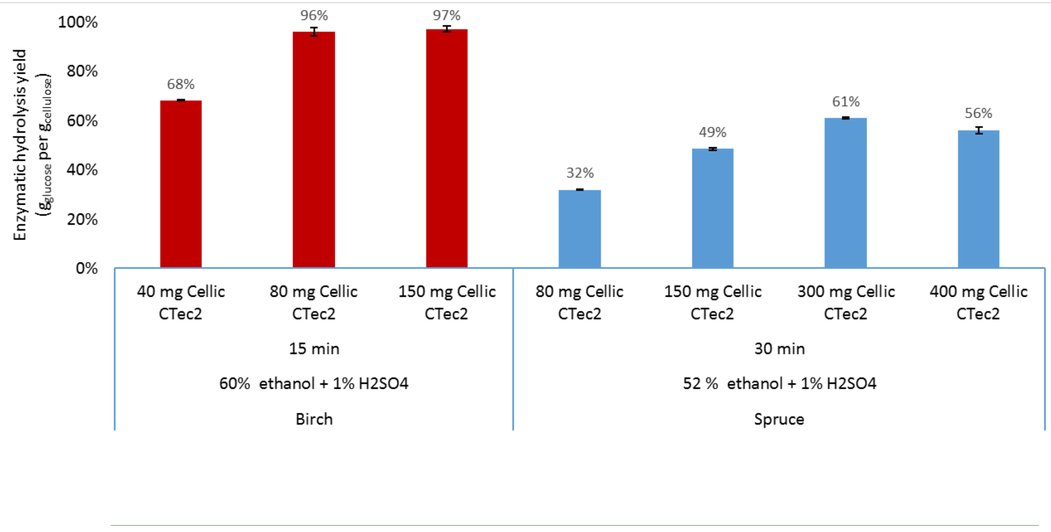
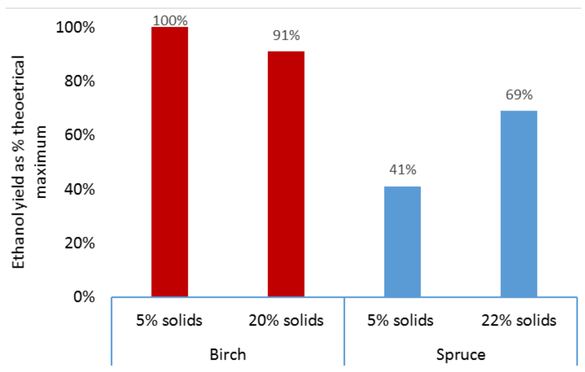
UN sustainable development goals.

Results

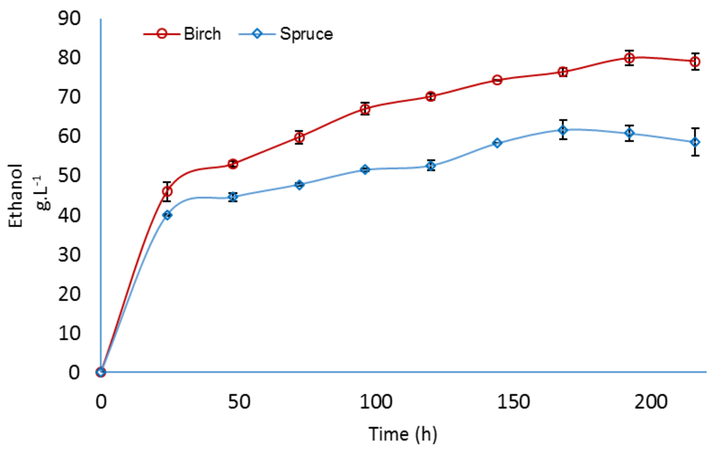


Hydrolysability
For a 2% solids loading, near complete saccharification of cellulose was achieved (96%) with birch whilst spruce exhibited an yield of 32% for the same enzyme loading of 80 mg of enzyme preparation (*ca.* 19 mg enzyme.g_{solids}^{-1}).



Comparison of ethanol yields in SSF
Hydrolysis in a freefall mixer (for 20 & 22% solids) provides better access to the enzymes thereby increasing the sugar yields and hence the ethanol titres.

High gravity fermentation
After 8 h of prehydrolysis, the ethanol titre was *ca.* 80 $g.L^{-1}$ for birch (after 192 h) and *ca.* 62 $g.L^{-1}$ for spruce (after 168 h).



Conclusions

OS pretreatment results in efficient delignification of biomass with a cellulose content of 72 and 78%, for spruce and birch respectively.

High gravity experiments have shown the highest ethanol titre reported thus far for spruce (*ca.* 62 $g.L^{-1}$) and birch (*ca.* 80 $g.L^{-1}$) after 168 h and 192 h, respectively.

The fact that the lignocellulosic biomass could be fermented to such high titres (*albeit* at a slightly higher enzyme loading) using native yeast demonstrates that this pre-treatment technology holds immense potential for cell (like the Brazilian 1G ethanol process) and enzyme recycling.

With an ethanol titre greater than 4%, this pre-treatment process offers economic feasibility for a large scale closed-loop biorefinery producing fuels from the cellulose fraction and platform chemicals from the hemicellulose and lignin fraction.

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