XyloFerm® - Yeast strains for efficient conversion of lignocellulose into ethanol

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Mission: cost-effective and environmental friendly production of ethanol

- Research & Development Company
- 11 patent families, 60 patents approved around the world
- Our patents related to strain development for fermentation of pentoses both xylose and arabinose in biomass derived streams
- Large know-how on lignocellulosic ethanol production
Presentation Outline

1. Challenges for 2\textsuperscript{nd} Generation Ethanol Production

2. Taurus Know-How

3. Lignocellulosic Fermentation with Taurus’ \textit{XyloFerm} \textsuperscript{\textregistered} T13
1. Microbial challenges for 2nd Generation Ethanol Production

For economical feasibility one need to

- Increase xylose fermentation capacity
- Minimize xylitol production and other by-products
- Be able to handle presence of lignocellulose derived inhibitors
- Be able to ferment at high substrate concentrations

Engineer and evolve yeast to obtain strains with high ethanol productivity and yield
Key Steps in Combining Lignocellulose and Yeast for Ethanol Formation

The Material, A or B:
- Biomass into sugar stream

A.
1. Pretreatment
2. Enzymatic digestion for mono-sugars
3. Liquid-solids-yeast mixing adjustments

B.
1. Pretreatment with Lignin separation
2. Enzymatic digestion for mono-sugars
3. Liquid-solids-yeast mixing adjustments

The Catalyst:
- Yeast for ethanol formation

1. Propagation (mild)
2. Adaptation (some inhibitors)
3. Fermentation (inhibitors)
Mixing the Catalyst with streams A or B

Mono-sugars into ethanol
Impact of Adaptation during Yeast Propagation

- Propagation in a growth media with a fraction of lignocellulose added corresponding to 0, 2.5, 5 or 10% WIS
- Adaptation of the cells with 2.5% WIS in the propagation step is favorable in terms of sugar fermentation capacity and ethanol yield.

a. WIS = Water Insoluble Solids
2. Taurus Know-How

We currently work in these areas:

• Strain development programs towards both efficient pentose fermentation and high tolerance towards inhibitors
• Patent for arabinose fermentation
• Fermentation in different process configurations
• Fermentation of lignocellulosic hydrolysates  
  – Experience with many agricultural and forestry derived materials incl. wheat straw, bagasse, corn stover, grass, birch and spruce
• Our strategy combine metabolic engineering with evolutionary engineering

Our know-how is covered in 11+ patent families
Xylose Fermenting yeast (GMO) Strains

XyloFerm® T13

XyloFerm® T11

XyloFerm® T7

XyloFerm® T4

Also in process: T10, T14, T15, T16, T17

- Strains may have different optima for depending on process configuration e.g. T4-batch and T7-fedbatch
Transfer of Process Technology

• From lab scale to industrial scale with comparable performance
• Up- and down-scaling
• Identify industrially relevant conditions

Lab scale, 3 l  PDU scale, 30 l  Demo scale, 10 000 l
Oh yeah, The Feedstock ..
3. Lignocellulose Fermentation with XyloFerm® T13

- Low by-product formation
  - Xylitol < 1% of consumed xylose
  - Glycerol < 3% of consumed glucose+xylose
- High ethanol yields

- Anaerobic lignocellulose fermentation with low by-product formation
- Main ”by-product” fraction is yeast (=Biomass): 0.5-5% g/g
Steam-pretreated (acid) wheat straw

- Xylitol yield < 0.5% of consumed xylose
- Glycerol yield 2.5% of total sugar
- At 48h: 0.48g EtOH /g total sugar
- Total sugar: Glucose, Mannose, Galactose, Xylose
Corn stover

- Xylitol yield < 0.5 % of consumed xylose
- Glycerol yield 2% of total sugar
- At 48h: 0.43g EtOH /g total sugar
**Corn cobs**

- Arrow (↓): HMF and Furfural metabolised, >90% of sugar fermented in 48h).
- Xylitol yield < 0.5 % of consumed xylose.
- Glycerol yield 2% of total sugar.
- At 80h: 0.45 g ethanol / g total sugar.
Bagasse

- Arrow (↓): HMF and Furfural metabolised, >90% of sugar fermented in 48h).
- Xylitol yield < 0.5 % of consumed xylose
- Glycerol yield 2% total sugar
- At 80h: 0.45 g ethanol / g total sugar
• Xylitol yield < 0.5% of consumed xylose
• Glycerol yield 2.5% of total sugar
• At 48h: 0.5g EtOH /g total sugar
• Total sugar: Glucose, Mannose, Galactose, Xylose
In Conclusion

Taurus XyloFerm® Yeast Technology can offer you a more efficient cellulosic ethanol production:

- High conversion rate of lignocellulosic sugars
- Reduced process time and increased yield
- Inhibitor resistant and low by-product formation
- Successfully tested in fed-batch, SSF and HSF
- Substantial know-how in yeast propagation, adaptation and lignocellulose processes
Can it really happen?
Yes it Can!

“At Taurus we fully believe that the second generation ethanol is an industry that is here to stay and we are looking forward to successful partnerships with many of you to make it happen”.

THANK YOU and TACK SÅ MYCKET!!