Bioethanol from straw, endless story?!

"Biofuel production caught between political restrictions and advances in research"

Alexander G. Jäger & Klaus Krennhuber

History of Biofuels & politics

Ethanol was used as a lighting fuel in the 1850s

Its use curtailed when it was taxed as liquor to help pay for the Civil War.

Ethanol use as a fuel continued after the tax was repealed

First Benz 1888, Ford's Model T in 1908.

…….and the story of political influence continued

Key elements of the EU Directive 2015

- 20% share of renewable energy by 2020
- 10% renewable energy in transport by 2020
- 7% CAP for food based
- 0.5% indicative target for annex IX part A fuels **(Advanced biofuels)**

Advanced biofuels according to EC 2015

(a) Algae (b) Biomass fraction of mixed municipal waste (c) Bio-waste (d) Biomass fraction of industrial waste (e) Straw (f) Animal manure and sewage sludge. (g) Palm oil mill effluent (h) Tall oil pitch. (i) Crude glycerine. (j) Bagasse. (k) Grape marcs and wine lees. (l) Nut shells. (m) Husks. (n) Corn Cobs (o) Biomass fraction of wastes and residues from forestry (p) Other non-food cellulosic material. (q) Other lignocellulosic materials(r) Renewable liquid and gaseous transport fuels of non-biological origin. (s) Carbon capture and (t) Bacteria, if the energy source is renewable in accordance with point (a) Used cooking oil (b) Animal fats

Bioethanol 1 G research
Wels / Upper Austria

2004 -2007 Several 1 G R&D Projects

Partners: AGRANA, Bioenergy, Kohlroser, Dörfler

Influence of Milling, Intergration Biogas / Bioethanol Production…

Bioethanol 2 G research
Wels / Upper Austria

2007 – 2008 Bioethanolproduktion aus Lignocellulosen mit Steamexplosion (Fabrik der Zukunft, Projekt 814953)

Partners: Energy Institute Linz, Technology Center Ennstal

Establishment of Voest Alpine Steam Ex Technology

Pretreatment by steam expolosion

Steam Explosion

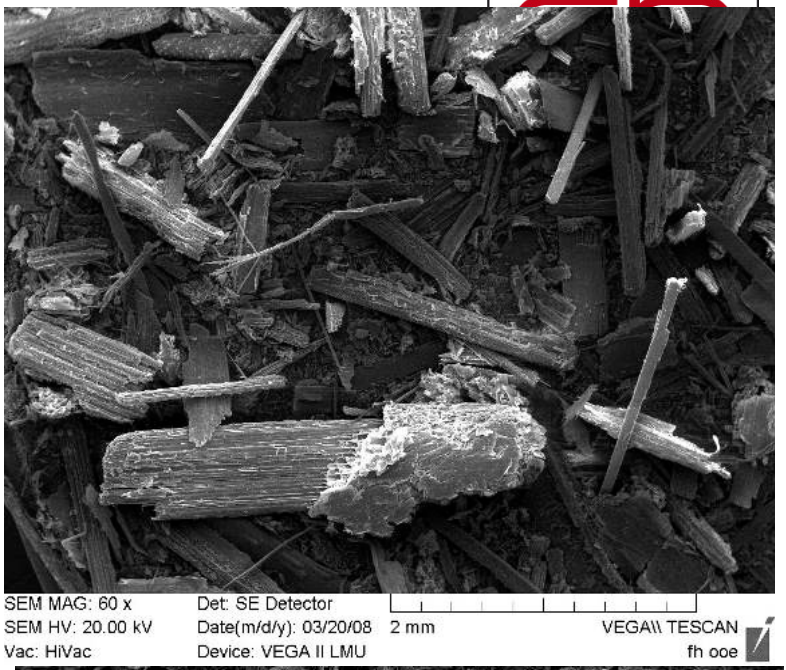
Steam Explosion -

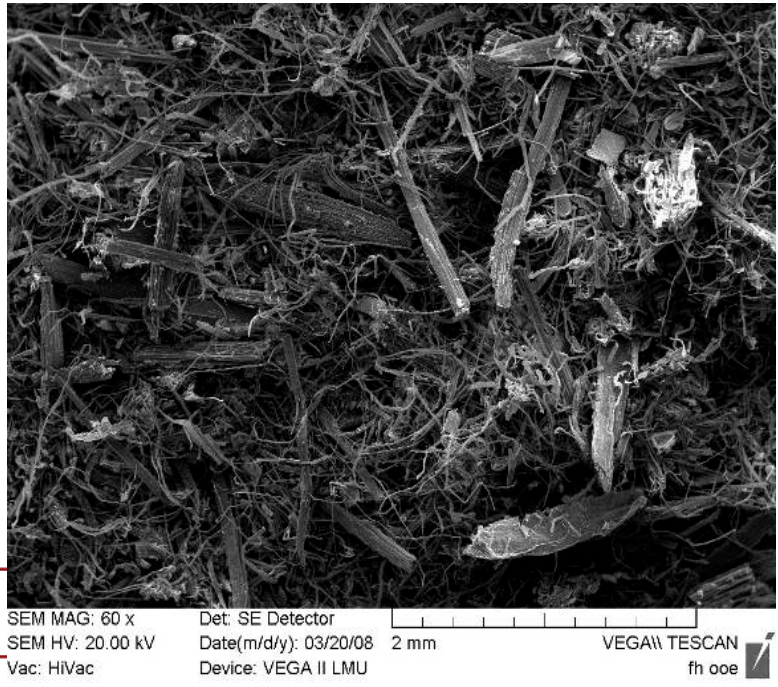
Hohe Temperatur und Druck:
- 180°C – 200°C,
- 5´- 20´,
- 15 bar.

dann eine plötzliche Entspannung

Niedrige/hohe Konzentrationen an Inhibitoren

Teilweise oder gänzliche Auflösung der Hemicellulose in Oligo-, Monosaccharide und flüchtige Verbindungen





Bioethanol 2 G research
Wels / Upper Austria

2007 -2009 Basisfinanziertes Projekt Klimaschutz: Bioethanol der 2. Generation und Biogas FH Oberösterreich

Combination 1 G – 2 G Technology

Optimization Pretreatment

Bioethanol 2 G research
Wels / Upper Austria

2009 -2011 Basisfinanziertes Projekt Steamexplosion der FH Oberösterreich

Energy Savings

Water reduction pretreatment

Inhibitor Identification

Bioethanol 2 G research
Wels / Upper Austria

2008 -2012 FH Plus in Coin SteamExplo: Otimization of bioethanolproduction from lignocelluloses by simultaneos Simultaneous Saccharification and Fermentatiom

Partners: Tech. University Vienna Prof. Kubicek

Tech. University Graz Prof. Nidetzky

Increase Biomass Content

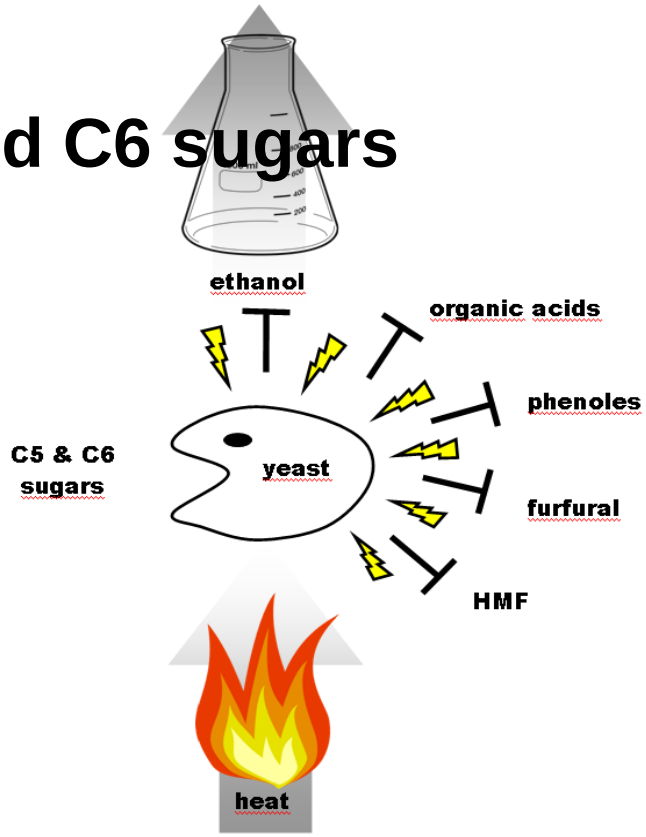
Simultaneous Saccharification and Fermentation

Adaptation of C5 yeasts

New feedstocks

Challenge: The super yeast

- Resistant against inhibitors
- Simultaneous utilization of C5 and C6 sugars
- Thermotolerant
- Osmotolerant
- Ethanoltolerant
- Industrial stability



Challenge

How to get enough straw into the process?

10 % Straw

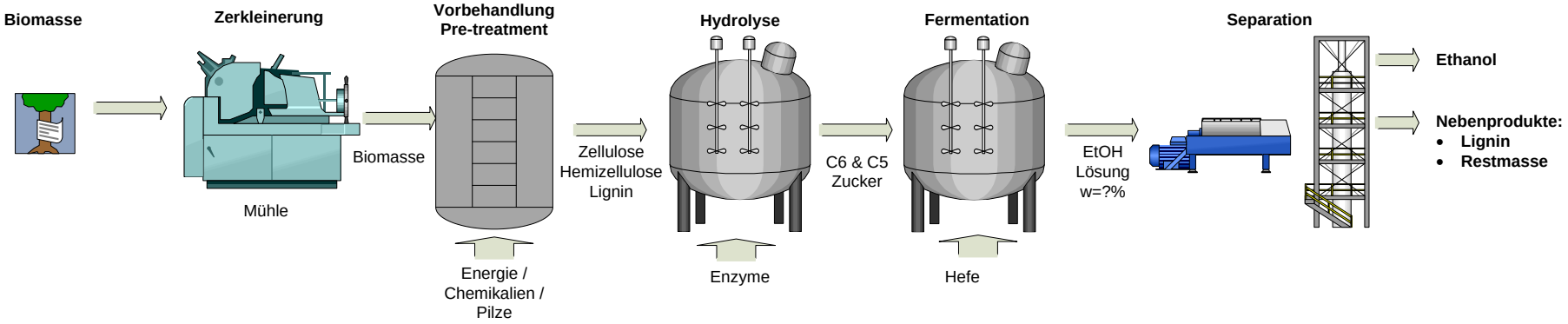
207 kg Ethanol/t
2.6 % Vol. Ethanol

Challenge

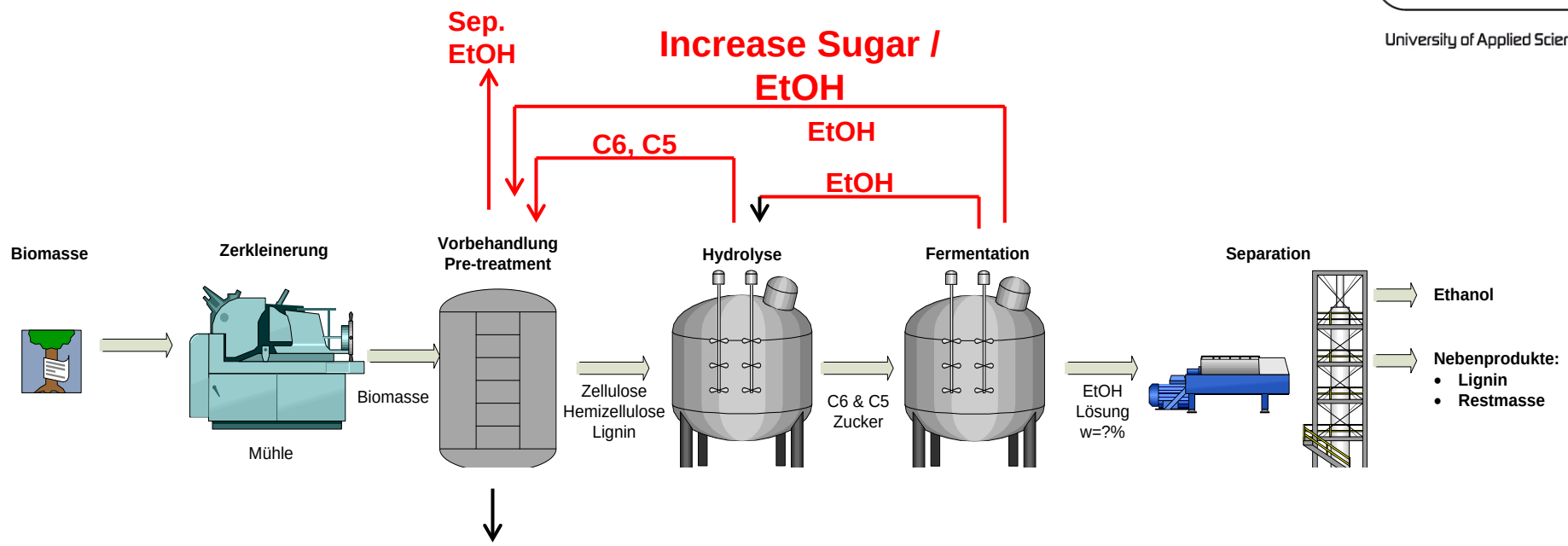
40 % Straw

828 kg Ethanol / t
10.2 % Vol. Ethanol

Strohethanol Prozess Basic



Straw ethanol advanced



Research topics:

Decrease / Separation Inhibitors N_2 Tretament

Simultaneous C_5 & C_6 Fermentation

Strategies for by products

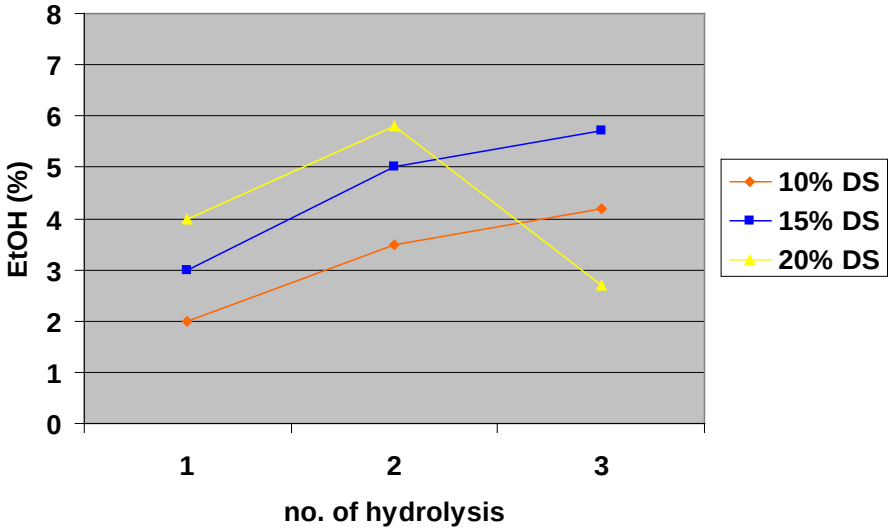
Variants

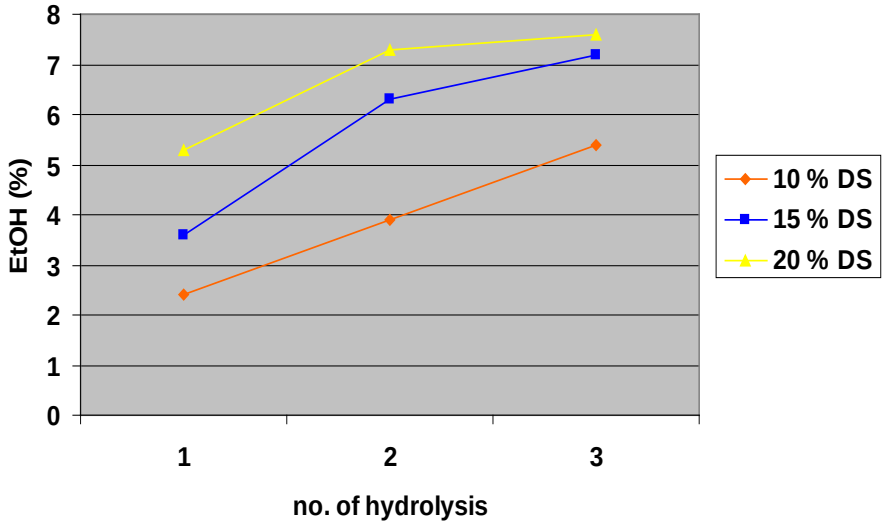
SHF – Separate Hydrolysis &Fermentation

SSF – Simultaneous Saccarification &Fermentation C_6

SSCF – Simultaneous Saccarification &Cofermentation C_6 & C_5

Results





Standard experiment

Inhibitor control

Results: Tolerance against inhibitors

Hydrolysate 6 x (glucose 150 g/L)

Result as vol. % ethanol

non-adapted	adapted
2.7 %	6 %

Turbo- 8

non-adapted	adapted
4.4 %	6.9 %

Osmophilic yeast

non-adapted	adapted
2.1 %	8.5 %

Malaga

Xylose-adapted yeast strains

	EtOH (%)	Remaining Xylose (g/L)
Candida utilis, aerob, control	0	125
Candida utilis, anaerob, control	0	125
Candida utilis, aerob, adapted	3.6	0
Candida utilis, anaerob, adapted	3.7	7

Xylose-adapted yeast strains (> 100 transfers):
Production of increased ethanol yields (xylose solution: 125 g/L)

Feedstocks

Wheat straw

Rye straw

Oat straw

Corn straw

Miscanthus

Corn cobs

Hay

Bioethanol 2 G research
Wels / Upper Austria

2011 -2014 REGIO 13

A Combined material and / or energetic use of plant based raw materials

B Strawethanol

Social Aspects

Sustainibilty

Pretreatment, Incease of C- Content by recirculation technology

Partner: Energy Institut Linz, Dr. Steinmüller

Biorefinery projects
Wels / Upper Austria

2016 -2020 IWB Combined Agro Forest Biorefinery

Combination of different feedstocks / different pretreatment methods / different microorganisms to produce different products

Ethanol, Butanol, Lactic acid……..

Sacc. cerev., Canidas, Clostridia, E. Coli

„CRISP / CAS9“

Partner: K Wood + Linz

Biorefinery projects
Wels / Upper Austria

2014 -2018 FFG Coin Screening / Cultivation

Downstreaming of Microalge

2017 -2019 ALGNETICS

Starch and Ethanol from Cyanobacteria

(CRISPR-Cas9)

Partner: Academy of Science Trebon CR

State of the Art Bioethanol 2 G

Demonstration plants succesfully in operation

Industrial plants succesfully in operation

Use of C6 and C5 sugars succesfully in operation

Costs ≈ 65 €-Cents/ l

Scientific Challenges

Optimisation of pretretment

Increase C Content → higher sugar → higher ethanol

→ lower downstreaming costs

Expansion of the spectrum of utilizable carbon

Optimization of enzymes – activity, costs

Optimization of pretreatment spectrum for 2 G processes

Integration 1 G 2 G

Conclusion 1

Policy extremly influences / regulates use of alternativ fuels

Public opinion influences policy

Lobbying deeply influences public opinion and policy

Conclusion 2

Technology for advanced biofuel production, & infrastructure is available

With new Feedstock like hay, grass etc. at least 50% of transport fuels could be replaced within short time

Major strategic **error** of European car manufacturers not to support biofuels like bioethanol or biodiesel

Hesitant behavior of EC prevents investments in alternative fuel production and research

Conclusion 3

Funding is difficult but always possible

Advices to reseachers

Try to maintain your know how on biofuel production

Be flexible

Wait for BF- day to be ready with improved an competitive technology

Be active in politics and social media

Keep on researching!

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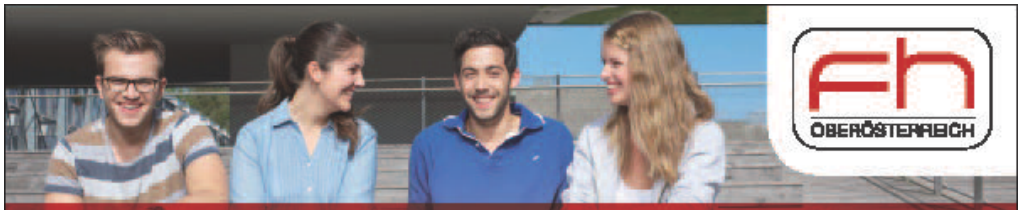

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