Butanol for sustainable aviation

Junicke, Helena

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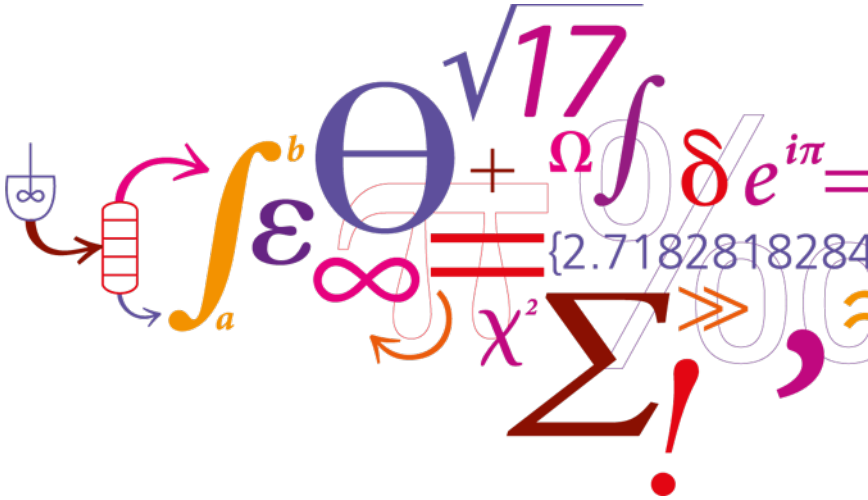
Dr. Helena Junicke
heljun@dtu.dk



DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

Outline

Introduction

- Alternative jet fuel pathways
- Alcohol-to-jet

Opportunities for butanol

- Butanol from waste
- The GreenLogic project

Methods and results

- Continuous enrichment studies
- Thermodynamic system design
- Modelling of full-scale reactors

Conclusions

Outlook

Alternative jet fuel pathways

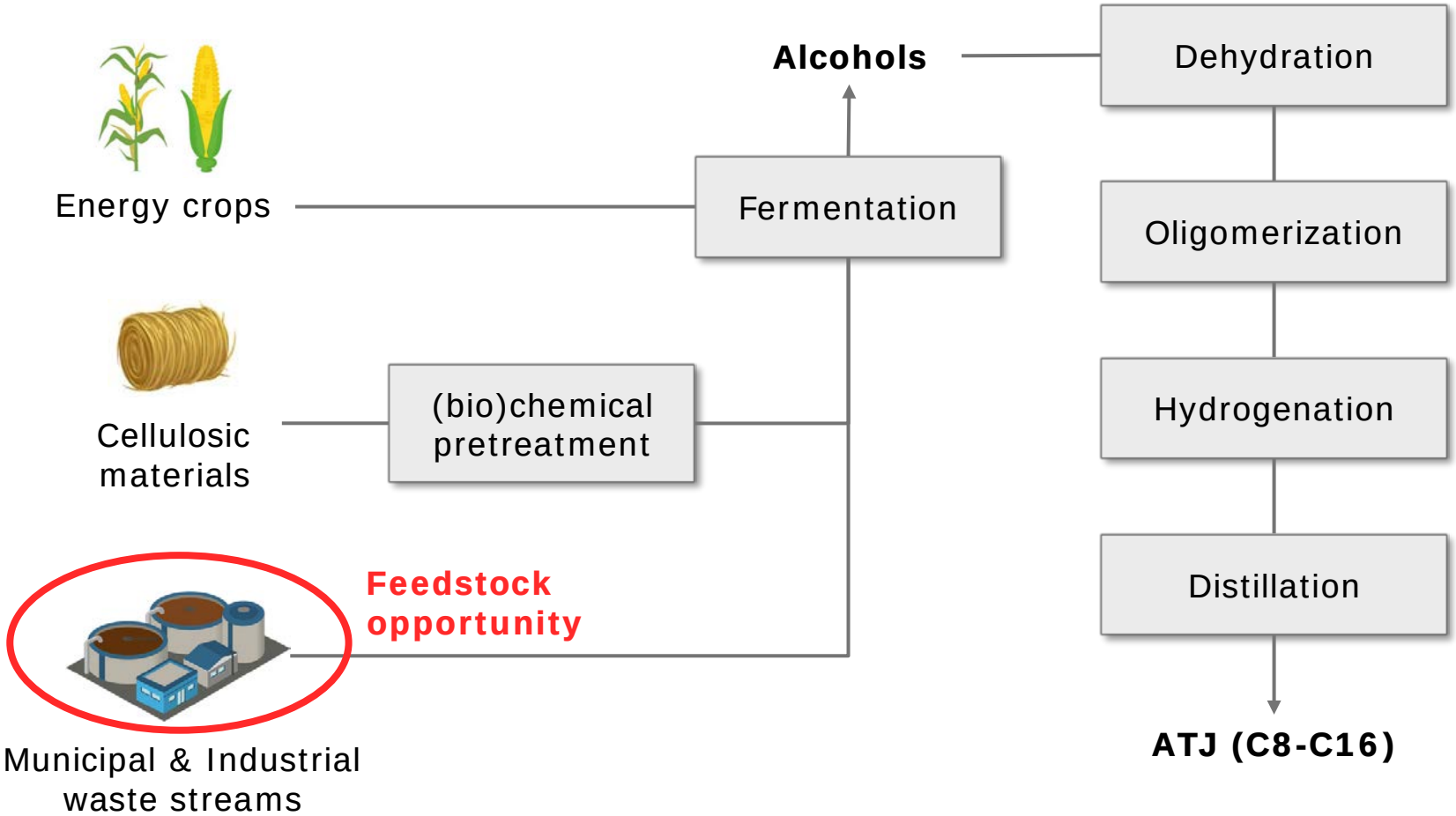
- There are five ASTM D7566 certified pathways for synthetic paraffinic kerosene (SPK) production

Type	Pathway	Description
Gas-to-jet	FT-SPK	SPK from syngas via Fischer-Tropsch (FT)
	FT-SPK/A	FT-SPK with increased aromatic content
Oil-to-jet	HEFA-SPK	SPK from hydro-processed esters and fatty acids (HEFA)
Sugar-to-jet	SIP-SPK	Synthesized iso-paraffins (SIP) obtained via farnesene intermediate
Alcohol-to-jet	**ATJ-SPK**	**SPK from C2-C5 alcohols**

FOCUS

Yang et al. "An overview on performance characteristics of bio-jet fuels." *Fuel* 237 (2019): 916-936.

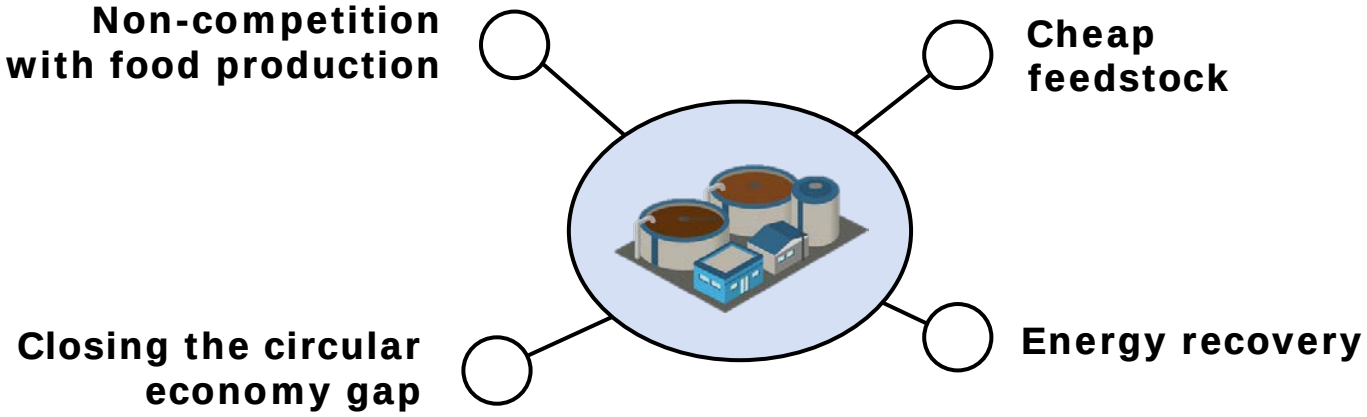
The alcohol-to-jet pathway



Wang et al. "Bio-jet fuel conversion technologies." *Renewable and Sustainable Energy Reviews* 53 (2016): 801-822.

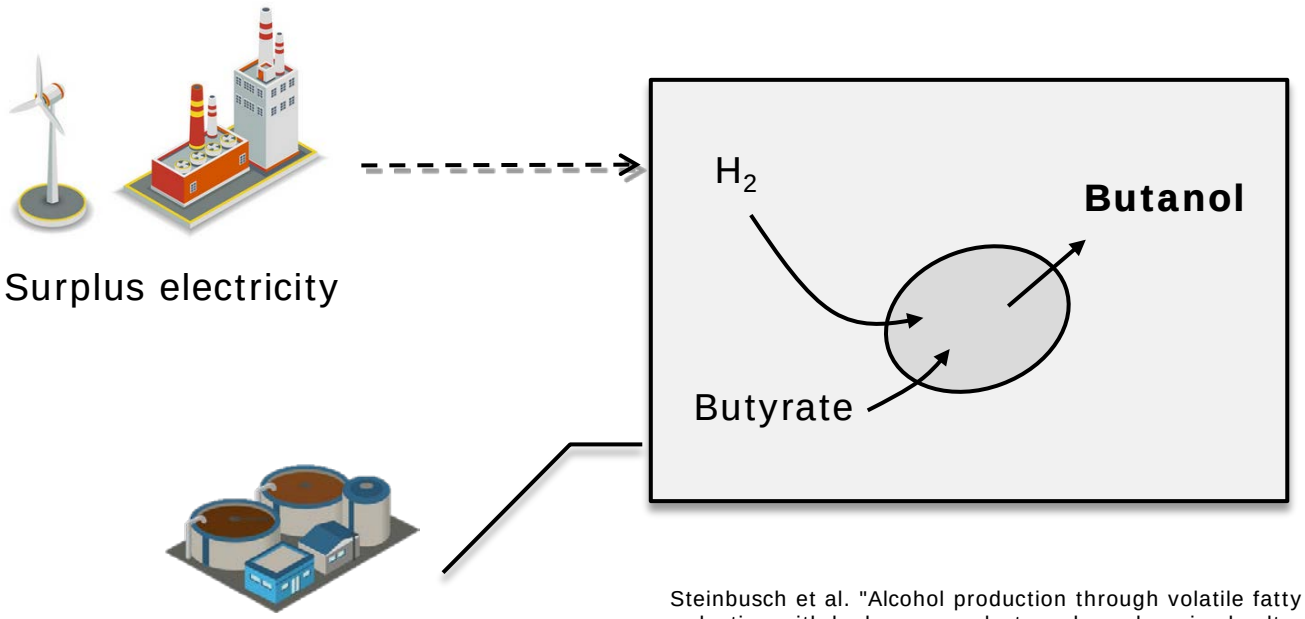
Opportunities

- ASTM D7566-18 permits blending iso-butanol and ethanol derived SPK with conventional jet fuels of up to 50%
- Sourcing C2-C5 alcohols from waste



Butanol from waste – How?

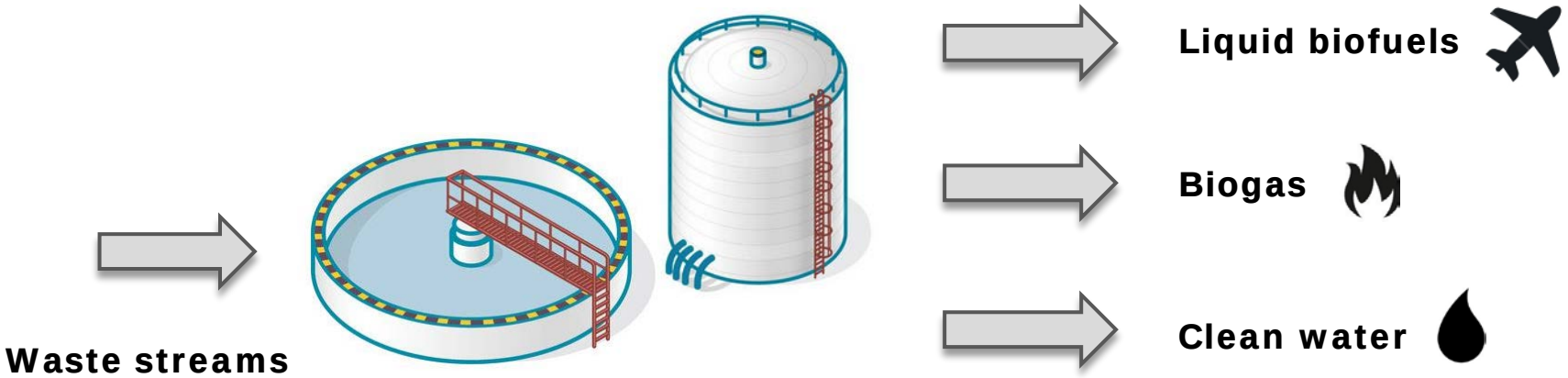
- Anaerobic mixed microbial cultures
- Non-standard conditions (pH 5, increased pH_2)



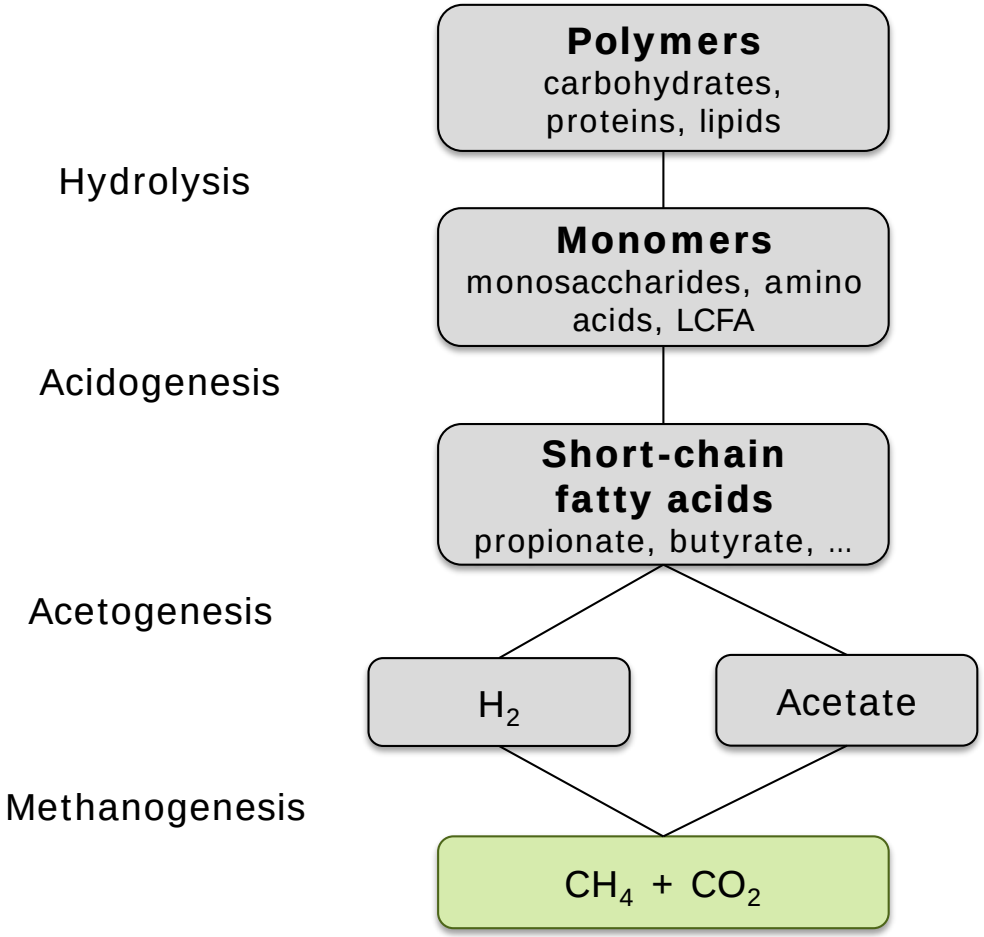
Steinbusch et al. "Alcohol production through volatile fatty acids reduction with hydrogen as electron donor by mixed cultures." *Water research* 42.15 (2008): 4059-4066.

The GreenLogic project

- Production of **C2-C5 alcohols** from industrial and municipal waste streams
- Upgrading waste water treatment plants (WWTP) into water **resource recovery** facilities (WRRF)



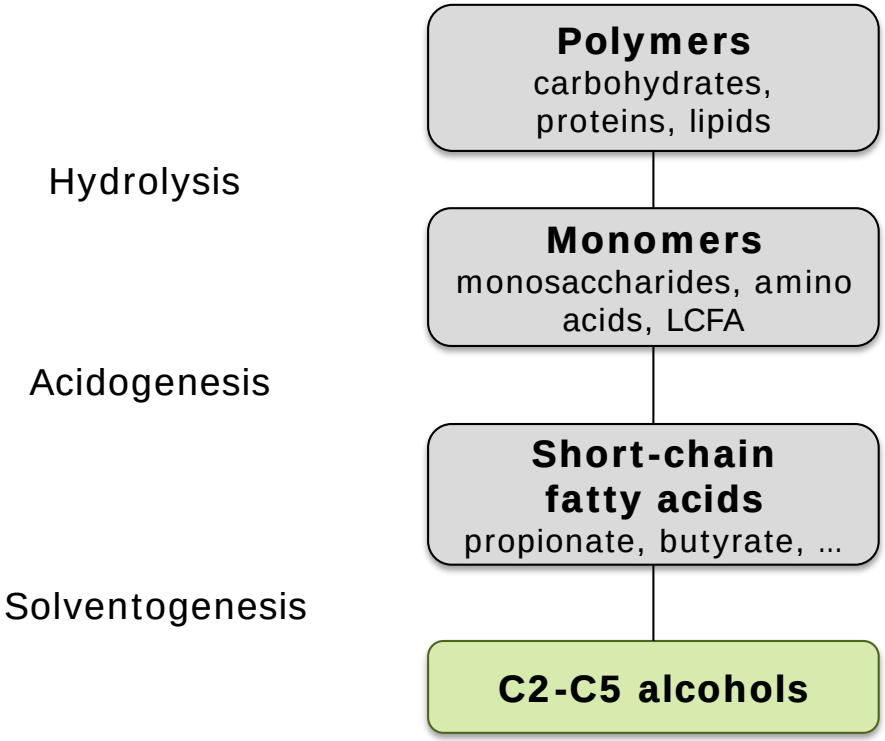
Anaerobic digestion: The classical view



Current focus

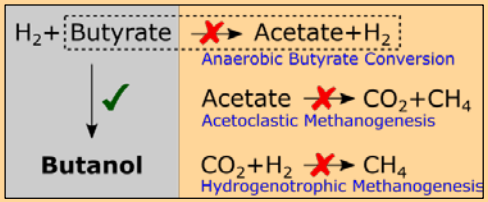
Different microbial groups degrade complex waste streams into biogas.

Anaerobic digestion: Butanol enrichment



New focus

Operate at pH 5 and high pH_2 to promote alcohol formation.

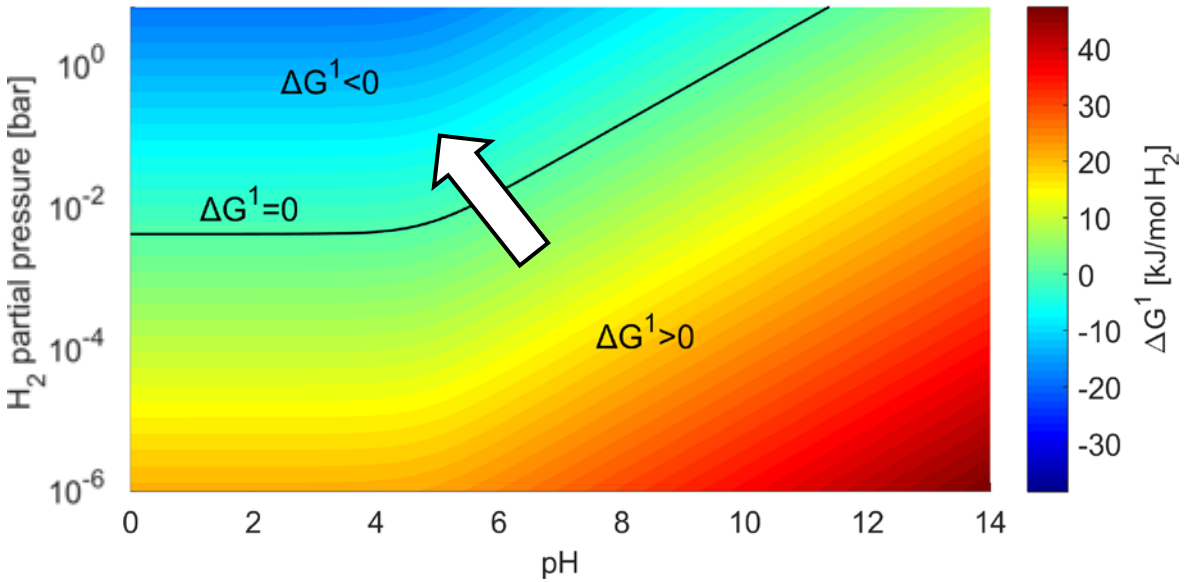


Thermodynamic system design

- Unlocking butanol formation
- Increase H_2, decrease pH (see arrow)

Butanol formation

$Butyrate^- + H^+ + 2H_2 \rightarrow Butanol + H_2O$



Modelling of full-scale anaerobic digesters

- From biogas towards butanol formation

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Conclusions

- **Butanol production** from waste under non-standard conditions
- **Mixed culture biotechnology** as a solution for cheap feedstock conversion into ATJ-SPK
- ATJ-SPK approval for C3-C5 alcohols expected in the **mid-term**; ethanol and iso-butanol are certified already

Outlook

- **Techno-economic analysis** of upstream (H_2 and butyrate sources) and downstream processing

- **Enrichment of new biocatalysts** for butanol formation (microorganisms, enzymes)

- Municipal and industrial waste streams as **cheap and sustainable feedstock** for jet fuel production

Thank you for your attention!

Project partners: