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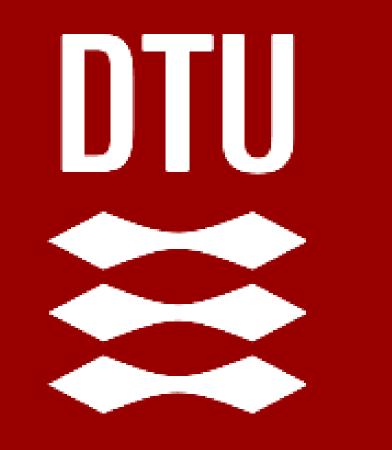
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New Strategies for Green Butanol Production

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Motivation

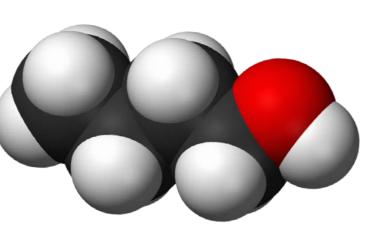
New national and international policies are pushing for a more sustainable production landscape. Once seen as waste, many resources are now the focus of valorization and recovery. Mixed culture biotechnology is held as a promising solution for producing valuable biofuels and chemicals from such low-value substrates and waste streams. In this context, butanol is a biofuel of particular interest.

Why biobutanol?

Why microbial mixed cultures?

Microbial mixed culture	Sterile pure culture
Cheap waste streams (non-sterile)	Expensive high-grade substrates (sterile)
Continuous	(Fed) batch
Ecological selection	Genetic engineering
Resource and energy recovery	Single product, maximized yield

50% higher energy density than ethanol



Properties similar

to gasoline

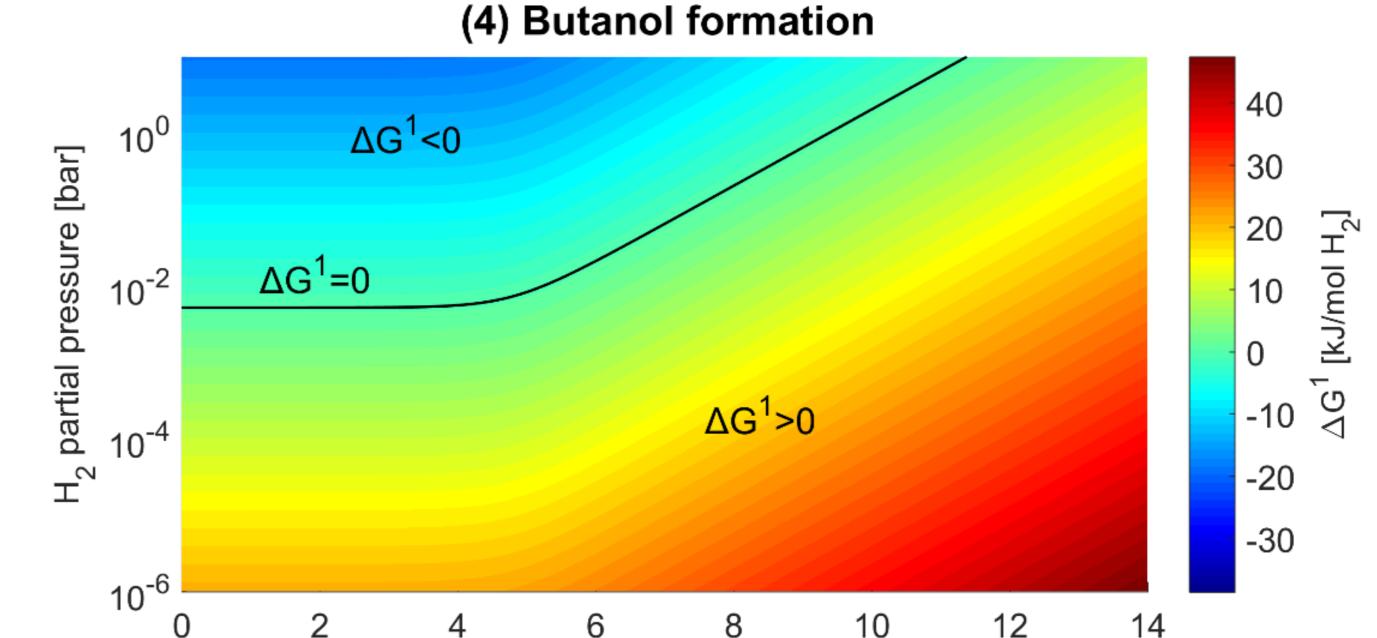
Drop-in replacement for fossil transport fuels

Enrichment strategy

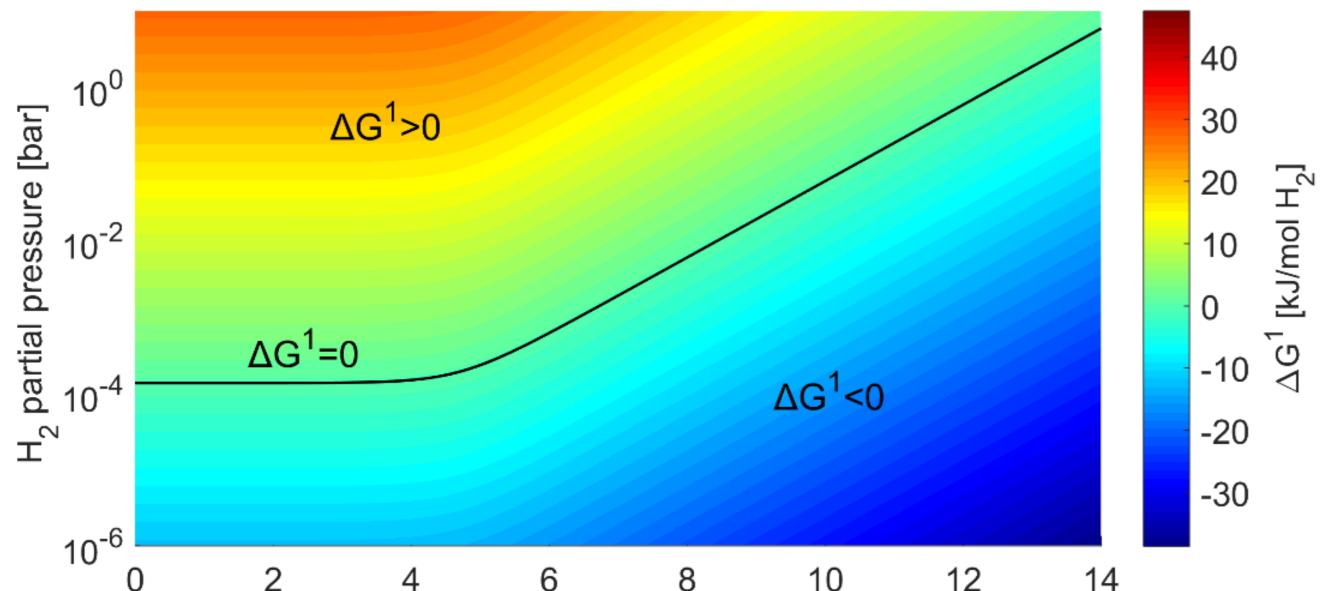
Starting from non-defined methanogenic communities **fed on butyrate and H**₂, butanol-producing microorganisms are enriched through directed ecological selection in a continuously-stirred tank reactor. Operating at **high H**₂ **partial pressure of 1.0 to 1.5 bar**, (1) anaerobic butyrate conversion becomes thermodynamically unfavorable, and thus also (2) acetoclastic and (3) hydrogenotrophic methanogenesis, reducing the amount of CH₄ and CO₂ produced as by-products.

- (1) Butyrate + $2H_2O \rightarrow 2$ Acetate + $H^+ + 2H_2$
- (2) Acetate + $H^+ \rightarrow CO_2 + CH_4$
- $(3) \operatorname{CO}_2 + 4\operatorname{H}_2 \rightarrow \operatorname{CH}_4 + 2\operatorname{H}_2\operatorname{O}$

(4) Butyrate⁻ + H⁺ + 2H₂ → Butanol + H₂O ΔG¹ = -6.8 kJ/mol-H₂, at p₀ = 1 atm and pH 7



(1) Anaerobic butyrate conversion



pH 6 10 12 14 0 10 12 14 pH

Only high H₂ partial pressure is not sufficient to promote butyrate reduction to butanol. As such, by controlling the **fermentation at pH 5** we will further inhibit (1) anaerobic butyrate conversion while favoring (4) butanol formation.

<u>References</u>

[1] Mansouri, S. S., Udugama, I. A., Cignitti, S., Mitic, A., Flores-Alsina, X. and Gernaey, K. V.: Resource recovery from bio-based production processes: a future necessity?, 2017, Current Opinion in Chemical Engineering, 18, 1-9.

[2] Kleerebezem, R. and van Loosdrecht, M. C. M.: Mixed culture biotechnology for bioenergy production, 2007, Current Opinion in Biotechnology, 18(3), 207-212.

[3] Dürre, P.: Fermentative Butanol Production, 2008, Annals of the New York Academy of Sciences, 1125, 353-362.

[4] Steinbusch, K. J., Hamelers, H. V. & Buisman, C. J.: Alcohol production through volatile fatty acids reduction with hydrogen as electron donor by mixed cultures, 2008, Water Research, 42(15), 4059-4066.

[5] Junicke, H., van Loosdrecht, M. C. M. & Kleerebezem, R.: Kinetic and thermodynamic control of butyrate conversion in non-defined methanogenic communities, 2016, Applied Microbiology and Biotechnology, 100(2), 915-925.

Acknowledgements

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