Isopropanol from industrial flue gas using *Cupriavidus necator*

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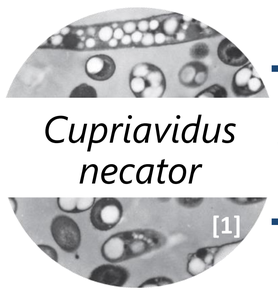
CO_2

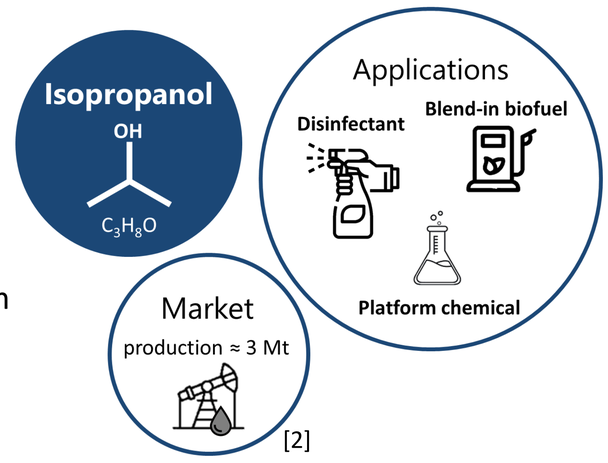
Background



Cupriavidus necator

[1]

- Hydrogen-oxidizing
- Facultative chemolithotroph
- Well-studied model organism

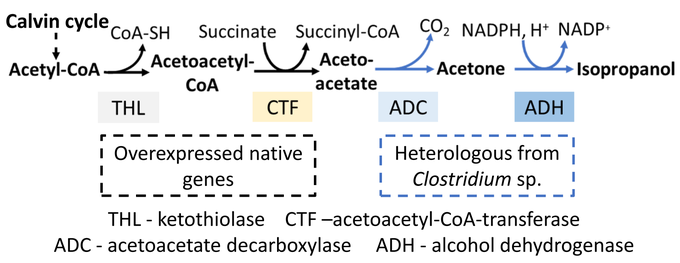


Key points

- 11 g L^{-1} isopropanol was produced from CO_2 as sole carbon source with 0.16 g_{IPA}/g_{CO2}
- Stable cell viability despite 3 bar overpressure and 11 g L^{-1} isopropanol demonstrated robustness of process
- Industrial biogas and incinerator flue gas as carbon source improved growth and product formation despite gas impurities

Methods

Genetic engineered strain



- Deleted PHB-synthesis pathway
- Plasmid-based system
- Inducible promoter

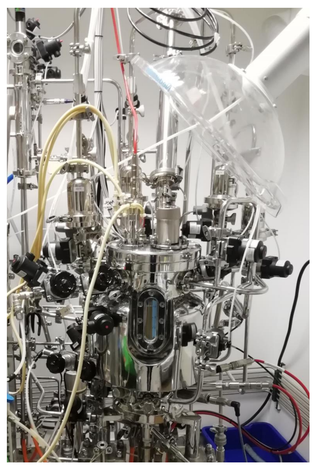
Gas cultivation

Challenges

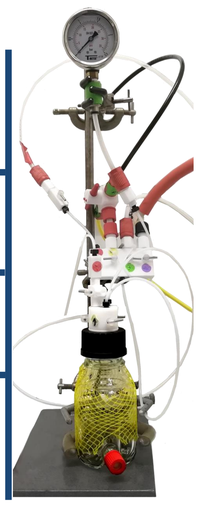
- Potential explosion risk (H_2 + O_2)
- Low solubility of H_2 and O_2

Solutions

- Limit headspace O_2 to < 4 % (explosion threshold) via nitrogen flush
- Application of up to 3 bar overpressure to enhance gas solubility

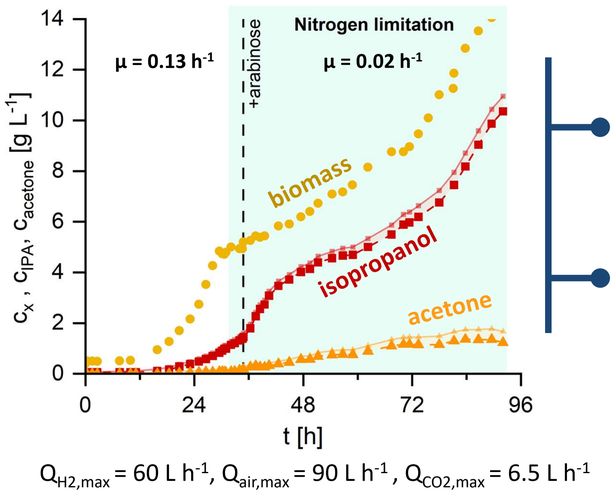


- 1.5 bar overpressure for increased gas transfer
- Configurable gas feed system
- Pressure decrease reflects metabolic activity



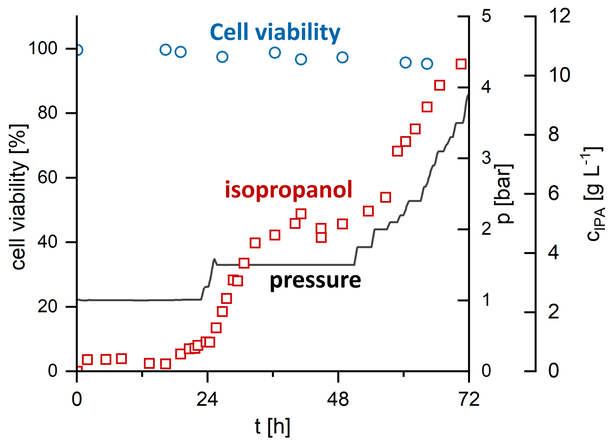
Results

Isopropanol formation in 7.5 L autotrophic bioreactor

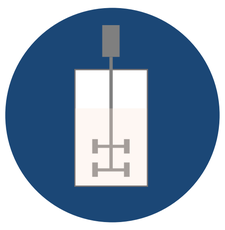


$Q_{H2,max}$ = 60 L h^{-1}, $Q_{air,max}$ = 90 L h^{-1} , $Q_{CO2,max}$ = 6.5 L h^{-1}

- 11 g L^{-1} isopropanol with 12 g L^{-1} biomass (heterotrophic: $c_{IPA,max}$ 16 g L^{-1} [3])
- During product formation phase production of 0.16 g isopropanol per g consumed CO_2

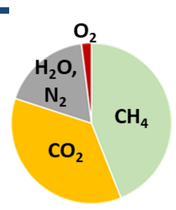


- Cell membrane integrity stayed > 95 % despite 3 bar overpressure and 11 g L^{-1} isopropanol

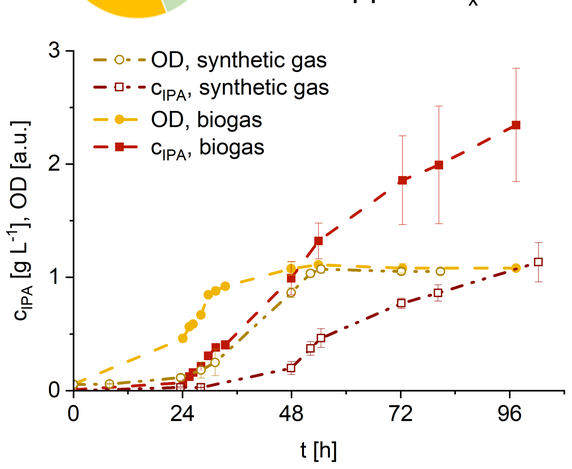


Proof-of-concept with industrial flue gas

Biogas

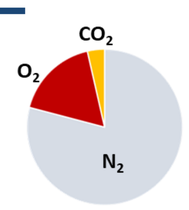


Impurities
200-750 ppm H_2S
10-20 ppm CO
120-130 ppm NO_x

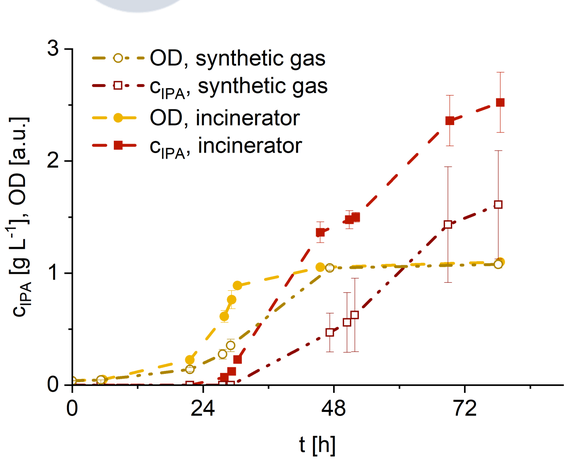


Industrial biogas: 40 % supplemented with 50 % H_2, 10 % O_2
Synthetic biogas: 16 % CH_4, 12 % CO_2, 42 % H_2, 10 % O_2, 20 % N_2

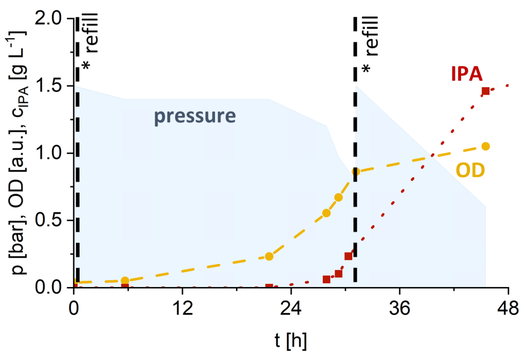
Incinerator



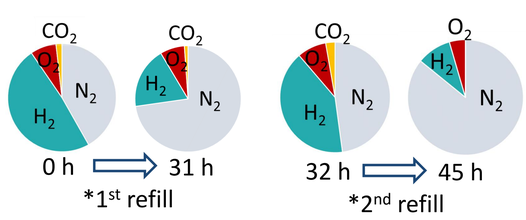
Impurities
50-90 ppm NO_x
10-20 ppm CO



Incinerator offgas: 70 % supplemented with 30 % H_2
Synthetic offgas: 56 % N_2, 4 % CO_2, 30 % H_2, 10 % O_2



*refill with 1.7 L incinerator gas + 0.8 L H_2



- Complete consumption of CO_2
- Increased product formation and accelerated growth with industrial flue gasses

[1] Panich, J., B. Fong, and S. W. Singer (2021). "Metabolic Engineering of *Cupriavidus necator* H16 for Sustainable Biofuels from CO_2". *Trends in Biotechnology* 39 **[2]** bluequarkresearch.com **[3]** Marc, J., E. Grousseau, E. Lombard, A. J. Sinskey, N. Gorret, and S. E. Guillouet (2017). "Overexpression of GroESL in *Cupriavidus necator* for heterotrophic and autotrophic isopropanol production". *Metabolic Engineering* 42

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