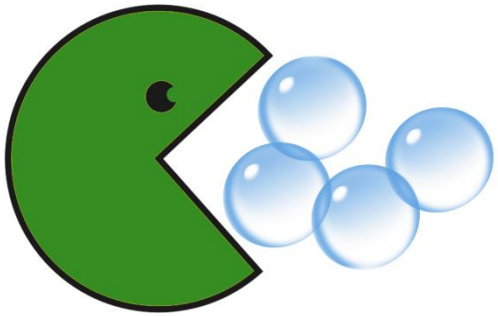
Syngip

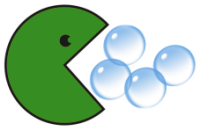
Pitch July 2016



Problem

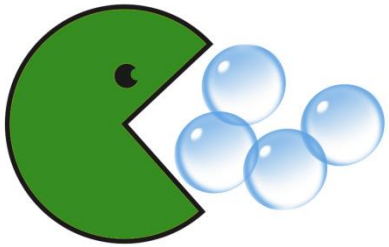
Industrial waste gas emissions (CO_2, CO)

e.g. one steel mill emits > 6,000,000 tons/year



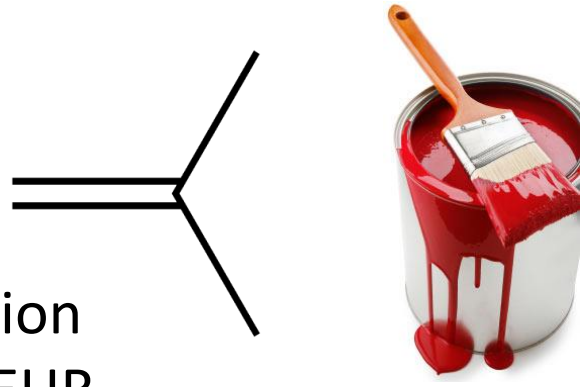
Solution

We can convert toxic and climate destroying waste gases via engineered bacteria into high value isobutene.



CO_2, CO, H_2 → Isobutene

Market



Isobutene market size

- 15,000,000 tons annual production
- market value > 30,000,000,000 EUR

Isobutene can be used as a

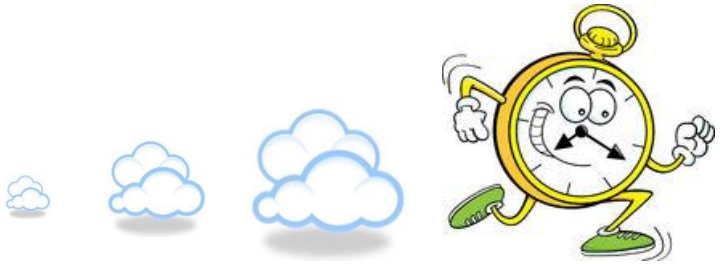
- **fuel** (ETBE, MTBE, Isooctane) or a
- **chemical** (butyl rubber, methacrolein)

- Selling price range: **1500 - 3000** EUR/ton
- Estimated production price: **< 400** EUR/ton

Unfair advantage

We combined two things into one superior product:

- Artificial, efficient pathways to value alkenes (**WO2016034691**)
- Fast growing and robust bacterial chassis (fastest gas-eating bacterium known)



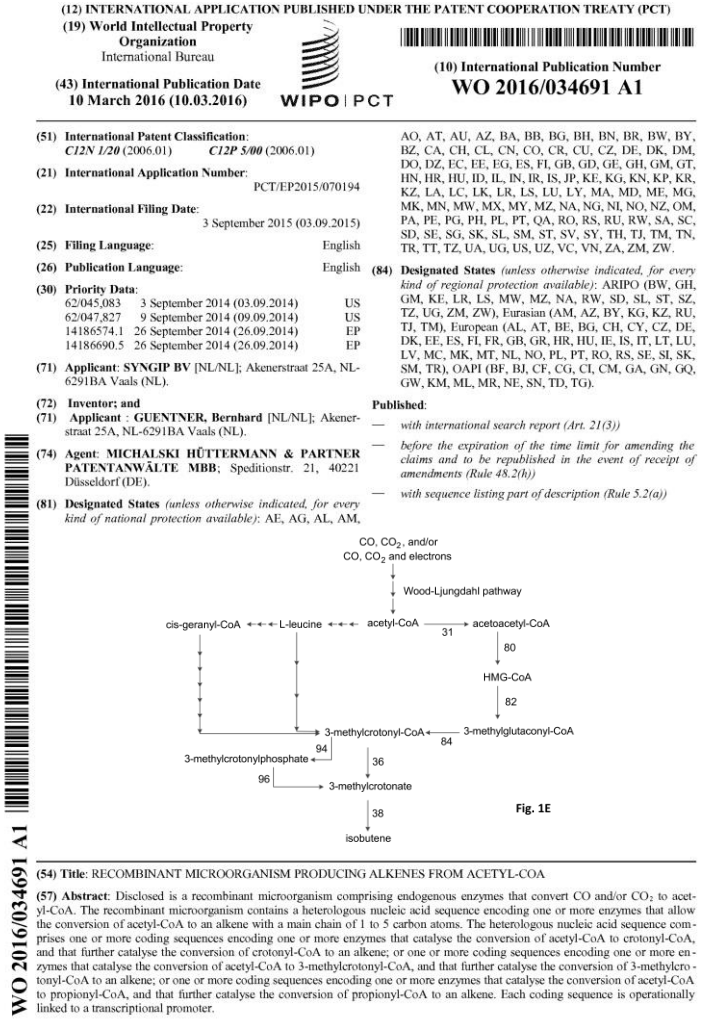


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Fig. 1E

(54) Title: RECOMBINANT MICROORGANISM PRODUCING ALKENES FROM ACETYL-COA

(57) Abstract: Disclosed is a recombinant microorganism comprising endogenous enzymes that convert CO and/or CO_2 to acetyl-CoA. The recombinant microorganism contains a heterologous nucleic acid sequence encoding one or more enzymes that allow the conversion of acetyl-CoA to an alkene with a main chain of 1 to 5 carbon atoms. The heterologous nucleic acid sequence comprises one or more coding sequences encoding one or more enzymes that catalyse the conversion of acetyl-CoA to crotonyl-CoA, and that further catalyse the conversion of crotonyl-CoA to an alkene; or one or more coding sequences encoding one or more enzymes that catalyse the conversion of acetyl-CoA to 3-methylcrotonyl-CoA, and that further catalyse the conversion of 3-methylcrotonyl-CoA to an alkene; or one or more coding sequences encoding one or more enzymes that catalyse the conversion of acetyl-CoA to propionyl-CoA, and that further catalyse the conversion of propionyl-CoA to an alkene. Each coding sequence is operationally linked to a transcriptional promoter.

WO 2016/034691 A1

Isobutene competition

<u>Status quo:</u> petrochemical production of Isobutene. But low cost feedstock (waste gas) makes Syngip‘s approach economical
+ **carbon tax** beginning with 2020

<u>Competition:</u> Global Bioenergies ferments isobutene from sugars

- **Expensive** sugar feedstock not price competitive

GLOBAL BIOENERGIES

→ We are the <u>only</u> ones who can make isobutene from waste gases!

Syngas competition

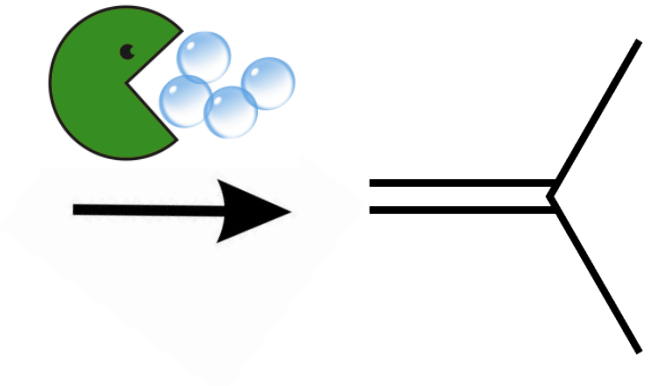
Lanzatech

- products: ethanol from waste gases
- ethanol is toxic for bacteria
- energy intensive distillation required
- slow growing bacteria (doubling time 4 hours)
- wrong process temperature 30-37 °C
- vitamins needed to be added (expensive)
- high contamination risk
- expensive reactor design (high CAPEX)
- sensitive to impurities (gas cleaning necessary)
- low gas uptake rate

LanzaTech
capturing carbon. fueling growth.

Syngip‘s tech at a glance

- Isobutene not toxic (high productivity)
- no energy intensive distillation required
- fast growing bacterium (fastest gas-eating bacterium known, doubling time **48 min**)
- ideal process temperature **40-70 °C**
- no vitamins needed
- no contamination risk
- no expensive reactor design needed (lower CAPEX)
- not sensitive to impurities (no gas clean-up necessary)
- high gas uptake rate



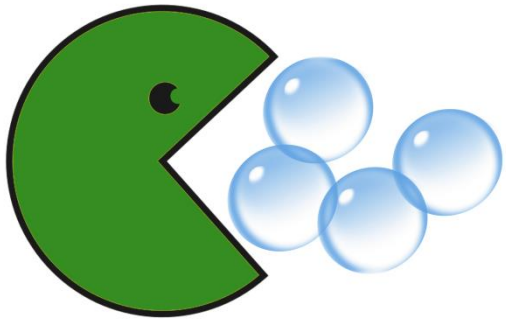
Roadmap/Partnerships

Road to commercial production

- **Step 1**: Pilot scale autumn 2016 (ArcelorMittal, Bio Base Europe Pilot Plant, Dow Chemical, Procone GmbH)
- **Step 2**: Demo scale 1500 L (expected for 2017-2018)
- **Step 3**: Commercial scale (expected for 2019-2020)

Summary

The way of the future: next level carbon capture and use (CCU)



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