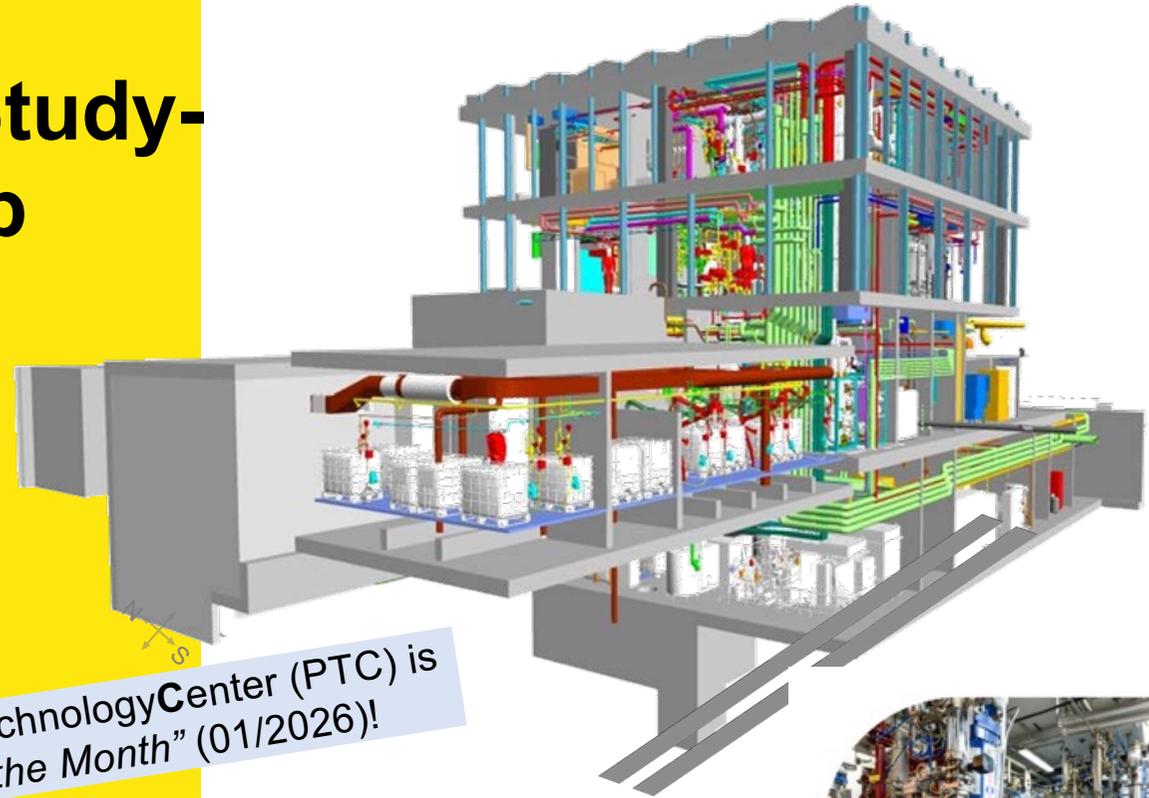


Welcome to the Study- Visit and Scale-up Workshop!

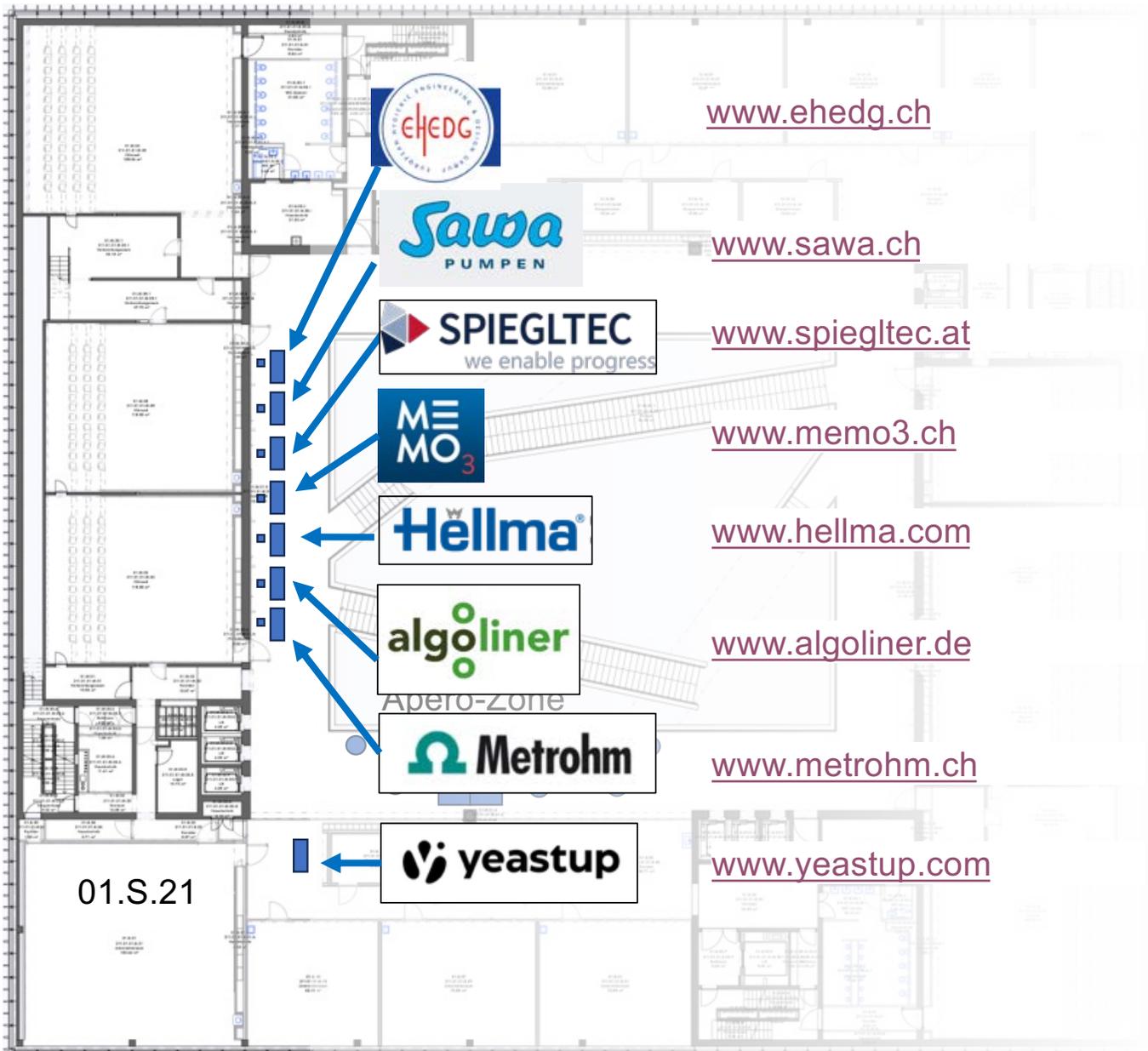


Our **ProcessTechnologyCenter (PTC)** is
"Facility of the Month" (01/2026)!



School of Life Sciences, CH-Muttenz
February 4th, 2026

member of
swissuniversities





Agenda

The FHNW School of Life Sciences is organising a Study Visit and Scale-Up Workshop at FHNW Campus Muttenz (Switzerland) on February 4, 2026. The event is supported by the "PILOTS4U – powered by COPILOT" initiative, as part of its "Scale-up & Growth" and "Exchange & Connect" programmes.

We are pleased to welcome all interested researchers, engineers, innovators and investors to Muttenz!



Visit the FHNW website

9.00 – 9.30	Registration and Coffee
9.30 – 9.45	Welcome
9.45 – 10.00	Introduction to Pilots4U powered by COPILOT
10.00 – 11.00	The FHNW School of Life Sciences and its applied R&D activities
11.00 – 12.30	Scale-up session Group A // Lab tour Group B
12.30 -13.30	Lunch and Company/Project Presentation
13.30 – 15.00	Scale-up session Group B // Lab tour Group A
15.00 – 15.15	Wrap up
15.15 – 16.00	Coffee



Pilots4U: Supporting the Scale-Up of the European Bioeconomy

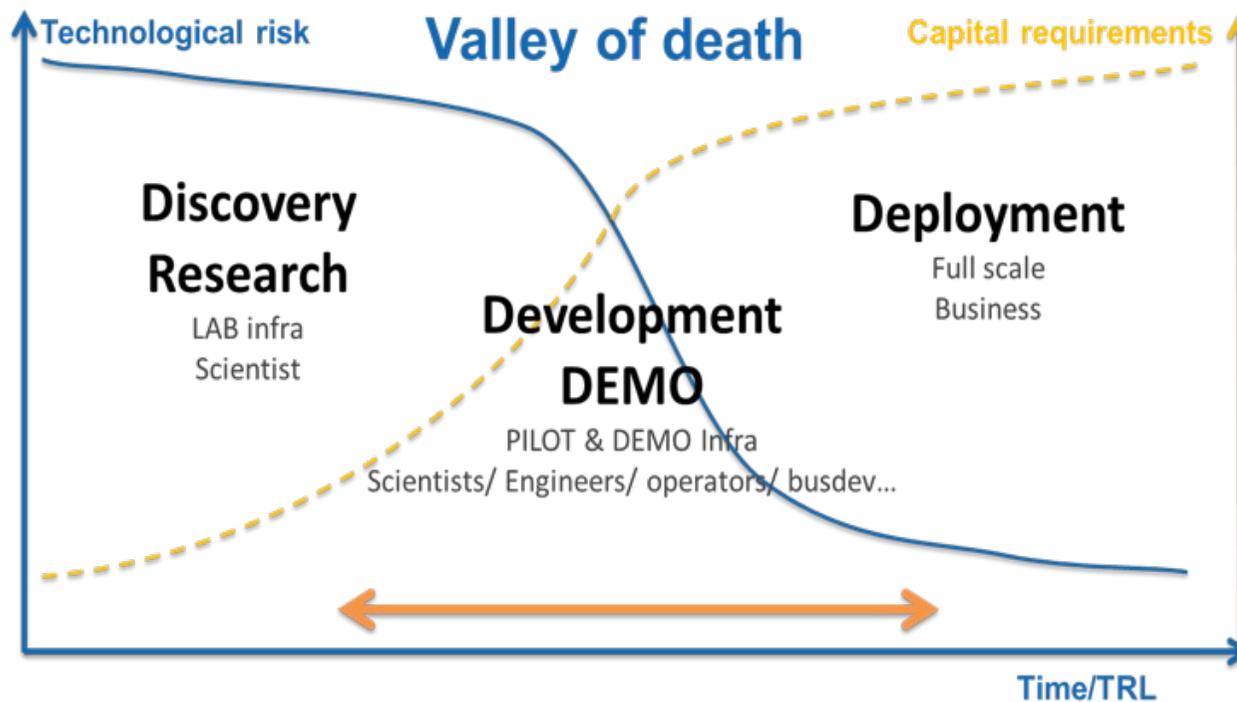
Yang Zou, PhD

COPILOT project coordinator

Pilots4U powered by COPILOT platform manager



Scaling up is a tricky phase to get through

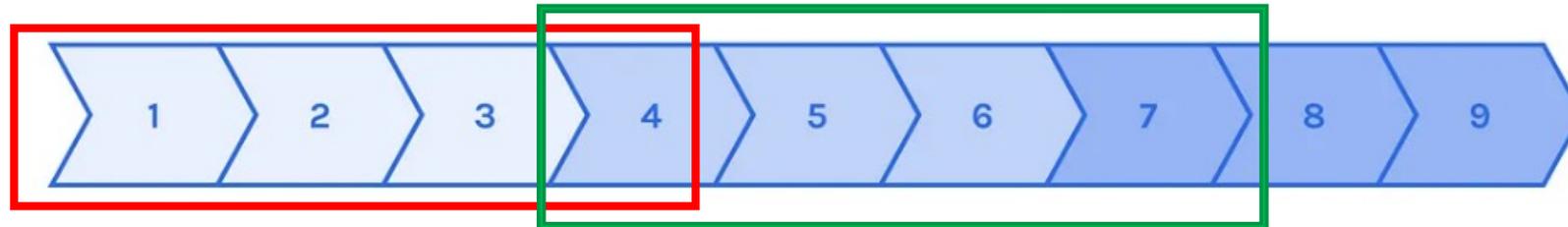


Shared Pilot Facilities
=
risk sharing & reduction

The TRL levels covered by Pilots4U

Technology Readiness Levels

PILOTS4U = pilot & demo infra



Research



Develop



Deploy

Availability of 120+ shared pilot & demo infrastructures for the bioeconomy in Europe



Support the Pilots4U ecosystem structurally as a strong network

Put these infrastructures clearly on the map within the EU Biotech Hub

Support to keep the infrastructure state-of-the-art



Pilots4U covering a broad scope of technology areas



Size reduction and Homogenisation

Chipping
Extrusion
Grinding
Milling
Densification



Thermal and Pressure techniques

Steam explosion
Microwave
Cold plasma
Ultrasonication
Torrefaction
Hydrothermal



Pulping

Chemical: sulphate/sulphite, organosolv, soda
Mechanical
Hybrid: Chemi-thermo-mechanical pulping, neutral sulphite semi-chemical pulping



Thermochemical conversions

Gasification
Pyrolysis



Algae technologies

Algae cultivation in open ponds, photobioreactors and fermenters



Separation technologies

Mechanical separation
Centrifugation
Membrane filtration
Particle filtering
Particle classification and sieving
Physicochemical separation
Chromatography
Crystallization
Distillation
Drying
Evaporation
Crystallization and precipitation
Field-Flow Fractionation
Flocculation
Extraction
Liquid-Liquid extraction
Solid-Liquid extraction



Fermentation and Digestion

Anaerobic digestion
Biomass fermentation and precision fermentation
Solid-state fermentation
Gas fermentation
Composting



Enzymatic catalysis

Enzymatic hydrolysis and enzyme immobilization
Remediation



Chemical conversions

Acid and alkaline hydrolysis
Carbon capture utilisation
Polymerisation
Heterogeneous catalysis
Reduction



Material technologies

Coating or lamination
Textile fibre spinning
Fibre web production
Nano/micro fibre production
Biocomposite processing



Sterilisation technologies

UHT
Pasteurisation
UV



Cell cultivation

Mammalian/Insect Cells
Plant Cells

Pilots4U co-organize Open Day Visits



Application Deadline (A.D.):	📍 2025 10 octobre 2025	📍 2026 15 decembre 2025	<ul style="list-style-type: none"> * Vouchers available 🚫 Call closed, no more vouchers available 📅 Call deadline was 8 May 2025
------------------------------	----------------------------------	-----------------------------------	---

- 📅 6 November
IBioIC, UK
- * 📅 21 April
CPI, UK
- 📅 14 October
LIST, LU
- * 📅 12 March
ARD, FR
- * 📅 26 November
BBEPP, BE
- 📅 Apr/May
Food Pilot, BE
- * 📅 24 - 25 Nov.
BRUSSELS, BE

Visit one of these pilot or demo infrastructures

- 📅 14 April
VTT Bioruukki, FI
- * 📅 19 March
DTI, DK
- 📅 6 June
NIZO, NL
- 📅 23 September
BEST, AT
- 📅 2 September
Acies Bio, SL
- 📅 4 February
FHNW, CH
- 📅 20 May
Biosphere, IT
- * 📅 Feb/Mar
BIO2CHP, GR

Co-funded by the European Union
 Circular Bio-based Europe Joint Undertaking
 Bio-based Industries Consortium

Check out the "Pilots4U database, network & activities"



Pilots4U co-organize PDI Fair



Call for Scaling-Up Facilities

BIOKET26
FRIBOURG

Open-Access Scaling-Up Facilities Pitch Session

Full registration in the Pilots4U database is mandatory

17 - 19 MARCH, 2026 | FRIBOURG, SWITZERLAND



Pilots4U co-organize Training Webinars



Date	Pilot Plant and Demo Infrastructures	Topic
22 May 2025	Bio2CHP	Pitch Training for Start-Ups in Biosolutions
26 May 2025	Acies Bio	Scaling innovative technologies - Different business models in scaling biosolutions
18 June 2025	LIST	Downstream from your Production Could be an Important Part of the Business Potential
25 September 2025	DTI	Choices Challenges and Collaboration in Process Scaling Up
1 October 2025	ARD	Scaling-Up Improvement, Environmental Integration Processes and Waste Characterization
10 October 2025	A4F	Biological Contaminants & Microalgae Crop Protection
20 January 2026	BEST	The Condensation of Liquids during Pyrolysis
10 February 2026	NIZO/BFF	Process and Microbial Modelling, Food Safety and Quality Aspects of Food Processing and Upscaling
26 February 2026	Biosphere	Intellectual Property and Patents for Biosolution Start-Ups
12 March 2026	Food Pilot	Integrating Novel Food Dossier Preparation into Your Product Development Process



The next generation platform Pilots4U powered by COPILOT



Database Add a facility Events Programs About us Contact & My account

Discover the new PILOTS4U database

A powerful and intuitive tool designed to bridge the gap between Bioinnovators and Europe's leading Pilot and Demonstration Infrastructures. This platform streamlines access to cutting-edge facilities and fosters seamless collaboration, empowering innovators to accelerate the development and commercialization of biobased technologies. By reducing barriers and connecting key players, it plays a vital role in bringing innovative solutions to market faster, driving sustainable growth and advancing.

[Find a facility](#) [Make an account](#)

n|w University of Applied Sciences and Arts Northwestern Switzerland School of Life Sciences

Facility of the month

Process Technology Center FHNW...

Innovation and practical implementation are the focus of applied research and development at the FHNW School of Life Sciences (HLS)...

[Read more](#)

Onsite event Scale-up & growth

Study Visit and Scale-Up Workshop @ FHNW, Switzerland

04.02.2026
Mutzens, Switzerland

Between May 2025 and May 2026, fifteen European Pilot and Demonstration Infrastructures (PDIs) will organise...

[Read more](#)

Online event Scale-up & growth

Online Training Webinar by BIOSPHERE: Intellectual property and patents for biosolution start-ups

26.02.2026

Between May 2025 and May 2026, fifteen European Pilot and Demonstration Infrastructures (PDIs) will organise...

[Read more](#)

Online event Scale-up & growth

Online Training Webinar by BEST: The condensation of liquids during pyrolysis

05.03.2026

Between May 2025 and May 2026, fifteen European Pilot and Demonstration Infrastructures (PDIs) will organise...

[Read more](#)

Onsite event Scale-up & growth

Study Visit and Scale-Up Workshop @ ARD, France

12.03.2026
Pomacle, France

Between May 2025 and May 2026, fifteen European Pilot and Demonstration Infrastructures (PDIs) will open...

[Read more](#)

Online event Scale-up & growth

Online Training Webinar by FOOD PILOT (ILVO): From R&D to Regulatory Approval: Food & Feed Application Advice by Food Pilot

12.03.2026

Between May 2025 and May 2026, fifteen European Pilot and Demonstration Infrastructures (PDIs) will organise...

[Read more](#)

<p>LUT Membrane Laboratory</p> <ul style="list-style-type: none"> Membrane filtration Membrane titration <p>Discover this facility</p>	<p>LUT Fiber Laboratory</p> <ul style="list-style-type: none"> Chemical spinning Chromatography <p>Discover this facility</p>	<p>Axel One Analysis</p> <ul style="list-style-type: none"> Chemical synthesis Extraction More technologies <p>Discover this facility</p>	<p>GEA Test Center Separation</p> <ul style="list-style-type: none"> Distillation <p>Discover this facility</p>	<p>Circular Economy Laboratory - LAB University of Applied Sciences</p> <ul style="list-style-type: none"> Physicochemical separation Facile classification and Microtechniques <p>Discover this facility</p>	<p>TITAK - Center of Food and Fermentation Technologies</p> <ul style="list-style-type: none"> Biosens and precision fermentation More technologies <p>Discover this facility</p>	<p>Bio Base Europe Pilot Plant</p> <ul style="list-style-type: none"> Biosens and precision fermentation More technologies <p>Discover this facility</p>	<p>XAMK Fiber Laboratory</p> <ul style="list-style-type: none"> Spinning Chemical pulping More technologies <p>Discover this facility</p>	<p>Plant One Delft B.V.</p> <ul style="list-style-type: none"> Steam explosion Biosens and precision fermentation More technologies <p>Discover this facility</p>	<p>Atilip Technology Centre</p> <ul style="list-style-type: none"> 3D object production Biosens and precision fermentation <p>Discover this facility</p>	<p>VSB - Technical University of Ostrava, Centre for Energy and Environment Technologies, Energy Research Centre</p> <ul style="list-style-type: none"> Heterogeneous catalysis Distillation More technologies <p>Discover this facility</p>	<p>KCL Piloting and testing services</p> <ul style="list-style-type: none"> Mechanical pulping Chemical pulping More technologies <p>Discover this facility</p>
<p>VTT Web Forming Pilots</p> <ul style="list-style-type: none"> Fibre web production <p>Discover this facility</p>	<p>Air Liquide Forschung & Entwicklung GmbH</p> <ul style="list-style-type: none"> Heterogeneous catalysis Heterogeneous catalysis <p>Discover this facility</p>	<p>Centre for Sustainable Fermentation and Bioprocessing Systems for Food and the Bioeconomy</p> <ul style="list-style-type: none"> Biosens and precision fermentation Extraction Bringing <p>Discover this facility</p>	<p>Demcon-QL Polymers</p> <ul style="list-style-type: none"> Polymerisation Extraction More technologies <p>Discover this facility</p>	<p>ENEA - Integrated Pilot Platform for Biofuel and Bioeconomy Applications</p> <ul style="list-style-type: none"> Distillation Membrane filtration More technologies <p>Discover this facility</p>	<p>Process Technology Center FHNW @ HLS</p> <ul style="list-style-type: none"> Distillation Membrane filtration More technologies <p>Discover this facility</p>	<p>GNANOMAT S.L.</p> <ul style="list-style-type: none"> Milling Chemical synthesis More technologies <p>Discover this facility</p>	<p>Fraunhofer CSP</p> <ul style="list-style-type: none"> Organosol and solids printing Biosens and precision fermentation More technologies <p>Discover this facility</p>	<p>Processum</p> <ul style="list-style-type: none"> Biosens and precision fermentation More technologies <p>Discover this facility</p>	<p>Brightlands - Pilot Plant for PET-polymerization and biomass conversion</p> <ul style="list-style-type: none"> Polymerisation Heterogeneous treatment More technologies <p>Discover this facility</p>	<p>e-nema biotechnology and biological plant protection</p> <ul style="list-style-type: none"> Biosens and precision fermentation <p>Discover this facility</p>	<p>Faculty of Polymer Technology</p> <ul style="list-style-type: none"> Grinding 3D object production More technologies <p>Discover this facility</p>



Follow Pilots4U LinkedIn Page



Pilots4U by CoPilot
3,221 followers
3d • Edited •

🔥 REGISTER NOW: 2 upcoming FREE Pilots4U Training Webinars (Feb 2026)
Looking to strengthen your scale-up journey, from process understanding to protecting your innovation? Join our next two online training sessions, ...more

Pilots4U REGISTER NOW for 2 UPCOMING Free Training Webinars

12 February 2026
organised by **NIZO**
Process and microbial modelling, including food safety quality aspects of food processing and upscaling

26 February 2026
organised by **BIOSPHERE**
Intellectual property and patents for biosolution start-ups

Info & Registration: <https://biopilots4u.eu/events/>

Stef Denayer and 75 others

6 comments • 16 reposts

Pilots4U by CoPilot
3,221 followers
1mo • Edited •

🚀 Pilots4U powered by COPILOT is officially launched! <https://biopilots4u.eu/>
A proud moment: we unveiled the brand-new Pilots4U platform during **Pitch Perfect and Boost the European Bioeconomy 2025!** This is a true milestone in our ...more



You and 156 others

9 comments • 20 re



Why are we doing scale-up @ School of Life Sciences / FHNW CH-Muttenz

1) From an academic / engineering point of view:

- Minimum requirement: In order to see, which effects occur when the process is operated in x10-x100 larger scale than in the (controlled) lab environment (and describe/quantify them, if possible)
- Advanced: In order to see, to which extent your simulations / (rigorous?) mass/heat transfer models do work in larger scale, too (or which adaptations are required to do so)

2) From an economic / industrial point of view:

- Especially Start-ups simply need some “Kilogram” to show to their (future) customer
- As a confidence-building measure for investors: “Look, we have a process in place!”
- Show, if and to what extent there is an “economy of scale” (=the larger, the cheaper)
- Further reasons: See “academic/engineering point of view” above!

Theranos failed to do so!

Why are we doing scale-up?

1) From an academic / engineering point of view:

- Minimum requirement: In order to see, which effects occur when the process is operated in x10-x100 larger scale than in the (controlled) lab environment (and describe/quantify the effects if possible)
- Advanced: In order to see, which effects extend your simulations / (rigorous?) mass/heat transfer models do work in larger scale, too (or which adaptations are required to do so)

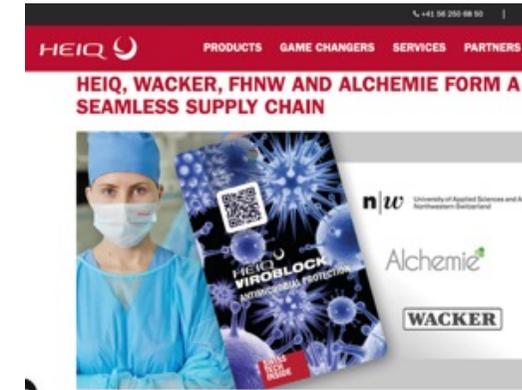
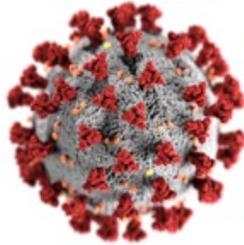
Why with us?
(a University of Applied Sciences)

2) From an economic / industrial point of view:

- The “speed” of Universities \neq (required) speed of industrial projects (3 years for ph.D. vs 3 month for concept phase)
 - Especially: Don't just simply need some “Kilogram” to show to their (future) customer
 - Further reasons: “Look, we have a process in place!” Theranos failed to do so!
 - Show, if and to what extent there is an “economy of scale” (=the larger, the cheaper)
- Universities are not equipped good enough (“Only Experts in specialised fields / technologies”)
 - Further reasons: See “academic/engineering point of view” above!
- Switzerland == expensive

HeiQ Viroblock

Why with us?



...During Easter 2020, around **5,000 kg of 'Viroblock'** chemicals for coronavirus protective masks were produced **in just 2 weeks**. To achieve this, the FHNW team transferred the HeiQ laboratory process to pilot scale, and **it still serves as the recipe for global production** today.

“Speed”, “Costs”?!



- process development (including patent application)
- Technical support during scale-up and Pilot installation

Request a **sample** and let's talk about your application

yeastup Our Products Hot Topics ▾ Upcycling About Talk to us **in**
Hiring

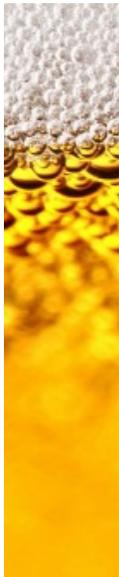
Ingredients That Make a Difference

We create functional proteins and beta-glucan fibers from yeast – enabling better plant-based, egg-free, and health-focused product innovation. Clean, versatile, and helping your ideas take shape.



We upcycle spent brewer's yeast into functional, high-performance ingredients for the food industry. Using our patented, resource-efficient process, we continuously separate soluble proteins and fibers from spent brewer's yeast – without harsh chemicals or unnecessary waste.

De-alcoholisation of Beer (and Wine) with *membrane technology*



BrauBeviale,
D-Nürnberg, 2011

- Development of an easy-to-operate stand-alone Membrane skid for the de-alcoholisation with Nanofiltration
- Now more than 5 references in Switzerland, Germany, Austria and abroad





Algae reactor with membrane contactor



Solid/liquid separation



Extraction



Drying



DSP Equipment: see our webpage
(FHNW Process Technology Center-PTC: <https://www.fhnw.ch/de/die-fhnw/hochschulen/lifesciences/process-technology-center-ptc>)

gamma*: Innovatives Gasmanagement bei der Mikroalgenkultivierung mittels Membrankontaktoren
Redl, W., Dewald, R.
Fachhochschule Nordwestschweiz, Hochschule für Life Sciences, Muttenz (BL)

Ein Herausforderung bei der Kultivierung von Mikroalgen ist das Gasmanagement: Die Alge benötigt **CO₂** in gelöster Form und gibt den bei der Photosynthese hergestellten **Sauerstoff** auch wieder **als Gas** ab – also in homogener Phase. Der Gasaustausch wird aber bisher immer über Gasbläschen bzw. an der Phasengrenzfläche Gas/Füssigkeit, also heterogen, betrieben. Durch den Einsatz von **Membrankontaktoren** kann **CO₂**, **bläschenfrei** ein- und **Sauerstoff bläschenfrei** ausgegast werden, was zu einer Prozessintensifizierung führen sollte.

Nachteil
herkömmliche Be- und Entgasung
- Gaskosten reduzieren nur durch Kultivierungs- bedingungen
- CO₂ wird nicht vollständig verwirbelt (Dauer- und CO₂ Defizit)
- Sauerstoff wird erst entfiel, wenn er Sättigung erreicht hat (nicht wachstumsfördernd)

Vorteil membrangetriggerte Be- und Entgasung
- keine Gaskostenbildung
- keine oberflächenspezifische Desaturierung möglich
- Galt CO₂ Sauerstoffkonzentration nahe Null
- Einfacher Scale-up
- kein Chemikalieninsatz
- keine Verblockung der Membran (bei entsprechendem Querschnitt)

Grundlagen
Membrangetriggerte Be- und Entgasung ist seit mehr als drei Dekaden bekannt, bisher aber aufgrund von Membranproblemen wenig bis gar nicht umgesetzt. Mit tubularen PTFE-Membranen ist es jetzt möglich, den bläschenfreien Gasaustausch zu ermöglichen. Dabei hilft ED-Druck, die Membranen an fiktisch jede Geometrie anzupassen. Der Stofftransport wird wie folgt beschrieben:

$$J_{i, m} = k_{i, m} \cdot A \cdot (c_{i, 1} - c_{i, 2})$$

Versuchsfluss und Ergebnisse
Aufbau
- In 7 parallele, tubuläre "Nagel"-Reaktoren
- In herkömmlicher Be- und Entgasung
- In mit membrangetriggelter Be- und Entgasung
Kultivierung gleichzeitig unter sonst gleichen Bedingungen (Stamm, Licht, Medien, Temperatur, Überbelastung)
Auswertung mittels MATLAB als logarithische Wachstumsfunktion

Parameter	herkömmliche Be- und Entgasung	Membrangetriggerte Be- und Entgasung
μ_{max}	0,14	0,21
K_d	0,01	0,01
μ_{eff}	0,13	0,20
μ_{eff} / μ_{max}	0,93	0,95

Zusammenfassung und Ausblick
Durch die Integration von Membrankontaktoren in Mikroalgenkultivierungen ist es gelungen, das Gasmanagement dauerhaft zuverlässig zu gestalten. Sowohl CO₂ konnte dabei bläschenfrei eingegast werden, als auch der Galt-Sauerstoff bereits bei der Bildung während der Photosynthese entfiel. In einem weiteren Schritt sollen nun Membrankontaktoren auch für einen 100-L-Fermentator eingesetzt werden. Aufgrund der guten Skalierbarkeit von Membrankontaktoren ist auch hier wieder von einer deutlichen Steigerung der Wachstumsgeschwindigkeit auszugehen.

Dank
Wir danken der RAPS-Stiftung International Gung Foundation, der Agroscope, dem Hightechzentrum Argaw und der Fa. Meno für die Unterstützung dieser Forschungsarbeiten.

gernet

Goals and Objectives

[ONE EARTH](#) > Goals and Objectives



Transformation

of residual biomass into high-value products through biotechnological processes, facilitating the development of integrated value chains across terrestrial and aquatic industries.



Improvement

of the environmental sustainability of biomass valorization by reducing the carbon footprint, enhancing resource efficiency, minimizing waste, and supporting a circular bioeconomy.



Research

and validation of novel bio-based products, including nutraceuticals, cosmetics, bio adhesives, fertilizers, and aquaculture feeds derived from residual biomass.

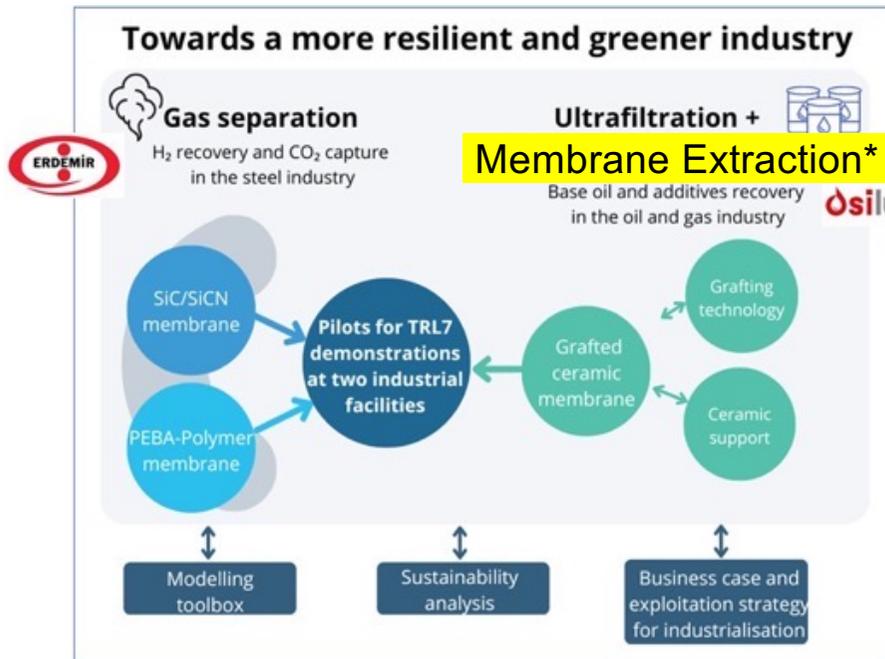


Assessment

of project potential and identification of opportunities to foster industrial initiatives and new business ventures, while ensuring the economic and social sustainability of proposed solutions.



member of
swissuniversities



*UF + ME shall replace 2 distillation steps (at 260°C and 360°C)



This project has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No. 101091812. All rights reserved. This document is protected by copyright. The contents and information in this document, in particular text, drawings and images it contains, are strictly confidential and may not be altered or amended, copied, used or disclosed without the express permission of the rights holder.

CUMERI HOME ABOUT PARTNERS RESULTS OUR NETWORK NEWS & EVENTS CONTACT

Customised membranes for green and resilient industries.

Enhance recovery of valuable components and improve energy efficiency at industrial facilities.

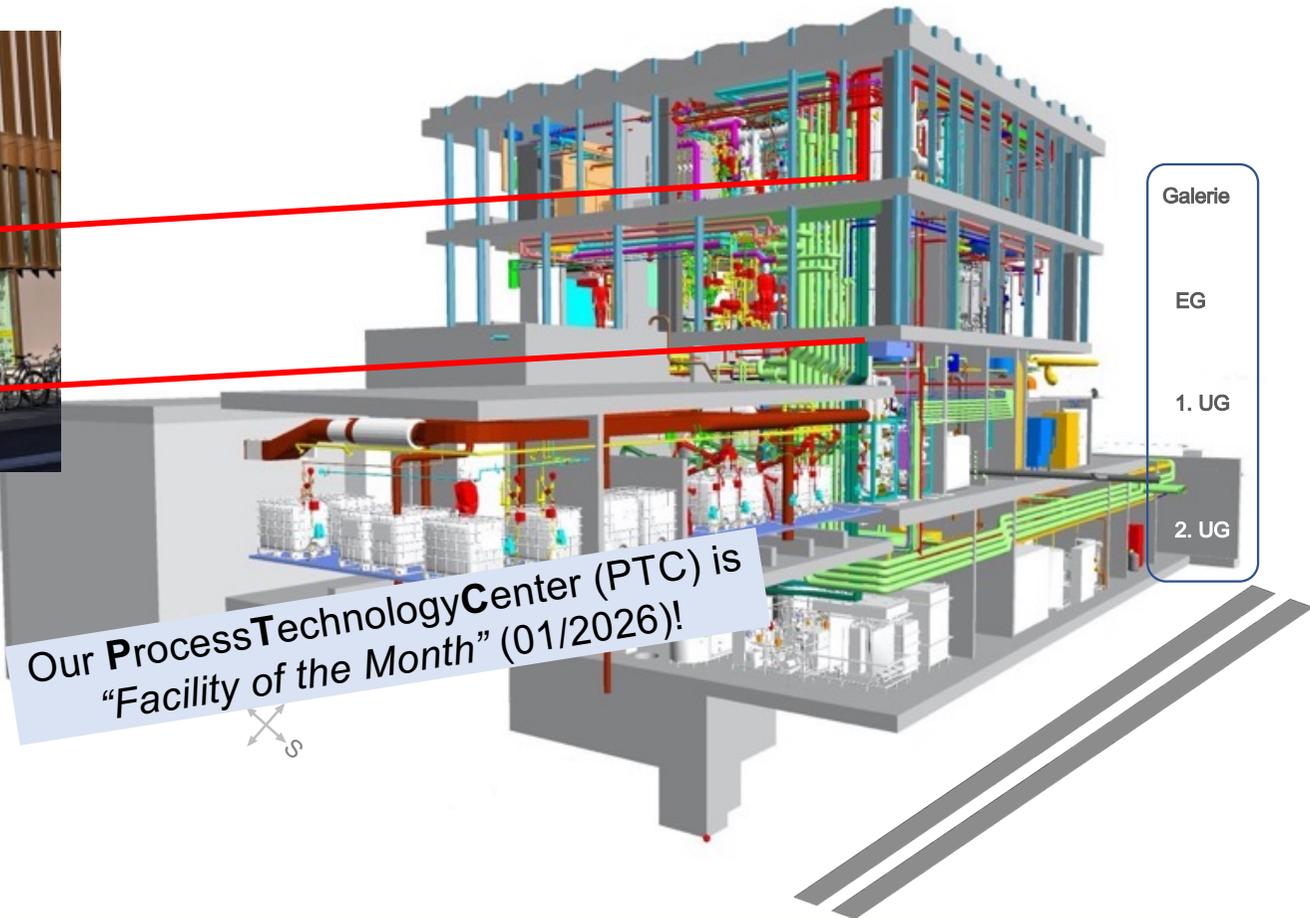
Explore Further

<https://cumeri.eu>



This project has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No. 101091812. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Health and Digital Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Process Technology Center



Our **ProcessTechnologyCenter** (PTC) is
"Facility of the Month" (01/2026)!

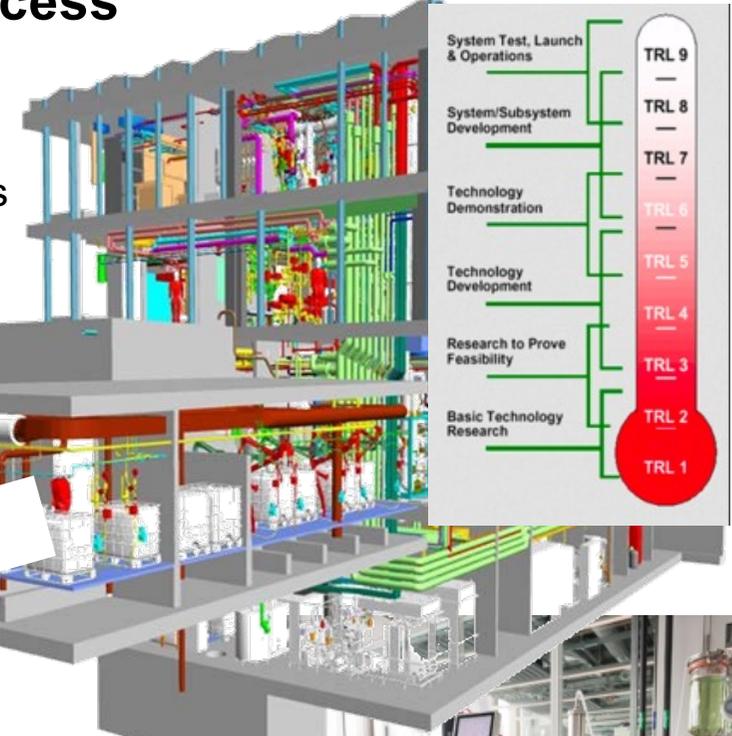


Hands-on education and process development @ our Process Technology Center (PTC)

1100 m² @ 16 rooms, 4 floors



„from Milligram to Kilogram“



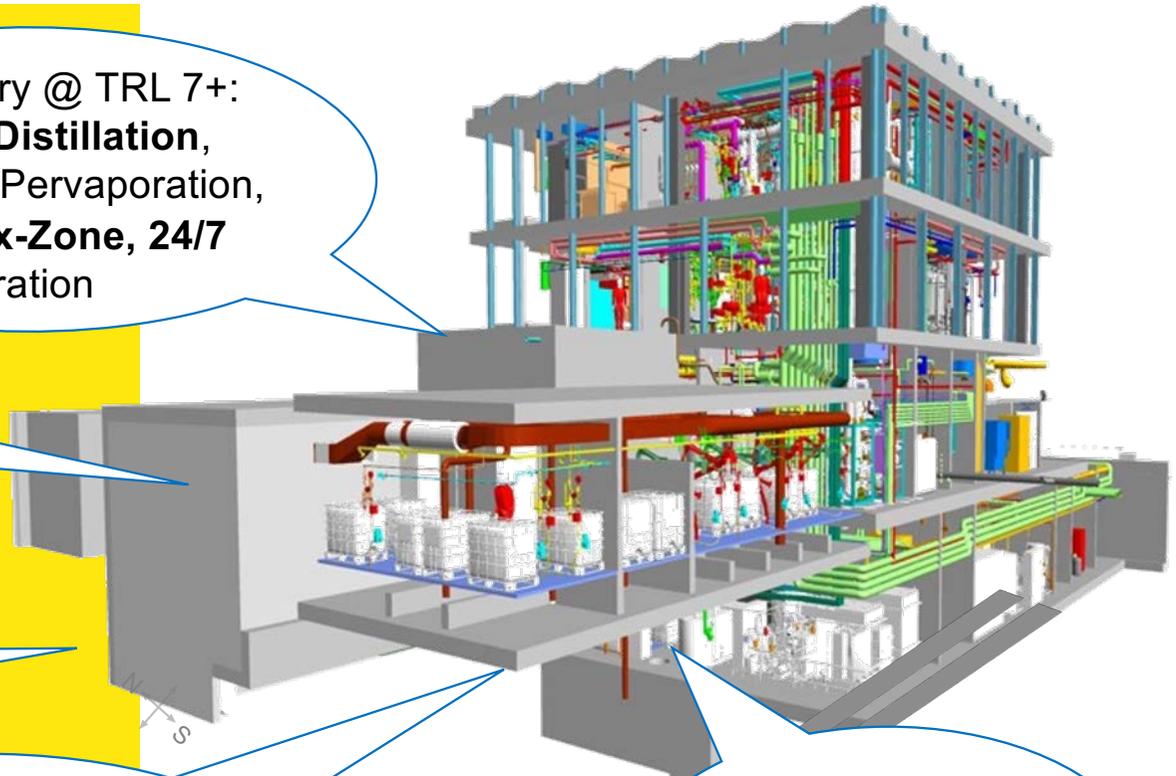
Reaction Technology (**100 l**),
Scale-up and scale-down
reactors, **flow chemistry**
Reaction safety (Ex-Zone)

(Bio-)Refinery @ TRL 7+:
Reaction, **Distillation**,
Rectification, Pervaporation,
Drying in **Ex-Zone, 24/7**
operation

Natural Products / **Green
Chemistry Lab** incl. 100 l
Microalgae reactor, Solid-
liquid extraction, Drying and
final fill

**Fully equipped Down-
Stream** from liquid to **solid
products (10 kg)** for Biotech,
Green Chemistry and Natural
Products

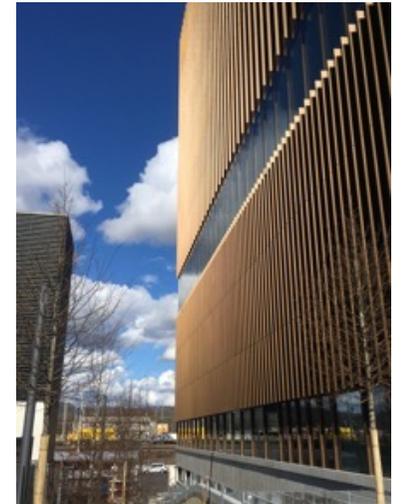
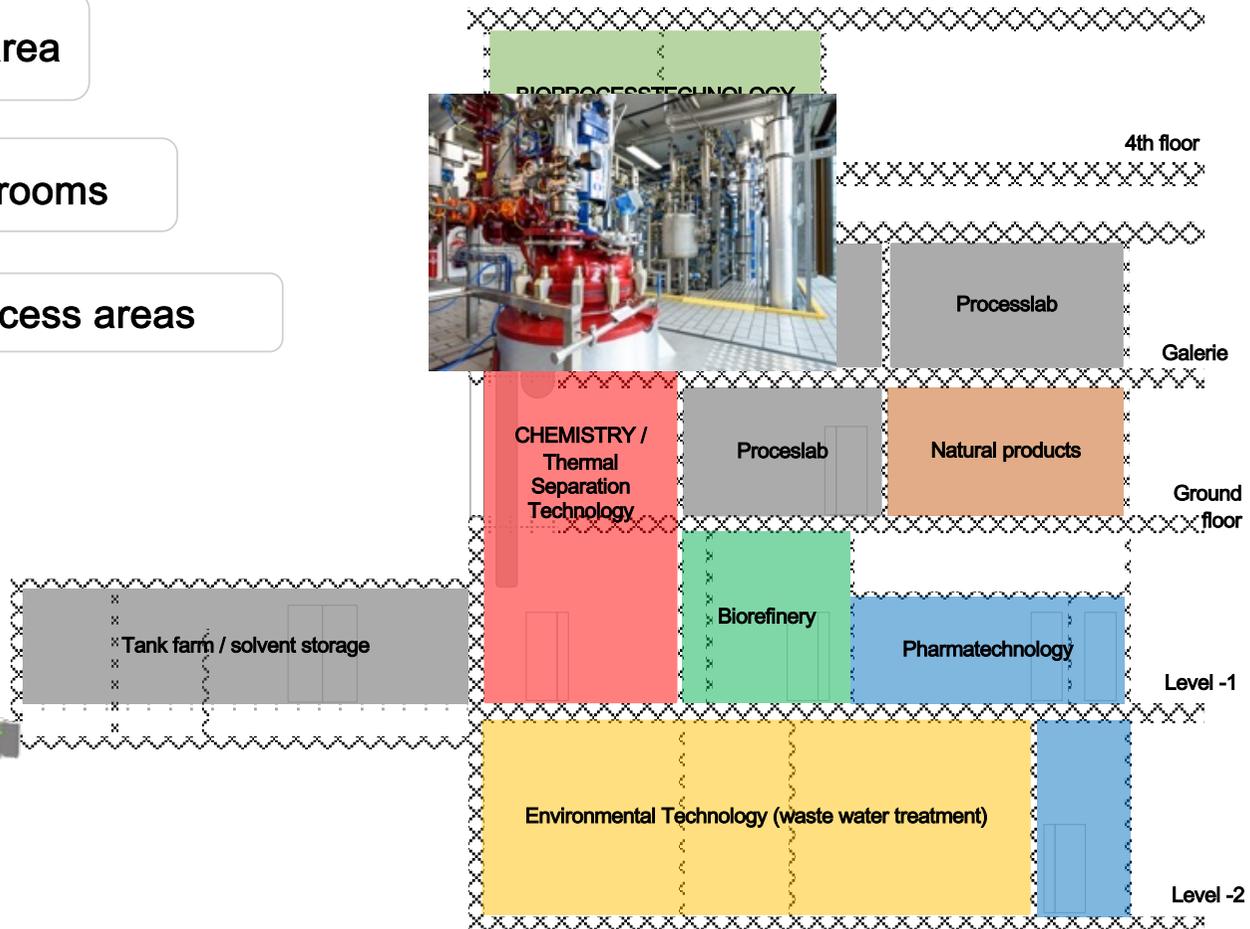
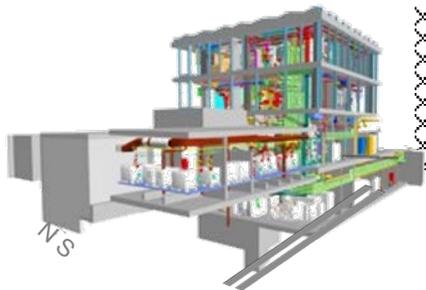
extensive Inline-
measurement and
Process control
(Siemens PCS neo)



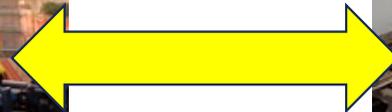
1'100 m² process area

16 process rooms

6 process areas



How to explain scale-up best?



...coming soon to the "Miniatur Wunderland" in Hamburg! (world largest indoor model train world)

Impressions from Students education



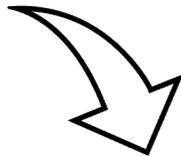
How we do projects

- **Direct financed aR&D- or third party financed projects**
(Innosuisse, Horizon Europe/CBE JU, Foundations, starting from >1 kCH 1000 kCHF)
- **Services / contract research**
- Supported by or via Bachelor-, Master-, ph.D. thesis (ph.D. in cooperation with Universities)
- (only) during internship time (2x per year for 2 weeks), reduced priority for projects
- Start of projects normally very soon after signing a contract (aimed for 1-2 weeks)
- Governance: Not all kind of projects are accepted

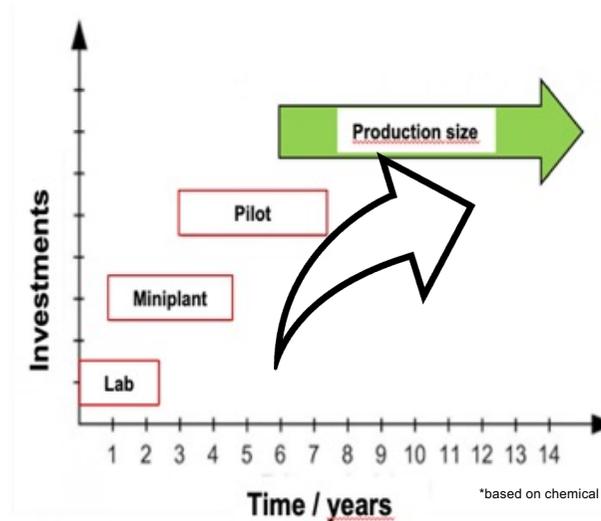
- **Clear and transparent IP approach: What you bring in, belongs to you, what we developed together is shared IP (exploration via agreement/licences)**



0.1 l lab scale



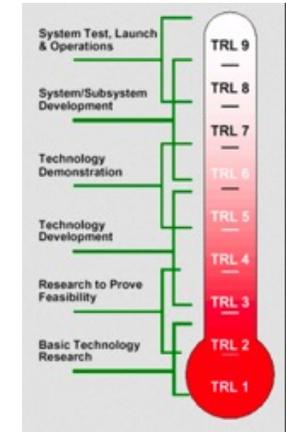
100 l pilot/production scale



*based on chemical process development

member of
swissuniversities

TRL =
„technology
readiness
level“



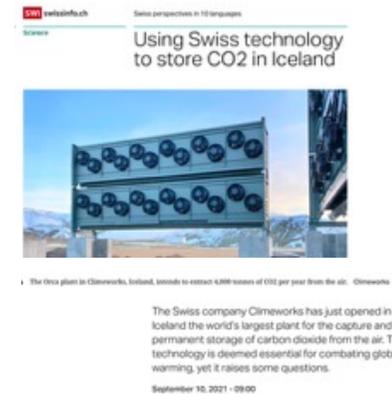
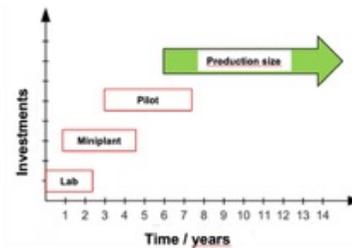
Are we courageous enough
to skip steps?

Process transfer & scale-up

- The current challenges require fast action! (e.g. „climate neutrality before 2050“)
- Many (disruptive) processes are described in literature, however only a view are now in operation (or at least in „pilot phase“)

From business point of view (only):

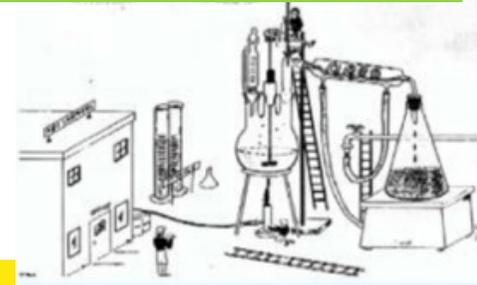
Disruptive/innovative ideas (processes) needs to be „transferred“ into (large-scale) production in very short time („time-to-market“!)



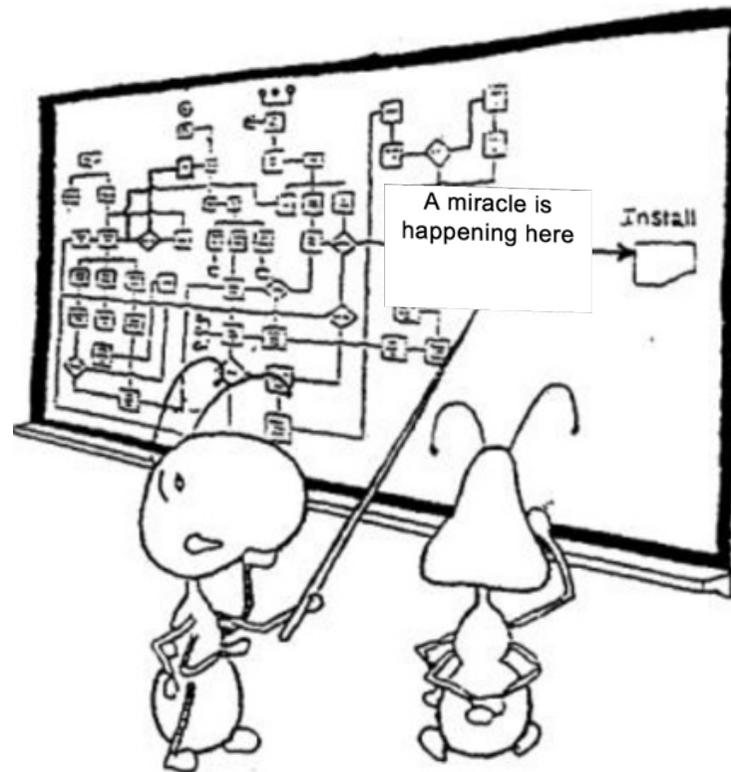
*based on chemical process development

„Process understanding“ is the key for successful implementation!

However: From Research to production (scale) there are a lot of Pitfalls!
(is there really a “technology readiness“?/ Do we have a robust process idea?)



Challenges and pitfalls at scale-up: Focus on the “right” things...



versus

*(Bio-)Process
Development -
and Scale-up
Challenges*



Engineering
Skills
(GEP)

Even if this warlike image is perhaps not ideal in these times, it does impressively demonstrate how important it is to involve engineering early on in projects. If you nevertheless take offence at this example, **we apologise**.

The outside-view on engineers....



Common understanding
of an engineer...

Engineers are Scientists, too!

They might not be experts in Biotech,
Chemistry or Pharmaceuticals, but:

Engineers look for the levers that can improve
the process best – and then offer a technical
solution that can be used to apply these levers
in a reliable manner

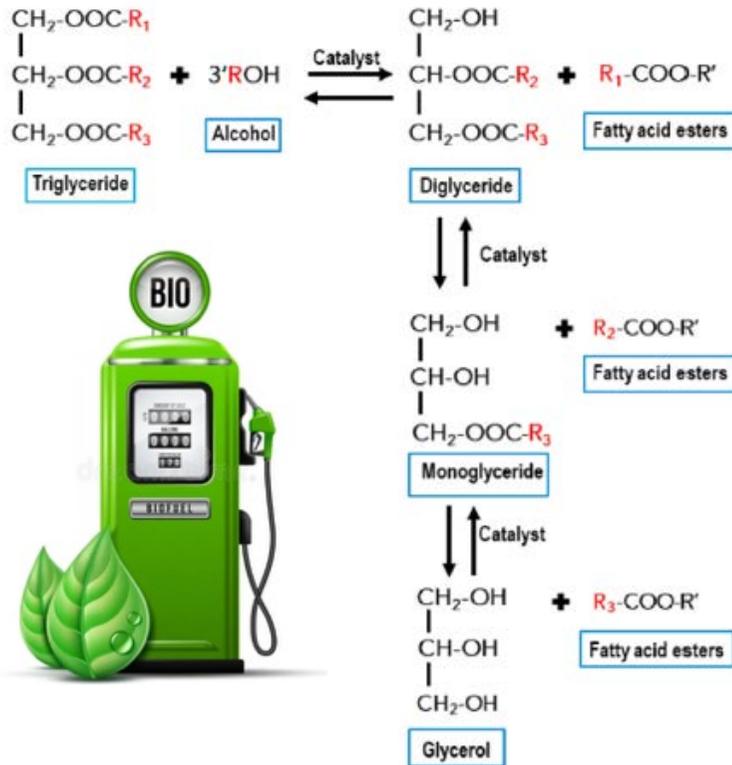
The key to successful process development /
improvement and scale-up is:



Process understanding!
What does the process
really need?

Biodiesel – a renewable fuel and potential starting material for sustainable aviation fuel

Stoichiometry tells you:



However, Chemists apply the following ratio

Molar ratio oil / alcohol	Yield / %
1:40	94.5 ³⁾
1:40	0.6 ⁴⁾
1:40	94.1
1:20	87.7
1:10	89.7

Here`s why:



➤ If you improve mixing, you`ll improve performance!

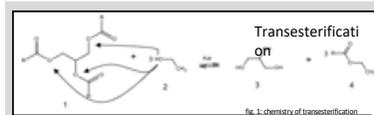
Reduction of excess alcohol during transesterification of various native oil sources

Prof. Dr.-Ing. W. Riedl; Dipl.-Ing. (FH) D. Mollet; F. Ippolito, BSc
School of Life Sciences, Institute for Chemistry and Bioanalytics
Gründenstrasse 40, CH-4132 Muttenz www.fhnw.ch/lifesciences

Abstract

The generation of fuels out of regenerative sources is one of the key technologies to overcome climate change and limited resources of crude oil. Such biofuels however have to fulfill the same strict quality standards as are valid for conventional fuels in order to guarantee a full compatibility with the state-of-the-art fuel engines. To achieve such qualities, a common (chemical) process technology as transesterification can be applied. Due to the very poor miscibility of the native oils with the reactants, excess alcohol is required.

This poster shows how the use of micro mixing and –reaction technology leads to a better mixing of both the native oil and the alcohol and thus a considerable reduction of the excess alcohol (-80%) with comparable yield and quality.



During the transesterification of native oils (1) (e.g. rapeseed or algae oil), glycerol esters will be split into crude glycerol (3) and fatty acid esters (4) which can be used as biofuels. Various catalysts and reaction conditions are described for the transesterification [1]. Most of the natural oils are immiscible with lower alcohols (e.g. methanol / ethanol). Thus, excess alcohol is required for starting a reaction between oil and the reactants (up to 15 times molar excess alcohol for 1 mol of



Micromixing and –reaction technology

Micromixing technology can be used for extensive mixing and reaction purposes in μ -liter scale. Due to the very small equipment dimensions only a small amount of product will be generated. Thus, even very exothermal processes can be tested. In addition, macroscopic effects (turbulence etc.) can be avoided allowing to study intensively the microscopic mass- and heat transfer effects.

used micromixers and –reactors:

T-mixer, LTF-mixer, ICIQ mixer, Ehrfeld-mixer, micro stirrer



fig. 3: test set-up for transesterification of several native oils using microreactors

test set-up:
Using syringe or gearpumps different native oils will be contacted with different alcohols by using microreactors followed by a reaction tube (up to 25 m length). At the end of the pipe, samples were taken to determine both quality and yield.

Conclusions / Outlook

It could be shown that the use of microreactors for the transesterification of native oils help to overcome the problem of the poor miscibility of both the native oil and the reactant alcohols. Thus, the excess alcohol used in conventional transesterification for a better miscibility can be reduced in a considerable amount (up to -80%). With a running actual project the scale-up ability of the microreaction process as well as alternative mixing and reaction technologies for pilot scale will be investigated.

Results and discussion

applied parameters¹⁾:

alcohols	Methanol, Ethanol
catalysts	H ₂ SO ₄ , TBD ²⁾ , KOH
flow rate ratio oil/alcohol	0.5...6
Molare ratio oil/alcohol	1/3...1/140

1) based on rapeseed oil 60°C reaction temperature, 60 minutes residence time
2) TBD: 1,3,7-triazabicyclo[4.4.0]dec-5-ene

- different types of microreactors were tested
- high throughput does not necessarily lead to better mixing / higher yield (depending of typ of microreactor)
- Mixtures are stable for 5-7 minutes, afterwards, repeated mixing is required to maintain good mixtures
- Mixtures can be formed with considerable reduced molare ratios

Molar ratio oil / alcohol	Yield / %
1:40	94.5 ³⁾
1:40	0.6 ⁴⁾
1:20	94.1
1:20	87.7
1:10	89.7

tab.1: Comparison of biodiesel yield at different molar ratios (TBD 1mol%, Methanol, temperature 65°C, Ehrfeldmixer)

3) from literature [1], confirmed by own trials / with methanol

4) with ethanol

Results:

Compared to results described in literature the continuous micromixing and –reaction leads to comparable yield but requires considerable lower oil/alcohol ratios of about 1:10 (lit.:1:40). Poor yield with „green“ ethanol, described in literature, were found in microreaction tests, too [3]. Unfortunately a expected further reduction of reaction time for the continuous microreaction compared to conventional lab scale reaction could not be found unfortunately.



Oil/Alcohol don't mix!



Excess Alcohol is required or: different way of mixing!

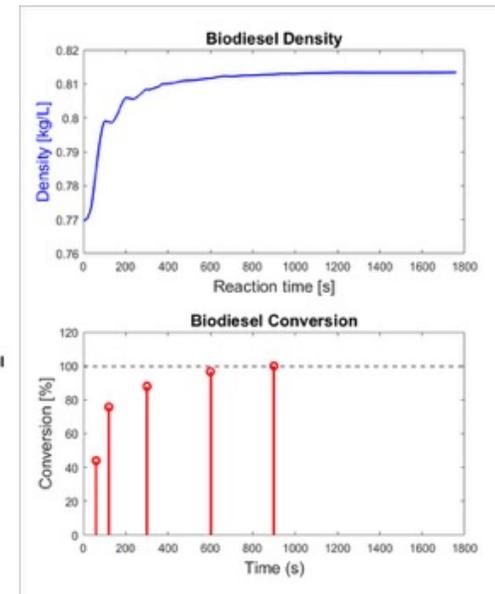
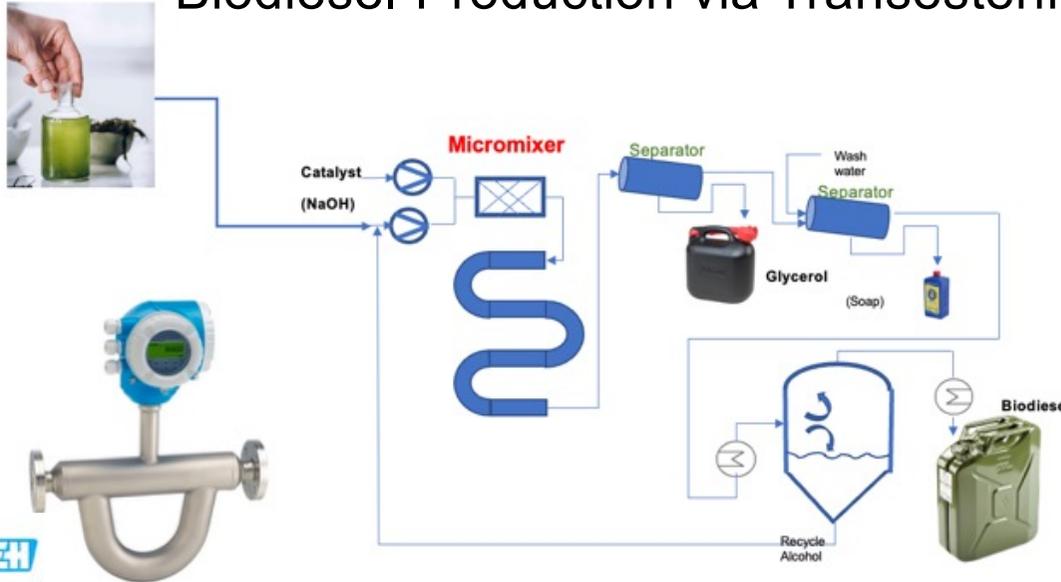
- Use of “Micromixers” (=Microreactors) help to intensify mixing and thus reduce the excess alcohol
- Same yield with 1:10 oil:alcohol ratio (Micromixer) instead of 1:40 (conventional mixing)
- **By focusing on the key challenges, (disruptive) process optimization takes place!**
- Scale-up in this case is a different story...

[1] A. Demirbas: Progress and recent trends in biodiesel fuels, Energy Conversion and Management 50, 2009

[2] U. Schuchardt: Transesterification of vegetable oils: a review, J Brazil Chem Soc, 1998

[3] D. Henke, J. Hagen: Katalysator-screening bei der Umesterung von Fetten und Ölen mit Ethanol, Chemie Ingenieur Technik, 81 (9), 2009

Biodiesel-Production via Transesterification in Microreactor



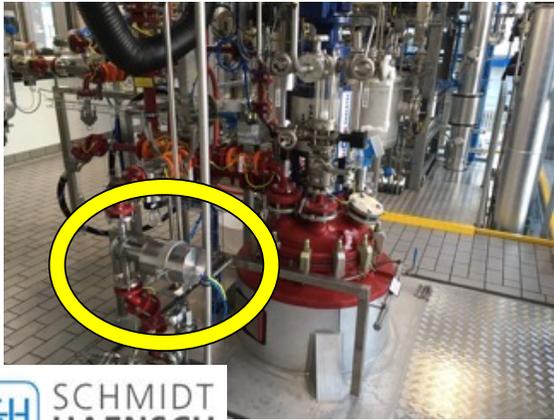
- In-Process Control and Product Quality Measurement via **Density** (Coriolis-Flow-Meter)
- Reduction of reaction time **from 60 min (batch) to 5-15 min (cont.)**

Endress+Hauser **EH**

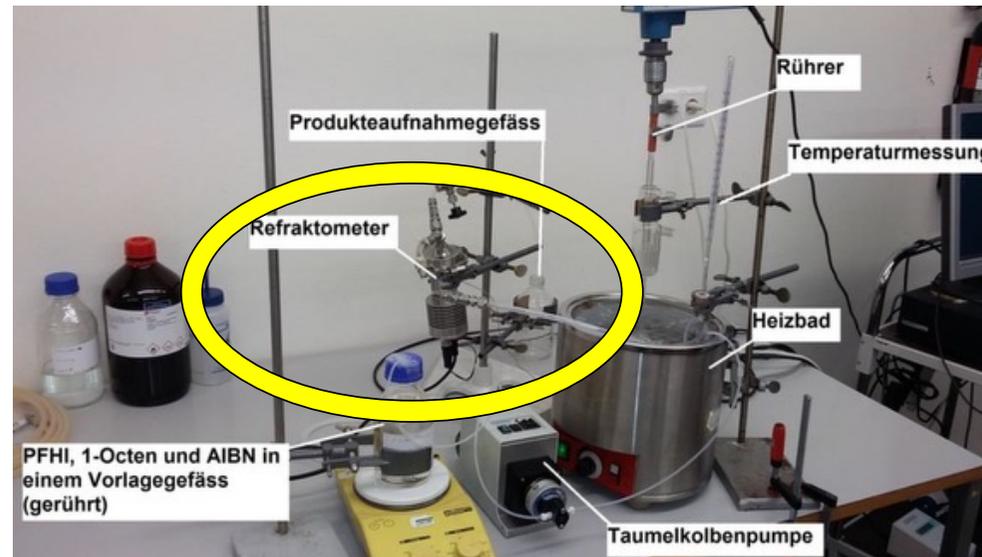
 Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie

Forschungsstelle	BFE
Projektnummer	St502131
Projektziel	Dezentrale Herstellung von grünem Treibstoff aus Überschussalgenöl
Grunddaten	
Projektstatus	Abgeschlossen
Startdatum	02.11.2020
Enddatum	30.09.2023
Gesamtkosten bewilligt	141'300.00 CHF
Bereich	Bioenergie
Forschungsart	Angewandte Forschung und Entwicklung
NARS-Klassifikation	Erzeugung, Verteilung und rationelle Nutzung der Energie

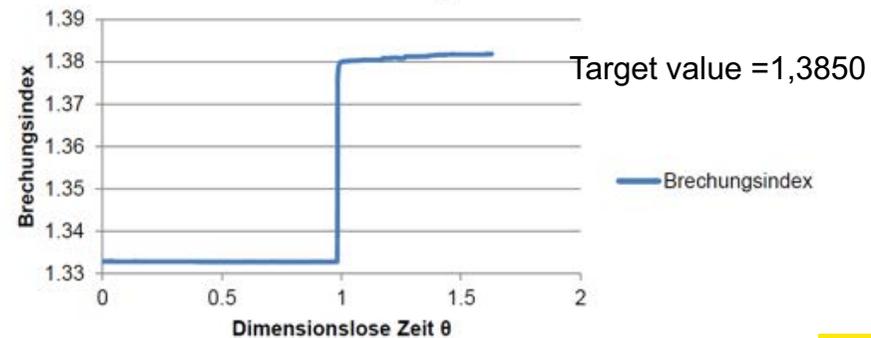


Another way of Inprocess-Control: Refractometric Index



From batch to conti:

- ✓ Adjustable tube length (residence time!)
- ✓ Adjustable flux
- ✓ Adjustable Temperature
- ✓ Measure the refractometric index at the end of the reaction!



Scale-up of Mixing / Homogenisation (following Penny's rationals):

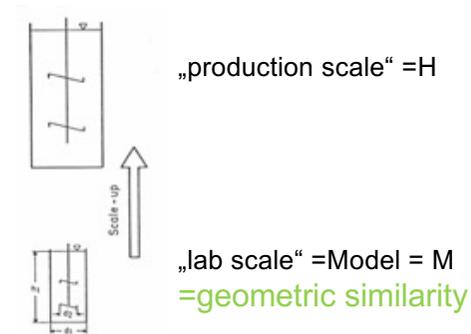
Assuming, that....



...Educts remain the same...



...Degree of mixing remains the same



=geometric similarity

for $(P/V)=\text{const.}$, then:

$$\frac{t_H}{t_M} = \left[\frac{d_{1,H}}{d_{1,M}} \right]^{2/3} = \left[\frac{V_H}{V_M} \right]^{2/9}$$

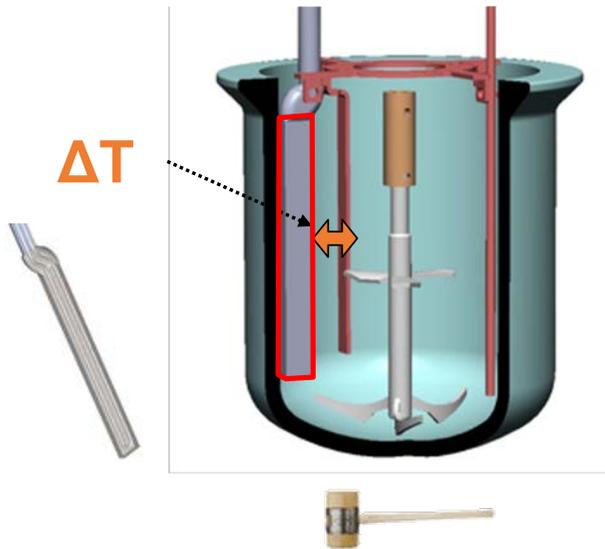
for $t_{\text{mix}} = \text{const.}$, then:

$$\frac{P_{\text{sp,H}}}{P_{\text{sp,M}}} = \left[\frac{(P/V)_H}{(P/V)_M} \right] = \left[\frac{d_{1,H}}{d_{1,M}} \right]^2 = \left[\frac{V_H}{V_M} \right]^{2/3}$$

- A typical approach to calculate the expected time in scaling-up of processes and/or required power intake

New approach for the scale-up of the heat transfer

Scale-Down-Reactor: **1 l**
Heat exchange via H/C-Finger



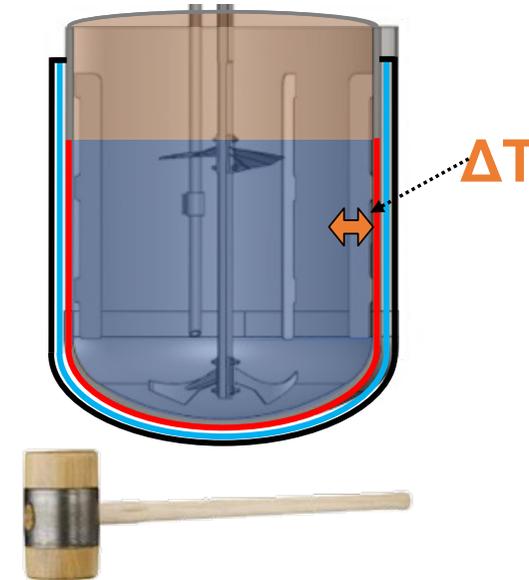
$$\frac{\text{Heat transfer area}}{\text{Volume}} : 2.8 \text{ m}^2/\text{m}^3$$

ΔT : 12 K

Direct Scale-Up



Production: **4'000 l**
heat exchange via jacket



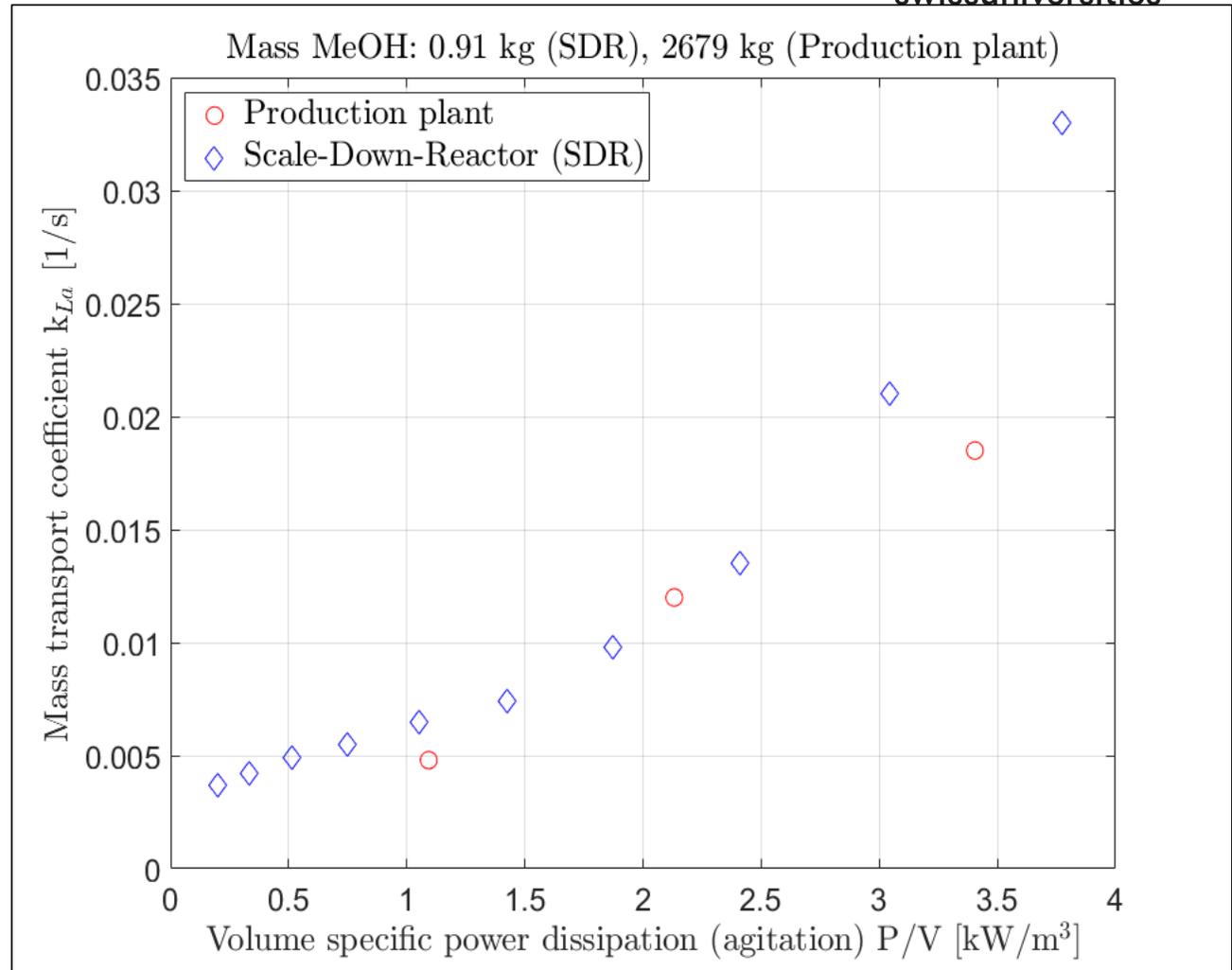
$$2.8 \text{ m}^2/\text{m}^3$$

12 K

- Reduce “over-performance” in lab-scale equipment for better fit to large scale equipment

Scale-down experiments

Mass transport



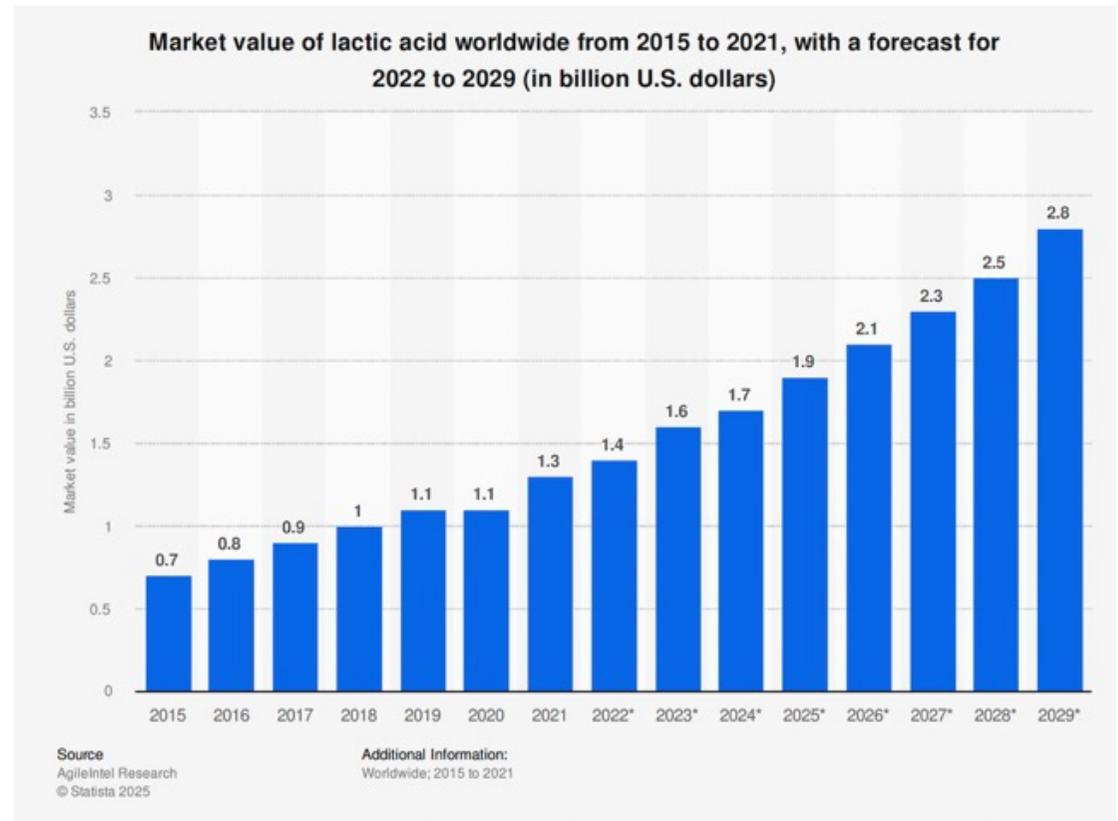
Scale-up in Green Chemistry and Biotechnology – (P)LA as example

Polylactic acid (PLA) is a **biodegradable**, thermoplastic polyester **derived from renewable resources** like corn starch or sugarcane. It is widely used in 3D printing, packaging, and medical applications due to its eco-friendly, biocompatible, and non-toxic properties.

Fun fact:



White beer provided in PLA plastic cups show a nice foam stability - from non-PLA plastic cups not!



LA production by fermentation

A variety of carboxylic acids are produced by fermentation ^[1]

Challenges:

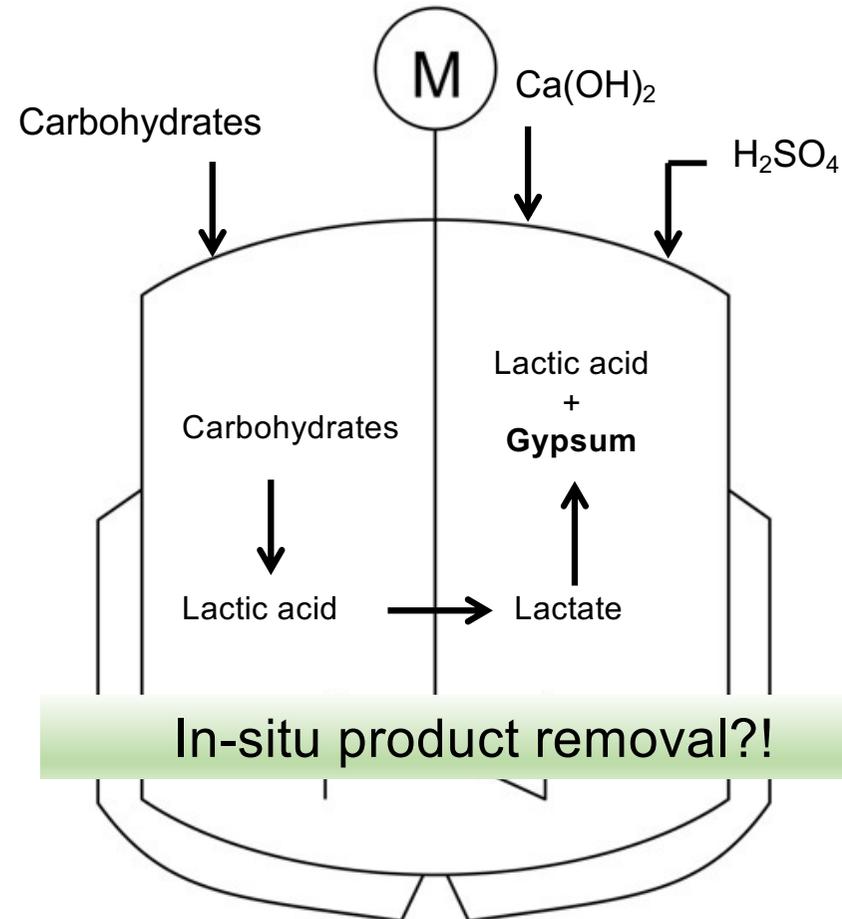
- Product inhibition by pH decrease

To avoid this: addition of chemicals:

Ca(OH)_2 - Lactate precipitates

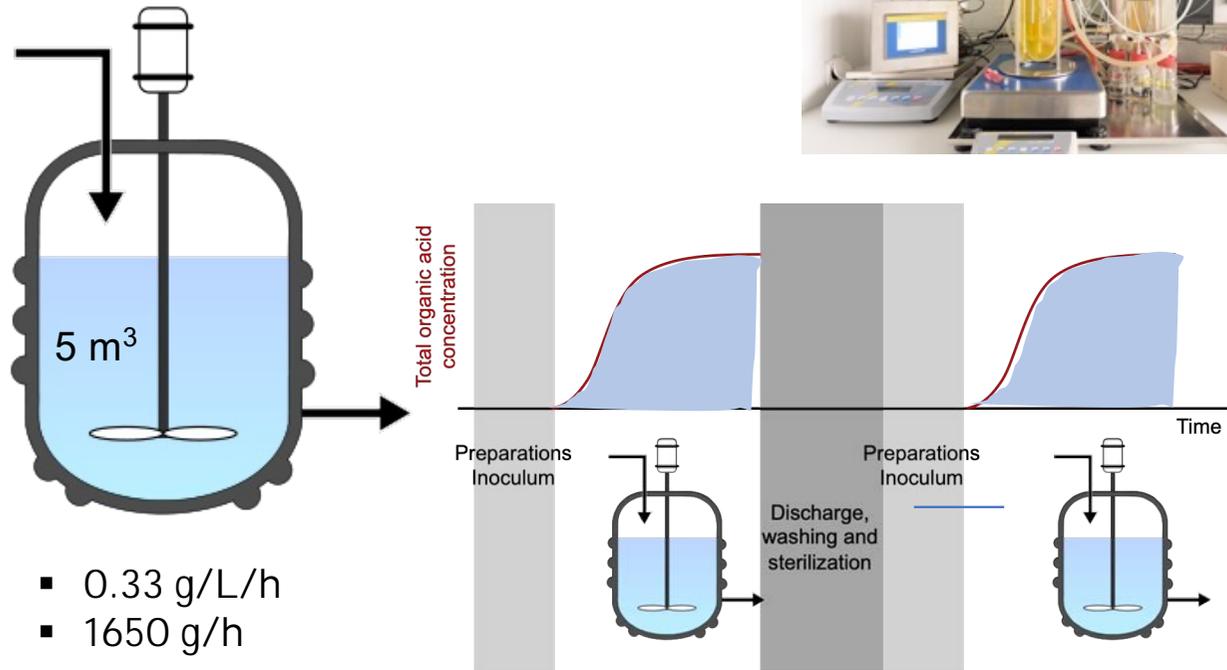
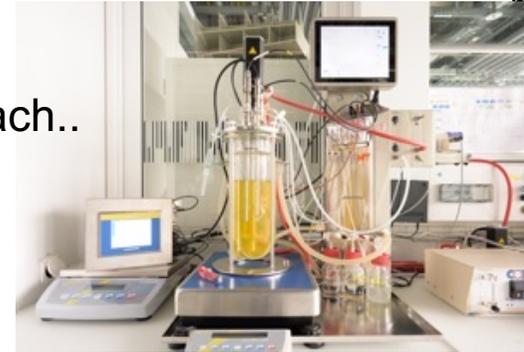
H_2SO_4 - sets lactic acid free

- Stoichiometric gypsum production!



[1] H.-J. Endres, A. Siebert-Raths, Technische Biopolymere, Hanser-Verlag, München 2009, 103

The beginning: A typical batch approach..

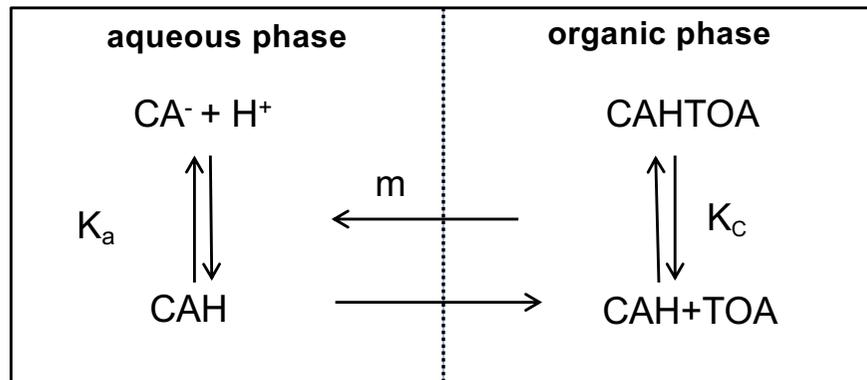


...with a clear and reproducible protocol – and “batch release” through (final) control (or inline with e.g. Raman...)

Direct capturing of LA from fermentation broth:

Techniques such as reactive distillation, stripping, adsorption and membrane-processes have been investigated to avoid continuous broth neutralization

➔ **Reactive liquid-liquid extraction** has shown to be an interesting technology for (carboxylic) acid capturing



CA = deprotonated carboxylic acid

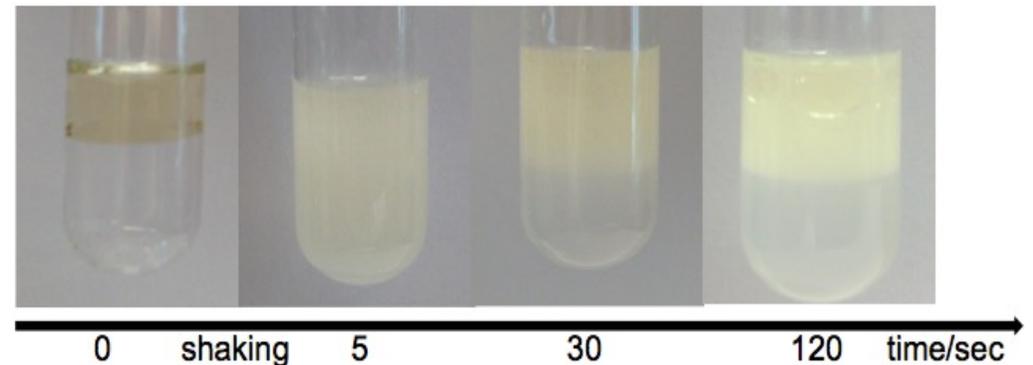
CAH = carboxylic acid

TOA** = tri-n-octylamine

m = distribution coefficient = $\frac{C_{LA,org}^*}{C_{LA,aq}^*}$

however....

**Systems form
stable Emulsions!**

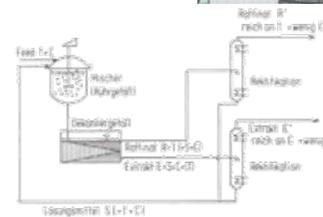


- Normally, this is the end of any further investigation in Liquid-Liquid Extraction!

(since to “brake” stable emulsions, additional technologies and/or long(er) times are required for e.g. large settler devices, centrifuges, salt/chemicals and/or temperature (cooling))

- No further process development nor scale-up activities!

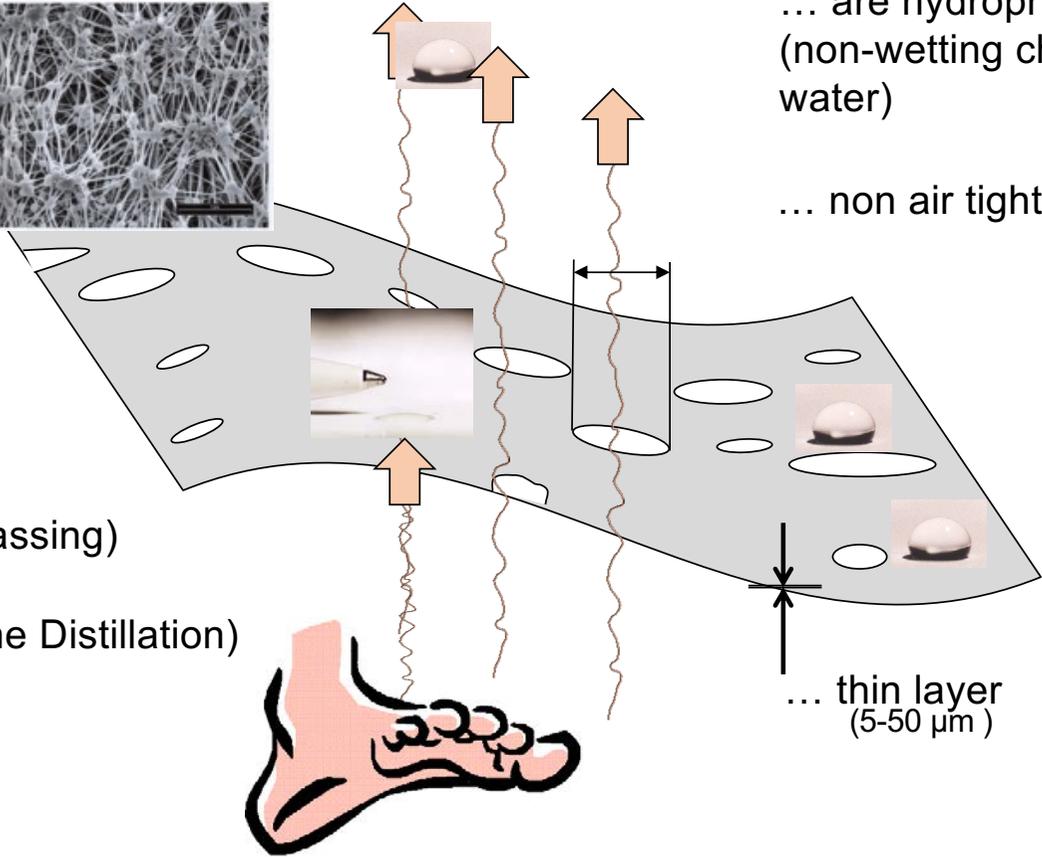
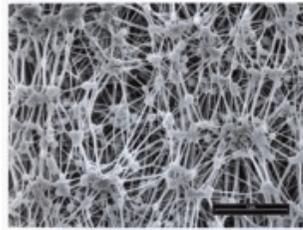
...although there is an effective separation technology available!



- **We (engineers) do have the simple and effective technology to continue!**



Microporous membranes for fluid-fluid contact

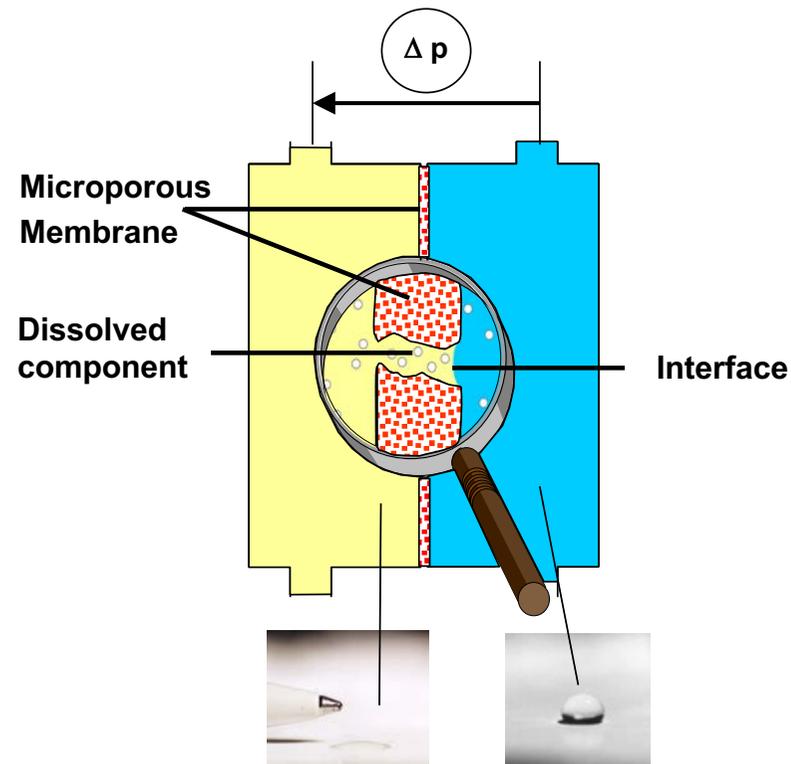


... are hydrophobic
(non-wetting characteristics for water)

... non air tight (breathability)

- Suited for:
- gas/liquid (Aeration / Degassing)
 - liquid/liquid (Extraction)
 - liquid/gas/liquid (Membrane Distillation)

Membrane assisted fluid-fluid contact: Liquid-liquid Extraction



Advantages:

- no phase dispersion required
- no density difference required
- Phase ration can be chosen in a broad range ($\gg 1:100$)
- **no emulsion formation**
- Operation irrespective of position
- Compact & modular design

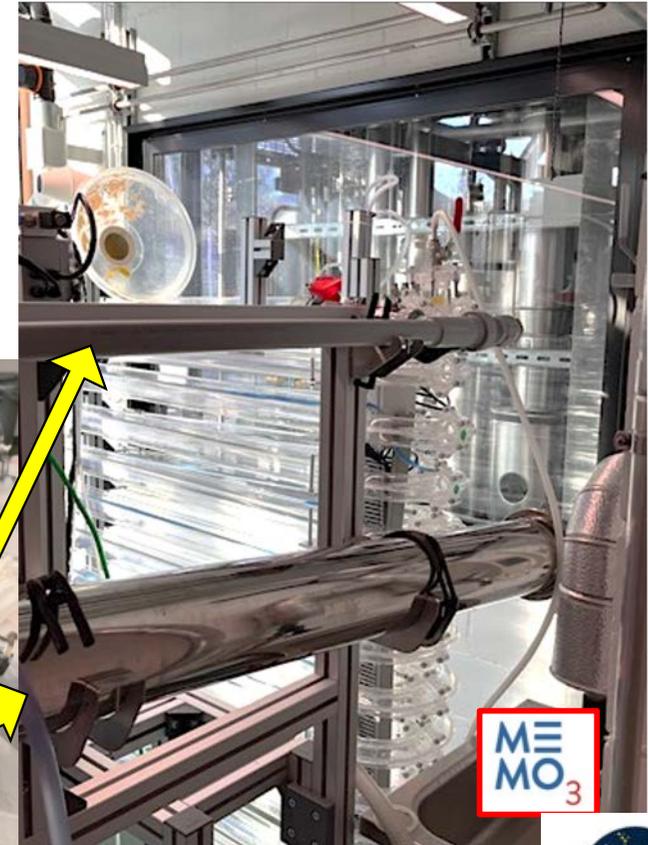
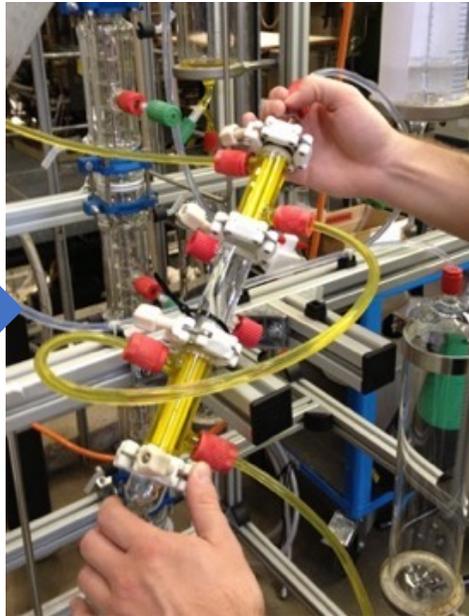
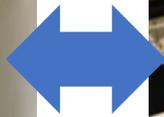
Disadvantages:

- Additional mass transfer resistance
- ~~Limitations caused by membrane design and stability~~ **no longer!!**

From the Keynote at "ISEC" – international Solvent Extraction Conference / October 2025 / Melbourne



Membrane assisted fluid-fluid contact: Liquid-liquid Extraction



From the Keynote at "ISEC" – international Solvent
Extraction Conference / October 2025 / Melbourne

Membrane-Supported Liquid-Liquid Extraction – Where Do We Stand Today?

Wolfgang Riedl^{1)*}

Abstract

Thanks to advances in materials science and manufacturing technology, membranes are now available for stable liquid-liquid extraction processes. Rigorous calculation models can be used to calculate the membrane areas required for a specific separation

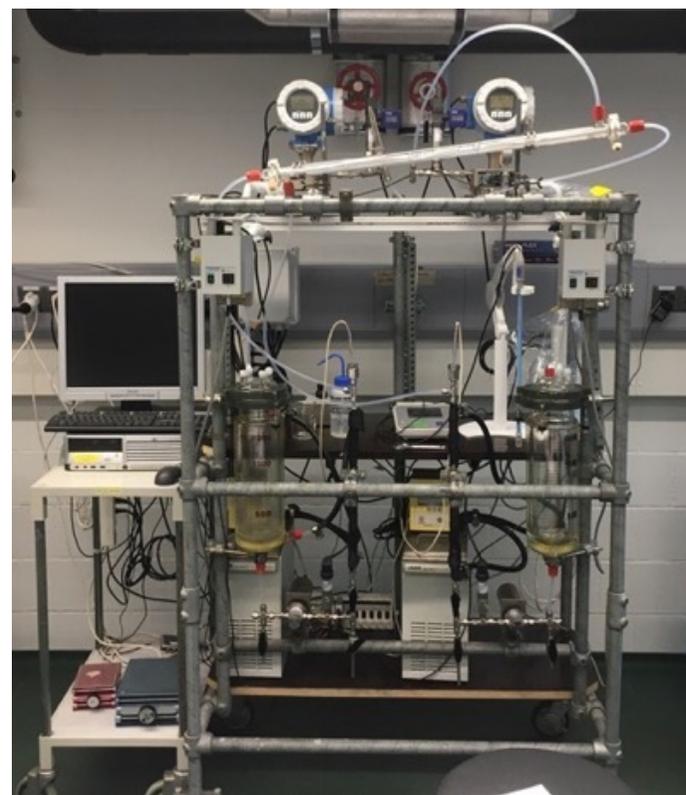
task as well as to optimize the module design. Rapid tests can determine the basic suitability and kinetic parameters. Thus, the general requirements for exploiting the specific advantages of this separation technology in technical applications are fulfilled.

Keywords: Mass transfer model, Membrane-assisted liquid-liquid extraction, Membrane contactors

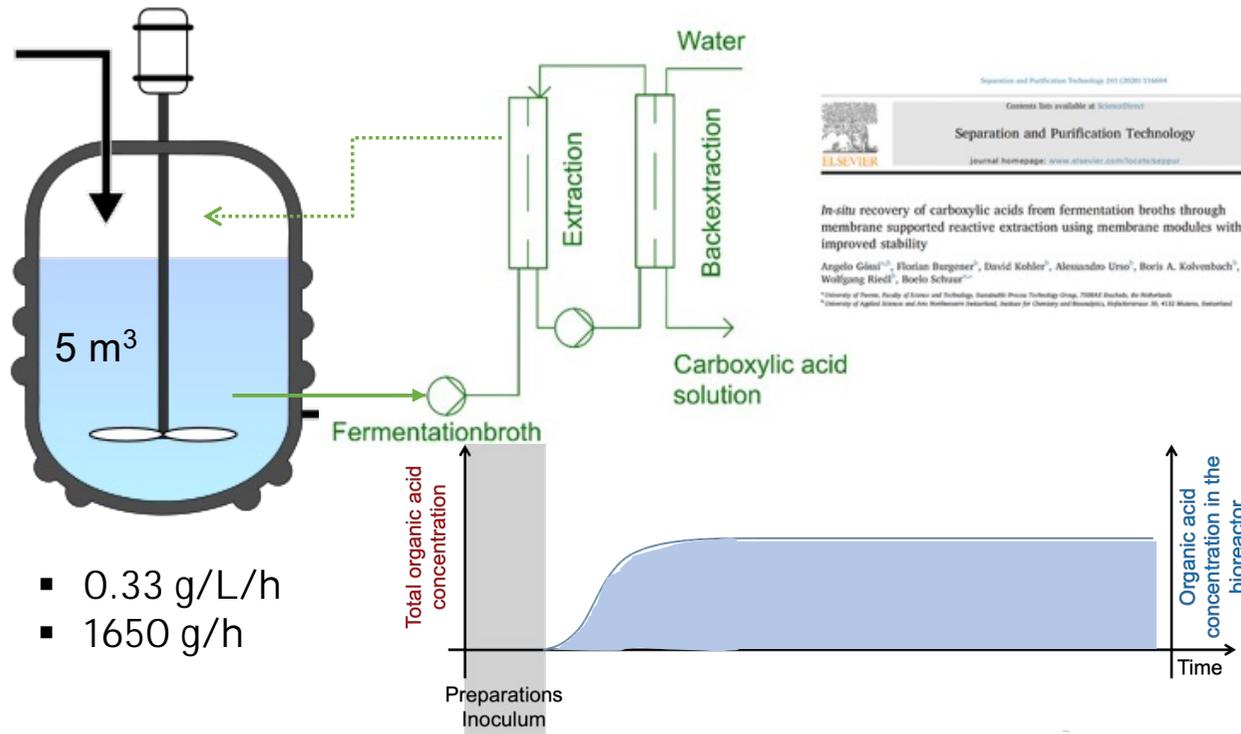
Received: October 25, 2020; **accepted:** January 13, 2021

DOI: 10.1002/cben.202000032

 This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.



From Batch to Conti: Adoption of the Measurement required?



- 0.33 g/L/h
- 1650 g/h

Separation and Purification Technology 2015, 27(10): 1148-1154
Contents lists available at ScienceDirect
Separation and Purification Technology
journal homepage: www.elsevier.com/locate/sepp
ELSEVIER

In-situ recovery of carboxylic acids from fermentation broths through membrane supported reactive extraction using membrane modules with improved stability

Argelo-Galés^{1,2}, Florian Bergner³, David Kohler³, Alessandro Ursi³, Boris A. Kolvenbach³, Wolfgang Riedl³, Beolo Schwarz^{1,2*}

¹University of Twente, Faculty of Science and Technology, Enschede Process Technology Group, 7500AE Enschede, the Netherlands
²University of Applied Sciences and Arts Northwestern Switzerland, Institute for Chemistry and Biotechnology, Hofackerstrasse 30, 4102 Biel, Switzerland
³University of Applied Sciences and Arts Northwestern Switzerland, Institute for Chemistry and Biotechnology, Hofackerstrasse 30, 4102 Biel, Switzerland

In-situ extraction of carboxylic acids out of fermentations broths using membrane contactors: A more sustainable pathway to platform chemicals

Motivation

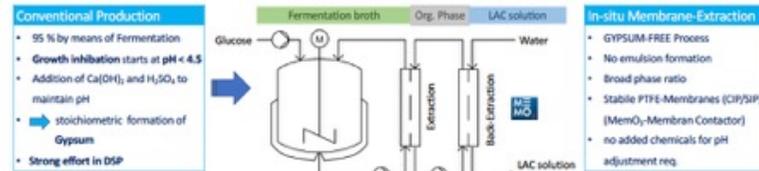


Fig. 3: Process Flow Diagram for membrane assisted direct LAC-Extraction and Back-Extraction

Membrane assisted direct LAC-Extraction

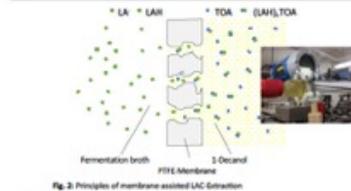


Fig. 2: Principles of membrane assisted LAC-Extraction

Works also with other Carboxylic Acids...

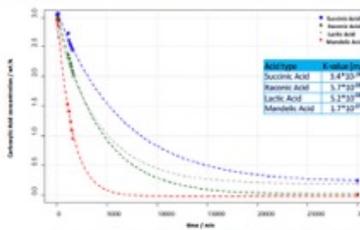


Fig. 2: Membrane-assisted Extraction of different carboxylic acids with 20% TODA in 3-Decead, 0.05 m² membrane area, room temperature, 0.7 l org. and aqueous phase, batch operation, Flow: 10 kg/h, F: near 50 kg/h.

Fermentation

- Lactobacillus plantarum @ 30 °C
- Growth Control via Glucose Dosage

Results

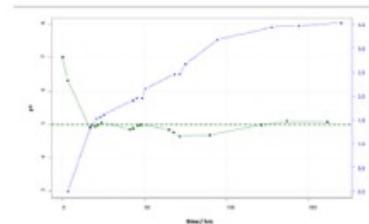


Fig. 4: Results from in-situ Lactic Acid extraction with 20% TODA in 3-Decead from fermentation broth with Lactobacillus plantarum, 0.05 m² membrane area, 30 °C, 0.7 l org. and aqueous Phase, target pH=5

- Continuous production of Lactic acid (no harmful impact on both the membrane and the solvent on the fermentation broth)
- pH-adjustment on constant level only by means of glucose dosage rate
- No added chemicals and no formation of Gypsum required

Conclusion and Outlook

- By using Membrane contactors, a Direct-Extraction of (different) carboxylic acids out of fermentation broth **without** the stoichiometric co-production of Gypsum is possible
- Process allows a continuous production and delivers a pure carboxylic acid solution for further applications (e.g. PLA production)
- Next step: **Piloting of the process in 20l and 100 l scale** in our new ProcessTechnologyCenter (PTC)

Corresponding address: * University of Applied Sciences and Arts Northwestern Switzerland, Institute for Chemicals and Biomaterials, 8400 Winterthur, Switzerland
 * University of Twente, Faculty of Science and Technology, Enschede Process Technology Centre, Enschede, The Netherlands
 Literature: [1] H.-J. Endres, A. Siebert-Bath, Technische Bioprozesse, Hanser Verlag, München, 2008, 310
 [2] D. Saha, Stoffliche Nutzung nachwachsender Rohstoffe: Grundlagen - Werkstoffe - Anwendungen, Springer Fachmedien Wiesbaden, 2011
 [3] A. Krugmann, "Extraction design for fermentative production of bio-based chemicals," Tech. Univ. Dordrecht, 2012
 [4] A. Rappelt, Bioprozessentwicklung und in-situ-Produktgewinnung von trans-Carbohydraten Oxidation, GfH, Zentrallaboratorium Verlag, 2007.
 [5] T. Malsb, Membranverfahren: Grundlagen der Membran- und Anlagenauslegung, 3rd ed. Berlin: Springer-Verlag Berlin, 2008.



➤ **Best Poster Award @ Dechema Fachsektion Extraktion** annual Meeting hold here in Muttenz, Feb. 2019

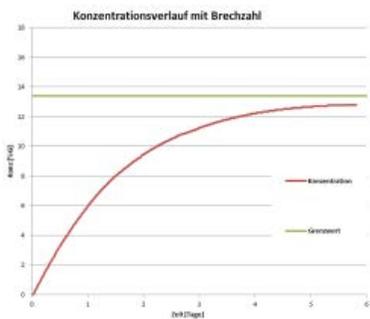
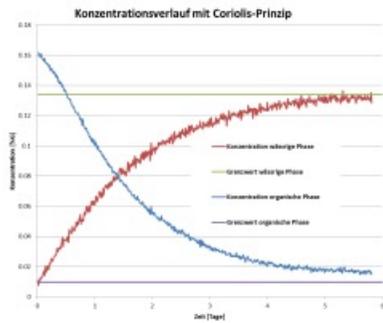
➤ **Also works for:**

- Succinic Acid
- Itaconic Acid
- Mandelic Acid and

- **Acetic Acid / Acetate**

-> THE most interesting feedstock for Fermentations generating high value end products

Scale-up requires in-process control!



Inlinemessung von Dichte und Brechungsindex bei der Flüssig-Flüssig Extraktion

Dipl.-Ing. (FH) D. Mollet; Prof. Dr.-Ing. W. Riedl
Hochschule für Life Sciences FHNW, Institut für Chemie und Bioanalytik
Gründenstrasse 40, CH-4132 Muttenz www.fhnw.ch/lifesciences

Abstract

Die Kombination der membrangestützten Flüssig-Flüssig Extraktion mit einer Inline-Konzentrationsmessung der beiden Phasen erlaubt es, den Stoffübergang laufend und ohne zusätzliche offline-Analytik zu verfolgen. Da Vermischen und Trennen der beiden Flüssigphasen entfällt, kann das Verfahren kontinuierlich und ohne lange Absetzzeiten betrieben werden. Bei diskontinuierlicher Fahrweise wird die Inline-Messung zur Ermittlung der kinetischen Daten [1] und zur Bestimmung des Abbruchzeitpunktes verwendet. Zur Untersuchung dieser Trenntechnik genügt ein einfacher Aufbau, um in kurzer Zeit neben der prinzipiellen Machbarkeit auch die erforderliche Kontaktfläche für einen technischen Prozess einfach bestimmen zu können.

Grundlagen

Bei der membrangestützten Flüssig-Flüssig Extraktion werden zwei Flüssigphasen über eine mikroporöse Membran in Kontakt gebracht. So kann ohne Gefahr der Bildung stabiler Emulsionen bei nahezu beliebigen Phasenverhältnissen und ungünstigen Dichteunterschieden extrahiert werden. Zur Bestimmung der Konzentrationen wird in der Regel eine indirekte Messung eingesetzt, d. h. es wird eine einfache physikalische Grösse gemessen. Die Messergebnisse werden mit einer Kalibrierung in die zugehörige Konzentration umgerechnet und können von geeignet Messgeräten, die diese Funktion enthalten, direkt angezeigt werden.

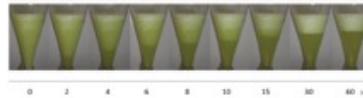


Bild 1: Entmischungsverhalten des Stoffsystems Toluol-Wasser-Caprolactam (angefüllt mit Fluoreszenz)

Versuchsanlage und Messgeräte

Am Institut für Chemie und Bioanalytik steht für die Untersuchung der membrangestützten Flüssig-Flüssig Extraktion eine eigens erstellte Versuchsanlage zur Verfügung, die mit moderner, flexibler Messtechnik ausgestattet ist. Abhängig von den Eigenschaften des zu verarbeitenden Stoffsystems können physikalische Grössen wie die Dichte, die Brechzahl, die elektrische Leitfähigkeit, die Absorption und die Masse zur Bestimmung der Konzentrationen in den beiden Kreisläufen Extraktionsgut/Raffinat und Solvent/Extrakt gemessen und ausgewertet werden.



Bild 2: Schema Versuchsanlage

Bild 3: Messgeräte
ESI Coriolis, Q3 MMSL, Q3 Brechzahl

Verlauf der Messwerte

Für die Versuche wurden eigens hergestellte Membranen aus speziell behandeltem α -Al₂O₃ verwendet. Es wurde der Konzentrationsverlauf von Caprolactam des Stoffsystems Wasser-Caprolactam-Toluol (50g:80g:420g) inline gemessen und aufgezeichnet. Mit der Verteilzahl dieses Stoffsystems von 0.134 bei ca. 25°C und den verwendeten Massen konnten die Grenzwerte einfach bestimmt und in den Messungen bestätigt werden.

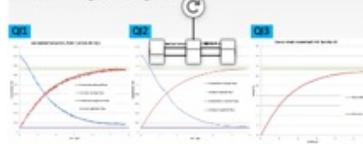


Diagramm 1 bis 3: Typischer Extraktionsverlauf

Auswertung und Ergebnisse

Die ermittelten Gesamtstoffdurchgangskoeffizienten sind abhängig von der Porosität der eingesetzten Membran und liegen im Bereich der in der Literatur beschriebenen Werte (vgl. Tabelle 1). Mit den neuen hochauflösenden Messgeräten werden die Prozessdaten mit guter Genauigkeit wiedergegeben, was Voraussetzung ist um die Stoffdurchgangskoeffizienten ohne zusätzliche Analytik bestimmen zu können.

$$\frac{dW}{dt} \cdot \frac{1}{A} = K \cdot (c_{ab} - VZ \cdot c_{auf})$$

Formel 1: Beschreibung des Stofftransportes

- A = Austauschfläche [m²]
- c = Konzentration [mol/L]
- VZ = Verteilzahl [-]
- K = Gesamtdurchgangskoeffizient [m/s]

Quelle	Gesamtdurchgangskoeffizient K
Messungen	$3.3 \cdot 10^{-4}$ m/s (mit online-Analytik)
Literaturwert	$3.1 \cdot 10^{-4}$ m/s [1] (mit offline Analytik)

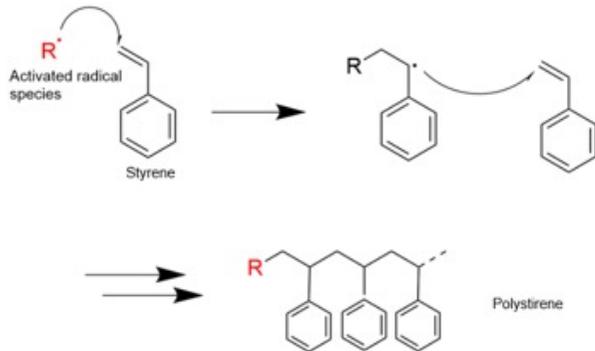
Tabelle 1: Gesamtdurchgangskoeffizienten K

Zusammenfassung

Es konnte gezeigt werden, dass mit dem Einsatz einfacher kommerziell erhältlicher Messgeräte der Konzentrationsverlauf der beiden Phasen bei membrangestützten Flüssig-Flüssig-Extraktionen ohne zusätzliche Analytik inline erfasst werden und der Prozess kontrolliert werden kann. Mit den gleichen Messdaten können die kinetischen Daten des verwendeten Stoffgemisches und der eingesetzten Membranen bestimmt werden.

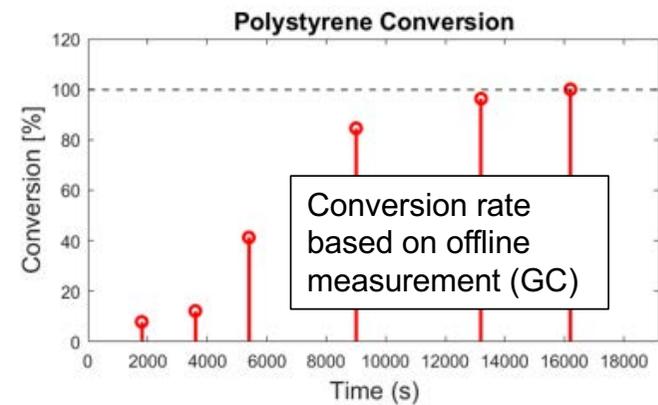
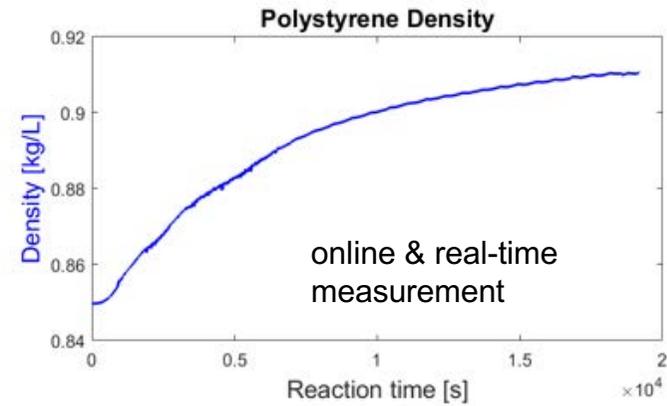
[1] Riedl, W.: Membrangestützte Flüssig-Flüssig Extraktion bei der Caprolactamherstellung. Dissertation, Shaker Verlag, 2002
[2] Huber, Ch., Touffin, M.: New MEMS-based micro-coriolis density measurement technology. ICNMM2011-58030

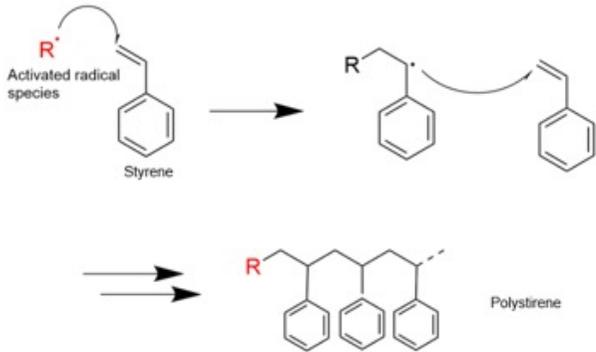
osity Measurement
(+H)



Endress+Hauser

ECCE – Lisbon/ 09/2025





Endress+Hauser **EH**

Density Analysis for Novel In-line Control Systems

P. Ciompi, C. Jablonski, W. Riedl
University of Applied Sciences and Arts Northwestern Switzerland - HLS, Muttenz - CH

Introduction

In-line process control is crucial for the future of chemical and biochemical processes, enabling real-time monitoring, improved product quality, enhanced safety, and optimized efficiency. Traditional process monitoring relies on off-line measurements, which introduce delays and limit the ability to make fast adjustments. In batch reactions, a key challenge is the reliable identification of the actual end of reaction point. This research explores the use of Endress+Hauser Coriolis flow meter sensors, typically used for mass flow measurements, as a novel tool for real-time in-line monitoring of density in a loop reactor. By continuously measuring these parameters, the study aims to provide deeper insights into reaction progression, enhancing process control and optimization.

Methods

Transesterification

Biodiesel from vegetable oils

$$C_{18}H_{34}O_2 + C_3H_7OH \xrightarrow{KOH} C_{15}H_{26}O_2 + C_3H_7CO_2C_{18}H_{33}$$

Triglyceride Ethanol Mixture of fatty acids Glycerol

- Reagents: Sunflower oil, Ethanol
- Catalyst: KOH
- Reaction Temperature: 60°C
- Offline Analytic: Gas Chromatography

Loop reactor setup

E+H Promass-Q Flowmeter

Coriolis flow meter for precise mass, volume, and density measurement, optimized for fluids with entrained gas.

Polymerization

Polyethylene

$$n \text{ Styrene} \rightarrow \text{Polymer}$$

- Reagents: Styrene
- Initiator: (AIBN)
- Reaction Temperature: 80°C
- Solvent: Toluene
- Offline Analytic: Gel Permeation Chromatography

Results

Transesterification

Reaction progress monitored through the density profiles correlated well with conversion values obtained by offline analysis of samples.

This approach allowed optimization of stopping criteria, reducing total reaction time.

Good Reproducibility: similar density profiles across repeated runs for both type of reactions.

Conversion values were validated by GC analysis of the biodiesel samples and GPC analysis of Polyethylene samples.

A moving average filter was applied to smooth the density signal and reduce noise.

Polymerization

Conclusions

- ✓ Optimization of stopping criteria led to reduced overall process time and costs, without compromising product quality.
- ✓ In-line density monitoring reliably tracked reaction progress in good accordance with offline analysis.
- ✓ The method proved to be robust and reproducible across two distinct chemistries: transesterification and polymerization, demonstrating broad applicability.
- ✓ The E+H Promass-Q sensor shows strong potential for process control in routine operations, ensuring efficiency and reliability.
- ✓ The research is expanding in using a Promass-I sensor for viscosity measurements which have higher correlation potential for polymers.

ECI25 | Endress+Hauser | Swiss Innovation Agency

Founded by **Innosuisse**
Swiss Innovation Agency
102.664 IP-ENG

ECCE – Lisbon/ 09/2025

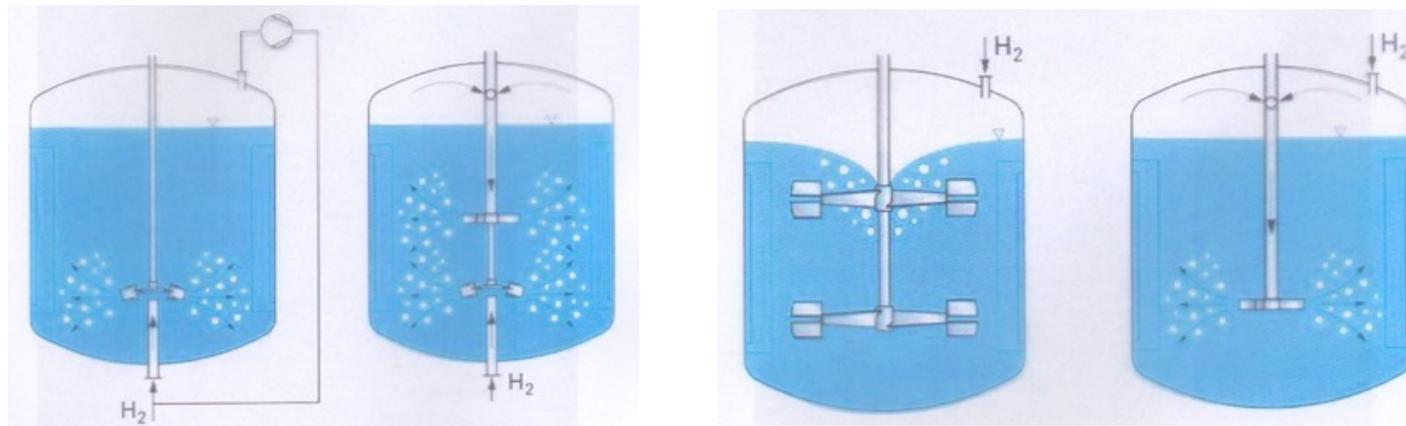
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

latest Plant design



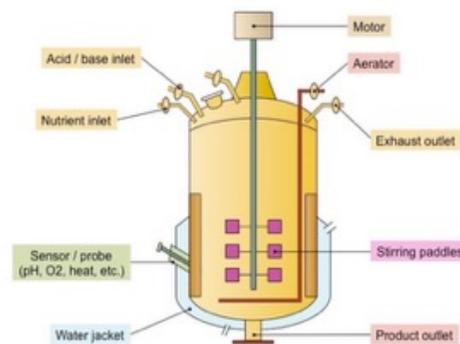
- Technology for the membrane-assisted de-alcoholisation of Beer, Wine and
- In-Process Control for the measurement of actual alcohol concentration and membrane performance was developed together with School of Life Sciences

Aeration / Degassing as a key process in reaction technology and (Gas-)Fermentation



Challenges in scaling-up with

- P/V (Energy consumption, agitator design and construction)
- Foaming
- Residence time for gases (yield!)



- Aeration, however, can be carried out bubble-free, too!

Gas Management @ microalgae cultivation:

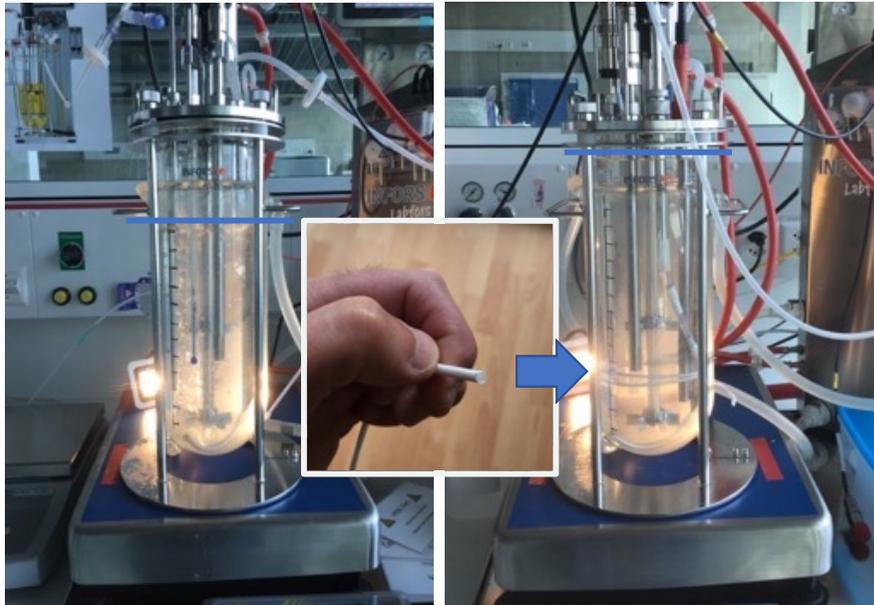
Transfer of CO₂ into and O₂ from the culture!

- Bubbles reducing active reactor volume
- Oxygen content in gas bubbles reduces growth
- Gas exchange every 70-200 m required

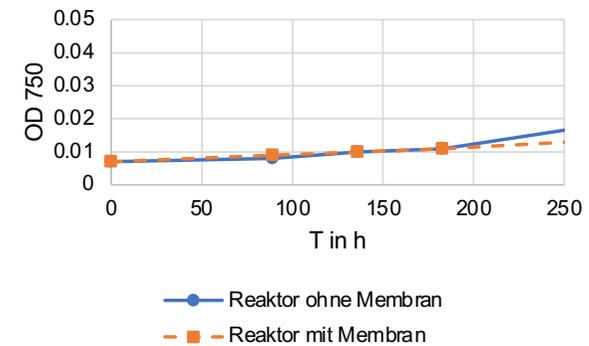


- ANY gas volume occurrence reduces available cultivation volume (and needs compensation via additional installation (-> cost!))

Aeration / Degassing with our Membrane contactor platform technology



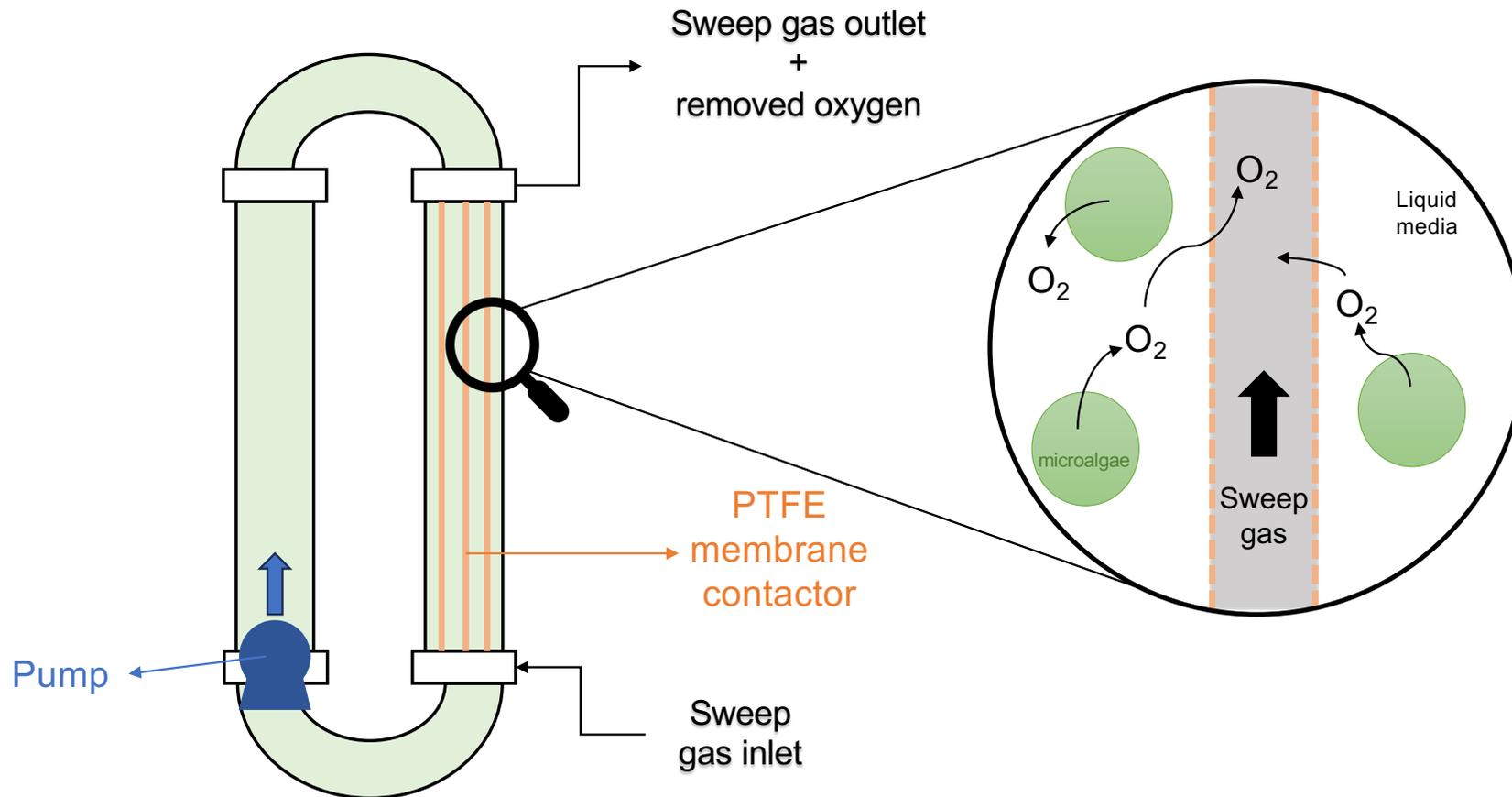
www.memo3.ch



- Using microporous membranes for bubble-free gas transfer (CO₂ into culture)
- **+30%** more effective cultivation volume (increase in room-time-yield) and
- NO negative effect on algae growth!
- NO foam formation

In situ oxygen removal from microalgae cultivation media by means membrane contactor

7.2 L loop photo-bioreactor



And the Microalgae?

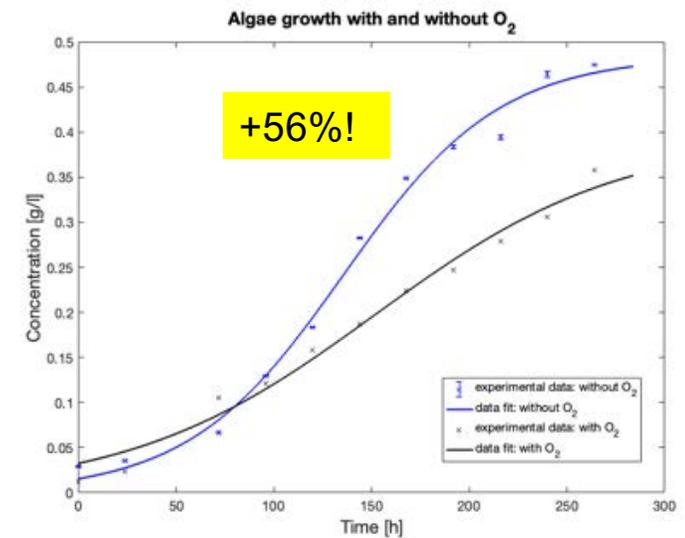
- Say “Thanks” and grow faster!



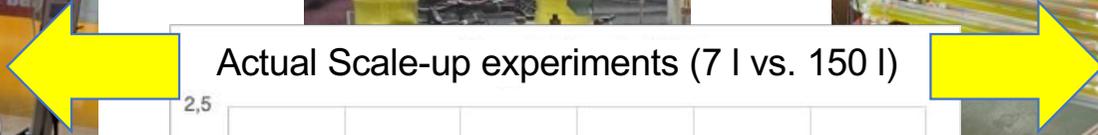
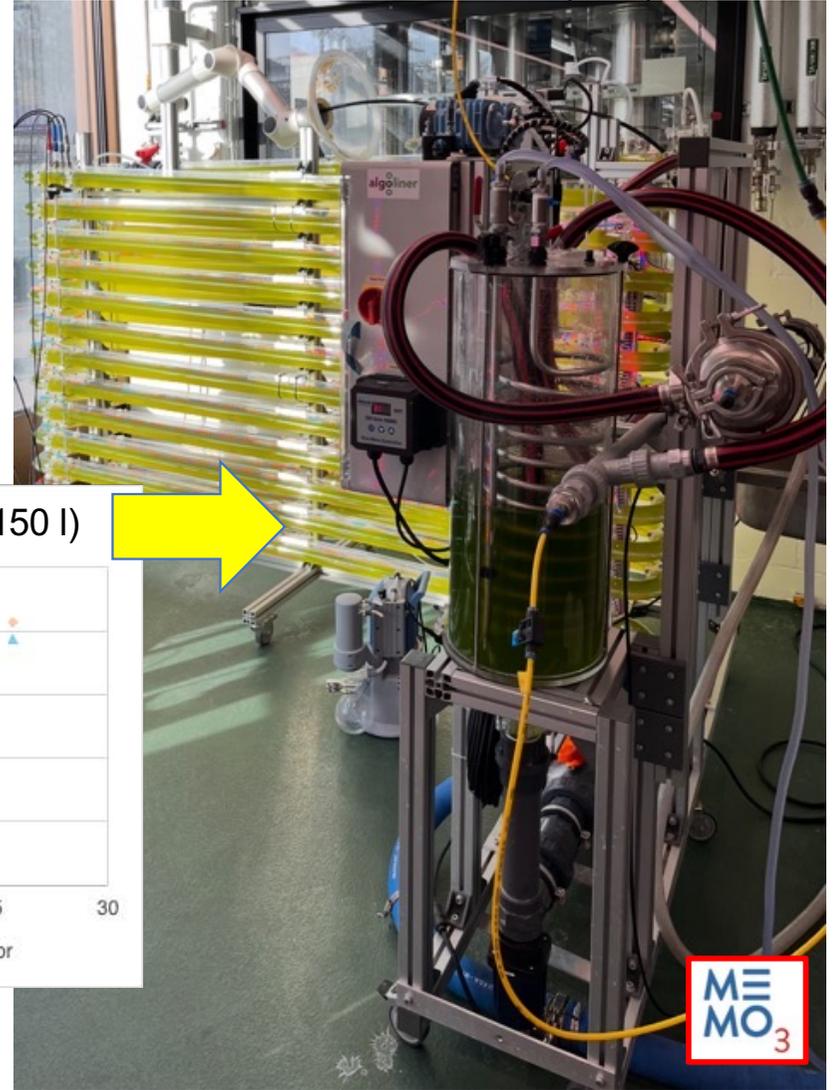
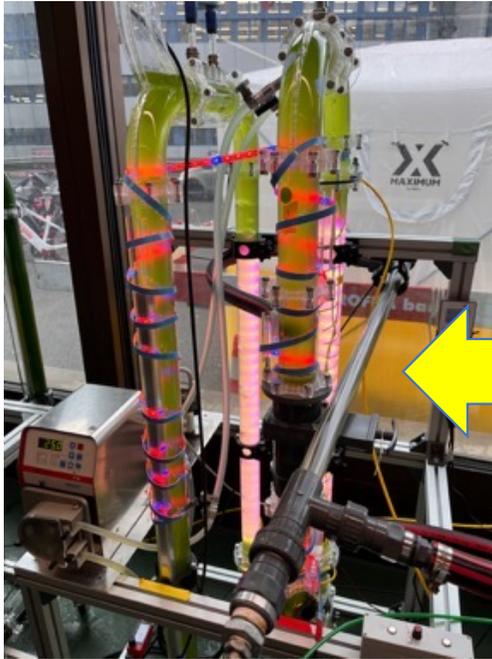
River water after (right) and after ozonation: decolourization takes place...



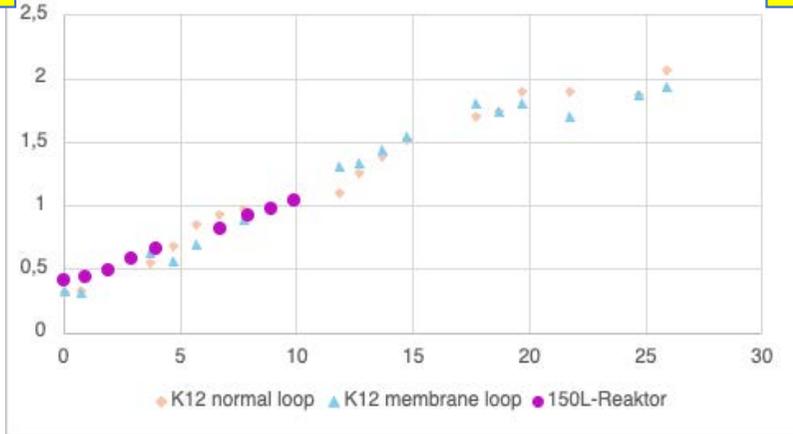
	with O ₂	without O ₂
Growth rate r	0.0159	0.0251



- Bubble-free Aeration and Degassing was tested already for other gases, eg. H₂, CO₂, O₃, NH₃...



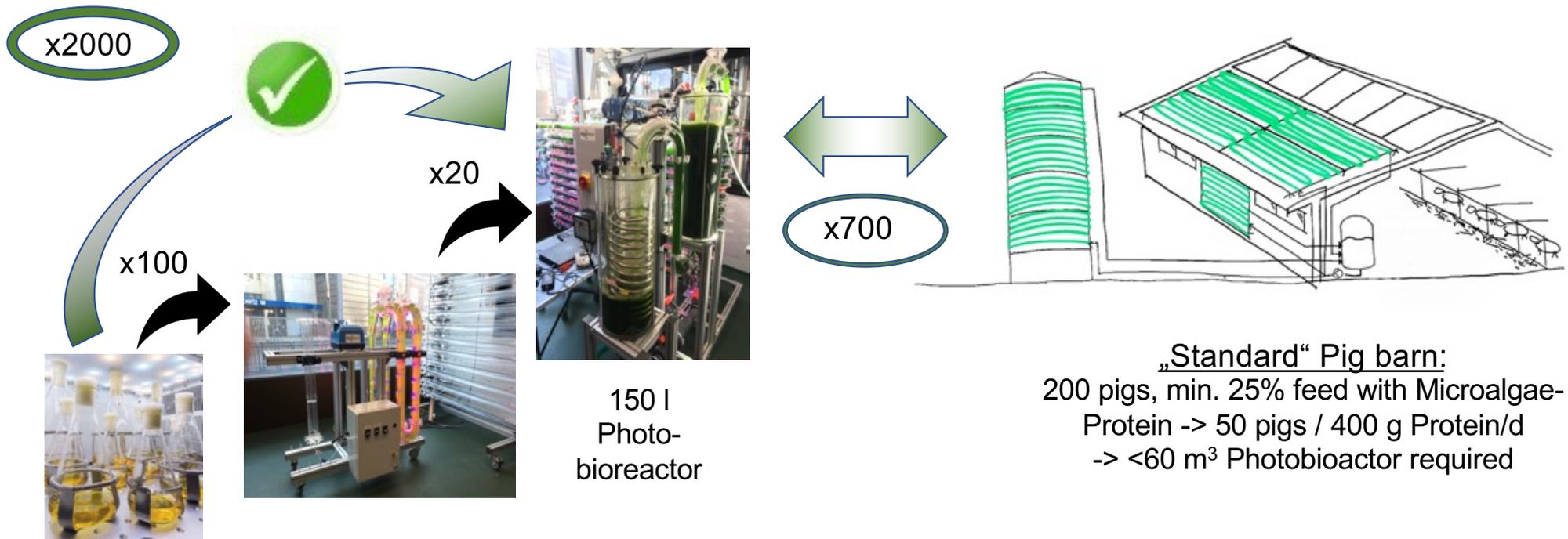
Actual Scale-up experiments (7 l vs. 150 l)



Funded by the European Union under grant agreement number 101135559. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Up- and Down-Stream, starting with 160 l Photobioreactor (with membrane aeration) and complete Downstream





Disruptive Membrane technology for
combined gas- and heat transfer

Building integration at the new Agroscope campus

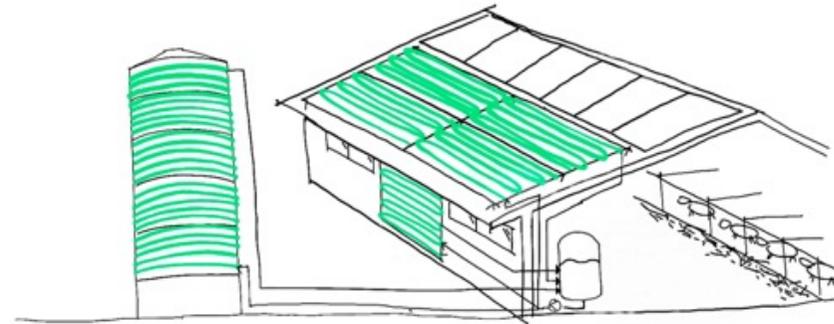
- 50m³ Bioreactor



“30 by 30”



Abbildung 2: Draufsicht Gebäude inkl. Algenanlage



Agroscope

Dr. Fabian Wahl, Agroscope

Installation of Microalgae-Reactors at Farmer's site for the production of (liquid) animal feed ("Algae smoothy")



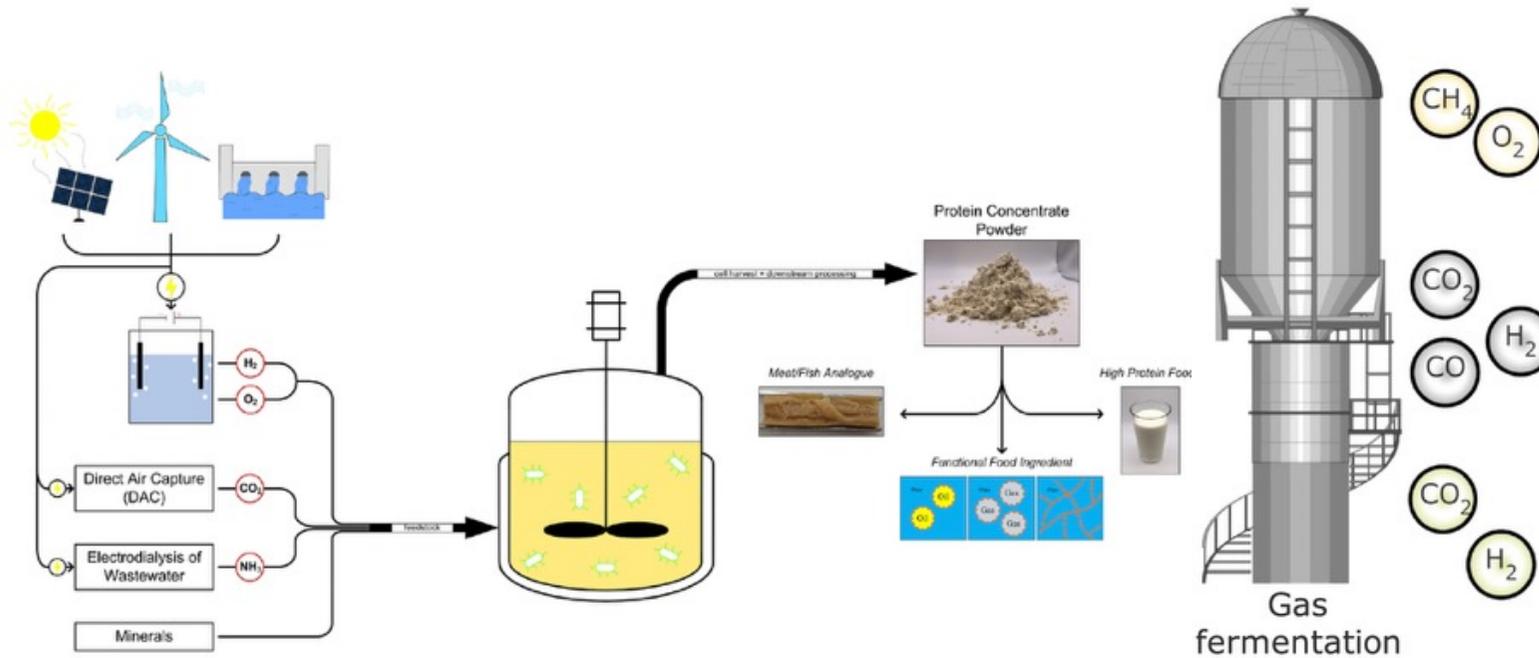
Endress+Hauser 

Robust PAT required for
- Easy "plug&play" operation



...and potential Remote Control

Gasfermentation for the production of Ethanol & Acetat as feedstock for further Fermentation processes (e.g. for Single Cell Proteins)

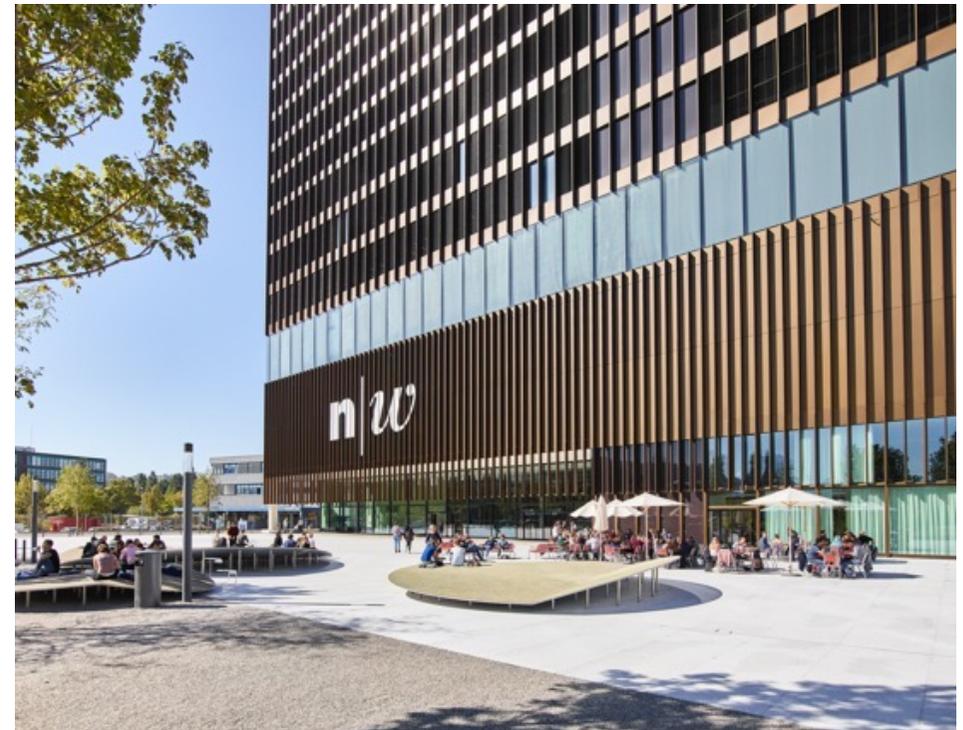


LanzaTech / ArcelorMittal / Gent-Site (BE)

From: Carlos Woern, Lutz Grossmann, Biotechnology Advances 69 (2023) 108240

from www.corporate.arcelormittal.com,
accessed on 2026-01-31

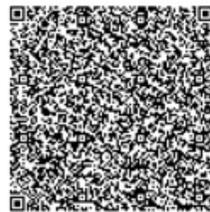
Thank you for visiting us!



Contact:

wolfgang.riedl@fhnw.ch

<https://de.linkedin.com/in/wolfgang-riedl-46ba24256>



Wolfgang Riedl FHNW /
HLS

See you (soon?) in Muttenz @ HLS!

For further information please visit our website:

<https://www.fhnw.ch/en/about-fhnw/schools/lifesciences/process-technology-center-ptc>



Natural materials technology
Many natural materials contain health-promoting compounds and other beneficial substances. The Natural Materials Technology lab extracts valuable ingredients from plants, and processes and packages them professionally.



Thermal separation processes and (bio)refinery
The (bio)refinery produces fuel and recovers solvents. The starting mixture is separated as energy-efficiently as possible based on different boiling points; bioethanol is produced in this way for example.



Bioprocessing
One goal of modern medicine is to provide patients with individually tailored therapies, but complex processes are required to produce the biological agents necessary. Bioprocess technology ensures that these processes run at higher yields and always deliver a high quality product.

Chemical Process Development and Process Safety

At the PTC we can measure chemical reactions precisely, make them more efficient with catalysts or test their explosion safety. In this way, processes can be established and optimized on a pilot scale.



Pharmaceutical process technology
Correct composition and production of medicines are crucial to their efficacy. A wide variety of drug forms are developed, manufactured and tested in the pharmaceutical process technology lab.

Environmental plant – wastewater management of the future

New wastewater treatment methods are analysed in the environmental plant; filtration and purification steps are tested and combined to ensure the best possible purification.



Contacts



Bioprocess technology
Prof. Dr. Thomas Villiger
FHNW School of Life Sciences
Institute for Pharma Technology
Hofackerstrasse 30, 4132 Muttenz
T +41 61 228 52 46 (Direct)
thomas.villiger@fhnw.ch



Chemical process development and process reliability
Prof. Dr. Andreas Zogg
FHNW School of Life Sciences
Institute for Chemistry and Bioanalytics
Hofackerstrasse 30, 4132 Muttenz
T +41 61 228 58 25 (Direct)
andreas.zogg@fhnw.ch



Cleanroom and sterile pharma production
Prof. Dr. Oliver Germershaus
FHNW School of Life Sciences
Institute for Pharma Technology
Hofackerstrasse 30, 4132 Muttenz
T +41 61 228 55 26 (Direkt)
oliver.germershaus@fhnw.ch



Pharmaceutical process technology
Prof. Dr.-Ing. Berndt Joost
FHNW School of Life Sciences
Institute for Pharma Technology
Hofackerstrasse 30, 4132 Muttenz
T +41 61 228 55 58 (Direct)
berndt.joost@fhnw.ch



Environmental technology plant
Prof. Dr. Michael Thomann
FHNW School of Life Sciences
Institute for Ecopreneurship
Hofackerstrasse 30, 4132 Muttenz
T +41 61 228 55 34 (Direct)
michael.thomann@fhnw.ch



Natural Product Technology
Prof. Dr. Wolfgang Riedl
FHNW School of Life Sciences
Institute for Chemistry and Bioanalytics
Hofackerstrasse 30, 4132 Muttenz
T +41 61 228 55 51 (Direct)
wolfgang.riedl@fhnw.ch



Thermal separation processes and (bio)refinery
Prof. Dr. Wolfgang Riedl
FHNW School of Life Sciences
Institute for Chemistry and Bioanalytics
Hofackerstrasse 30, 4132 Muttenz
T +41 61 228 55 51 (Direct)
wolfgang.riedl@fhnw.ch

