

Überwachung und Regelung von Substraten und Produkten bei der Herstellung organischer Säuren

Roland Schneider & Joachim Venus

Leibniz Institute for Agricultural Engineering and Bioeconomy ATB Potsdam

 **Mini-Symposium**
Bio-PAT

Anwendung von PAT für robuste Bioprozesse
Fokus: Biobasierte Produkte und Bioökonomie

19.04.2023
09:30 – 14:00 Uhr
TU Berlin, Raum H2036
Straße des 17. Juni 135
10623, Berlin
Mehr Informationen:
www.bio-pat.org/event/bio-pat-mini-symposium

Präsentationen von
  
  

unterstützt von
Gefördert durch:

aufgrund eines Beschlusses des Deutschen Bundestages
Senatsverwaltung für Wirtschaft, Energie und Betriebe BERLIN

Promising Bio-based chemical targets as assessed in 2004 and 2010

Bio-based chemical opportunities

2004	2010
1,4-Dicarboxylic acids (succinic, fumaric and malic)	Succinic acid
2,5-Furan dicarboxylic acid	Furanics
3-Hydroxy-propionic acid	Hydroxypropionic acid/aldehyde
Glycerol	Glycerol and derivatives
Sorbitol	Sorbitol
Xylitol/Arabinitol	Xylitol
Levulinic acid	Levulinic acid
Aspartic acid	-
Glucaric acid	-
Glutamic acid	-
Itaconic acid	-
3-Hydroxybutyrolactone	-
-	Biohydrocarbons
-	Lactic acid
-	Ethanol

Werpy, T. G. Petersen. 2004. Top Value Added Chemicals from Biomass, Vol 1: Results of Screening for Potential Candidates from Sugars and Synthesis Gas.
<https://www.nrel.gov/docs/fy04osti/35523.pdf>

Bozell, J.J., Petersen, G.R. 2010. Technology development for the production of biobased products from biorefinery carbohydrates - the US Department of Energy's "Top 10" revisited. Green Chemistry. 12:539-554



The processes for producing organic acids from biomass/residues include the following 4 main steps:

- (1) **Pretreatment - breaking down the structure of the feedstock matrix**
- (2) Enzymatic hydrolysis - depolymerizing biopolymers like starch, cellulose etc. to fermentative sugars, such as glucose (C6) and xylose (C5), by means of hydrolytic enzymes
- (3) Fermentation - metabolizing the sugars to organic acids
- (4) **Separation and purification of the products - purification of organic acids to meet the standards of commercial applications**



Pilot plant facility for at Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB Potsdam)

Beyond Petrochemicals: The Renewable Chemicals Industry**

P. N. R. Vennestrøm, C. M. Osmundsen, C. H. Christensen, and Esben Taarning*

Chemical	Market type	Market size (Mty ⁻¹) ^[a]	Major player(s)	Feedstock
acetic acid	existing	9.0	—	ethanol
acrylic acid	existing	4.2	Arkema, Cargill/Novozymes	glycerol or glucose
C ₄ diacids	emerging	(0.1–0.5)	BASF/Purac/CSM, Myriant	glucose
epichlorohydrin	existing	1.0	Solvay, DOW	glycerol
ethanol	existing	60	Cosan, Abengoa Bioenergy, ADM	glucose
ethylene	existing	110	Braskem, DOW/Crystalev, Borealis	ethanol
ethylene glycol	existing	20	India Glycols, Dacheng Industrial	glucose or xylitol
glycerol	existing	1.5	ADM, P&G, Cargill	vegetable oil
5-hydroxymethylfurfural	emerging	—	—	glucose/fructose
3-hydroxypropionic acid	emerging	(≥0.5)	Novozymes/Cargill	glucose
isoprene	existing/ emerging	0.1 (0.1–0.5)	Danisco/Goodyear	glucose
lactic acid	existing/ emerging	0.3 (0.3–0.5)	Cargill, Purac/Arkema, ADM, Galactic	glucose
levulinic acid	emerging	(≥0.5)	Segetis, Maine Bioproducts, Le Calorie	glucose
oleochemicals	existing	10–15	Emery, Croda, BASF, Vantage Oleochemicals	vegetable oil/fat
1,3-propanediol	emerging	(0.1–0.5)	Dupont/Tate & Lyle	glucose
propylene	existing	80	Braskem/Novozymes	glucose
propylene glycol	existing/ emerging	1.4 (≥2.0)	ADM, Cargill/Ashland, Senergy, Dacheng Industrial	glycerol or sorbitol
polyhydroxyalkanoate	emerging	(0.1–0.5)	Metabolix/ADM	glucose

[a] Market size of an existing market is given as its current size including production from fossil resources; for emerging markets the expected market size is reported in parenthesis.

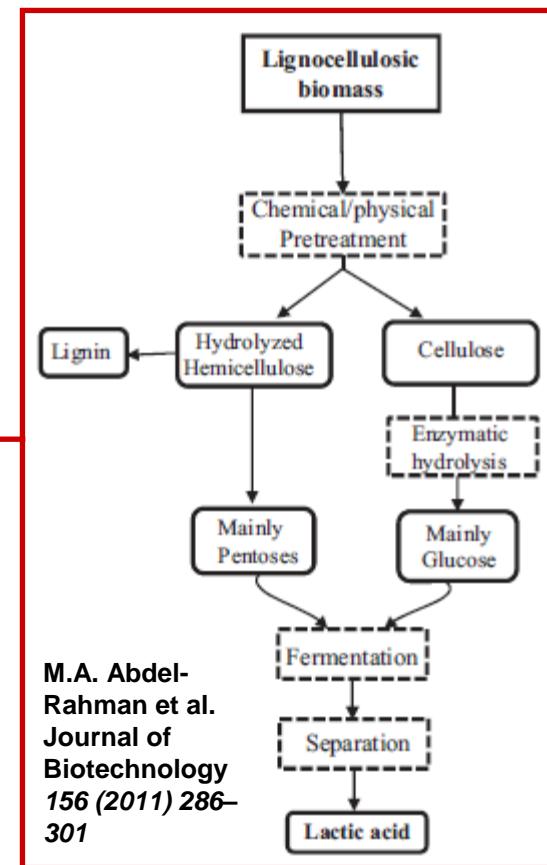


Table 1: Overview of chemicals that are currently produced, or could be produced, from biomass together with their respective market type, size of the market, and potential biomass feedstock. Major players involved are also given.

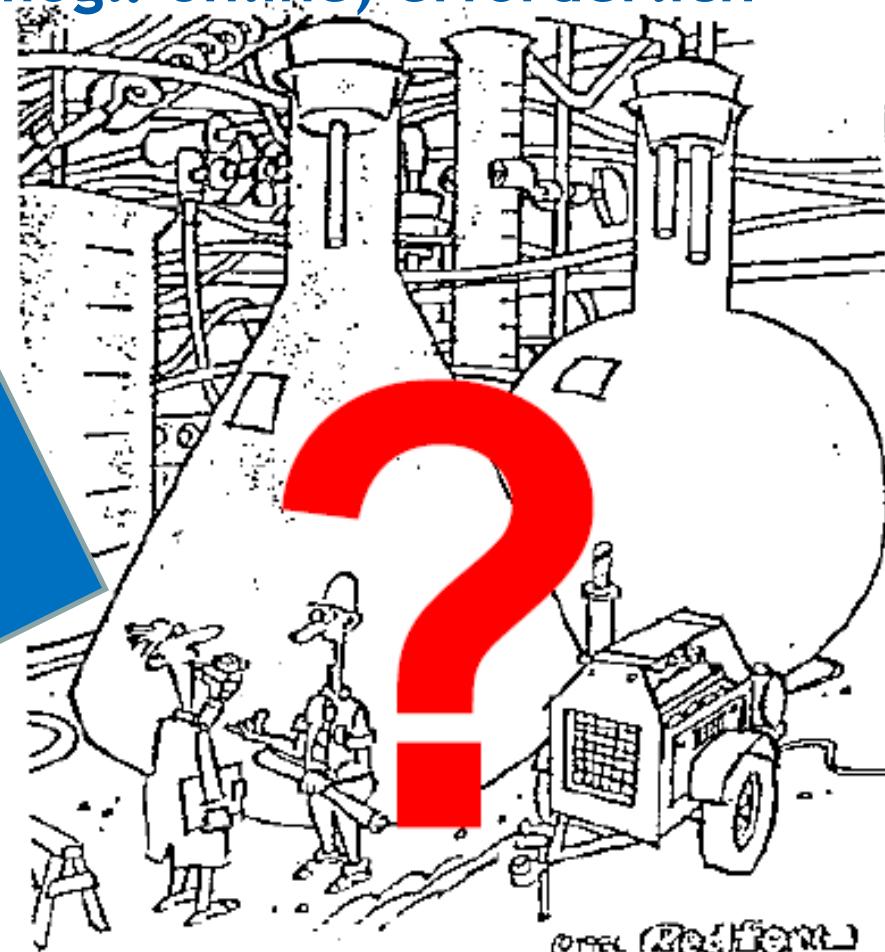
“The most demanding efforts are to make the processes economical, with the production cost as low as possible.”

Biofuels, Bioprod. Bioref. (2020); DOI: 10.1002/bbb.2104

- Advanced pretreatment methods for breaking down the recalcitrant lignocellulosic structure
 - sugar release ↑
 - inhibitory compounds ↓
- Application of mixed microbial cultures & multi-substrate processes
- Increase of the microbial conversion performance per volume of the bioreactor
 - ⌚ space-time yield
 - Number of active microbes ↑
 - Specific activity of the microbes ↑
- Development of application-specific bioreactor systems and process analytical techniques (PAT)
- Advanced strategies such as simultaneous saccharification and co-fermentation (SSF), develop continuous mode fermentation processes
- Improved DSP (incl. integrated/in-situ product recovery) for high-quality products
- **Establish of optimal process conditions for the biocatalyst**

Quantifizierung von Bioprozessen

⇒ Prozessinformationen (mögl. online) erforderlich

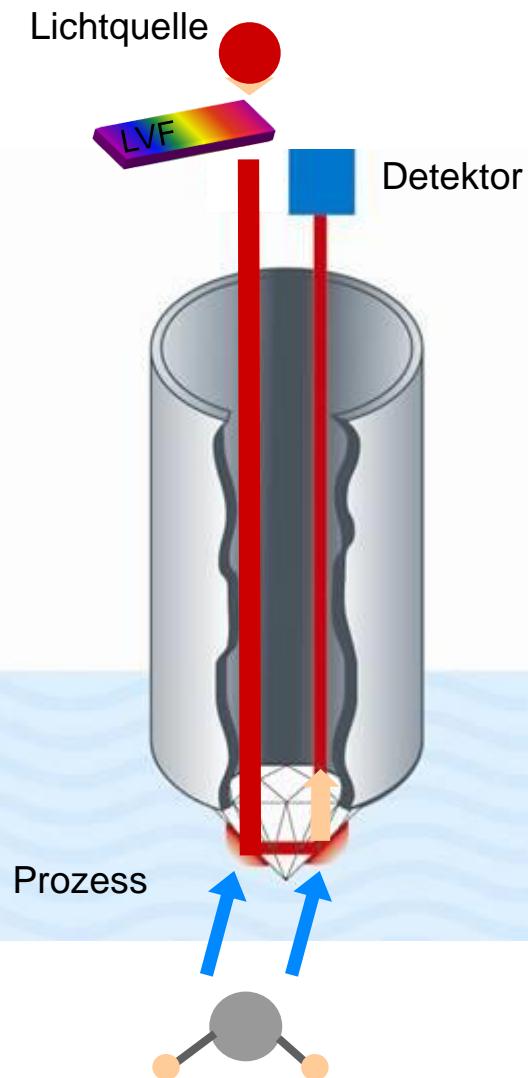
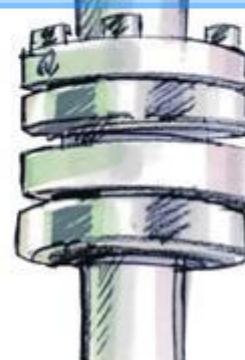


"Got a few problems going from lab scale up to full-scale commercial."

E+H-Sensor Concens CVS90



E+H CVS90 ist ein einfach bedienbarer
Konzentrationssensor für flüssige Gemische auf Basis
eines MIR-Spektrometers





Flüssigkeits-analyse

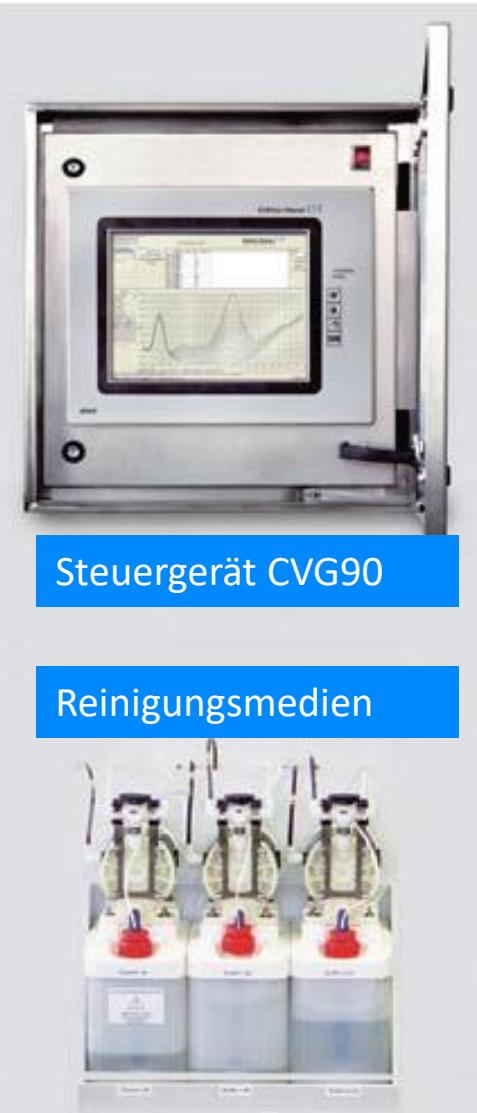
Endress+Hauser EH

Die Inline-Konzentrationsmessstelle

Spektrometer
CVS90



Pneumatische
Wechselarmatur
CVA476



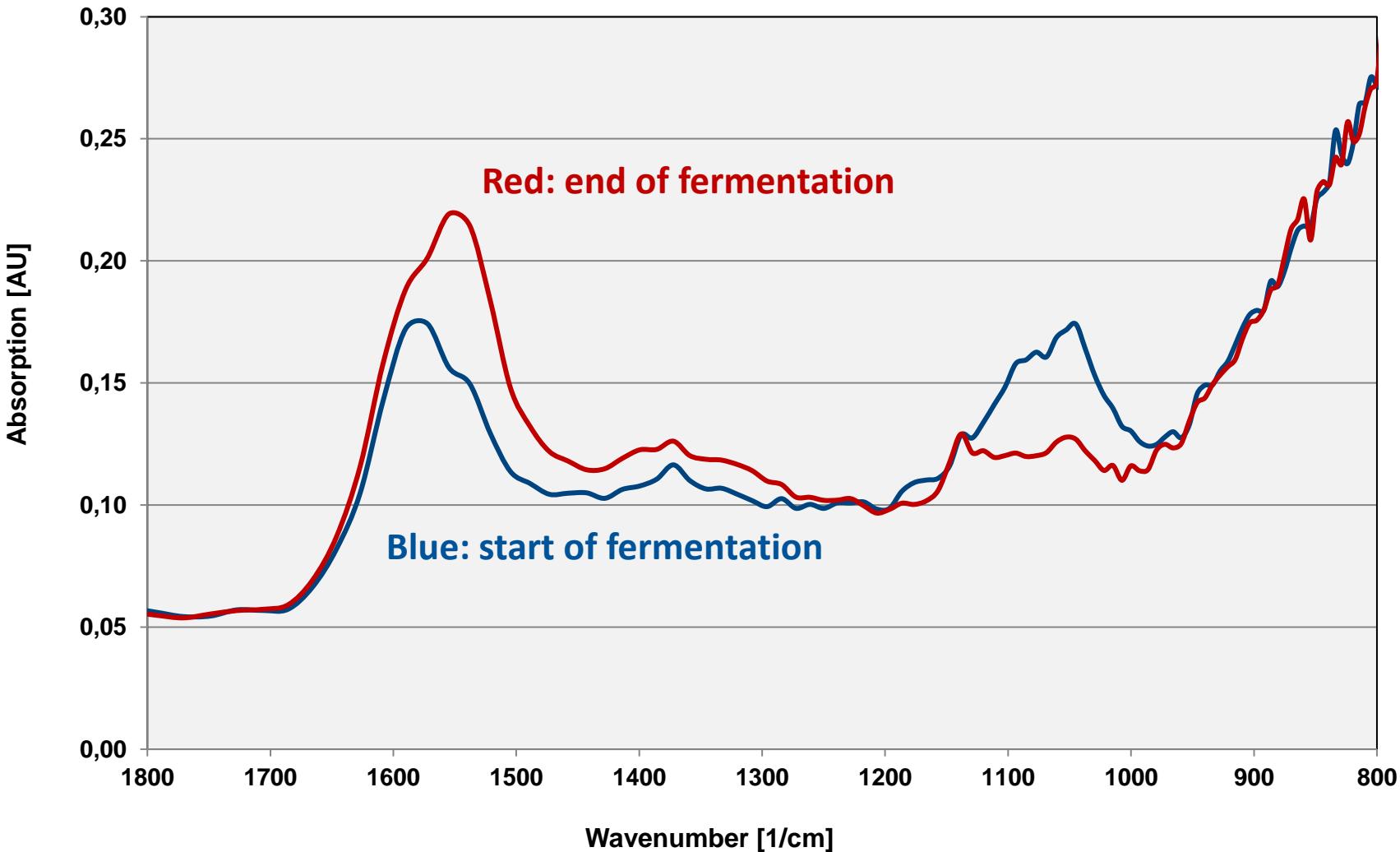
Reinigungsmedien



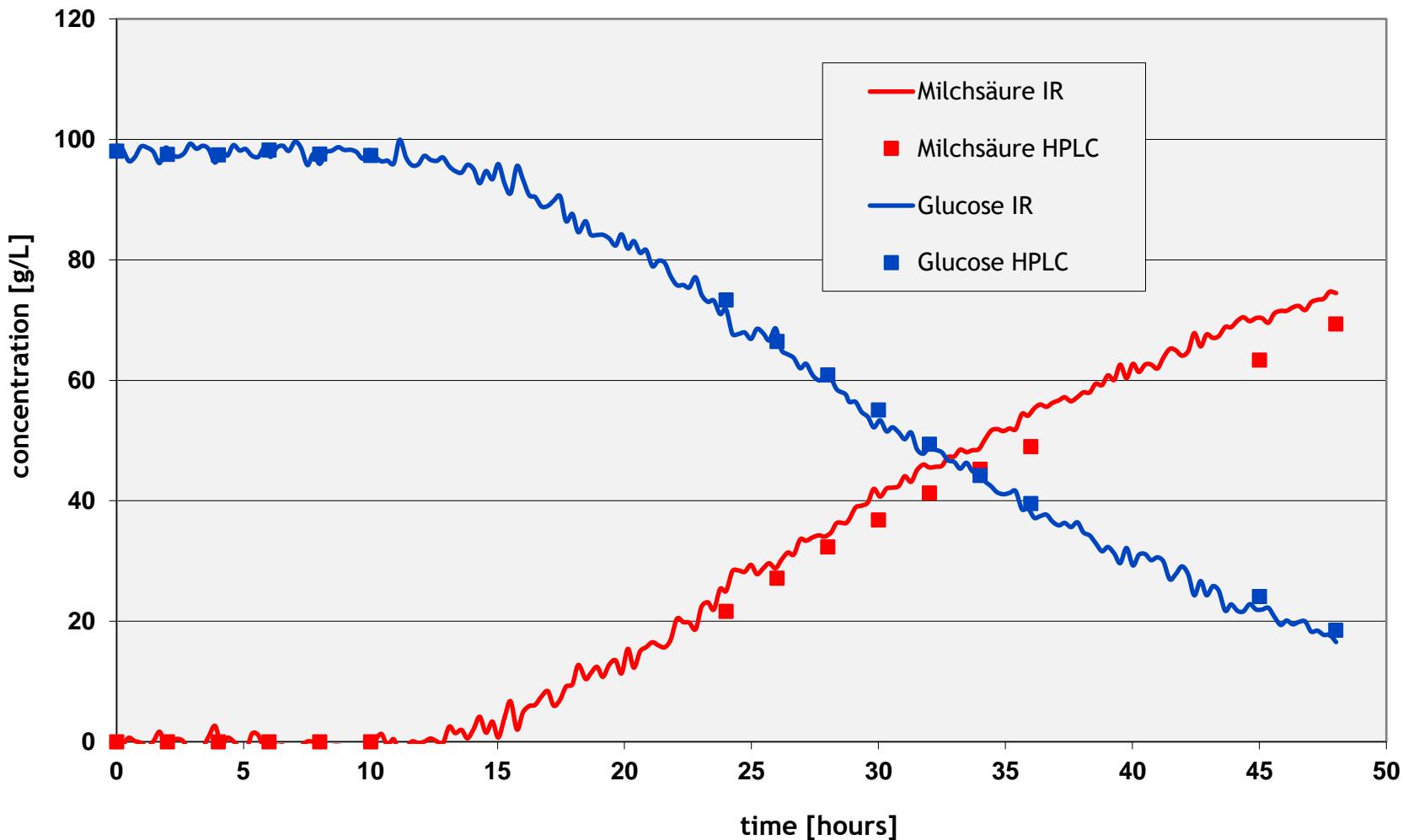
Der Versuchsaufbau mit einem 5-L-Fermenter



Spectra of fermentation samples



SF1222 – after offset adjustment



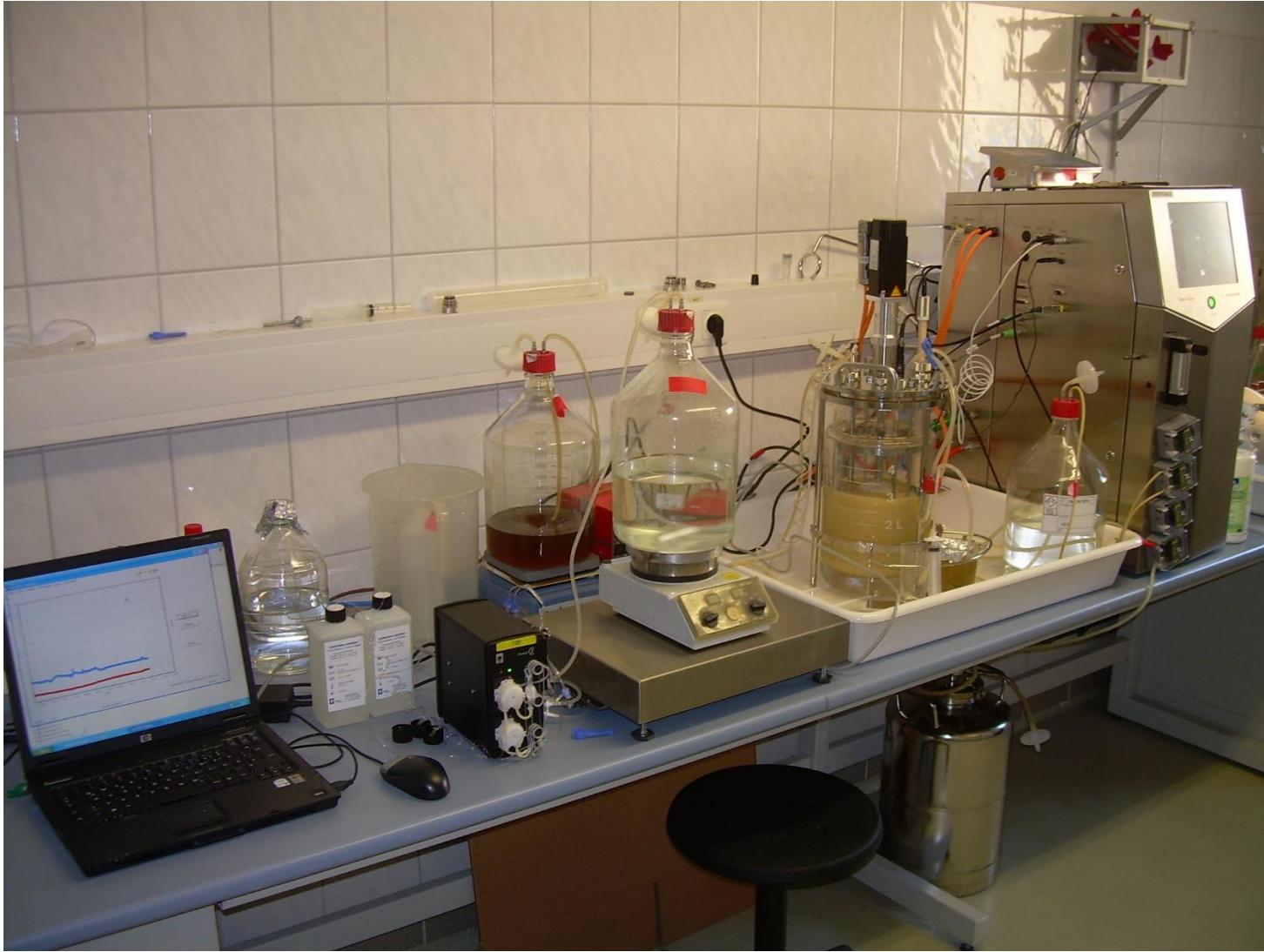
TRACE C2 Control

- Online Monitoring und Regelung -

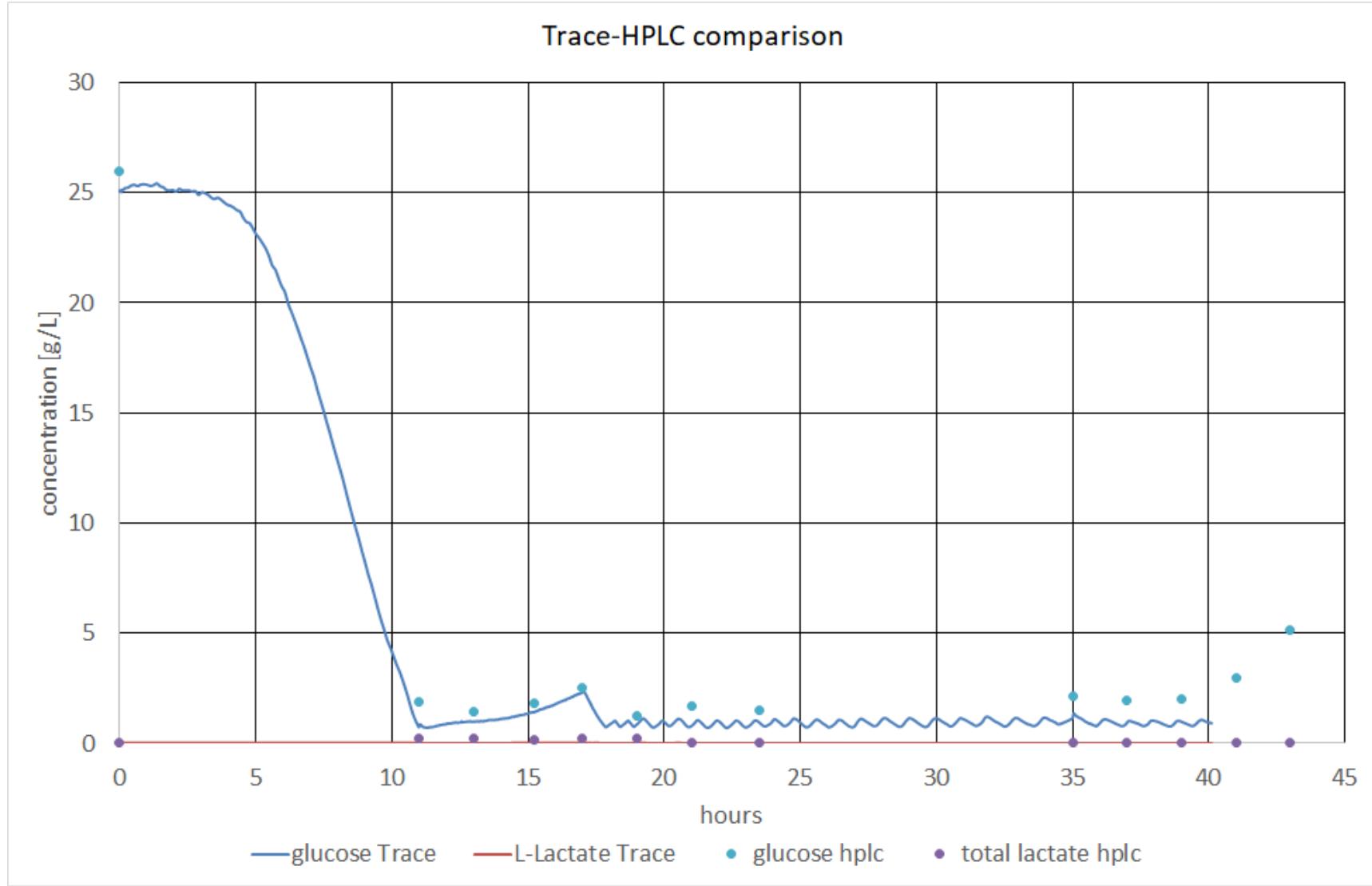
- Glukose / Laktat, Ethanol und Methanol
- Integrierter PID-Regler und Fütterungspumpe
- Sichere und wirtschaftliche Nutzung
- Geringer Wartungsaufwand und Platzbedarf
- Robuste Biosensoren
- Volumenfreie Probenahme



Versuchsaufbau konti-Fermentation

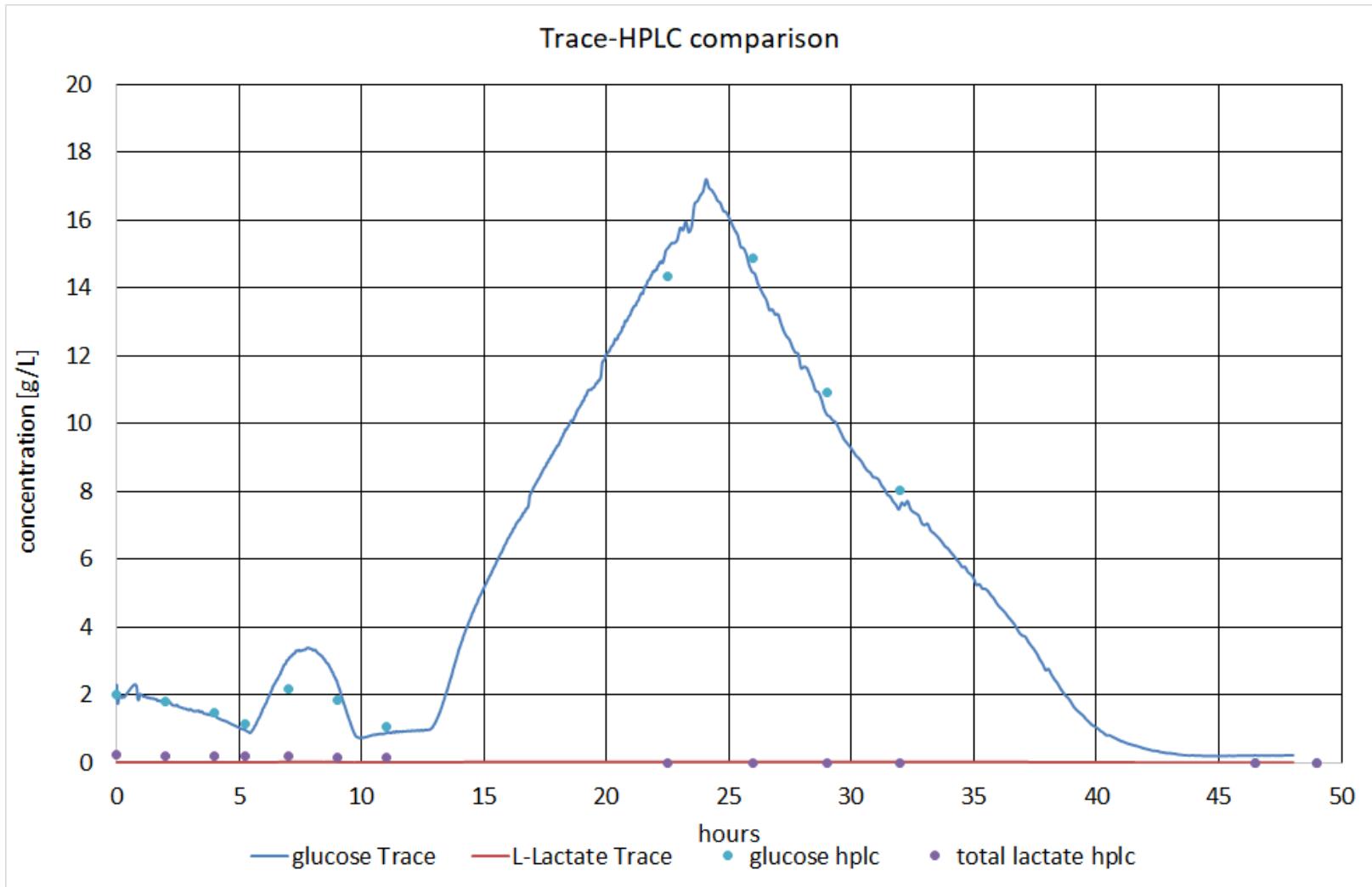


Bernsteinsäurefermentation – Glucose-Feed: SF 3684



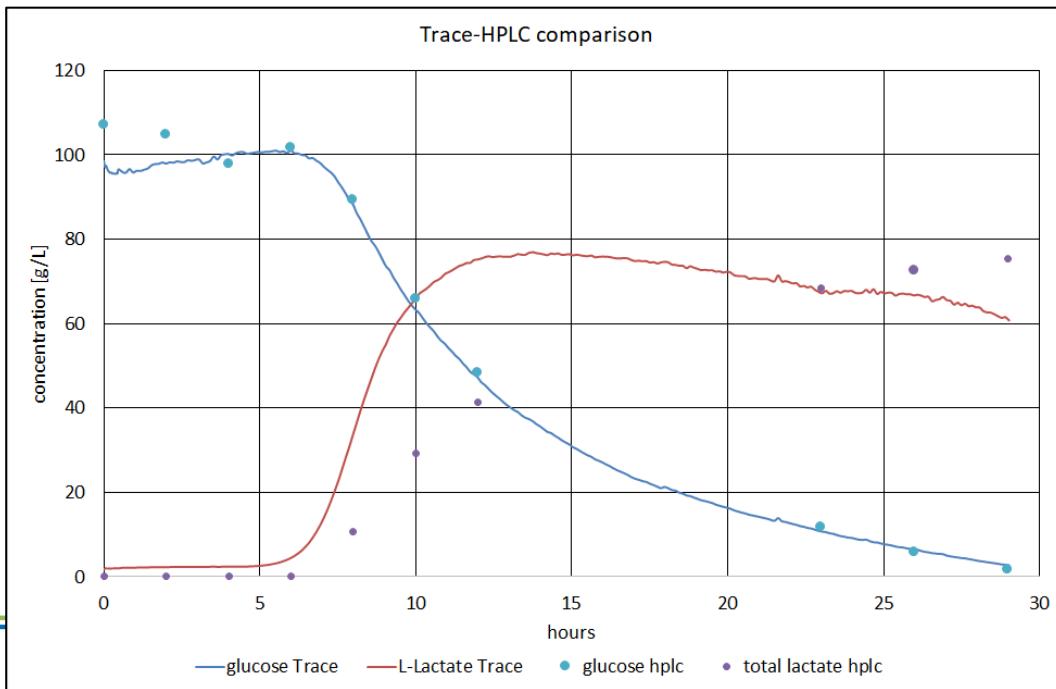
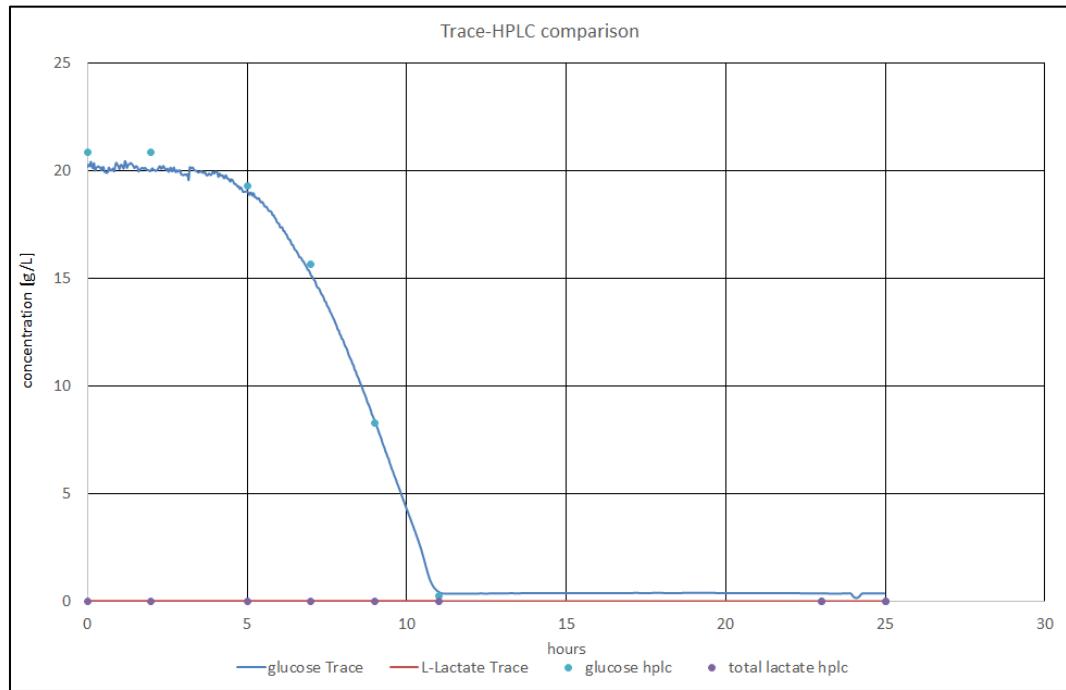
Bernsteinsäurefermentation – SF 3685

(PID-Regler – Pumpe leider zu stark/Überdosierung Glucose)



Milchsäurefermentation

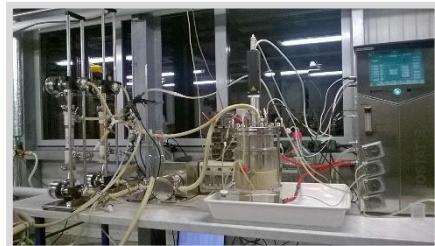
– Glucose-Milchsäure- Messung: SF 3682/86



Zusammenfassung und Ausblick

- Die Konzentration der entstehenden Milch- und Bernsteinsäure sowie verbrauchten Glucose kann mit vergleichbarer Genauigkeit/Reproduzierbarkeit gemessen werden - auf offline bestimmte HPLC-Werte bezogen
- Abweichung unter Fermentationsbedingungen größer als unter Probenbedingungen, aber akzeptabel
- Übertragung auf gemischte Substrate steht noch aus. Erste Versuche zeigen, dass dies machbar, aber nicht trivial ist
- Übertragung in den Prozess (komplexe Medien, scale-up & Langzeitstabilität)

Further process engineering challenges of producing bio-based products



Feedstocks

Advanced strategies such as simultaneous saccharification and co-fermentation (SSF)



Logistics Availability (regional, seasonal)



Processing

develop continuous mode fermentation processes
Scale-up to increase TRL

Products

Improved DSP (incl. integrated/in-situ product recovery) for high-quality products



Thank you for your attention!

Contact:

Dr. Joachim Venus (group leader)
Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)
Max-Eyth-Allee 100, 14469 Potsdam, GERMANY
Fon: +49(331)5699-852 | email: jvenus@atb-potsdam.de



<https://youtu.be/JnkB0WRIO-o>