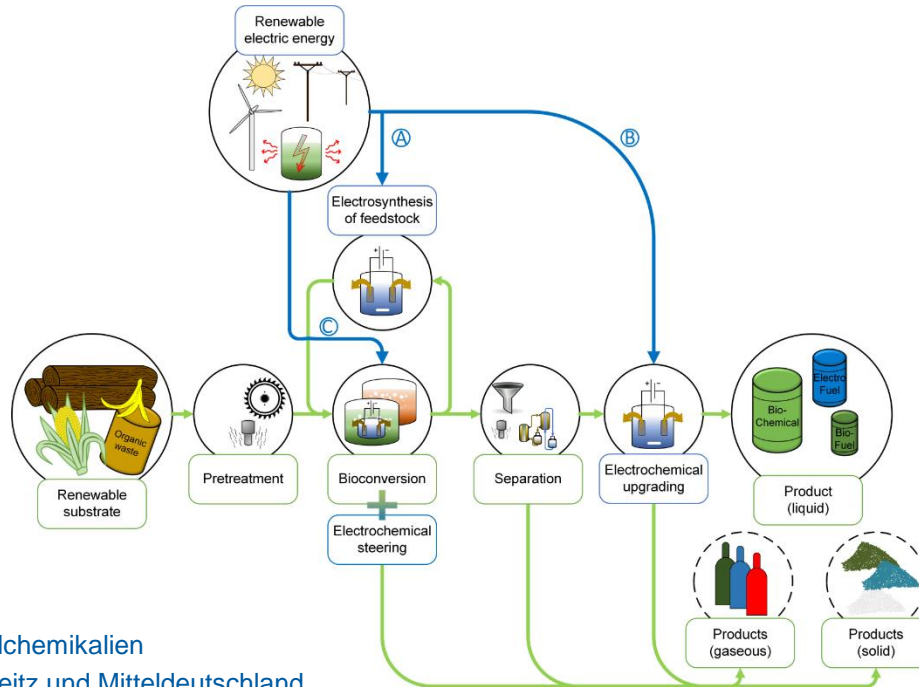


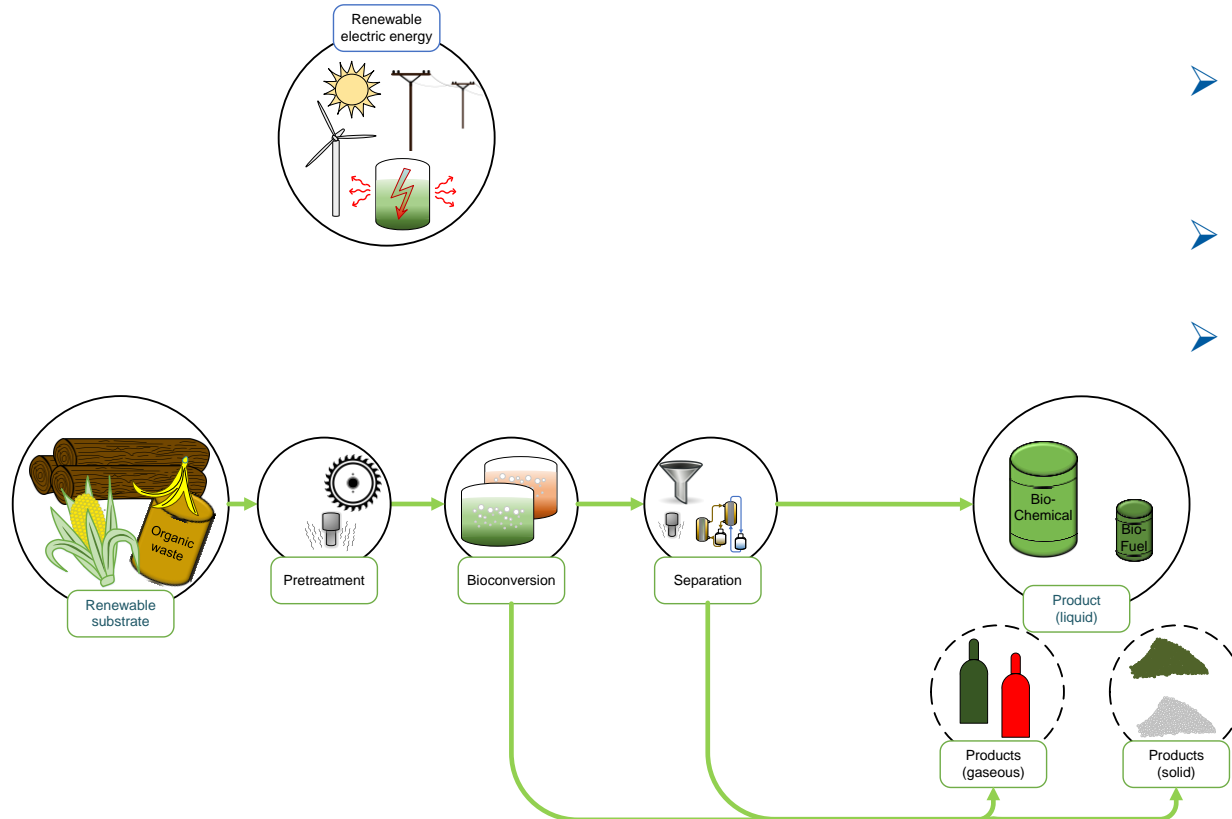
Electrification of Biotechnology for Electrobiorefineries

Prof. Dr. Falk Harnisch
(falk.harnisch@ufz.de)



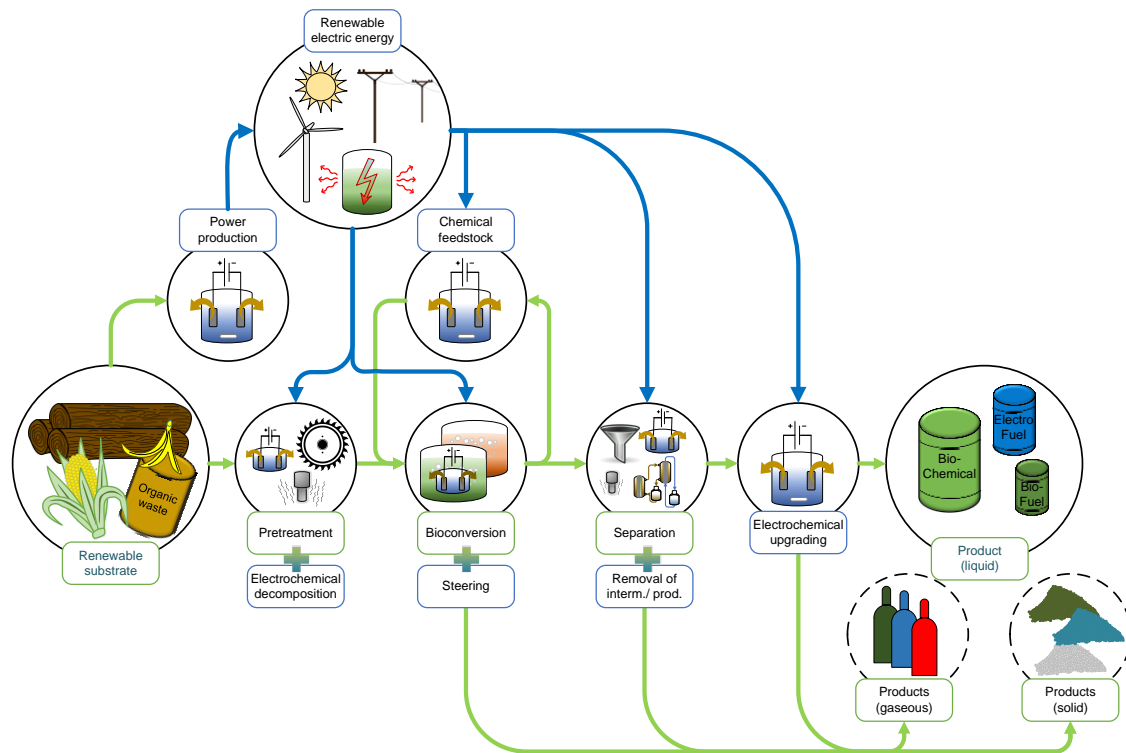
BioZ Dialoggruppe Fein- und Spezialchemikalien
BioZ Biobasierte Innovationen aus Zeitz und Mitteldeutschland
Zeitz, Germany, online

The status quo: Biorefineries



- Strong competition of fuel and chemical production with food and feed
- Limited product portfolio from biomass
- Limited connection between renewable electric energy and biomass utilization

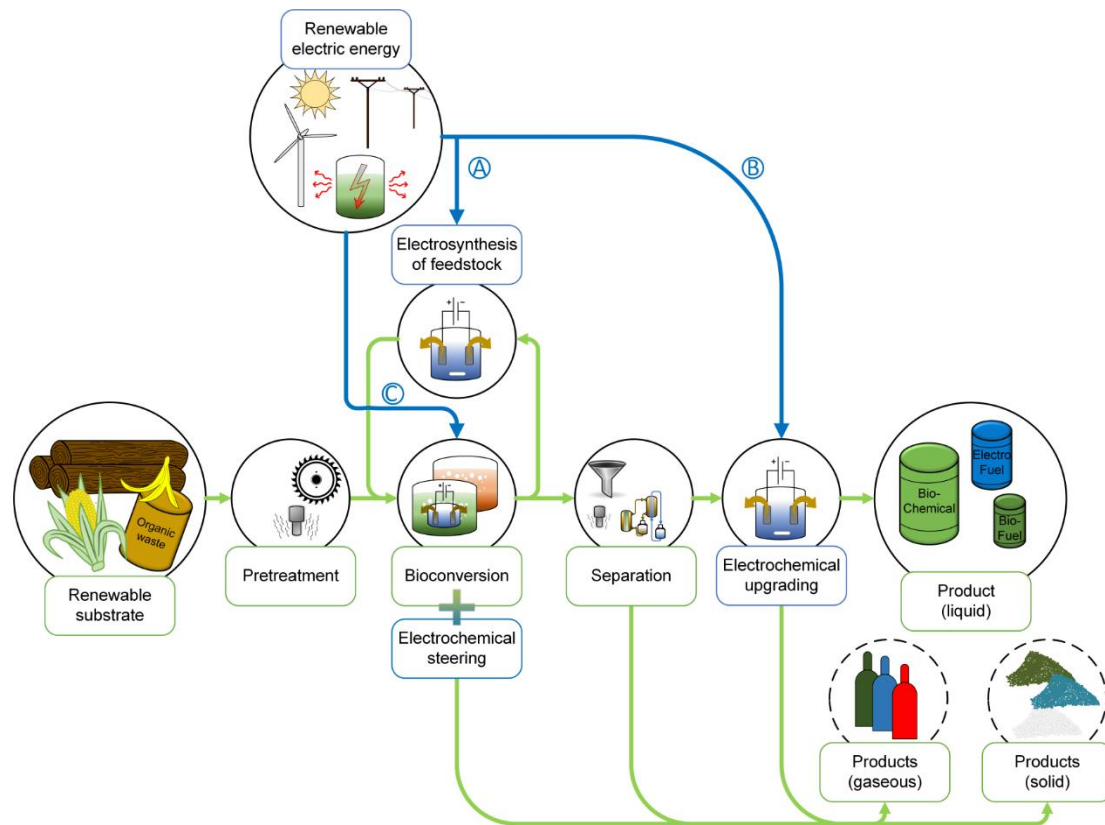
The future: Electrobiorefineries



- Diversification of the feedstock to non-food, non-feed and waste
- Increased diversity of product portfolio from biomass
- Strong linkage between renewable electric energy and biomass utilization for chemical and fuel synthesis

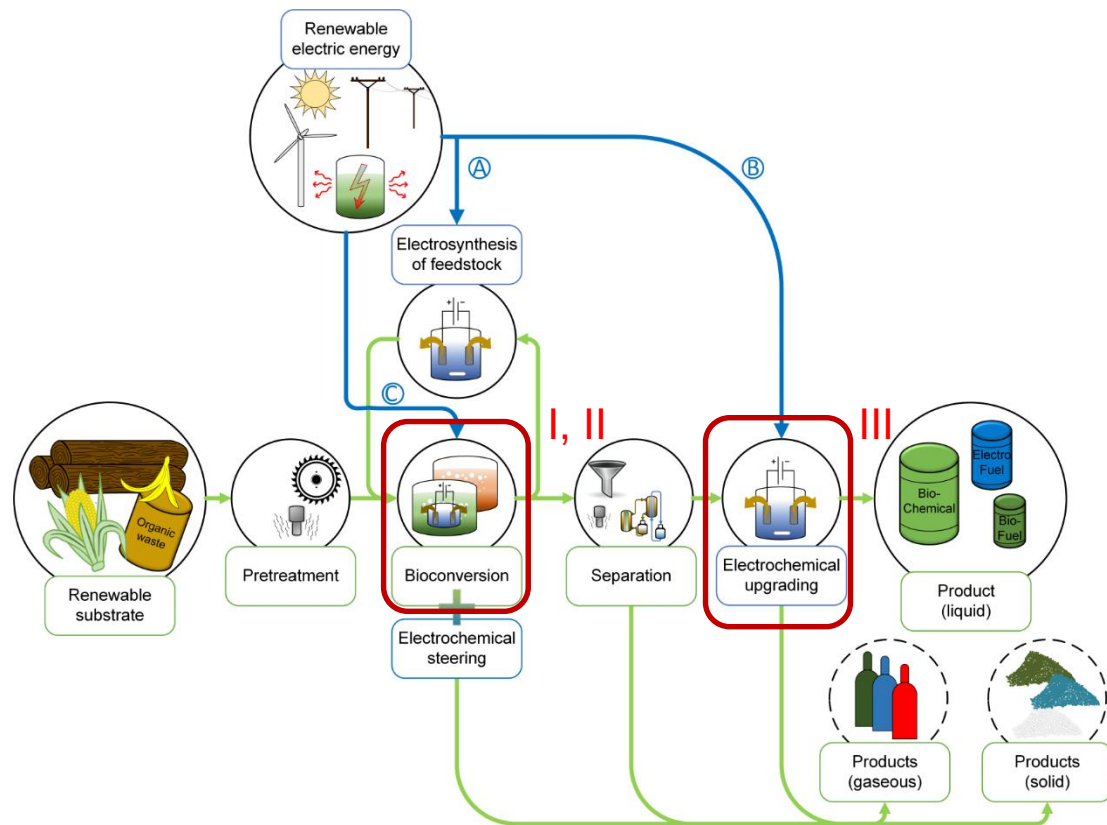
Angew. Chem., Int. Ed. 57 (2018) 10016-10023
ChemElectroChem 6 (2019), 4126 - 4133

The future: Electrobiorefineries



Angew. Chem., Int. Ed. 57 (2018) 10016-10023
ChemElectroChem 6 (2019), 4126 - 4133

The future: Electrobiorefineries



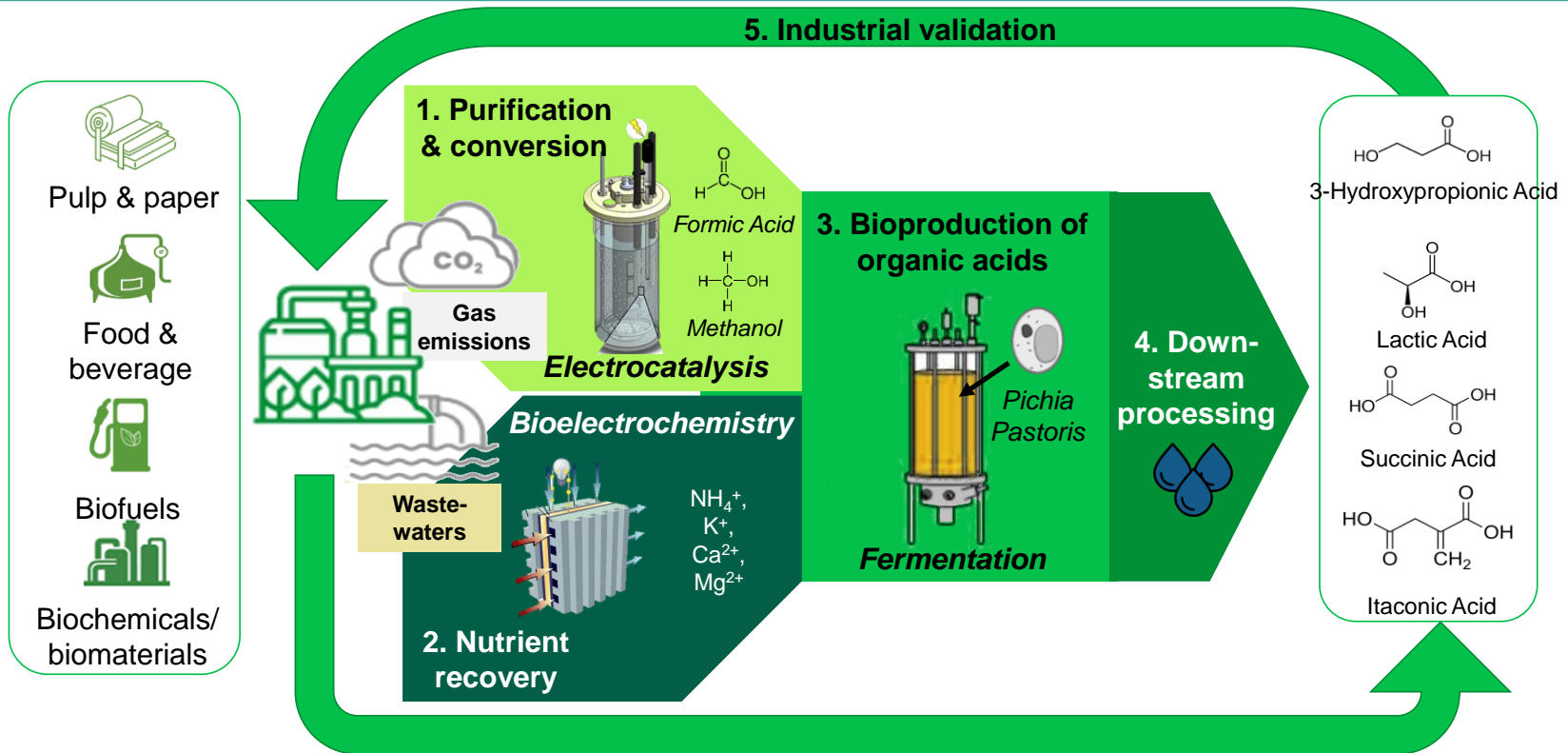
Focus of today:

- I. Providing microbial feedstock
- II. Providing microbial feedstock
- III. Upgrading microbial products

Angew. Chem., Int. Ed. 57 (2018) 10016-10023
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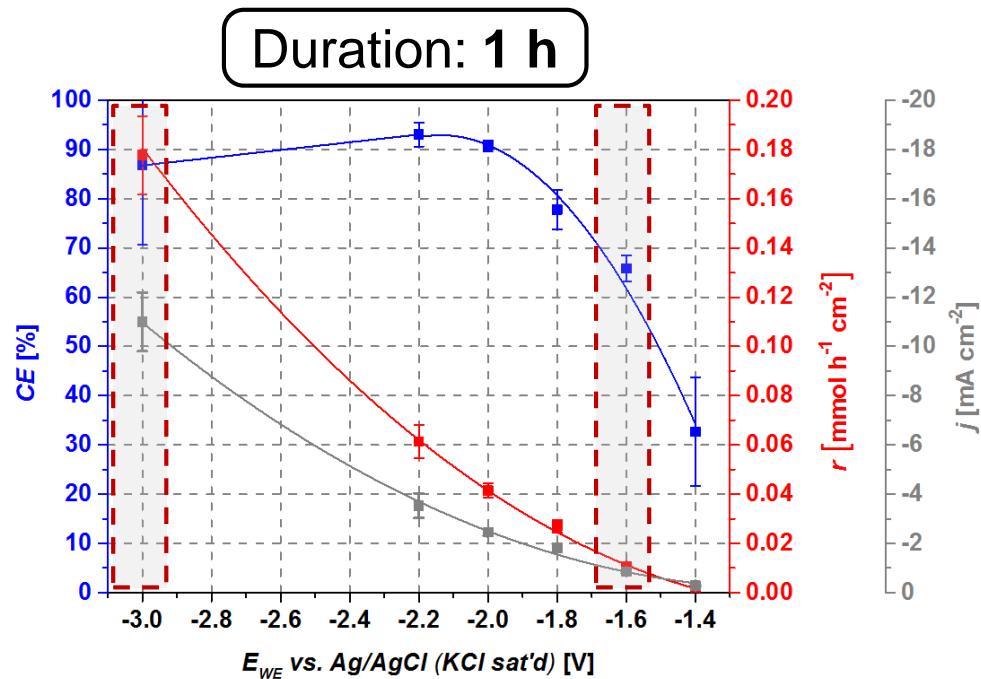
From CO₂ to polymer bricks

Process integration (H2020-project: VIVALDI)



From CO₂ to formate as C₁-feedstock

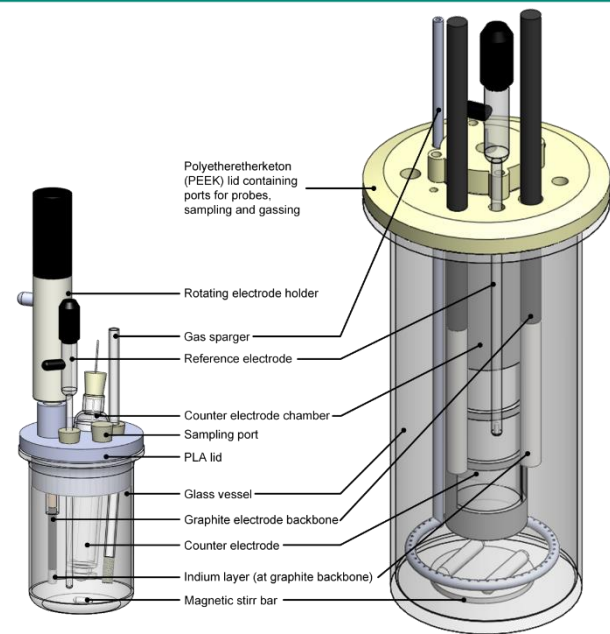
Engineering the electrochemical process



All experiments in 0.05 mol L⁻¹ NaHCO₃ (pH 6.5) as electrolyte solution, $\kappa = 4.5$ mS cm⁻¹; $n = 6$; mean value \pm CI ($\alpha = 0.05$).

ChemSusChem 10 (2017) 958-967; *Appl. Catal. B-Environ.* 238 (2018) 546-556

ChemElectroChem 6 (2019) 3731-3735; *Eng. Life Sci.* 17 (2017) 77-85, *Front. Energy. Res.* 7 (2019) 98

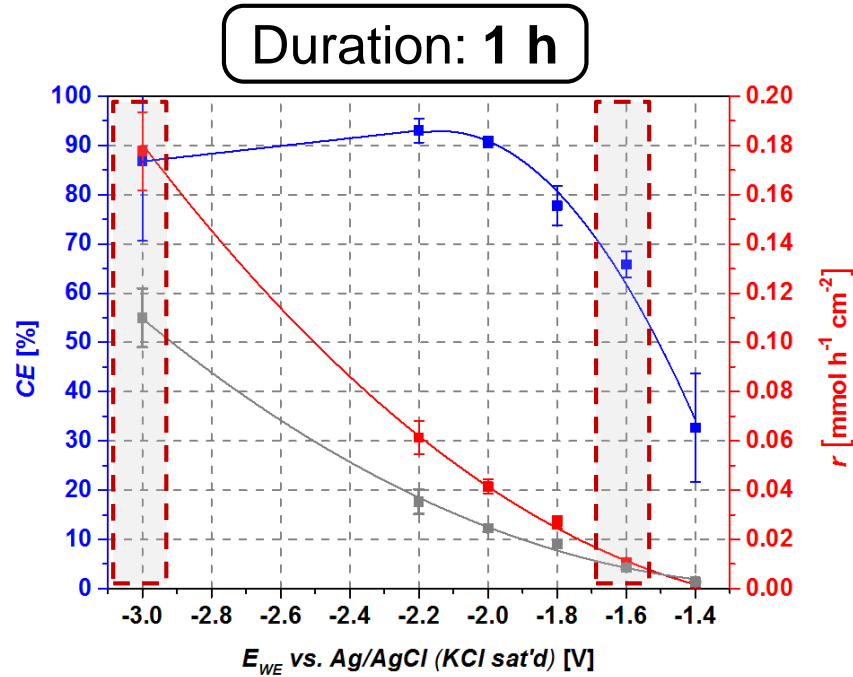


50 mL

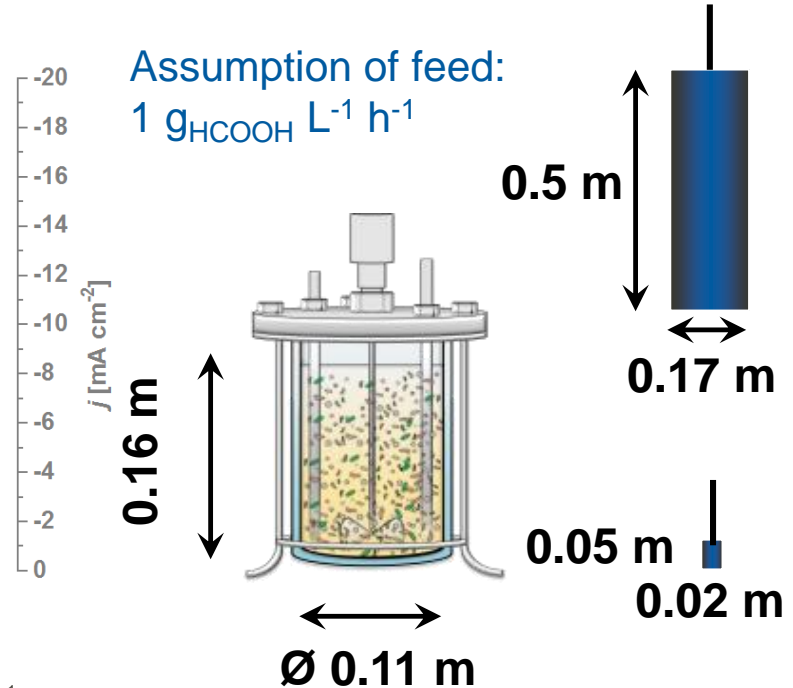
825 mL

From CO₂ to formate as C₁-feedstock

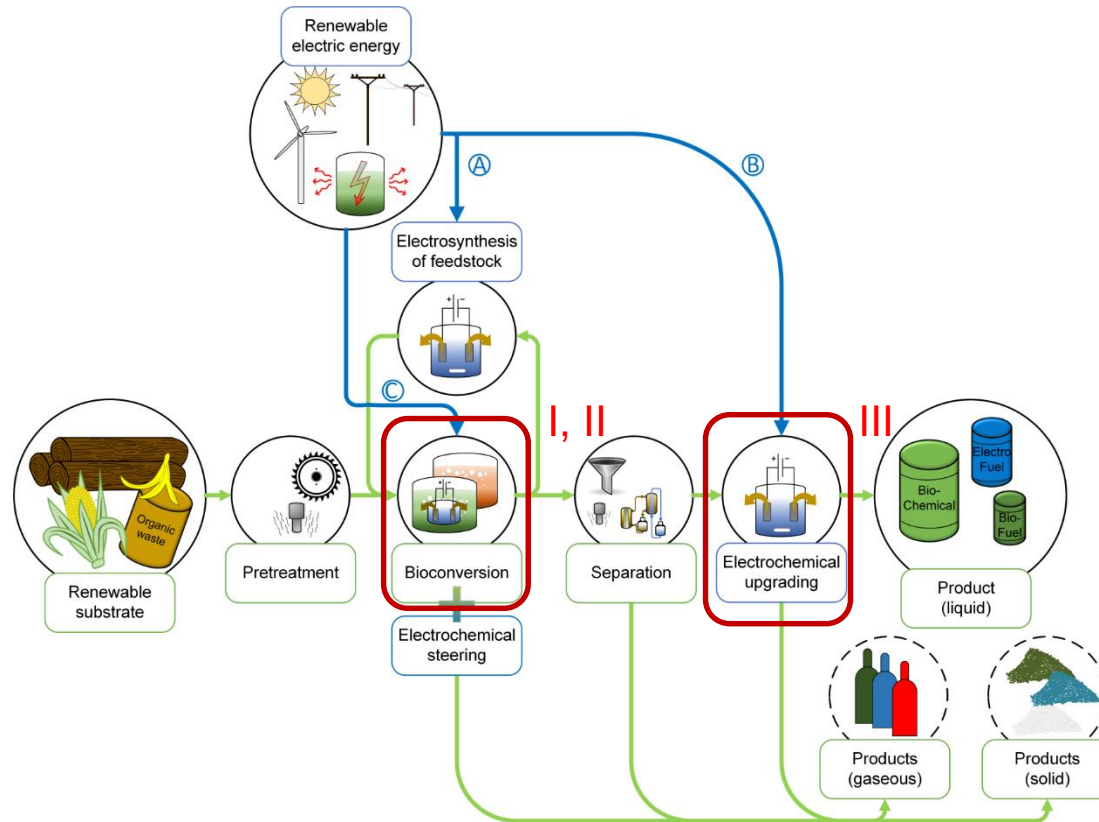
Engineering the electrochemical process



All experiments in 0.05 mol L⁻¹ NaHCO₃ (pH 6.5) as electrolyte solution, $\kappa = 4.5$ mS cm⁻¹; $n = 6$; mean value \pm CI ($\alpha = 0.05$).



The future: Electrobiorefineries



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ChemElectroChem 6 (2019), 4126 - 4133

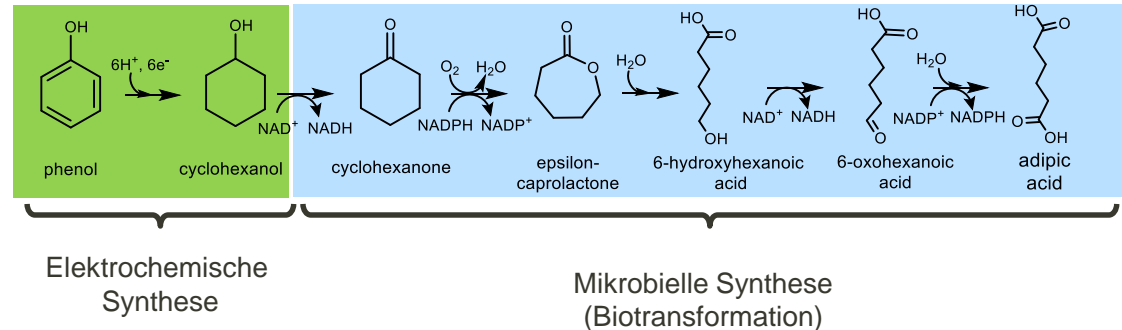
Biobasierte Polymerbausteine



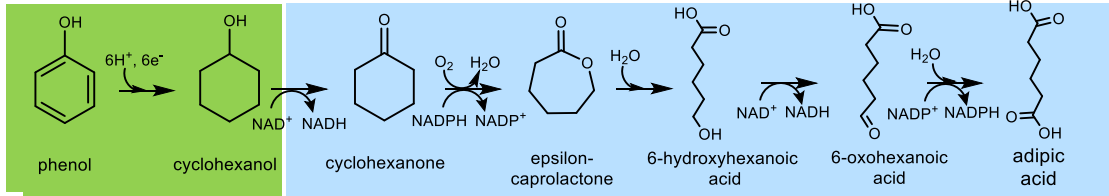
- **Status quo:**
Polymere auf petrochemischer Basis
- **Herausforderung:**
Polymere auf Basis erneuerbarer, nachhaltiger Rohstoffquellen im Rahmen einer biobasierten Kreislaufwirtschaft



- **Lösung:**
Elektrifizierung einer biobasierten Wertschöpfung
- **Beispiel:**
Polyamide/ Nylon-6,6
Vielfältiges und universelles Polymer
Nylon-6,6 besteht zu 50% aus Adipinsäure



Biobasierte Polymerbausteine



Elektrochemische
Synthese



Mikrobielle Synthese
(Biotransformation)

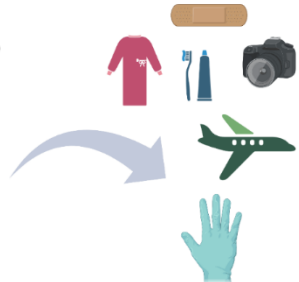
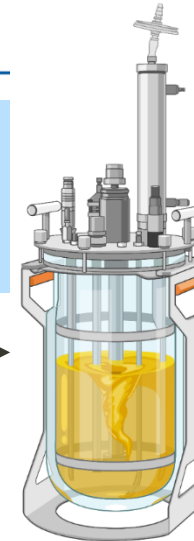
Kompetenzen

- Prozessidentifikation und –entwicklung in der nachhaltigen Elektrosynthese
- Entwicklung von Ganzzell-Biokatalysatoren
- Entwicklung von kombinierten mikrobiellen-elektrochemischen Prozessketten (Elektrobioraffinerien)

Hintergrund:

Proof-of-concept: *Green Chemistry*, 25 (12), 4662 - 4666

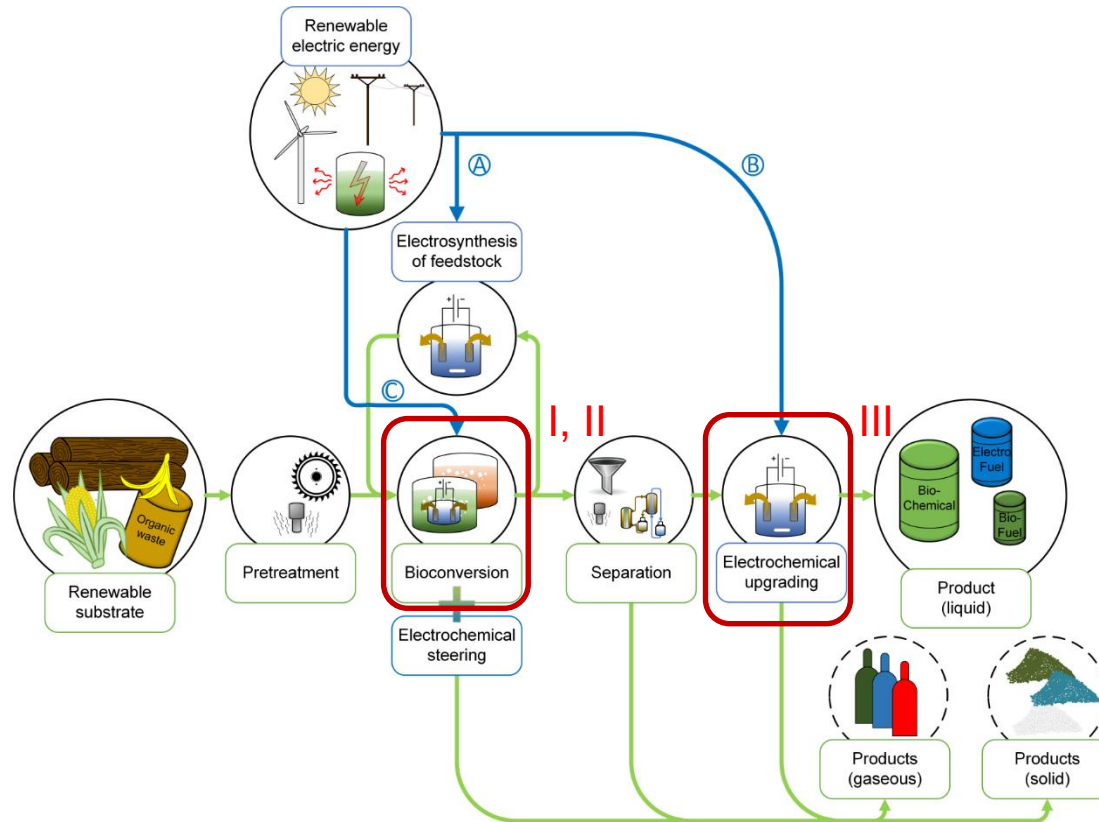
UFZ-Patente: WO2018046104, WO2020052762



TRL 2 - 4

TRL 5 - 6

The future: Electrobiorefineries



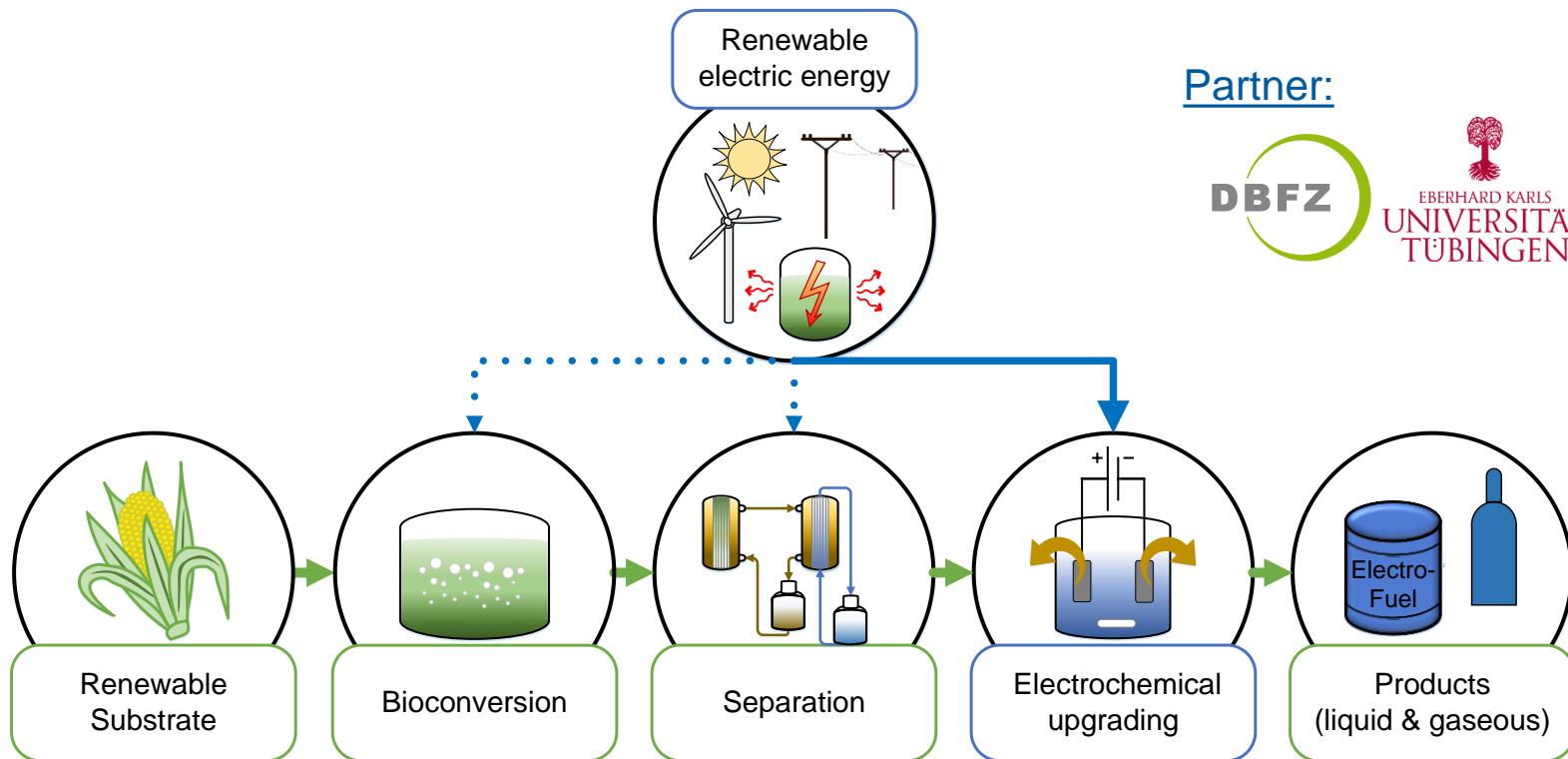
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ChemElectroChem 6 (2019), 4126 - 4133

Electrobiorefineries

Drop-in fuel additive from biomass and electric power



Partner:



Electrobiorefineries

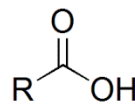
Drop-in fuel additive from biomass and electric power



corn beer

steered microbiome

0.59 gCOD g⁻¹COD
[MCCA/ corn beer]

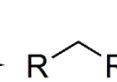


R being
[CH₂]₄-CH₃ to
[CH₂]₇-CH₃

middle chain carboxylic
acids (MCCA)

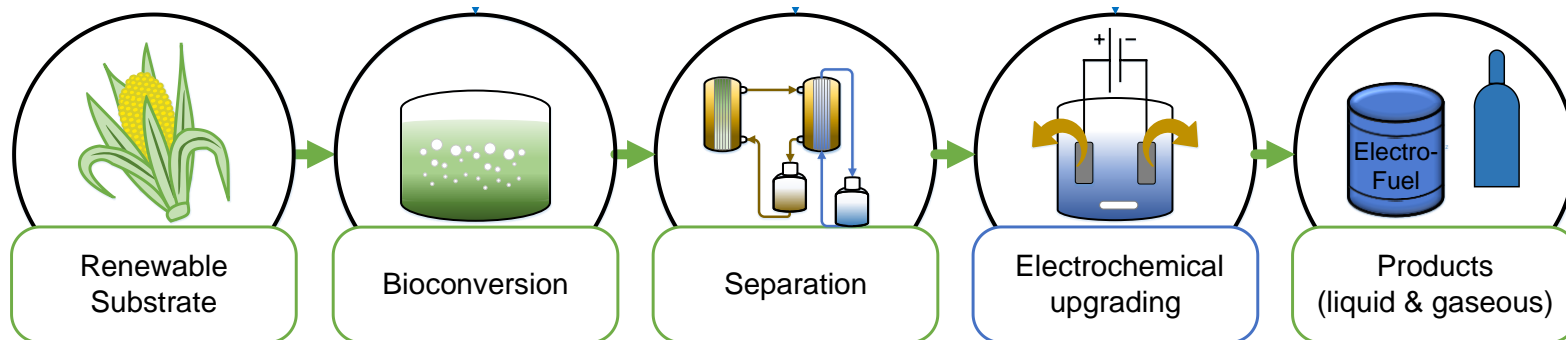
Kolbe-reaction

CE: 80%



R being
[CH₂]₄-CH₃ to
[CH₂]₇-CH₃

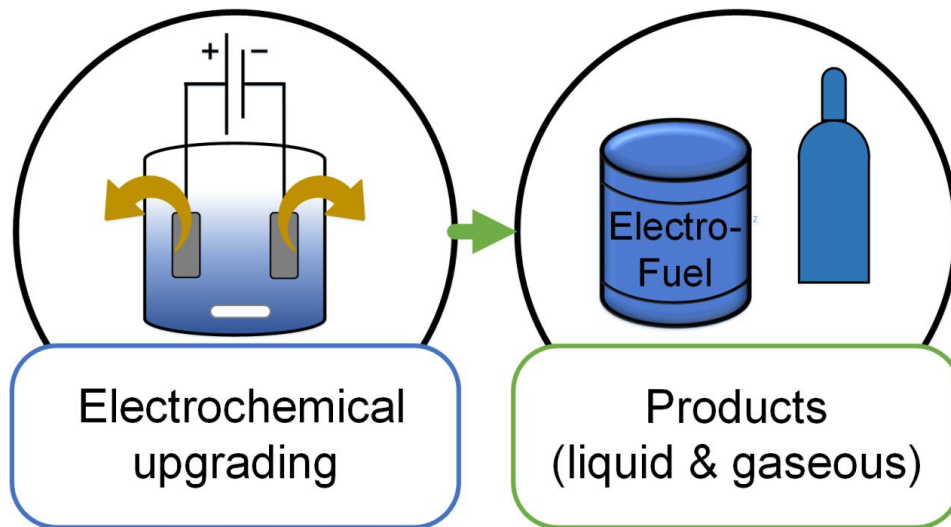
mixture of alkanes



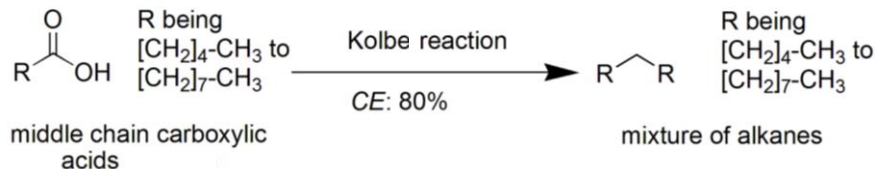
Energy & Environmental Science (2017) 10 2231 – 2244; *ChemSusChem* 9 (1), 50 – 60; *ChemElectroChem* 4 (6), 1378 - 1389
WO 2016012279A1; PCT/EP2015/065877

Electrobiorefineries

Drop-in fuel additive from biomass and electric power



- High diversity of feedstock can be exploited
- Drop-in fuel additive is gained with
 - >50% carbon yield
- Simple DSP
- Technical scale demonstration



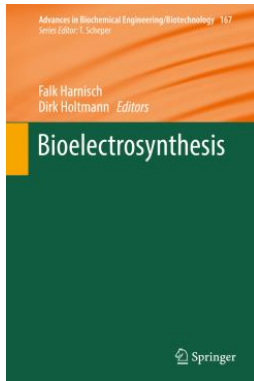
Energy & Environmental Science (2017) 10 2231 – 2244;
ChemSusChem 9 (1), 50 – 60; *ChemElectroChem* 4 (6),
1378 - 1389
WO 2016012279A1; PCT/EP2015/065877, *Fuel*, accepted

Take home messages:

Wir arbeiten an der Zukunft von Elektrobioraffinieren!

- Screening and feedstock
- Screening, utilizing and engineering microbial resources
- Microbial electrochemical synthesis & electroorganic synthesis
- Scaling and engineering of reactors and processes
- New process lines
- More to come

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Series Editor: Th. Scheper et al.
Volume 167: Bioelectrosynthesis
Volume Editors: F. Harnisch & D. Holtmann