The Fuel Science Center

Adaptive Conversion Systems for Renewable Energy and Carbon Sources

Workshop 2025+

Aachen, 07.06.2023

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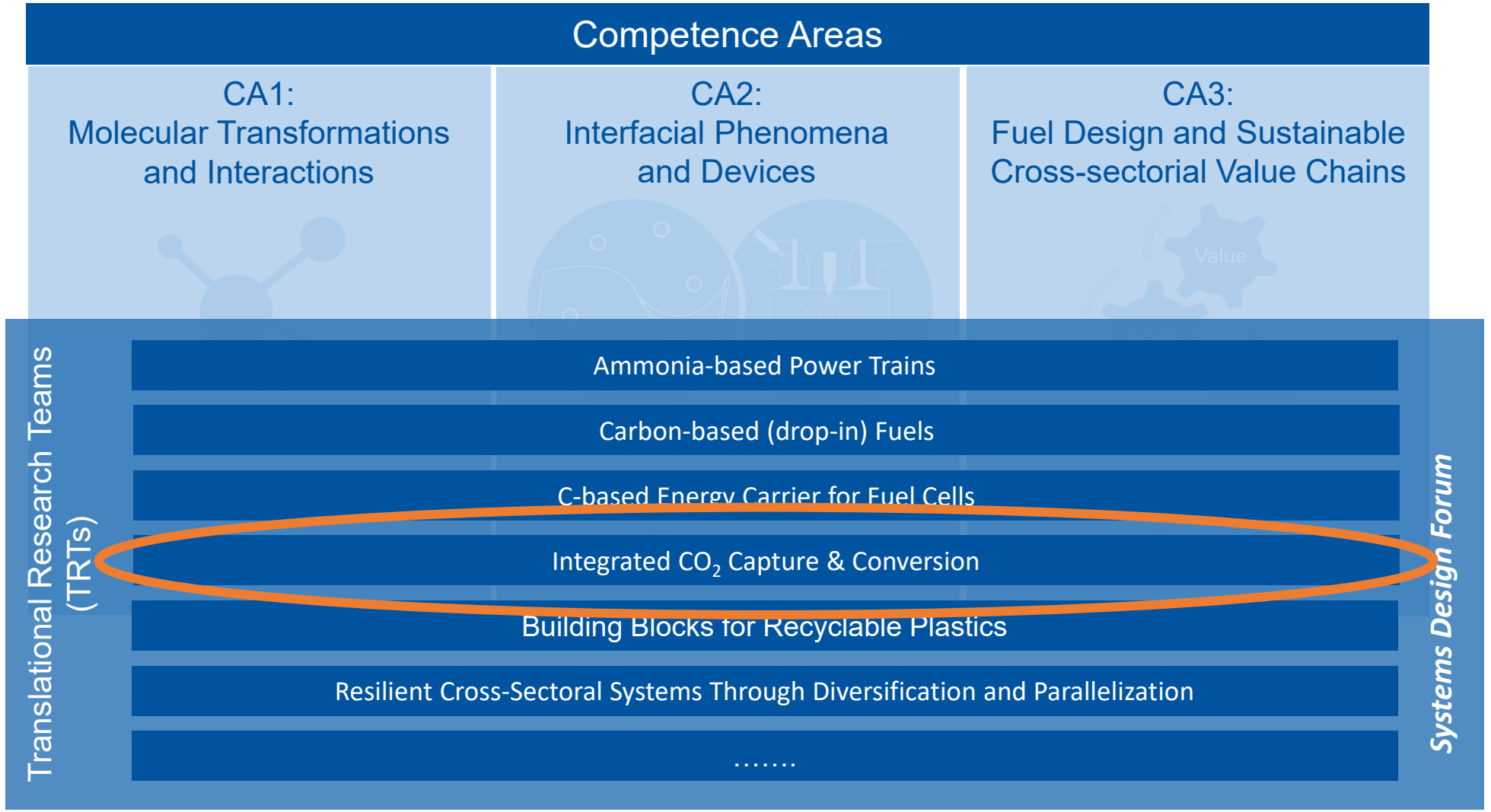
Structure of the Research Program: Examples for new TRTs



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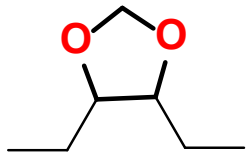
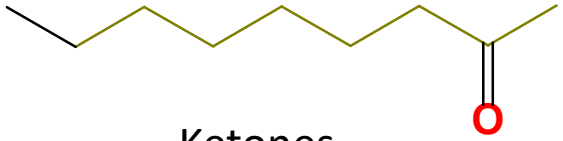
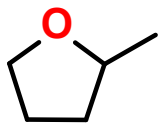
The Fuel Design Process: Molecular Structures for Fuels & Chemicals



Acetals
(e.g. OMEs => cyclic acetals)

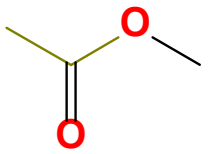


Ketones
(e.g. methylketones)



Furanics
(e.g. 2-MTHF)

NH_3
Ammonia
(and amines)

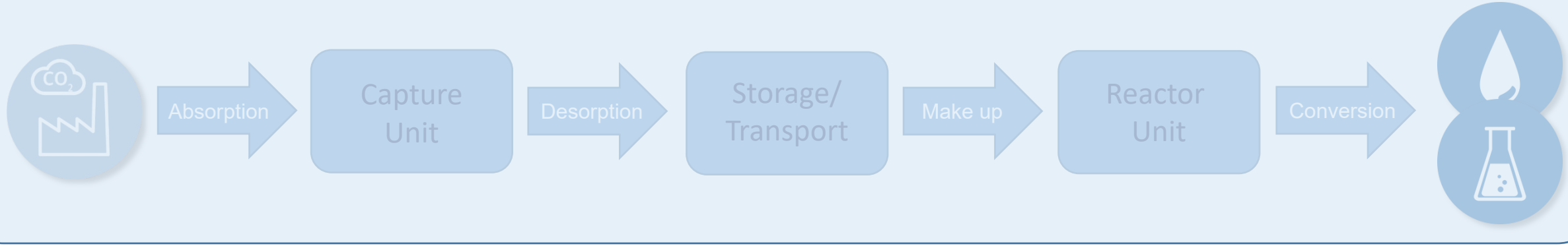


Esters
(e.g. acetate)

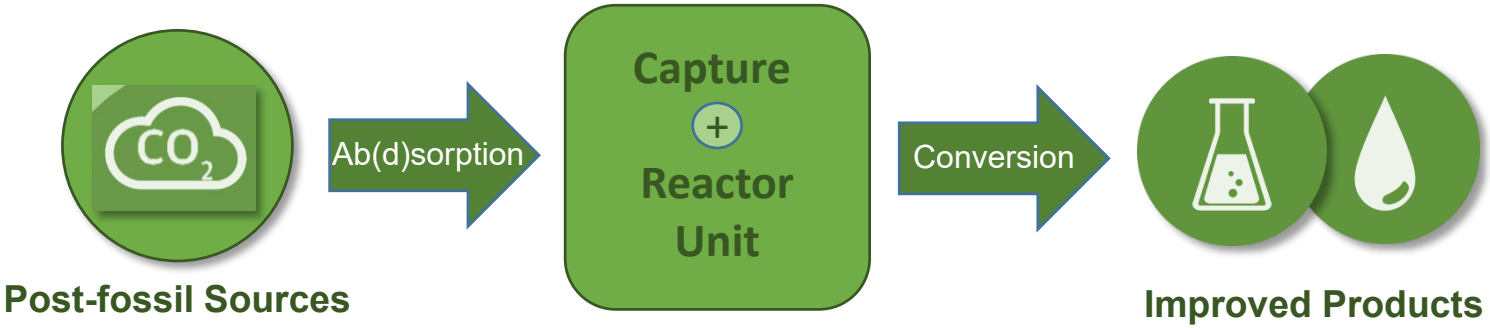
Alcohols
(e.g. HyFiT)

Integrated Carbon Capture and Conversion – Challenges and Opportunities

Carbon Capture and Conversion (CCU) – Traditional Approach



Integrated Capture and Conversion – Recent Approach (FSC focus)



Post-fossil Sources
(*biogenic, air*)

Integrated Process
(*multifunctional, multidimensional, dynamic*)

Improved Products
(*function, emission, recyclability*)

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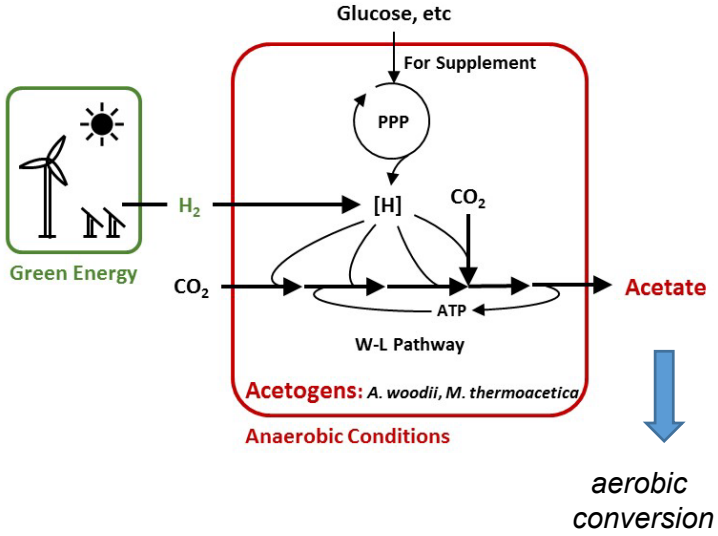
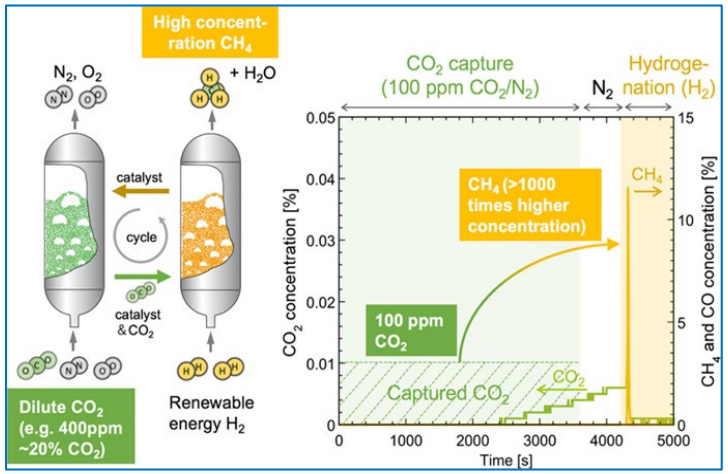
Integrated Carbon Capture and Conversion (IC^3) – Literature Examples

Biological



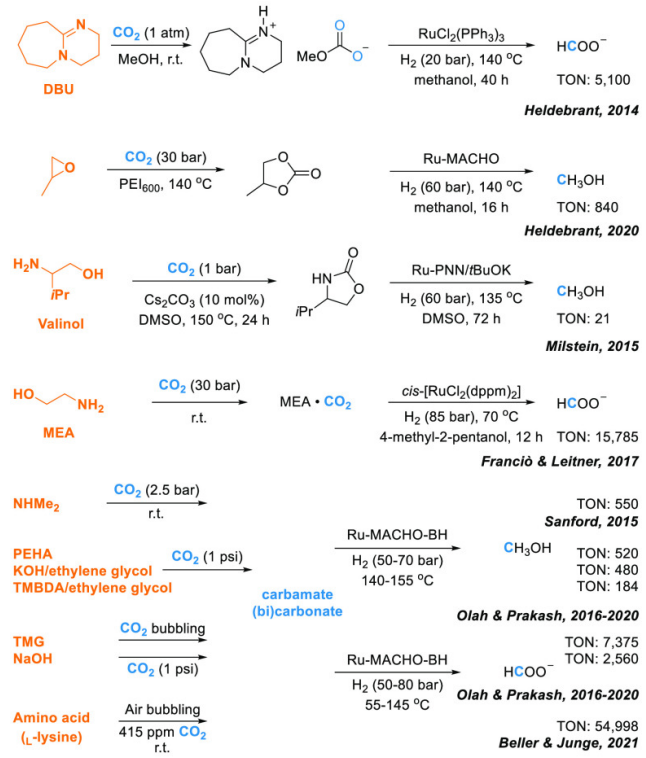
Park et al.
Nat. Metabolism. **2019** *1*, 643–651.

Heterogeneous



A. Urakawa, et al.
ACS Sust. Chem. & Eng. **2021**, 9, 3452-3463

Homogeneous



Review: M. Beller et al.,
JACS Au, **2022**, *2*, 1020–1031.

=> A number of reviews/perspectives have appeared since Sept 2022

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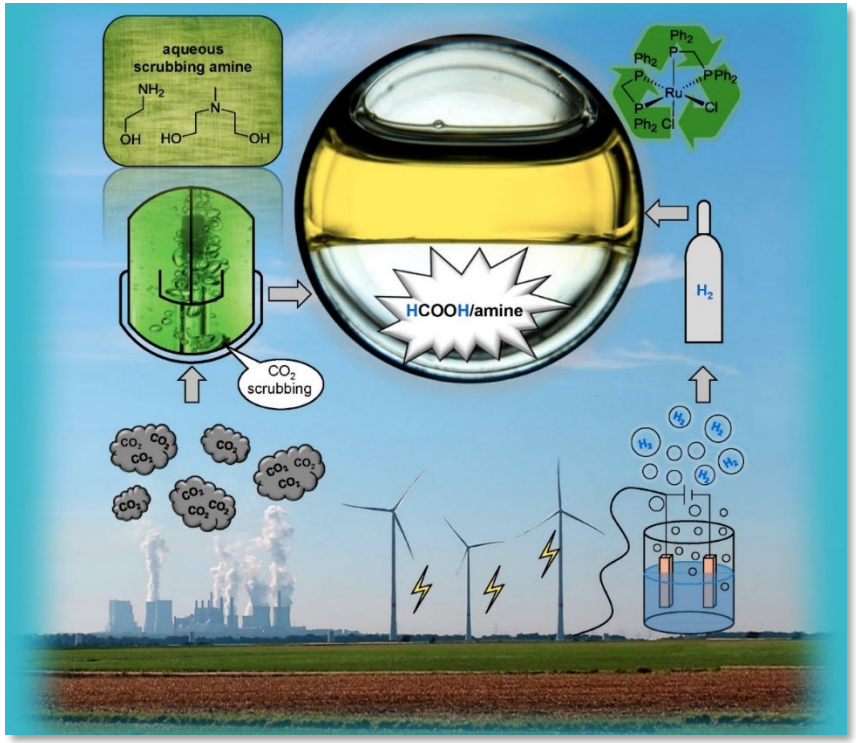
Integrated Carbon Capture and Conversion (IC^3) – FSC Examples

Current state-of-the-art

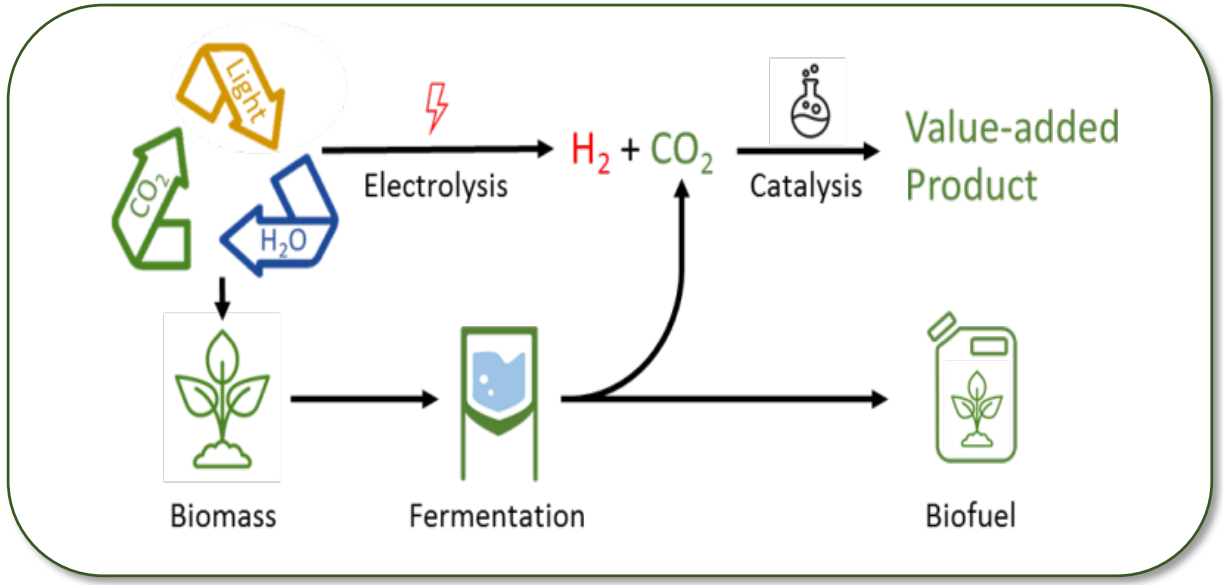
Converting captured CO_2



with A. Jupke;
ChemSusChem, **2017**, *10*, 1085-1093.
Green Chem. ***2019***, *21*, *6307-6317*

New „integrative“ approach

Converting biogenic CO_2 „in situ“



with L. Blank;
Green Chem., **2021**, *23*, 9860-9864.

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Integrated Carbon Capture and Conversion (IC^3) – Questions

1) **Is this concept part of current research activities in your specific area or discipline?**
   If so, how would you define the state-of-the-art?

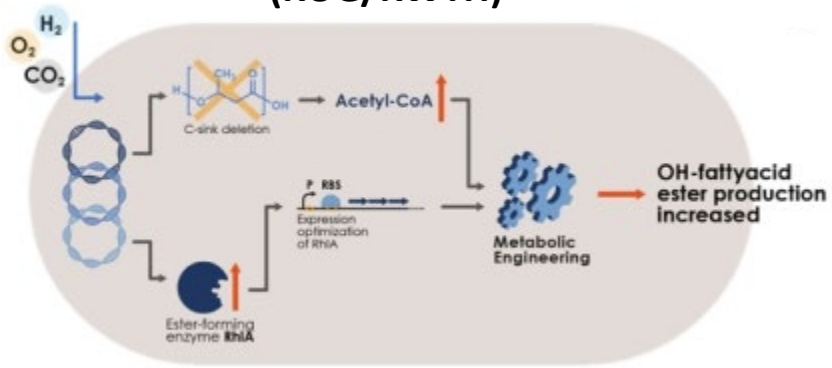
2) **Is the concept part of current research activities in your team?**
   If not, which of your activities would you consider relevant?

3) **Scientific / methodological developments and breakthroughs from your research area**

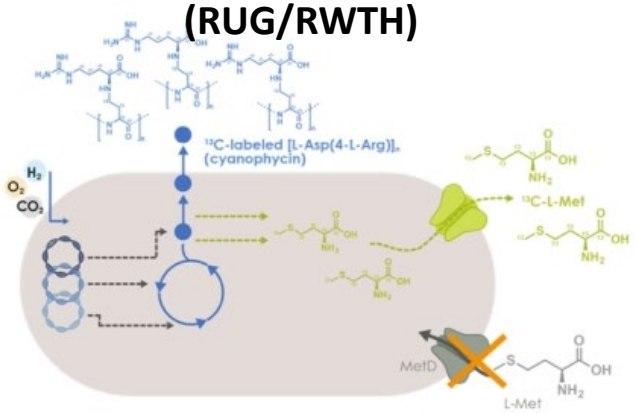
Integrated Carbon Capture and Conversion (IC^3) – Bio-Catalysis as Example

Ongoing microbial H_2-driven CO_2-fixation studies in Lauterbach and Blank lab within the H2020 project ConCO_2rde (in total 11 PhDs):

OH-fattyacid ester production (RUG/RWTH)

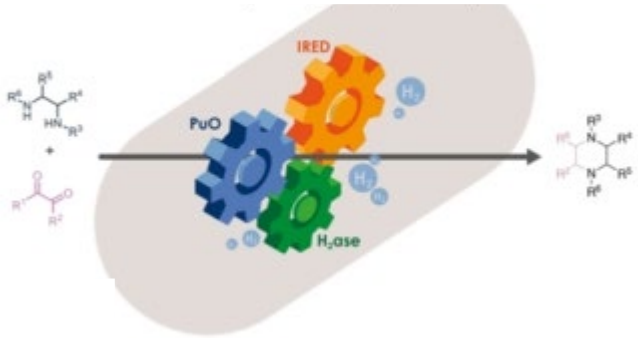


Synthesis of isotop-labeled amino acids (RUG/RWTH)

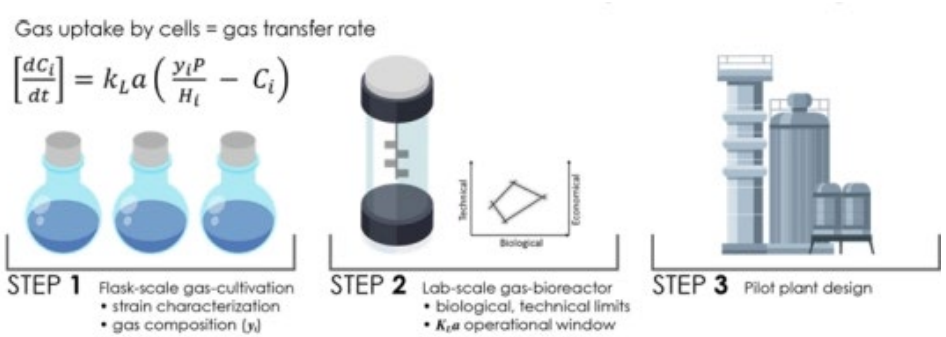


Production of piperdines (RWTH/INSA)

Production of functionalized piperazines (RWTH/RUG)



Gas Fermentation (ACIB/RWTH)



<u>Lauterbach publication list on H_2 conversion:</u>

Nat. Commun., **2023**, 14, 2693.
J. Am. Chem. Soc., **2022**, 144, 37, 17022–17032
Chem. Commun., **2022**, 58, 10540-10543
Angew. Chem. Int. Ed., **2021**, 60,15854–15862
Metab Eng., **2021**, 68, 199-209.
Chem. Commun., **2020**, 56, 9667 - 9670
Angew. Chem. Int. Ed., **2020**, 5 20229:10929–10933
Green Chem, **2019**, 21, 1396-1400

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Integrated Carbon Capture and Conversion (IC^3) – Bio-Catalysis as Example

- Adaptive combination of Knallgas bacteria (CO_2-fixing) and Pseudomonas production strains (Lauterbach and Blank)

  Angew. Chem. Int. Ed. ***2023****, 62, e202215013 (Carbon-Negative Biosynthesis)*

- Bubble-free gas fermentation (membrane technology for safety, efficiency) in collaboration with M. Wessling

  Biotechnol Bioeng. ***2023*** *120:1269-1287* (Membrane stirrer system)

- Production of chemicals/biomass by recombinant Knallgas bacteria using formate from chemical synthesis

  Curr. Opin. Chem. Biol. **2019** 49:91-96. (Review about Knallgas bacteria)

- Polymer (PHA) production from CO_2 by Knallgas bacteria for further functionalisation

  J Biotechnol. **2015** 20:119-27 (High PHA production by C. necator)

Integrated Carbon Capture and Conversion (IC^3) – PIs and Disciplines

Biology: **Blank, Lauterbach**, Rother

Process: **Jupke, Mitsos, Wessling,** *Khetan*, Leonhard

Chemistry: Bolm, **Herres-Pawlis**, **Klankermayer, Leitner, Palkovits,** *Picini*, Simon, ***Tüysüz***

Electro-Catalysis: Eichel, Mayrhofer, *Mechler*, N.N./CEC

Analytics: DeBeer, **Wiegand**, **Zobel**

System: **von der Assen, Walther**

=> Electrochemical approaches?
=> Overlap/Synergy with other TRTs?

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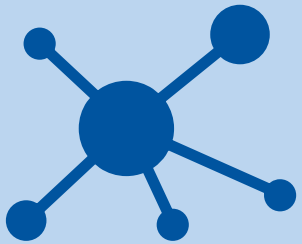
Scientific Challenges and FSC Competences

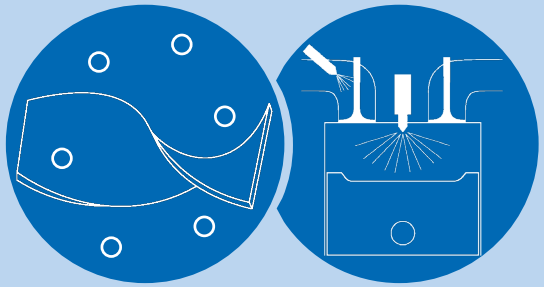
Competence Areas

CA1: Molecular Transformations and Interactions



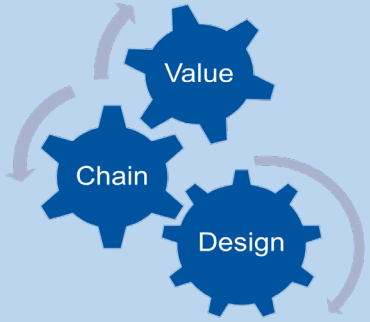
synthetic targets
catalyst & materials
multifunctional systems
dynamics / mechanisms

CA2: Interfacial Phenomena and Devices



phase equilibria
mass transfer and kinetics
model-based reactor design
dynamic reactor modeling

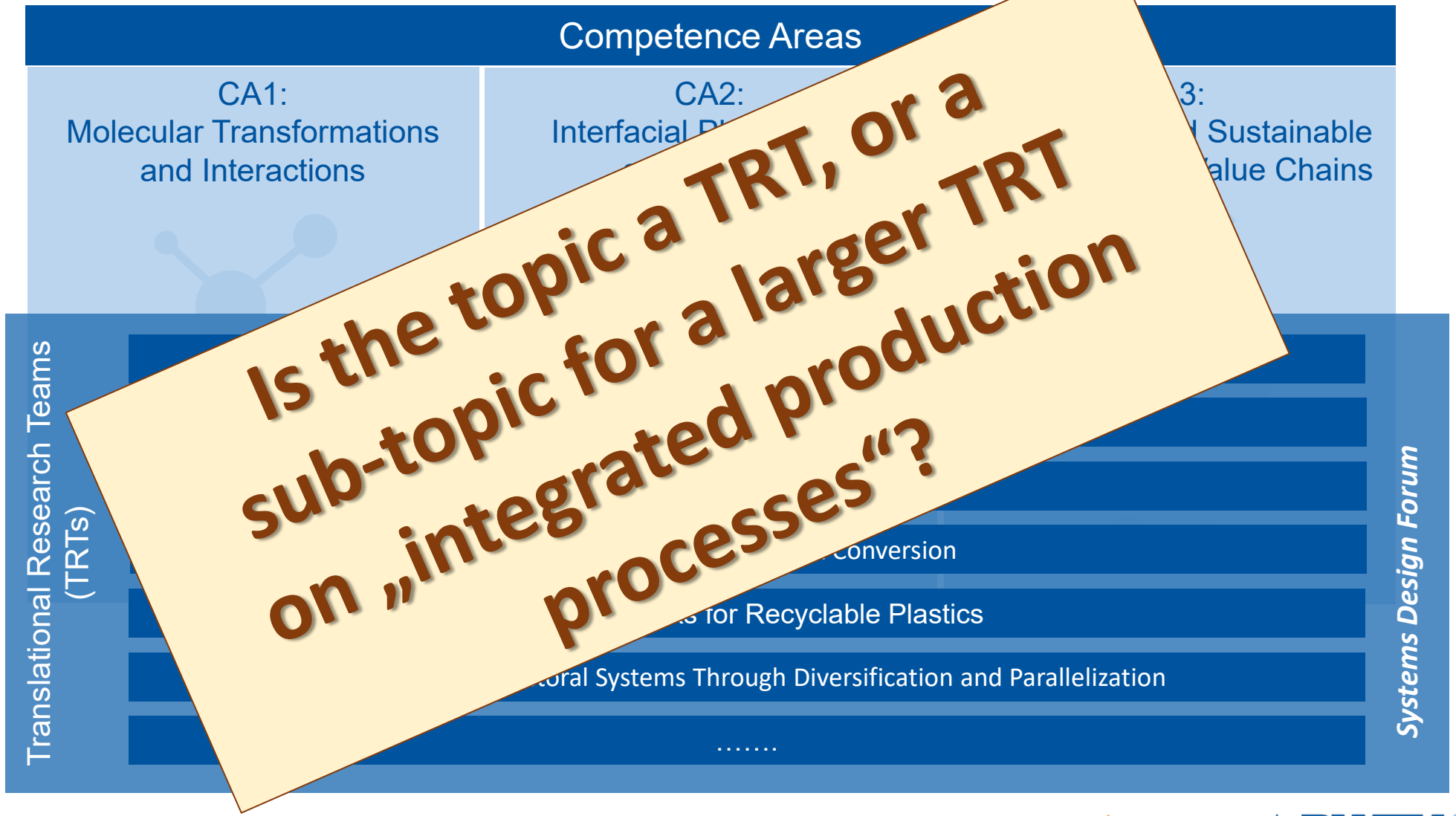
CA3: Fuel Design and Sustainable Cross-sectorial Value Chains



conceptual process design
value chains
LCA & TEA
decentralized production

Integrated CO_2 Capture & Conversion

Structure of the Research Program: Examples for new TRTs



Is the topic a TRT, or a sub-topic for a larger TRT on „integrated production processes“?

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