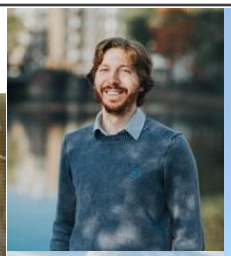
Green Chemical Reaction Engineering at the Engineering and Technology Institute of the University of Groningen, [illegible]ds

Dr. Peter J. Deuss

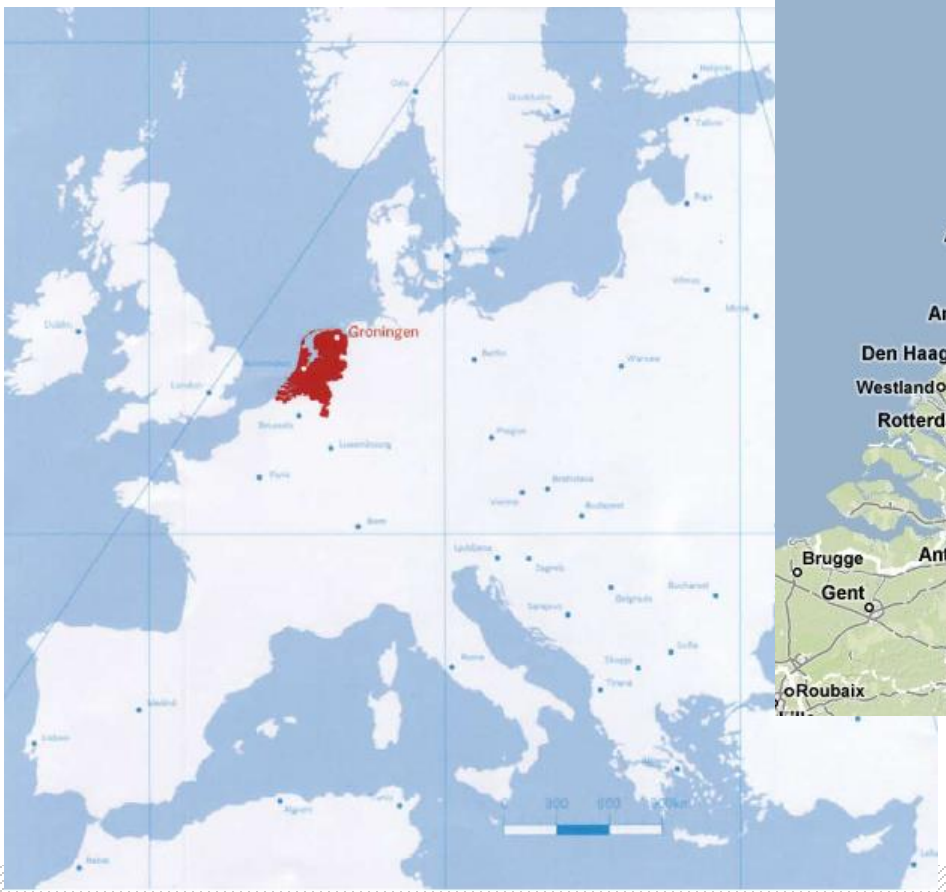
Prof.dr.ir. Erik Heeres

Dr. Jun Yue



Also Prof. F. Picchioni, Dr. P.P. Pescarmona and Dr. P. Raffa (Product Technology)

Groningen, NL



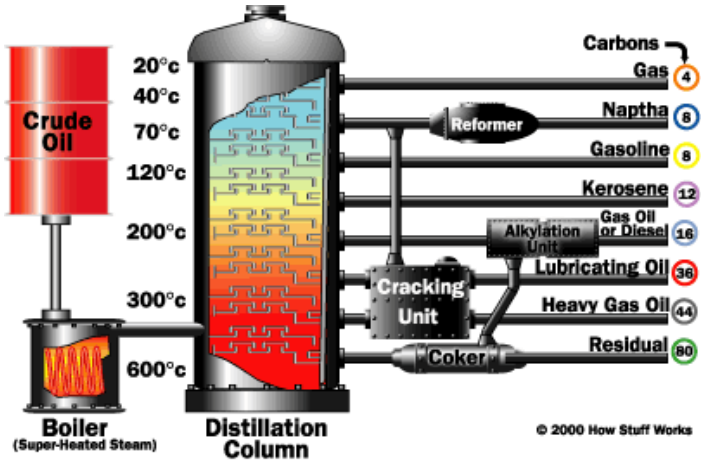
The University:

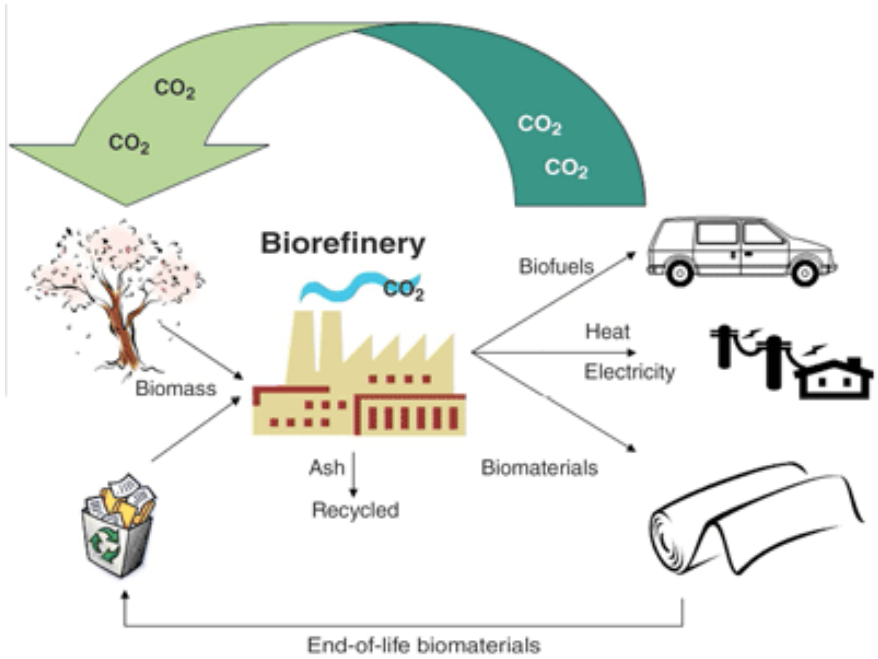
- 28,756 students (1 September 2016)
- 5,990 international students (1 September 2016)
- 167 Master's degree programmes and specializations, of which 126 taught in English
- 48 Bachelor's degree programmes, of which 29 taught in English
- 2,019 PhD's
- a third of the academic staff is international
- The three spearheads: Energy, Healthy Ageing and Sustainable Society

Faculty of Science and Engineering

Nobel Prize 2016
Prof. B. L. Feringa

Green Chemical Reaction Engineering





New catalysts, new technology, new processes

Research Theme Green Chemical Reaction Engineering

Biomass

CATALYSIS

- Research at the interface between chemical engineering and chemistry
- Preferably using real feeds
- Homogeneous and heterogenous catalysis

Biofuels

Biobased chemicals

Biobased materials

Biofuels: specific topics

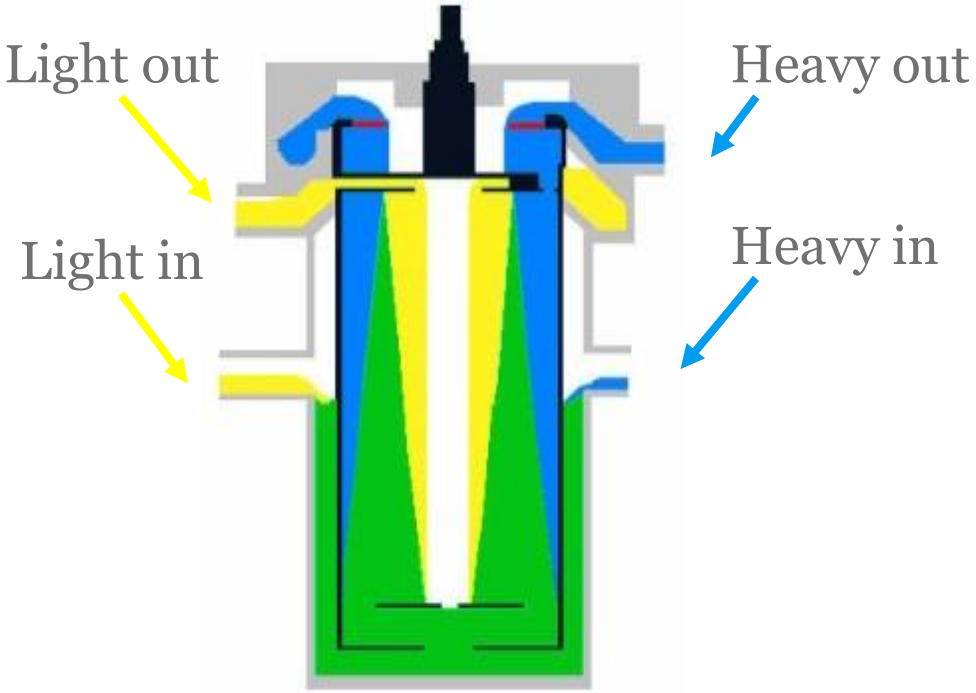
- (Catalytic) Pyrolysis -> BioBTX
- Pyrolysis oil upgrading using catalytic hydrotreatment
- Biodiesel intensification using advanced technologies
- Green gas by gasification in supercritical water

Biobased chemicals: specific topics

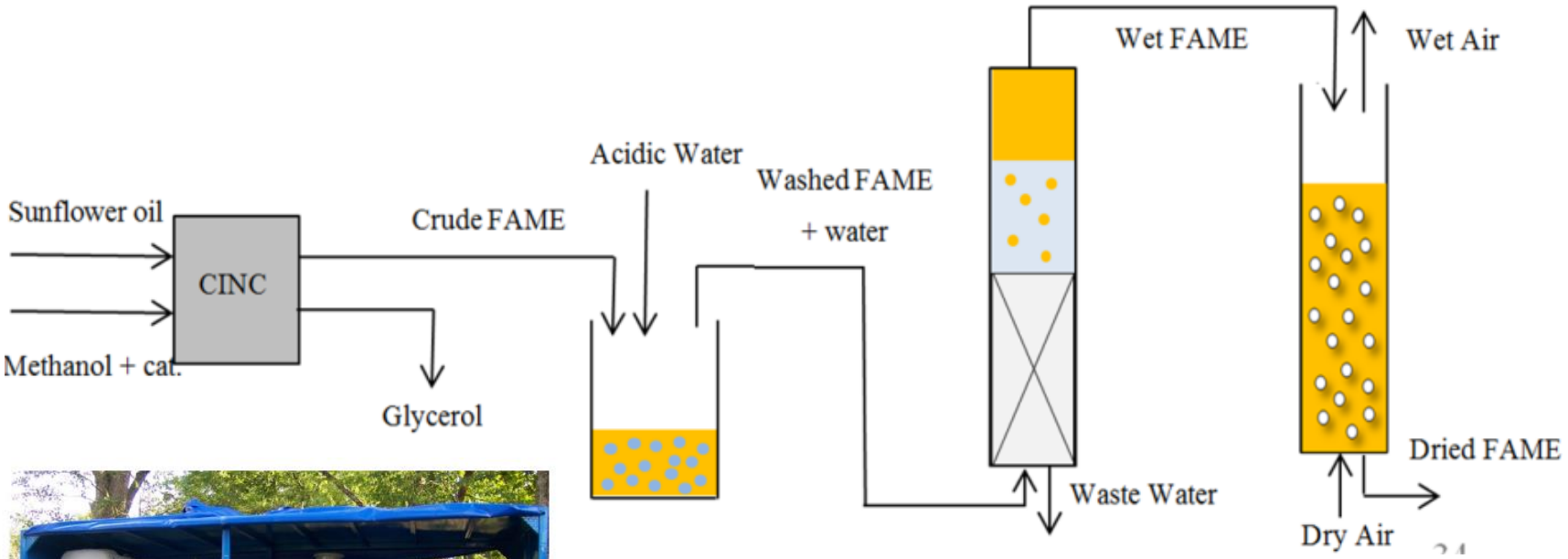
- Platform chemicals
  - Levulinic acid and derivatives
  - Hydroxymethylfurfural (HMF) and derivatives
- Lignin and humin valorization using catalytic technology
- Polysaccharide modifications
  - Starch
  - Aquatic polysaccharides

Intensification and Separation:

Centrifugal contactor separator (CCCS) devices



Mobile biodiesel unit using CCCS technology



Source: http://www.biodiesellogic.com

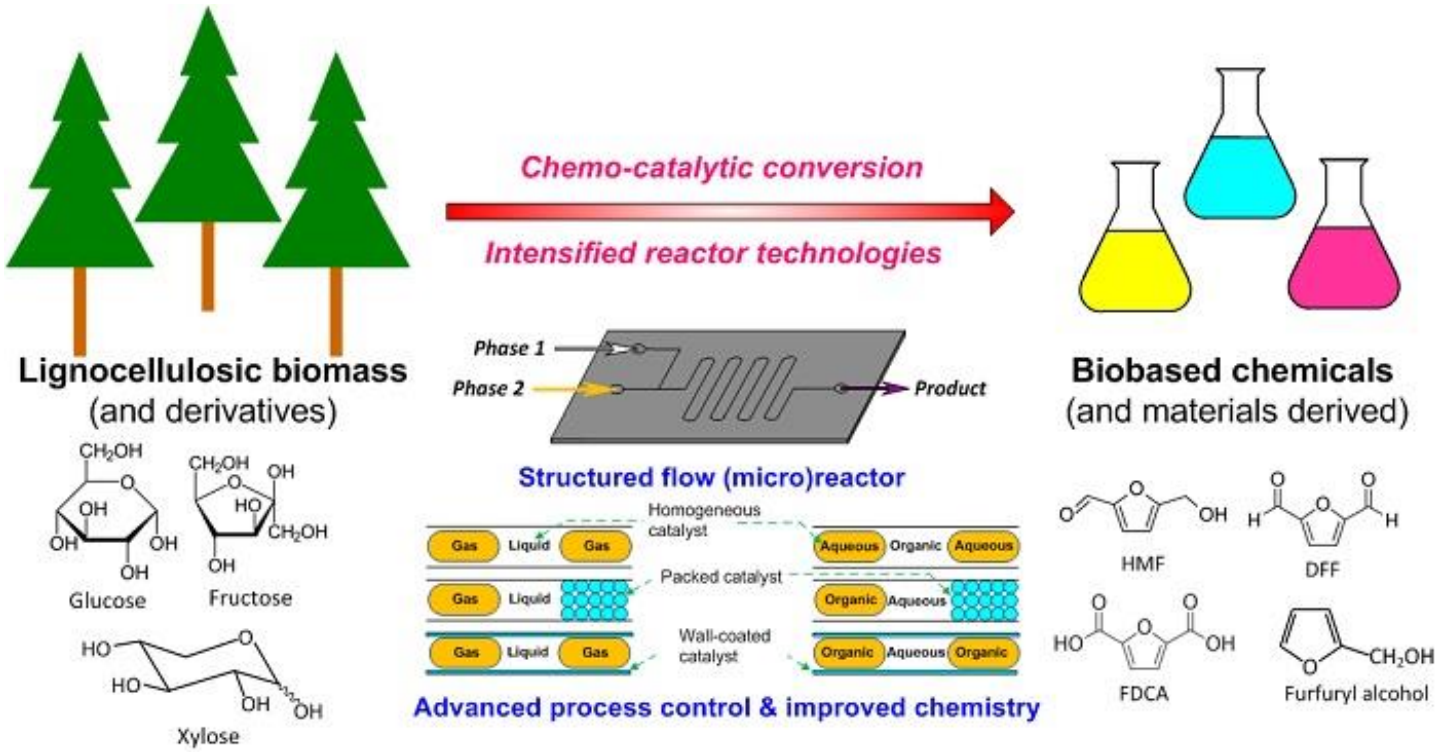
Flexible

On demand available

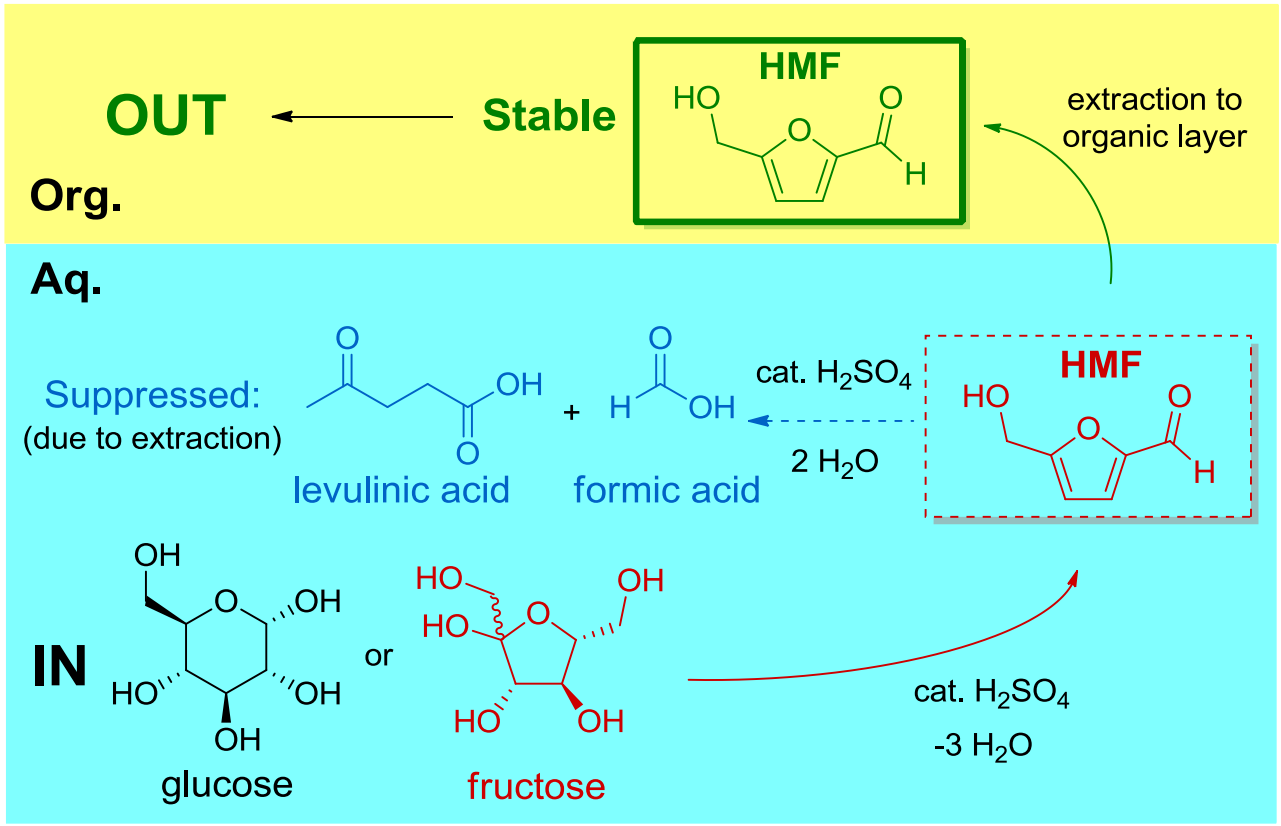
Jatropha/rubber seed

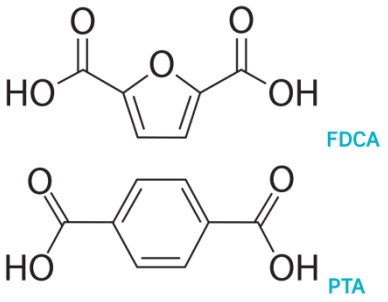
Intensification and Separation:

Structured flow (micro)reactors



Carbohydrates to HMF

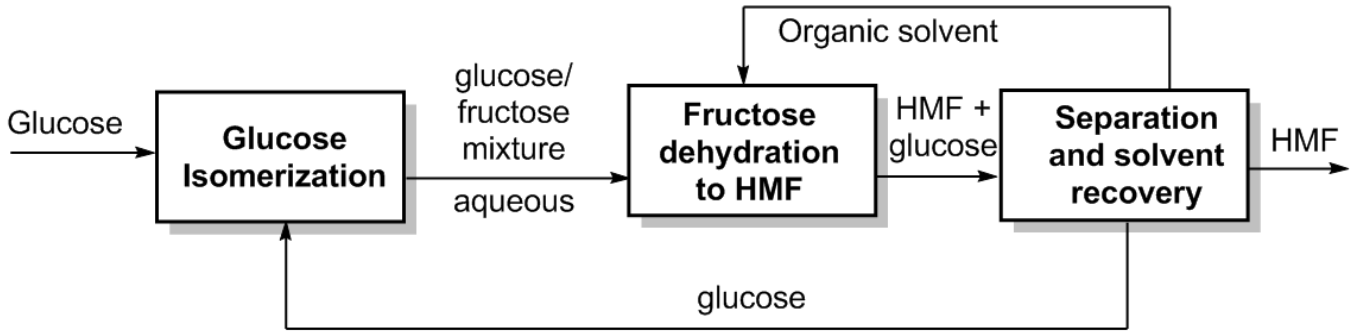




PEF

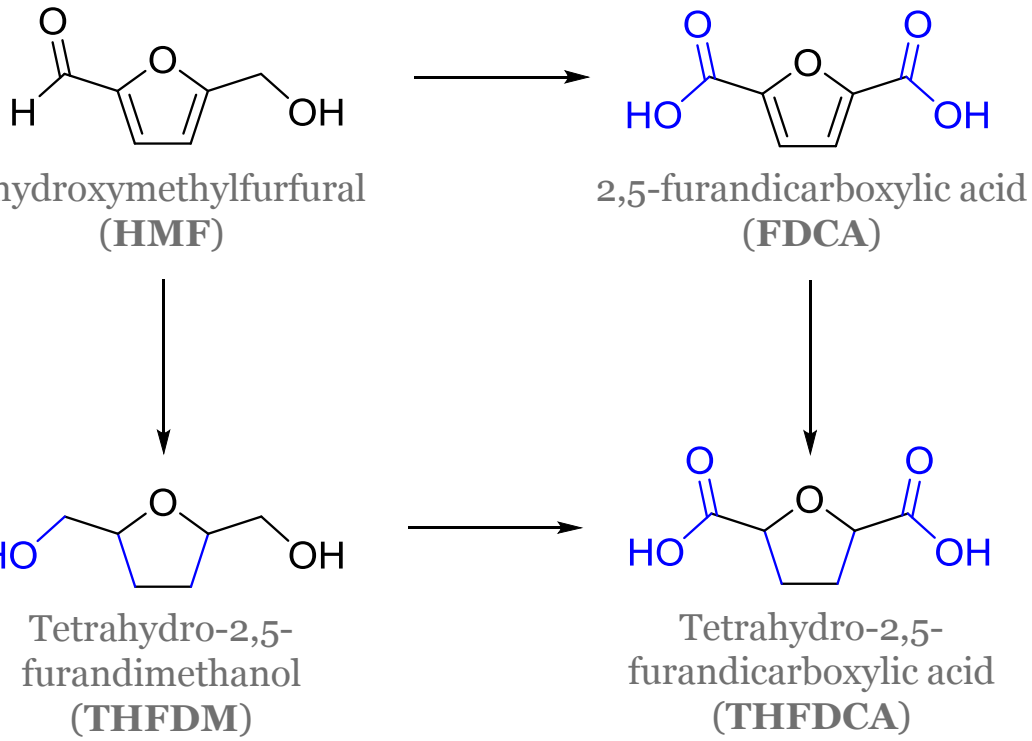
R. van Putten, J. vanderwaal, E. d.eJong, C. Rasrendra, H. J. Heeres, J. G. de Vries, Chem. Rev., 2013, 3, 1499
B. Girisuta, L. Janssen, H. Heeres, Chem. Eng. Res. Des., 2006, 84, 339.
B. Fachri, R. Abdilla, H. H. van de Bovenkamp, C. Rasrendra , H. J. Heeres, Sustainable Chem. Eng., 2015, 3, 30

Carbohydrates to HMF in continuous flow



B. Lubach, Master thesis, University of Groningen, Groningen, 2015 (manuscript in preparation)

HMF derivatives



5-hydroxymethylfurfural (**HMF**)

2,5-furandicarboxylic acid (**FDCA**)

Tetrahydro-2,5-furandimethanol (**THFDM**)

Tetrahydro-2,5-furandicarboxylic acid (**THFDCA**)

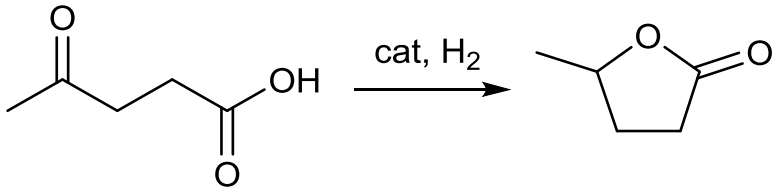
Oxidation – Reduction

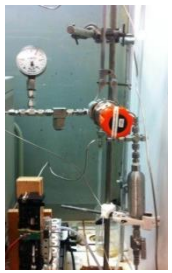
or

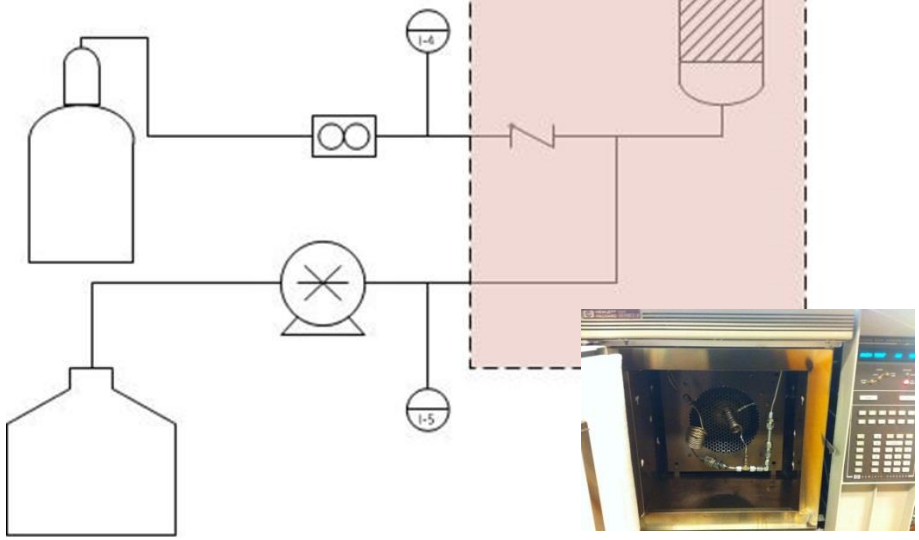
Reduction – Oxidation

G. Bottari, A. J. Kumalaputri, K. K. Krawczyk, B. L. Feringa, H. J. Heeres, K. Barta, ChemSusChem 2015, 8, 1323
K. Hiemstra and I.Chaabane, Master thesis, University of Groningen, Groningen, 2017 (manuscript in preparation)

Continuous hydrogenation of LA to GVL

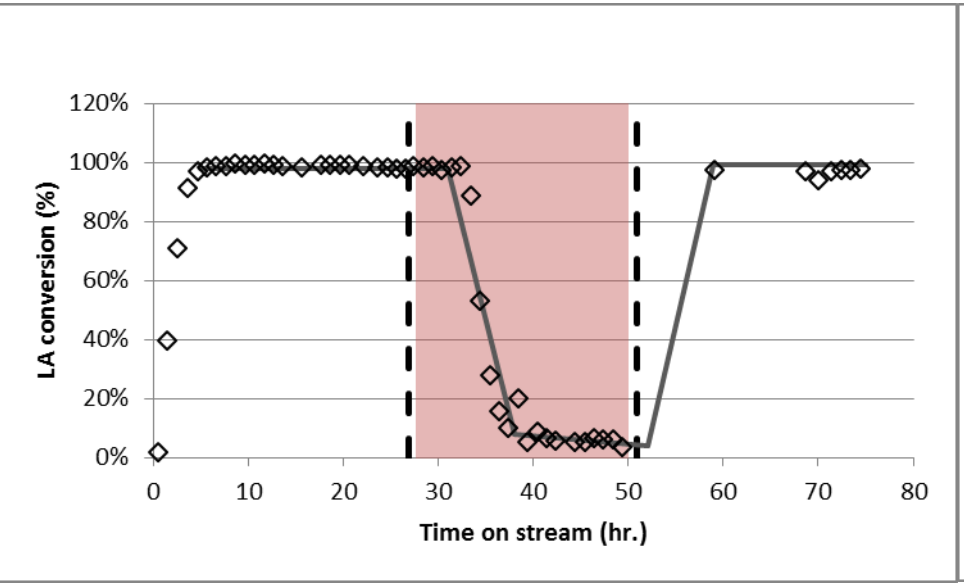


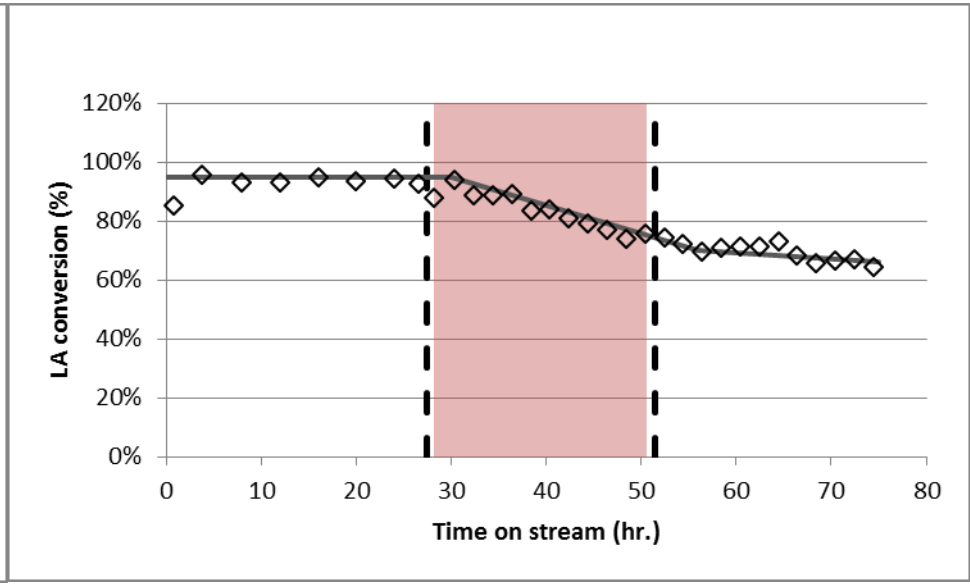




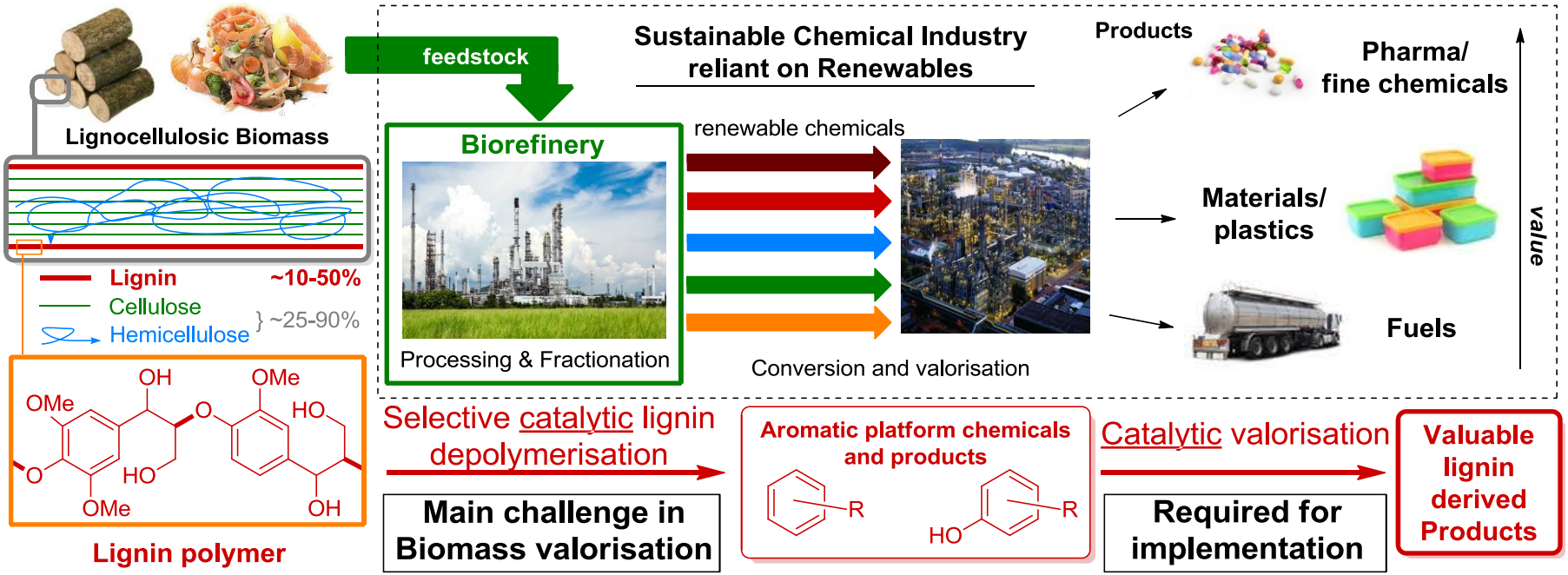
Hydrogenation of LA to GVL

- Catalyst evaluation
- Effects of impurities





Valorization of Lignin:



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Strengths and interests for collaboration

- Catalysis of Renewables
- Analysis of complex mixtures
- Determination of reaction pathways and kinetics
- Use of real feedstocks
- Reactor engineering

- New waste streams /biomass feedstocks
- Implementation of new catalytic technology

Thank you

btg

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Netherlands Organisation for Scientific Research
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RISTEK

Ciaran Lahive

Chris Lancefield

SuBiCat
A new Generation

CatchBio

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