GreenSolRes

Deliverable 2.3

Report on design of demo plant

Demonstration of solvent and resin production from lignocellulosic biomass via the platform chemical levulinic acid

The project leading to this application has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 720695

Bio-based Industries Consortium

BIO-BASED INDUSTRIES Public-Private Partnership

Horizon 2020 European Union Funding for Research & Innovation

About GreenSolRes

The need to establish economic and sustainable large-scale operations for the conversion of renewable resources to chemical building blocks is becoming increasingly urgent in the context of climate change and depleting fossil fuel reservoirs. Pathways for manufacturing of bio-based fuels and chemicals have been developed but most of them rely on sugar and starch crops for feedstock. GreenSolRes aims at a sustainable and competitive industrial production of the platform chemical levulinic acid (LVA) from lignocellulosic wastes and residues originating from forestry and agricultural sector. Further, the conversion of LVA into industry relevant building blocks γ-valerolactone (GVL), 1-methyl-1,4-butanediol (MeBDO) and 2-methyltetrahydrofuran (2-MTHF) will take place by new catalytic technology developed and demonstrated during the course of this project. Finally, these chemicals will be upgraded to solvents and resin monomers for the production of high added value adhesives and consumer products. This project was started in September 2016 and has a duration of four years.

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Hybrid Catalysis Custom Synthesis & Screening

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About this document

Deliverable Nº:	2.3	
Title	Report on design of demo plant	
Workpackage:	WP2 - Hydrogenation of levulinic acid	
Responsible beneficiary:	GFBiochemicals	
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Reviewers:	Walter Leitner	
Version:	1	
Due date of deliverable:	31.08.2017	
Version date:	23.08.2017	
Contact:	b.engendahl@GFBiochemicals.com	
Nature:	Report	
Review status	WP leader accepted	01/08/2017
	Reviewer accepted	21/08/2017
	SC accepted	28/08/2017
	Coordinator submitted	29/08/2017

Dissemination Level		
PU	Public	
CO	Confidential, only for members of the consortium (including the Commission Services)	X

Publishable Summary

The goal of WP2 is to deliver an engineering package of a full size levulinic acid hydrogenation plant with a capacity of 10.000ton per annum (10 kta) as well as a set of samples trials of the three hydrogenation products γ- valerolactone (GVL), 1,4-pentanediol (MeBDO) and 2-methyltetrahydrofuran (MeTHF).
The reaction of levulinic acid to γ- valerolactone (GVL), 1,4-pentanediol (MeBDO) and 2-methyltetrahydrofuran (MeTHF) is the second process step in the overall GreenSolRes value chain. In this step two different reactions take place:

1. The multistage hydrogenation of levulinic acid to GVL and MeBDO
2. The dehydrative-cyclisation of MeBDO to MeTHF.

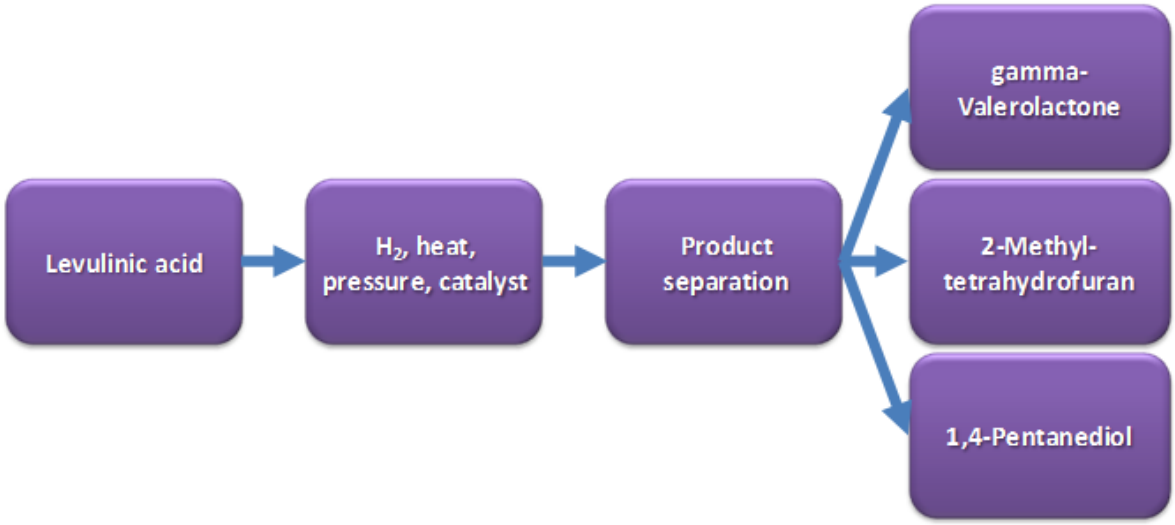

Figure 1: Second part of the value chain demonstration: Hydrogenation of levulinic acid to high-value products and building blocks.

In order to deliver a working process the reaction and process knowhow had to be transferred and gathered by the engineering team of both RWTH and GFBiochemicals. Process data was collected and gaps in the data identified.
A first process design and a list of over 300 parameters was compiled, data gaps were identified and assigned an impact on the process design. In several iterations over the course of six month, the process design was updated with new data available. RWTH and GFB engineers challenged each resulting version of the process design in multiple face to face sessions. The resulting improvements were integrated in the final process design.
Vapor liquid equilibrium (VLE) data of the product mixtures was identified as a high impact parameter that had to be obtained via a subcontract to a third party. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the graphical result of one of the measurements conducted by LTP (Laboratory for thermophysical properties, Oldenburg Germany).

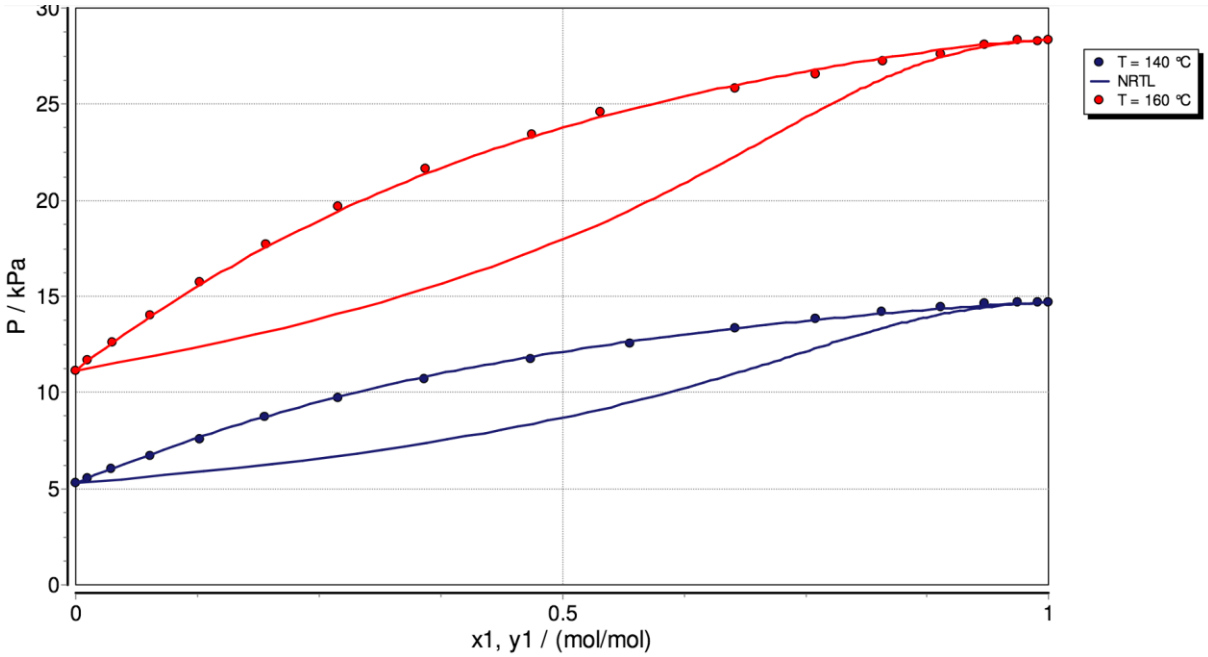

Figure 2: px-diagram of the binary mixture of GVL and MeBDO at two different temperatures. Dots = measured, line = calculated

The process reaction and separation strategy were decided upon and a detailed process description as well as process flow diagrams based on ASPEN calculations were prepared.

The scope of the demonstration plant was defined as follows:
The set-up's main task is testing the stability and activity of the homogeneous hydrogenation catalyst. In order to keep the set-up simple, all steps of the process that are not related to the hydrogenation catalyst stability will be carried out off-line such as e.g. the final product separation into marketable products with high purities. The plant is designed for continuous operation (up to 1.000 h with 1 service a day) in the main operating mode.

Brief process description:
The plant can be separated into three consecutive sections; Namely,

(1) Feed Mixing Unit,
(2) High-Pressure Reaction Unit and
(3) Low-Pressure Separation Unit.

In the feed mixing unit the raw materials can be loaded into a day tank. The catalyst can be added. The reaction takes place in High-Pressure Reaction Unit. Levulinic acid is converted 100% into GVL while the conversion of GVL to MeBDO is a variable in the operation of the set-up. Hydrogen is added and good gas dispersion is achieved using gas intake stirrers.
After exiting High-Pressure Reactor Unit the product mixture is treated in the separation section. The first step of the separation is to reduce the hydrogen pressure. The next step is to remove the reaction byproduct water. The final separation step is to remove organic product stream. The products are collected in product drums for future work-up.

A detailed process description was shared under confidentiality with three vendors to receive quotations for the construction of the demo plant.