Project Lumen: Plasmonic Catalysed Reactions in a Flow Reactor
sunlight fueled chemistry

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Introduction

Project Lumen focuses its research on finding ways to reduce the use of fossil fuels and substitute them for sunlight by using a state-of-the-art reactor set-up which uses a LED lamp to simulate sunlight.

The main subjects in this project are the design and the testing of a reactor set-up which possibly increases its performance, the optimization of the reactions with the plasmonic catalysts and the techno economics for the reactions and for scale-ups of the reactor set-up.

Method of research

Plasmonic catalyst:
A plasmonic catalyst is used to lower reaction energy and to (partially) replace heating by turning sunlight into heat.

Reactions:
The reaction chosen to test the reactivity of the plasmonic catalyst is the hydrogenation of methyl benzoate.

Problems previous reactor set-up:
In the previous reactor setup, there were problems concerning the pressure and gas flow which were both irregulars. Also, the pistons produced an irregular liquid flow of the reaction mixture.

Results

Figure 1

- For the hydrogenation of methyl benzoate the catalyst synthesized was **Ru/Al_2O_3** (Fig. 1)

- It was also a research goal to design a new reactor setup which solves the problems from the previous research groups concerning irregular pressure and gas flow. There is a Process flow diagram shown in figure 2 which contains two different designs of setups that are placed parallel to each other.

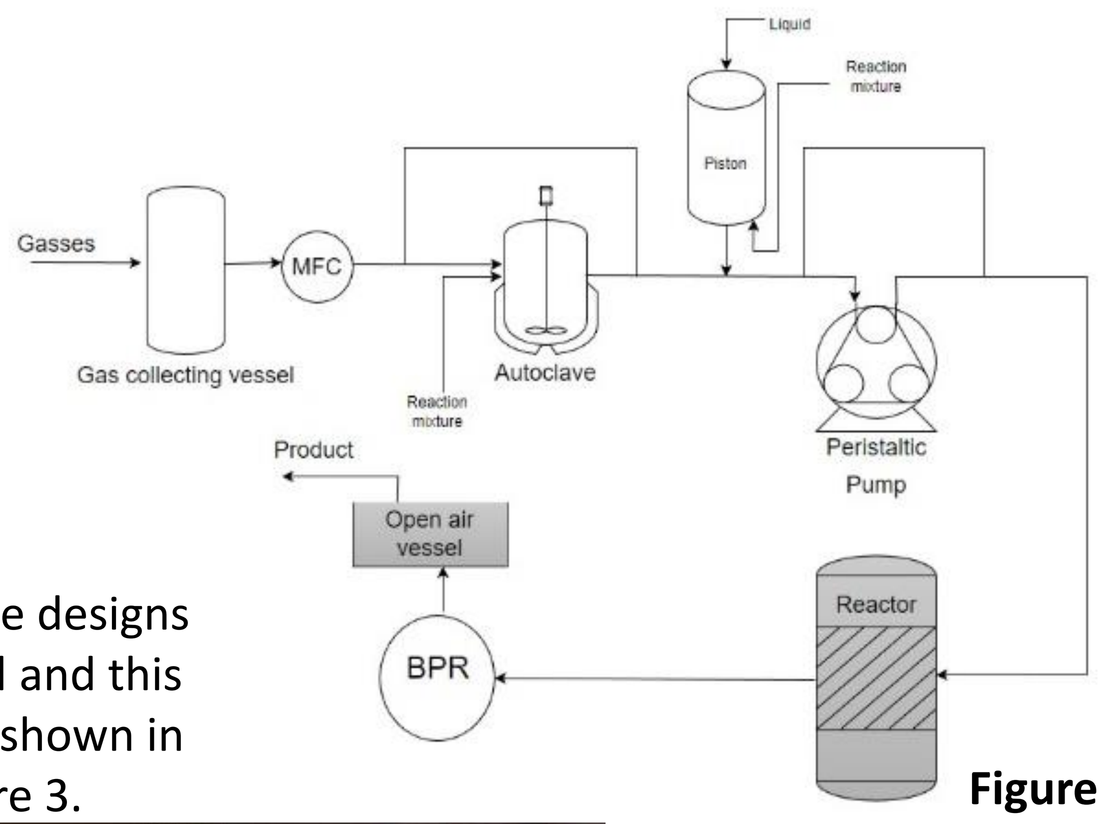

Figure 2

- One of the designs was build and this design is shown in figure 3.

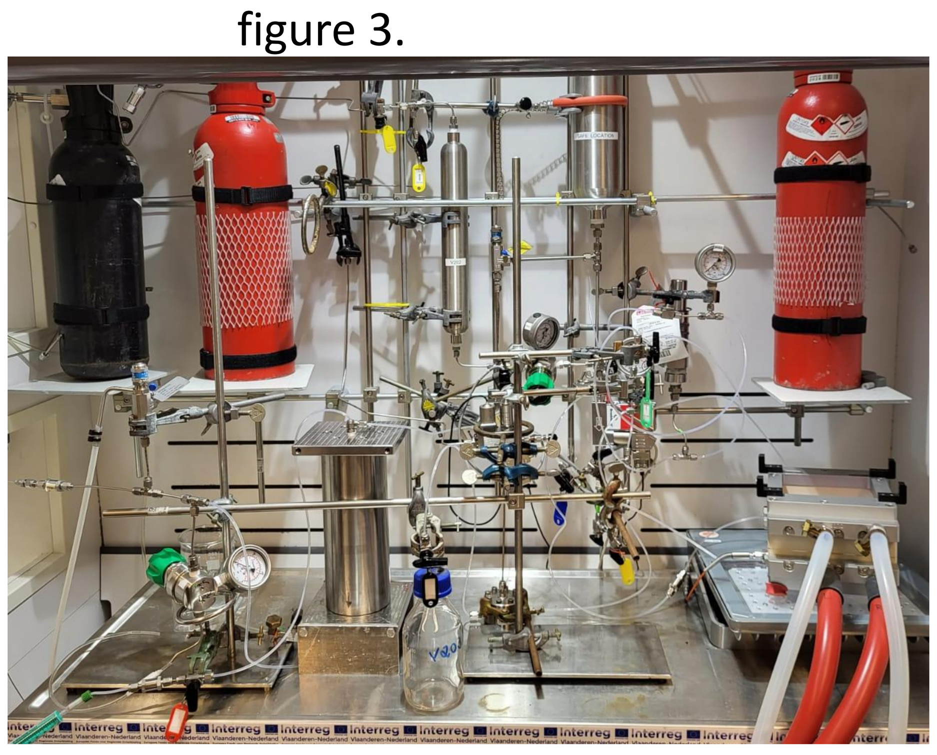
Figure 3

Results

Plug flow results:
To get a better yield, it is important that the reaction mixture mixes well enough with the gas. To test this plug flow, tests were done by changing different parameters. The goal was to get an even gas-liquid ratio for the stretches. The table with the different parameter values is shown in table 1 and the best result is shown in figure 4.

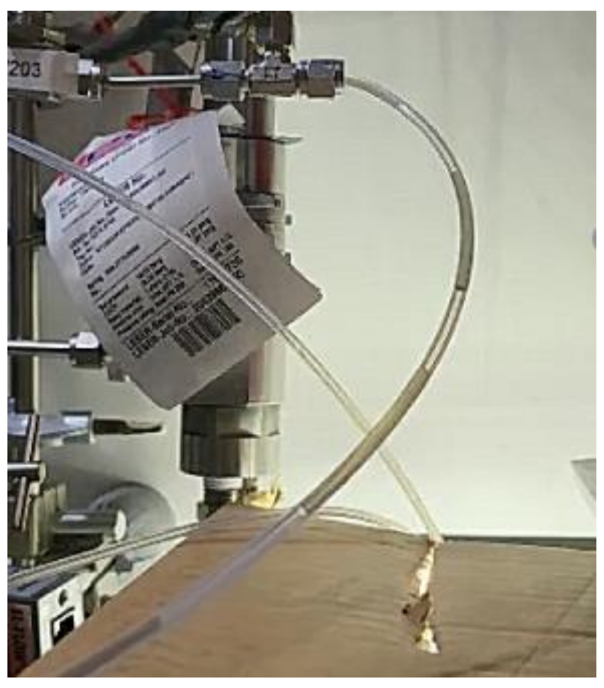
Figure 4

Table 1: Reactions performed in the one-piston setup

#experiment	Mass flow gas [mg/min]	Liquid flow [ml/min]	BPR [barg]
1	1.5	2	N.A.
2	0.5	2	N.A.
3	0.5	10	N.A.
4	0.25	10	N.A.
5	0.05	10	N.A.
6	0.05	6	N.A.
7	0.1	2	6.45
8	0.1	2	1.2

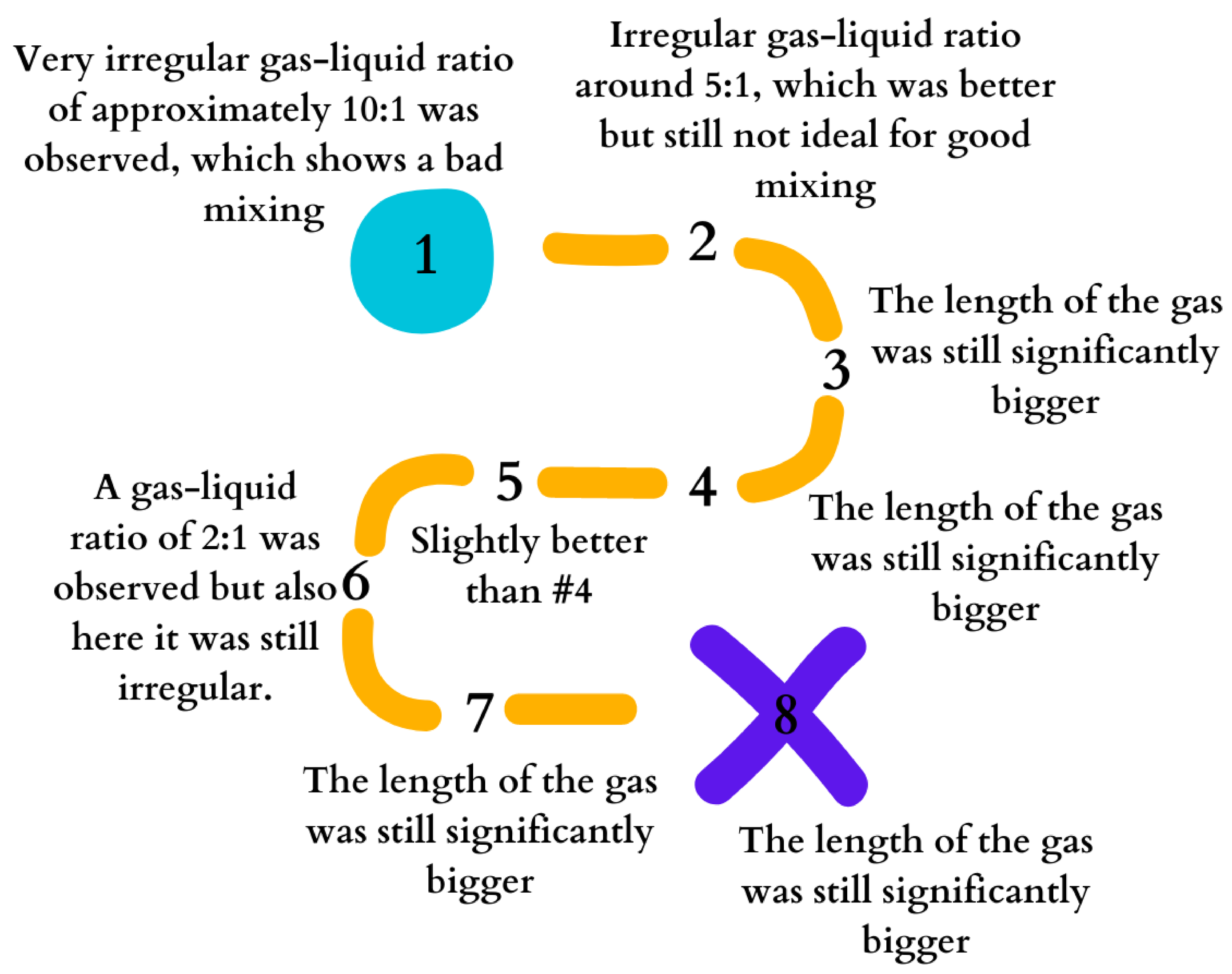

Table 2: Reactions performed in the one-piston setup

#experiment	Gas flow [mg/min]	Liquid flow [ml/min]	Yield [%]
1	0.1	10	0.096
2	0.1	2	0.473
3	0.5	2	0.117
4	0.1	2	0.201

For these experiments a few parameters are held constant:
- 0.1 mg/min mass gas flow
- 2 ml/min reaction mixture flow
- 1.2 barg back pressure regulator
- 0.1M Methyl benzoate – 44mL
- 6wt% Ru/Al2O3 – 3mL

Conclusion & Recommendations

- Further research is required to optimize the catalyst to improve its reactivity. Further research is also required for improving the gas-liquid mixing and its effects on the reactions.

- The one-piston setup presented a plug flow that was not observed before. This implies that the gas-liquid mixing is now better, but finding ways to maintain a constant plug flow is still necessary.

- Besides that, it is recommended to replace the piston for the peristaltic pump, which would possibly help to keep the flow constant.

project LUMEN

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