Further development of gas-fermentation towards syngas utilization and electro-fermentation

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Biorefineries & Digital Methods and Solutions

Introduction

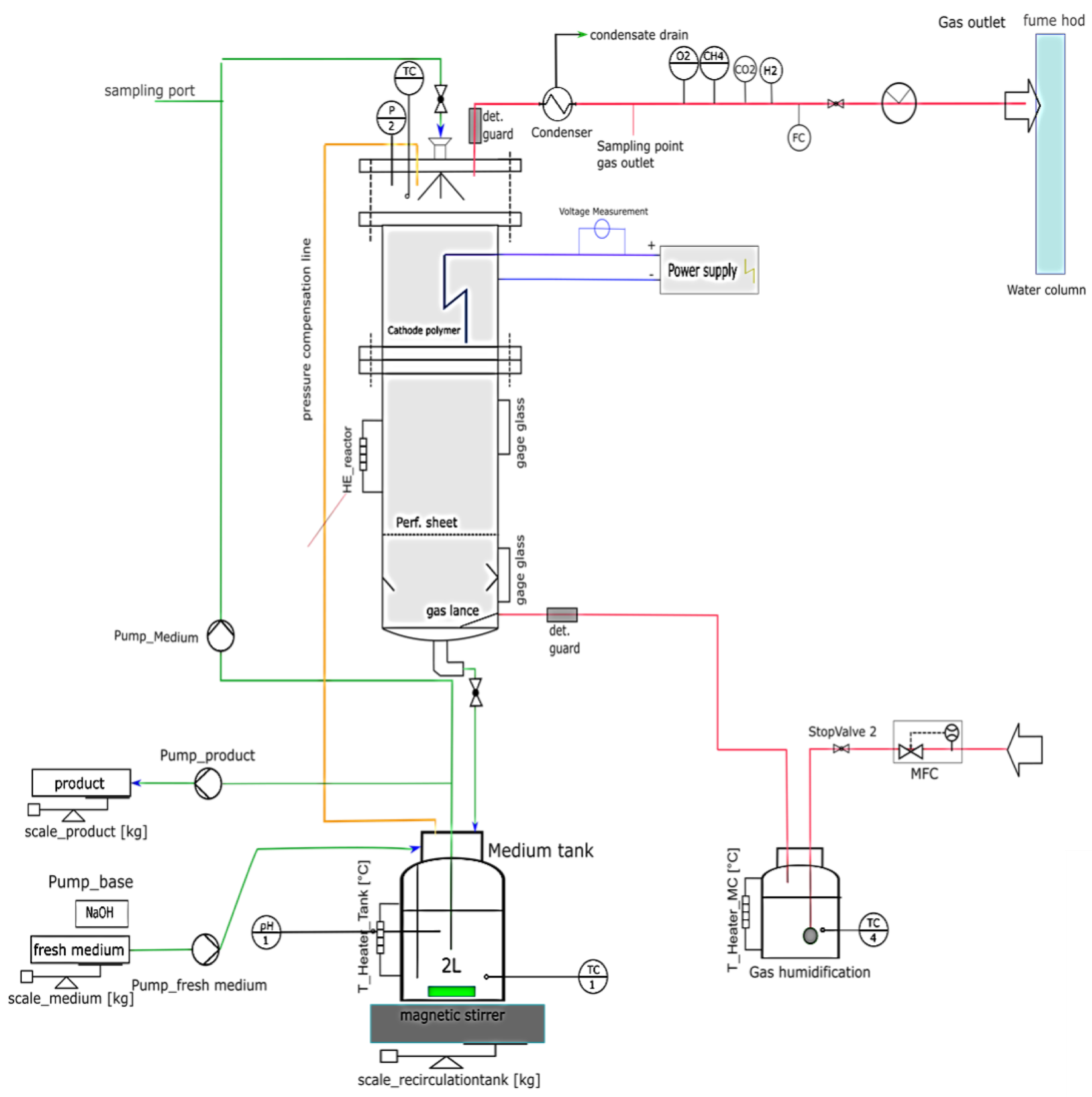
Gas-fermentation is the conversion of gaseous feedstocks (e.g. CO_2-rich off gases, CO, H_2) into valuable products such as organic acids and alcohols by microorganisms such as clostridia.

By supplying electrical energy (an alternative source of reducing/oxidizing energy), the fermentation environment can be further optimized, resulting in products with higher purity, a broader product spectrum and higher cell densities.

The **aim** of the work presented herein was to set- and start-up a reactor for gas and optional electro fermentation.

Reactor set-up

For gas-fermentations, bubble column, gas lift, jet loop or trickle-bed reactors can be used, the latter allowing a high mass transfer due to a large contact area between microorganisms / gas / liquid phase.

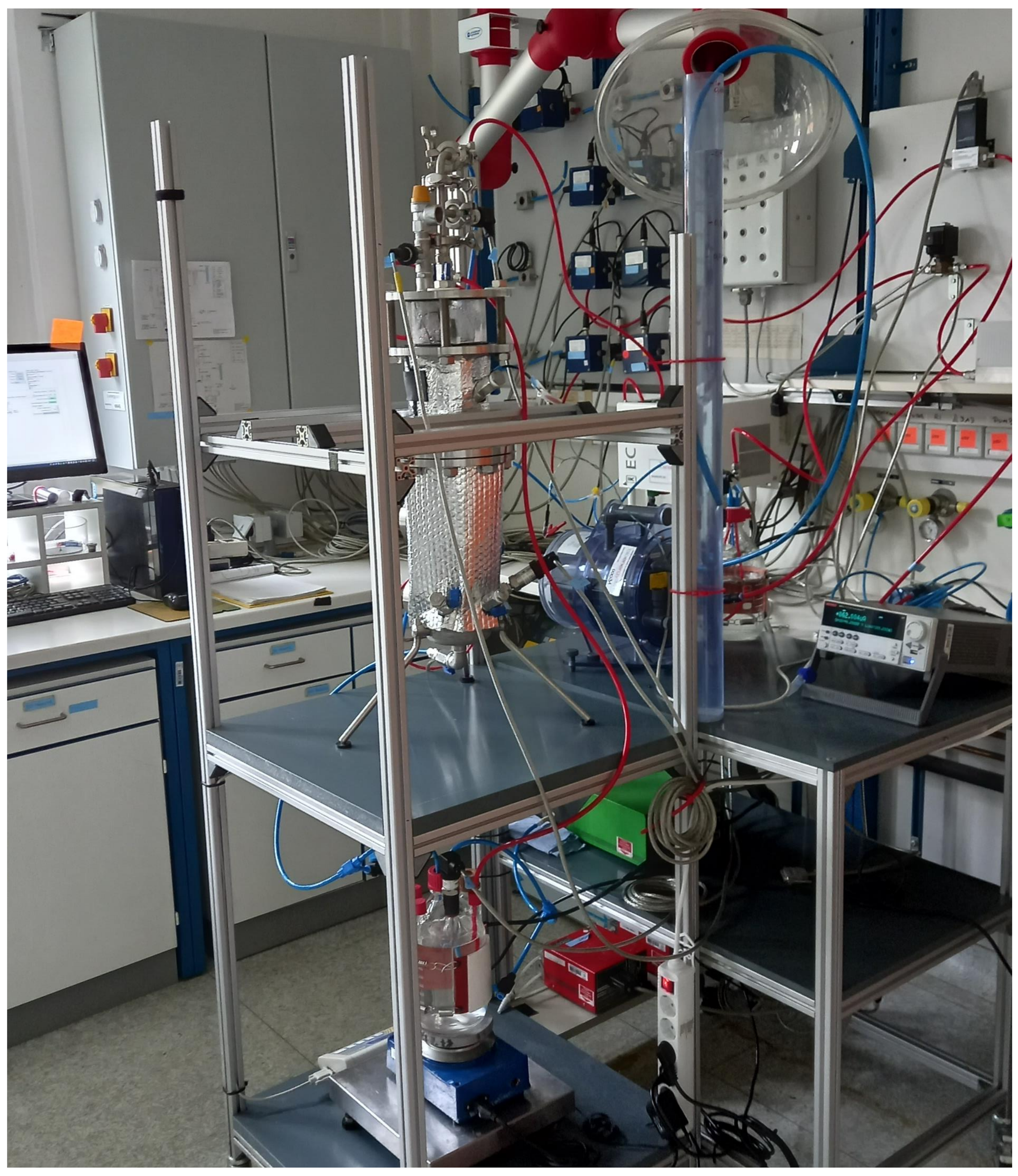


P&I flow chart of the trickle-bed reactor, which could be used for gas- and electro- fermentation

Substrate gas (red line) and liquid nutrient medium (green line) are guided in counterflow. The gas is adjusted via mass flow controller, moistened and enters the reactor at the bottom. The liquid medium is continuously recirculated and enters the reactor at the top.

The temperature of the gas humidification chamber, the medium tank and the reactor jacket can be adjusted.

Temperature, pH, pressure (in the case of electro-fermentation, also current flow and resistance) in the system and off-gas composition are continuously monitored and recorded with inline sensors. Liquid and gas samples can be easily taken and analyzed offline, e.g. using HPLC, IC, ICP, and micro-GC..



Described trickle-bed reactor at lab scale (4.7 L)

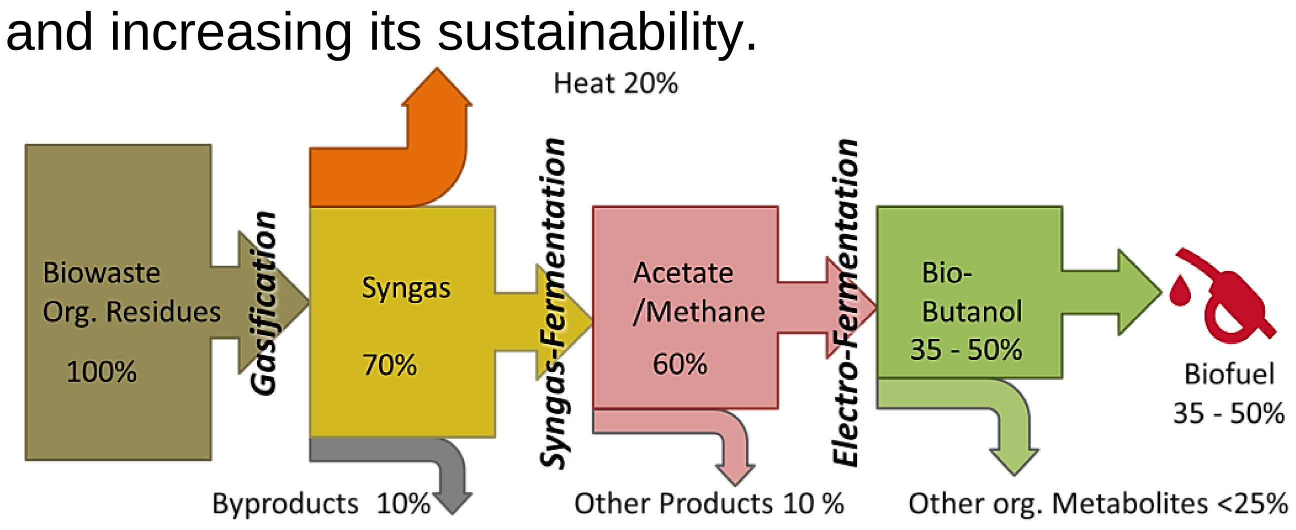
Results

Gas-fermentation experiments were carried out successfully. After starting the reactor and optimizing the process, a stable production of 0.85 g acetate (CH_3COOH) per day from CO_2 and H_2 (10% CO_2, 40% H_2 and 50% N_2, 2.5 L/h gas flow) was achieved.

First lab scale **electro-fermentation** experiments were carried out with glucose (instead of gaseous C-sources) to test the principle. These basic experiments showed a shift in the metabolism of *Clostridium acetobutylicum* when a voltage of 2 V was applied. This shift led to increased concentrations of butanol (4 → 5 g/L) and ethanol (1 → 1.2 g/L) as well as increased glucose consumption, compared to trials where no voltage (0 V) was applied.

Outlook

Next, the use of syngas in gas fermentation is planned. Syngas consists of CO_2, CO and H_2 and is produced by gasification, e.g. of organic residues. This is another important step towards decoupling the chemical industry from its dependence on fossil fuels and increasing its sustainability.



Process chain and carbon conversion efficiency – from waste to value

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