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Short Communication

Production of Advanced Biofuels via Biomass Gasification

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BIOMASS GASIFICATION

Statement of the Problem: The development of lignin derived energy products is one way to increase the value of bio-refinery residues. Gasification of (lignin-rich) Biorefineries residues, followed by product gas cleaning and anaerobic fermentation, offers a potential to produce higher added-value products such as biofuels and chemicals. MILENA indirect gasification allows complete fuel conversion and produces a high value gas composed of CO, H_2 and CO_2, as well as compounds such as CH_4, C_2-C_4 gases, benzene, toluene and xylene (BTX), and tars. The separation of the most valuable components of the product gas is a good way to maximize the value from the feedstock via co-production schemes. The product gas, after appropriate cleaning to remove impurities, can be applied in the gas fermentation process. Some anaerobic microorganisms can be used as a biocatalyst for the microbial conversion of syngas into short-chain organic acids and alcohols (i.e. acetate and ethanol). The ability of these microorganisms to withstand some of the impurities contained in the syngas and their flexibility to use different syngas compositions makes them an attractive alternative to the chemical catalytic processes.

Methodology: A lignin rich feedstock is gasified with steam at 780°C using MILENA indirect gasifier, at TNO. The product gas after removal of the main impurities consists of CO, H_2, CO_2, N_2, CH_4 and traces of other gaseous hydrocarbons, benzene and H_2S. The influence of the obtained syngas quality and composition is evaluated in the fermentation process. Conclusion & Significance: Despite many advantages, the integration of gasification with syngas fermentation is still in an early stage of development, where many questions exist concerning the syngas quality needed in the fermentation process. In this work a first attempt to combine the two processes is presented.

According to the Intergovernmental Panel on Climate Change (IPCC), scenarios that have a good chance of restricting global warming to less than 2°C involve substantial cuts in anthropogenic greenhouse gas (GHG) emissions, implemented through large-scale changes in energy systems. The use of renewable energy sources and fossil fuels, in combination with carbon capture and storage (CCS), could help to reduce GHG emissions in the energy sector. Electricity can be produced from no carbon sources, such as wind, hydro, and solar energy, and from carbon-based feedstocks, which are also needed for the production of fuels, chemicals, and various materials.

There are three main alternatives for producing carbon-based feedstocks: (1) biomass harvesting, that is, relying on photosynthesis as the mechanism for capturing CO2 from the atmosphere; (2) CO2 capture via physical or chemical processes from the atmosphere or seawater; and (3) recycling, through the utilization of suitable materials, such as recycled paper and plastics, waste wood, or through CO2 capture from flue gases. The future potential of the latter option depends on whether burning of hydrocarbons to produce process heat and/or electricity will remain common, which is uncertain.

The future magnitude of biomass resources is currently debated, and estimates of bioenergy potentials vary widely due to differences in the approaches adopted to consider important factors, which in themselves are uncertain 1, 2. Moreover, biomass supply may be limited by a scarcity of resources, such as land and water, and society may want to avoid overreliance on biomass harvesting due to concerns regarding negative environmental and socioeconomic impacts. Therefore, it is reasonable to expect that future biomass use will be prioritized for applications for which alternatives at similar cost levels are not available.

For example, heat can be produced and stored based on geothermal heat and renewable electricity. As another example, biomass based electricity may not be needed at locations and during time periods when other renewable or fossil-free alternatives are available. Widespread application of various storage and demand management strategies, together with renewable supply options, such as wind and solar energy, could limit the periods of the year that are suitable for fuel-based thermal electricity generation to hundreds rather than thousands of hours, and might restrict the periods for continuous operation of such plants to days or weeks instead of months.

In such a scenario, it will be advantageous to combine the continuous production of renewable fuels, materials, and chemicals with intermittent generation of heat and electricity. Biorefineries concepts that are based on large-scale gasification represent one such combined production solution. In contrast, large thermal production plants that produce only electricity and/or heat are unlikely to be economically viable. In this context,

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it will be desirable to introduce novel solutions that exploit the infrastructure that has been built up in recent decades for biomass-based heat and combined heat and power (CHP) production.

The Nordic countries of Sweden, Finland, and Denmark have been forerunners in the development of large thermal production plants using biomass for electricity and/or heat production. In Sweden, more than 60 units, with a thermal capacity of >50 MWth (250 dry tons of biomass/day) biomass or waste (with 40 units of >100 MWth, 500 dry tones of biomass/day), have been built at a cost of more than 100 M€ per 100-MWth unit. The main technology used in this sector is bubbling or circulating fluidized bed combustors, and Sweden alone has a total installed thermal capacity of 6400 MWth (1200 MMBtu/hour).