

Production of Syngas via Dehydration of Biogenic Aqueous Formic Acid coupled with the Water-Gas Shift Reaction

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Abstract

Biomass-derived formic acid (FA) represents a promising intermediate for sustainable and renewable syngas production. Starting with the OxFA-process, which enables the partial oxidation of wet biomass into aqueous FA under mild conditions, efficient biomass utilization derived from a broad range of bio-based waste products is feasible. FA can serve as a versatile storage molecule for hydrogen (H₂) and carbon monoxide (CO), making it a promising renewable syngas source. The conversion of FA to CO occurs via dehydration using acidic catalysts, while H₂-production is achieved with a second step through water-gas shift (WGS) reaction [1-2]. Figure 1 illustrates the overall concept for producing syngas from waste biomass.

The presented work investigates the catalytic two-step process route for continuous syngas production from FA on a technical relevant scale by using a fixed bed reactor. In the first step, aqueous FA is dehydrated over Brønsted-acidic heterogeneous catalysts under gas-phase conditions. Experimental measurement for the dehydration already shown FA conversions up to 60 %. The high catalytic activity can mainly be attributed to the strong acidity of these materials. In addition, CO-selectivity above 98 % were achieved using catalysts such as ZSM-5 zeolites or TiO₂. In initial long-term experiments, deactivation was observed, which is likely caused by coke formation.

In the subsequent step, the conversion of formic acid via dehydration will be coupled with the water-gas shift (WGS) reaction. To this end, various catalyst systems will be investigated, focusing on high activity and catalyst stability. In order to achieve significant activity at temperatures below 200 °C, ultra-low temperature WGS catalysts based on the Supported Ionic Liquid Phase (SILP) concept will be tested [3]. By adjusting the process parameters, it is aimed to generate biomass-derived synthesis gas with variable H₂/CO ratios.

[1] P. Preuster et al., Energy Technology, 2018, 6, 501–509.

[2] W. Supronowicz et al., Green Chemistry, 2015, 17, 2904–2911.

[3] P. Wolf et al., Green Chem., 2019, 21, 5008–5018.

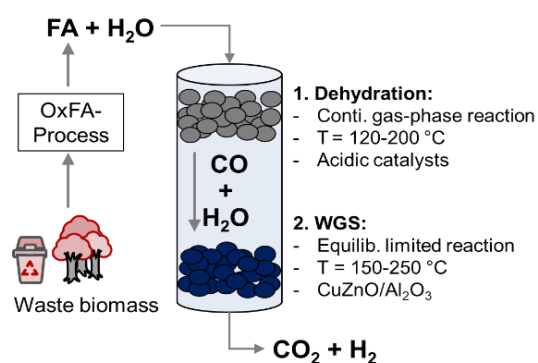


Figure 1: Illustration of the process concept of biomass valorization for syngas production via formic acid.