Hydrogen Production from Biomass via Formic Acid and Methyl Formate: An Economic Comparison of Different Process Routes

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Abstract

In recent years, hydrogen has gained increasing importance as a key component in the fight against climate change. One strategy to obtain sustainable hydrogen is its production from diverse biomass wastes. In this study, we propose a new approach, that generates hydrogen from waste wet biomass via the intermediate formic acid (FA) or its derivative methyl formate (MF) under milder operating conditions. In the first catalytic step, wet waste biomass streams, such as algae, beech wood or sewage sludge are selectively oxidized in aqueous solution to form formic acid. Recent studies on this so-called OxFA-Process, have revealed that the introduction of methanol as co-solvent effectively suppresses the formation of undesired CO_2, resulting in minimal carbon loss. Nevertheless, the incorporation of methanol triggers the subsequent transformation of FA into MF. The FA/MF ratio is determined by the methanol/water solvent ratio and the equilibrium of the esterification reaction. To extract hydrogen from the intermediates, individual process pathways are required, depending on the MF/FA-ratio. Figure 1 demonstrates the diverse process pathways through which the resulting products, FA and MF, can be further converted into hydrogen. In this study, we conducted simulations in Aspen Plus® V12 to explore the impact of three different methanol proportions in the OxFA-Process on the efficiency of the overall hydrogen production route. Our goal was to optimize the process routes to achieve the highest possible hydrogen yield. Subsequently, we performed an economic analysis by considering current data and compared the different routes based on various characteristics. To further investigate the most promising route (OxFA-Process with 10 wt-% methanol), a sensitivity analysis was performed, and the obtained results were compared with alternative sustainable hydrogen production routes, such as biomass gasification. The research findings indicate that the proposed approach can lead to a competitive price for hydrogen production, given the underlying assumptions. Furthermore, this method holds considerable appeal as it can directly apply wet biomass wastes, requires mild operation conditions and generates hydrogen in high selectivity.

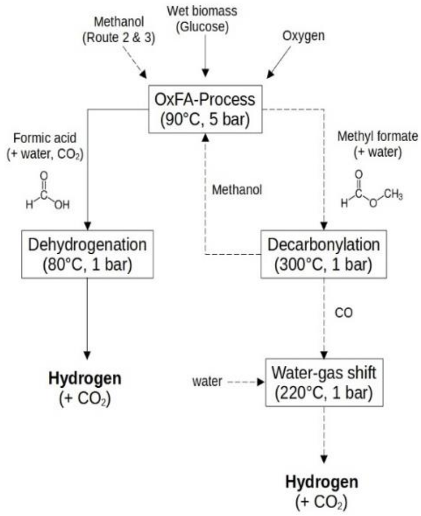

Figure 1: Schematic representation of the production of hydrogen via FA/MF from the OxFA-process.