Sustainable methanol production from wet biomass waste in a novel mild and competitive process

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Methanol is a versatile chemical feedstock and a promising clean fuel alternative with vast market potential expected to grow in the future.[1] To significantly reduce climate impact, efficient and economic methanol production from non-fossil feedstocks is urgently required. Biomass waste, especially agricultural, forestry, or industrial residues, presents significant potential as a feedstock. In our research, we developed a novel process route that could be a game changer for biomass-to-methanol conversion, as it operates under mild process conditions (pressures below 10 bar and temperatures around 200 °C) and reduces the need for prior biomass drying and intensive product purification. This route could complement future methanol synthesis or even outperform sustainable alternatives based on harsh gasification and expensive power-to-X technologies. The proposed concept can be divided in three steps as shown in Figure 1: 1) Oxidation of wet biomass waste to formic acid, 2) Esterification of formic acid to methyl formate and 3) Hydrogenolysis of methyl formate to Methanol.

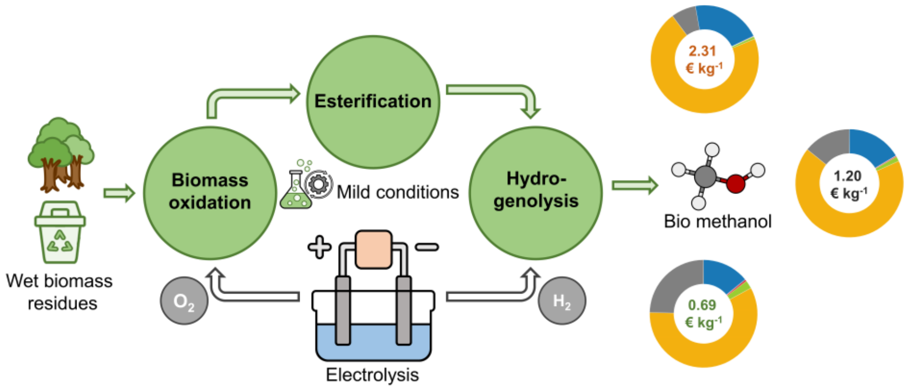

Figure 1 Visualization of the novel biomass to methanol production route.

In this study, the previously unexplored pathway via the two intermediates formic acid and methyl formate was simulated in Aspen Plus assessing possible operating scenarios and achievable methanol prices. Depending on the assumptions applied competitive methanol production costs between 0.69 and 2.31 € kg^{-1} are feasible. While the first steps of biomass oxidation reassambles an already established process, that is demonstrated to deliver formic acid in the lower ton scale[2], the hydrogenolysis of methyl formate was investigated experimentally to support the simulation with valuable first hand data. Long-term stable continuous formation of methanol is demonstrated in high selectivity (>95 %) by applying novel inexpensive copper-based spinel catalysts.[3] Following the simulation results the novel concept yields a superior single-pass carbon efficiency of >80% compared to biomass gasification routes or even fossil methanol production. By integrating biomass valorization with hydrogen and oxygen from water electrolysis, the need for fossil-based reactants is completely eliminated. Furthermore, a fully decentralized and autonomous system can be achieved expanding the application field of this technology. Since biomass typically accumulates in decentralized locations, the new process can be implemented close to these sources, minimizing feed transport distances and further reducing greenhouse gas emissions. Although still in the early stages of development, the new process opens up possibilities for the future, such as enabling agricultural cooperatives to locally produce methanol and use it as a drop-in fuel for their own consumption.

Acknowledgments

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References

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