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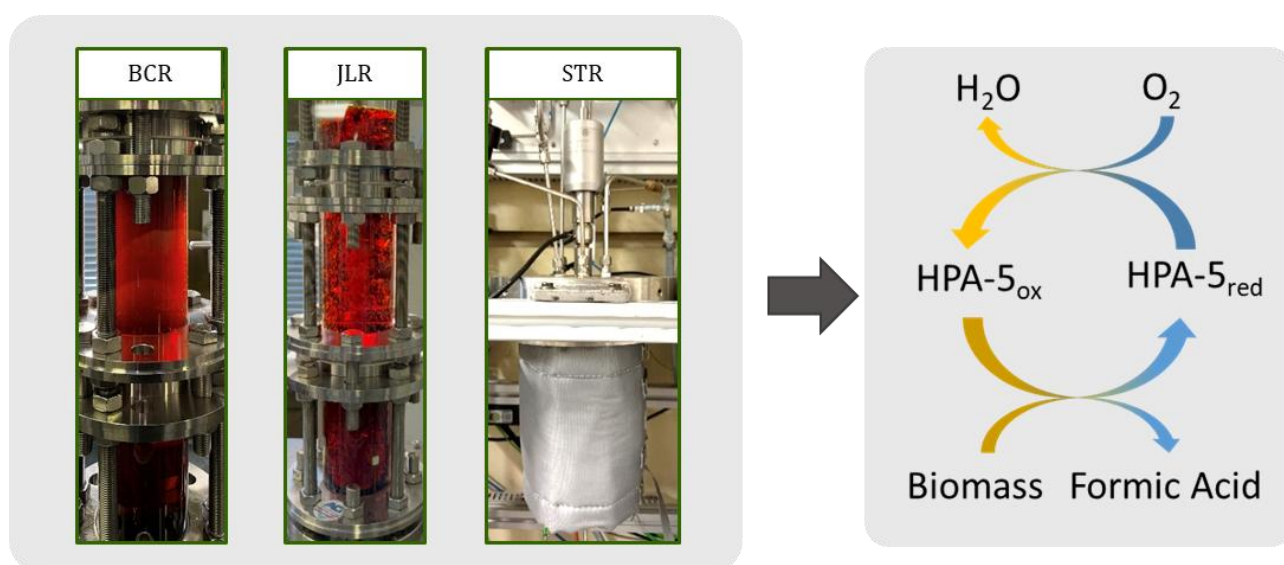
Intensification of the modified OxFA process by evaluation of different reactor concepts

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Lignocellulosic biomass, the structural component of woody plant cell walls, is a renewable and carbon-neutral resource. Currently, lignocellulosic biomass accounts for approx. 16% of total waste generation in Europe, yet only 77% of this biomass is recycled. In light of this and the increasingly challenging geopolitical landscape, there is growing interest in using lignocellulose as a raw material for the chemical industry to combat climate change and reduce dependence on fossil raw materials.¹ This paradigm shift presents new challenges for catalytic chemistry. While simple heterogeneous catalysts suffice for gas-solid systems converting fossil resources, the structural complexity of biomass requires gas-liquid multiphase systems, placing significantly higher demands on catalysts.^{2,3} The BioValCat project (Enhanced Biomass Valorization by Engineering of Polyoxometalate Catalysts) aims to develop versatile homogeneous catalytic processes for the selective transformation of lignocellulose into industrially viable valorization technologies. The project is based on the OxFA process, in which biomass is oxidized with O₂ to formic acid, which is widely used in industry, such as in the textile industry.⁴

The process is a gas-liquid multiphase system that relies heavily on the transport of oxygen in the liquid phase, which can be a limiting factor. This study investigates how mass transfer and the catalytic conversion of biomass to formic acid can be improved through different reactor setups and chemical system modifications. Key hardware and chemical parameters were systematically varied to identify the main drivers of process intensification. Three different model substrates representing the major components of lignocellulosic biomass and three different solvent systems were investigated to vary the chemical system. To vary the hardware parameters, three reactor systems with nearly identical geometric dimensions but different phase-mixing mechanisms were implemented and their performance was compared. Depending on the system, the phase mixing is achieved by using a stirrer, a nozzle, or a sparger. The reactor concepts investigated include the stirred-tank reactor (STR), which is classically used for OxFA processes.⁴ The jet loop reactor (JLR), selected due to promising results for the glycerol oxidation reported by Wirth et al.³ and the bubble column reactor (BCR), which was chosen for investigation due to its simple construction, which requires neither moving parts nor additional components within the reactor. This comprehensive study provides significant insights into the process intensification of the homogeneously catalyzed biomass oxidation, thereby laying the foundation for the scalable, safe, and economical production of formic acid from biomass.



Graphical abstract.