Membrane-assisted reactive extraction of biobased 3-hydroxypropionic acid through an integrated process of extractive bioconversion: a step forward for bio-process intensification

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Within the actual transition from a fossil fuel-based to a bio-based economy, or bio-economy, the sustainable production at the industrial scale of bio-based polymer building blocks, such as 3-hydroxypropionic acid (3-HP, CAS number 503-66-2), is growing (1). 3-HP can be manufactured using petrochemical feedstock, but it is widely believed that biotechnology will provide a more sustainable route using renewable feedstocks (2). Nevertheless, to develop a robust biotechnological process, it is necessary to resolve technical issues, such as the inhibitory effect of the acid and its precursor, 3-hydroxypropionaldehyde. This can be obtained through integrated extractive bioconversion by which the product is continuously produced and recovered (3).

The integrated process targeted in this study includes 3-HP bioconversion from glycerol by *L. reuteri* and its reactive liquid-liquid extraction mediated by a hollow-fiber membrane contactor (HFMC). The HFMC aims to prevent the cells from direct contact with the organic phase while giving a high specific surface area without emulsifying. Moreover, a back-recovery step can be coupled to the extraction step with a second contactor to favor the mass transfer and get the product back in an aqueous phase (Figure 1). Regarding the extraction step, two extractants (trioctylamine and Aliquat 336) were used alone or in mixture, combined with three organic diluents (decanol, vegetable oil and oleyl alcohol). Both the extraction efficiency and biocompatibility were assessed for each extraction phase. Model solutions and real bioconversion broths (*in situ* product recovery) were used as the aqueous phases

containing 3-HP. For the back-extraction step, different aqueous phases containing basic or neutral salts were tested and the effect of temperature was considered. Mass transfer coefficients in the HFMC were determined in order to identify transfer limiting conditions.

Results show a great impact of the solvent selection, the nature of the extractants and the composition of the aqueous phases on the overall extraction yield and kinetics. Interestingly, extraction by a synergistic mixture of amines showed high performances over a wide range of pH, including the optimal range for bioconversion by *L. reuteri*. However, the performance of the whole process was shown to strongly depend on the coordination between the upstream and downstream operations in the quest for both extraction efficiency and biocompatibility.

To the best of our knowledge, this work reports for the first time a membrane based extractive bioconversion process for 3-HP production. These pioneering results represent a potential breakthrough towards the implementation of a robust and intensified biotechnological process at the industrial scale.

References

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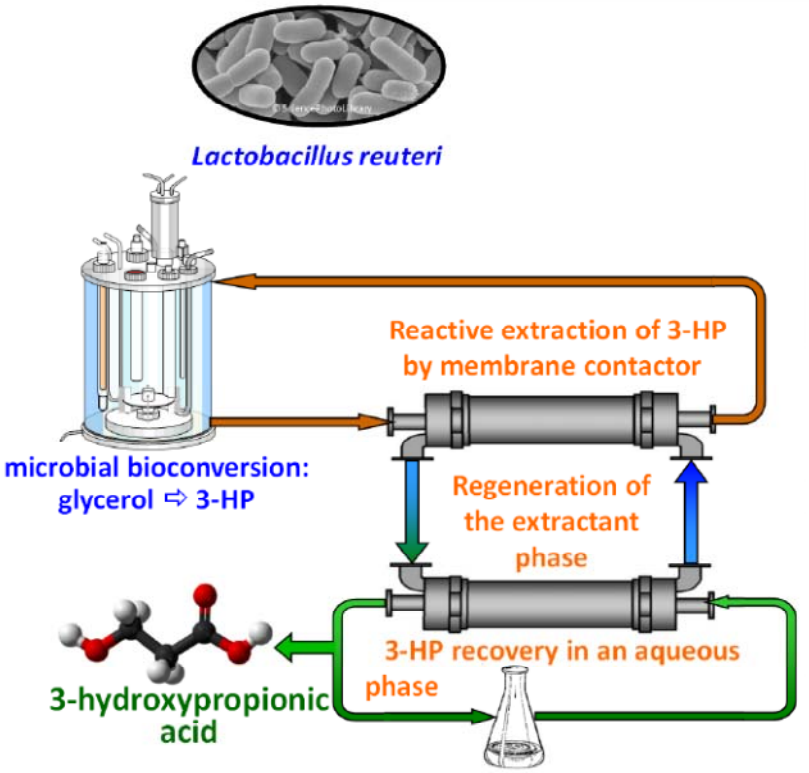

Figure 1: Integrated process for extractive bioconversion of 3-hydroxypropionic acid