Synthesis of 5-Hydroxymethylfurfural from D-glucose by hybrid catalysis : from “batch” to continuous process

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5-Hydroxymethylfurfural (5-HMF) is a platform molecule of great economic interest, it is the product of the dehydration of 6-carbon sugars such as D-fructose and D-glucose. As D-glucose is more available and less expensive than D-fructose, it is interesting to use it as a substrate. However, D-glucose has a lower selectivity and dehydration yields of 5-HMF than D-fructose. This problem can be overcome by using hybrid catalysis, combining enzymatic and mineral catalysis. Xylose isomerase allows the first isomerisation step, the second reaction consists of dehydration by exploiting the acidic properties of tosylic acid. The conditions of the two catalysis are diametrically opposed, so it is a question of making concessions on both sides in order to be able to move from “batch” to continuous flow. Previously, the development of an “H-reactor” demonstrated that it was possible to combine the two catalysts in a 2P1S hybrid reactor [1]. This reactor had two aqueous phases called donor and receiving, and an organic phase to transport the D-fructose from the donor phase where isomerisation took place to the receiving phase containing the acidic resin [1]. For continuous flow, a modular system from the company Ehrfeld made it possible to obtain some optimal parameters (temperatures, flow rates, residence times and pH) for the individual reactions. Our strategy was to combine the two catalysts in cascade and to a 1P1S hybrid process. The first step was to produce a xylose isomerase issue from Streptomyces Sp. Sk more resistant at acidic pH and to immobilize it on metallic supports (Figure 1-b). Then, to optimise the conditions of dehydration of D-fructose with heterogeneous tosylic acid in batch and in continuous flow. Finally, to implement the combination of immobilized glucose isomerase and heterogeneous tosylic acid in the continuous flow reactor (Figure 2).

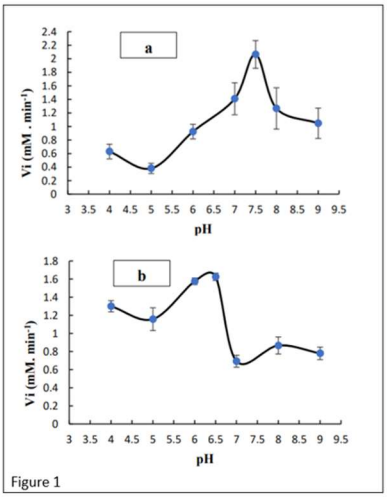

Figure 1

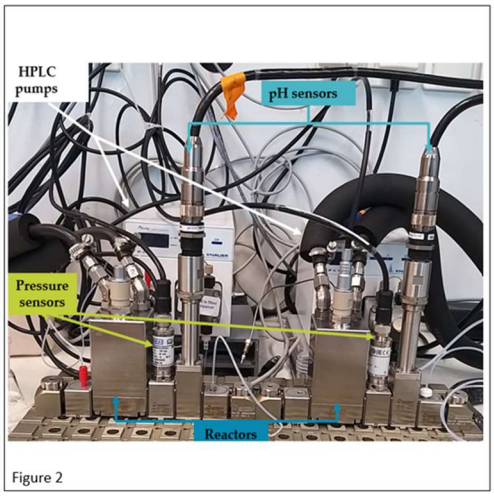

Figure 2

Figure 1: Initial velocity (mM.min^{-1}) versus pH for Sweetzyme (A) and xylose isomerase from Streptomyces sp.SK (B).
Figure 2: Modular system from the company Ehrfeld comprising two reactors, two HPLC pumps, two pressure sensors and two pH sensors.

References

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