

N°1006 / PC

TOPIC(s) : Homogenous, heterogenous and biocatalysis / Biomass conversion

Hybrid catalysis, an efficient multi-step (bio)catalytic process for the direct production of 5-HMF from glucose

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PURPOSE OF THE ABSTRACT

The use of biomass as a raw material is particularly attractive as a potentially competitive strategy to overcome the scarcity of fossil fuels and try to minimize the negative environmental impact associated with their use. Indeed, biomass is the main source of renewable carbon and usable to obtain chemical intermediates. Nevertheless, the transformation of highly functionalized molecules from biomass requires a renewal of the knowledge acquired during the implementation of existing petrochemical processes. Thus, the concept of bio-refinery is currently the focus of many international studies. The conversion of biomass in these new production units requires the design of new processes and the control of these new chemical transformations marking Industrial renewal.

The bio-based chemical building-blocks production through durable and environmental friendly process asks for the conception of new "custom made" catalytic systems, recyclable and recoverable. The combination of biocatalysis and chemocatalysis, called hybrid catalysis, is part of these new concept that could respond to the emerging challenges of biomass valorization. In this context of hybrid catalysis emergency, we collaborate to develop a new chemoenzymatic process for the 5-hydroxymethylfurfural (5-HMF) production. It is a key platform molecule for biosourced monomers as 2-5-furandicarboxylic acids, a potential substitute for the terephthalic acid used in textiles fibers and food-grades plastics. The 5-HMF production ask for the glucose isomerization into fructose and the fructose dehydration to 5-HMF.

This original catalysis coupling process allows to shift the thermodynamic equilibrium of the glucose enzymatic isomerization reaction, theoretically about 50%, by the integration of a simultaneous chemocatalytic fructose dehydration to 5-HMF.

The purpose of our works is to define compatible reaction conditions for both catalysis types, in both, operating conditions (pH, T°, concentration) and implementation for the two reactions in cascade or in "one-pot". The optimal conditions for each step have been determined independently in a first time for, in a second time, establishing a sequenced global system.[1]

This system possess a liquid membrane allowing the fructose extraction and the fructose continuous supplying from the first isomerization step toward the second step for the final transformation in 5-HMF by catalysis on an acidic resin. The first assays of this sequential system have allowed a glucose thermodynamic equilibrium shift of 72% (against 50% initially), leading to a dehydration yield about 20% in 5-HMF, validating the proof of concept of this hybrid catalysis. The operating conditions and the implementation could be optimized yet for an efficient continuous integration of the two catalysis. It's the first time that hybrid catalysis in cascade reaction is really implemented for obtaining 5-HMF from D-glucose.

FIGURES

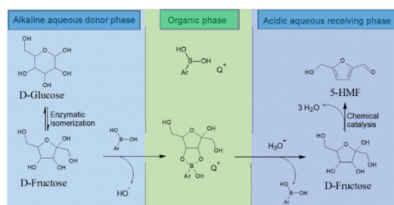


FIGURE 1

Hybrid catalysis concept developed

Hybrid catalysis concept developed

FIGURE 2

KEYWORDS

Enzymatic catalysis | Heterogeneous catalysis | Hybrid catalysis | One-pot system

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