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PROCESS INTENSIFICATION IN BIOTECHNOLOGY: TOWARDS AN INTEGRATED BIOREFINERY

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Abstract

The strong growth of the world population and accompanying social development leads to pressure on the climate, scarcity of resources, environmental problems and reduction in biodiversity. One of the possible human mitigation responses is the development of a bio-based economy inspired by the use of renewable resources (biomass) and the full fractionation and transformation of it into food/feed – materials/chemicals – energy in the so-called cascade-approach.

Biorefineries, already existing for some decades now, were mostly focused on the food production chain. Nowadays, however, we are moving towards an integrated biorefinery in which either all compounds present in the biomass will be valorised as much as possible, or new biomass streams (including biowaste) will be tackled. New challenges exist in the disclosure of lignocellulosic biomass (second generation) in order to valorise not only the food components but also the straw, fibres, leafs, etc. Disclosure of these rather persistent molecules in an environmentally-friendly and sustainable way is still an important challenge. On the other hand, the extraction of several high-added value compounds (e.g., polyphenols) can be a success by using rather mild disclosure methods in order to keep its glycosilated forms intact and active. Although great expectations exist and a lot of development is going on at lab and pilot scale, still many problems need to be solved. It is known that between 50 and 70% of all the costs of a biorefined product are linked to it's downstream processing.

The integration of fermentation or bioconversion processes with subsequent separation or purification processes will become the challenge of the coming years in order to allow a real breakthrough of the integrated biorefinery of the future. The integrated recovery of the produced molecules or the (in-situ) removal of inhibiting chemicals from the process will keep them under certain threshold limits leading to more efficient conversion processes or reduction in feedback inhibitions. The economical value of this integrated approach lies in the increase in conversion efficiency (less substrate that is not used) at higher rates and less energy consumption in the further downstream processing. Removal of organic acids by electrodialysis and related concepts will allow to produce acids without concomittant production of huge amounts of waste products (such as gypsum). Recovery of volatile alcohols by integrated pervaporation systems will reduce toxicity in the fermentation broth and lead to a first concentrated product flow. Other technologies such as membrane distillation, membrane extraction, adsorption or crystallization have also large potential in these integrated systems. An important discussion in these integrated systems concerns the need for a first (membrane) separation of the cells from the broth allowing a cleaner process to proceed for the further separation of the produced molecules. In fact, such membrane-based fermentors can probably become standard technology in the future. Not only fermentation (whole-cell based) processes can be integrated, but also enzyme reactors are under development. The immobilization of enzymes on beads or membranes can save on enzyme cost and improve the quality of the produced new molecules. Challenges and problems of these integrated conversion-separation processes will be discussed in detail leading to new insights in future biorefineries including (semi-) continuous processes compared to batch processes.