EDITORIAL

Biorefinery: Where Do We Come from, Where We Are, Where Are We Going?

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First generation biorefinery

Biorefinery has been defined as the sustainable conversion of biomass towards a spectrum of biobased products for different industrial fields, among which the food and feed, chemical, and energetic sectors. This concept was assessed at the beginning of the century and it was initially related to biofuels production through processing of dedicated biomass, i.e., sugar or oleaginous crops specifically cultivated for bioethanol and biodiesel production, respectively. Despite the consequent development of strategies for culture intensification, biofuel costs have not been competitive when compared with fossil-based counterparts. Low energy product values have contributed to this evidence; furthermore, with respect to conventional refinery fed with fossil sources, biofuel production needs to face up to higher costs associated with related raw materials, due to the facts that they are typically seasonal, widely distributed in larger territories, complex and variable in composition.

Next generation biorefinery

In order to enlarge the spectrum of biobased marketable products, two routes, among others, have been identified and pursued: lowering costs of raw materials, and getting products with peculiar and advanced proprieties and applications, non-replicable by fossil-based counterparts. The former objective has been addressed by increasing the relative amount of exploited organic fraction, or by obtaining goods from residual biomasses (leftovers, waste, and non-dedicated crops); lignocellulosic materials have received a large interest for both their abundance and content of sugar-based fibers, potentially usable for deploying fermentative processes commonly fed with simple sugars. In particular, the term *second generation bioethanol* has been associated with bioethanol production from lignocellulosic fractions. Thus, the more generic *second generation biorefinery* concept has been used for the conversion of non-dedicated biomass towards a wide range of *biobased products*; nowadays, all strategies addressed to valorize residual biomasses are more commonly included in the larger concept of *next generation biorefinery*.

Integrated multi-purpose biorefinery

Attempts for valorizing matrices, which were previously simply considered waste, have allowed the development of several processes capable of converting diverse organic fractions into possible products, although at a low/medium technology readiness level so far. Such advances have accosted biorefineries to conventional fossil-based refineries significantly. In agreement with the latter refineries, massive exploitation of raw material is a feasible option in the occurrence of a complex system including different integrated operation units, so target organic fractions represent specific substrates for the obtainment of specific products, possibly concerning differentiated markets, in consecutive steps. Biorefineries, where raw material is processed in subsequent stages by consecutive or integrated processes, are mentioned

as *integrated multi-purpose biorefineries*. This approach can couple the advantages of minimizing process waste to the possibility of obtaining goods with higher added values. Finally, all organic matter still occurring in final effluents is typically sent to cheap and versatile final consolidated operations, such as anaerobic digestion and composting, respectively dedicated to the production of CH_4-rich biogas and soil additives.

Biorefineries in the EU

The EU has boosted biorefinery developments, by taking into consideration that related research and industrial development are excellences of the Union, representing key sectors for the communitarian economy and society. The Commission published a key document (EU, 2012), which was revised in 2017, determining the strategic role of biorefineries for the development of EU politics in the framework of the bioeconomy; the strategy was further amended in 2018 for accelerating sustainable development towards the so-called *Agenda 2030* and its *Sustainable Development Goals*, SDGs. This last update addressed EU priorities for processes scale-up, opening new dedicated markets, unlocking investments and supporting local small biorefineries. Accordingly, joint initiatives have been promoted among the Commission and consortia of (agro)industrial actors, by co-financing highly applicative and industrial competitive projects for the creation of new value chains based on biomass conversion. In particular, two active public-private partnerships have been created: a) the BBI JU (*Bio-based Industries Joint Undertaking*) among the EU Commission and a consortium of companies operating in the bioeconomy called *Bio-based Industries Consortium* (BIC); b) the EIP-AGRI (*European Innovation Partnership for Agricultural productivity and Sustainability*), partnership including different actors, among which agricultural associations, research centers, non-governance associations interested in rural development (*Rural Development Programmes*, RDPs).

European Commission (2012) ***Innovating for Sustainable Growth - A Bioeconomy for Europe****. ISBN 978-92-79-25376-8*

European Commission (2018) ***A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment - Updated Bioeconomy Strategy****. ISBN 978-92-79-94145-0*