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Editorial

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Catalytic Byproduct Valorization in Future Biorefineries

For reasons of environmental and economic viability, future biorefinery operations must minimize waste. Mimicking the strategy of maximizing resource utilization in fossil fuels-based refining and in the chemical industry, considerable research efforts have been recently aimed at identifying new ways of valorizing byproducts generated in the refining or upgrading of lignocellulosic biomass, its components, and other sustainable biomass feedstocks to yield value-added chemicals and new materials for various applications. Key to the translation of the reaction paths conceived for biobased waste processing into industrially amenable technologies is the design of highly active, selective, and durable catalysts and the development of sustainable process engineering solutions. These topics have been studied intensively using a wide variety of approaches.

The "Catalytic Byproduct Valorization in Future Biorefineries" Virtual Special Issue's (VSI) numerous articles offer a picture of the current state of this emerging field (https://pubs.acs.org/page/ascecg/vi/catalytic-byproduct-valorization-future-biorefineries.html). The VSI showcases the diversity of side streams and the multifaceted chemistry of their transformation into intermediates, commodities, fine chemicals, and polymer precursors. Not unexpectedly, lignin features prominently, with the research reported providing a firmer connection between feedstock pretreatment (functionalization and fractionation through acidic, reductive, or oxidative means) and subsequent processing of derivatives like carboxylic acids, aromatic ethers, and isoeugenol. While glycerol continues to attract attention, studies on other streams and platform molecules have gained traction, such as the upgrading of saccharide-derived organic acids (formic, itaconic, succinic), furans, sorbitol, and the chitin-derived platform molecule acetylglucosamine. Each of these oxygenates is catalytically converted through a variety of reactions: (transfer) hydrogenation and hydrogenolysis retain their dominant role and are complemented by oxidation, isomerization, alkylation-esterification, and (cyclo)dehydration.

Also included in the VSI are new developments in catalyst design, such as the use of artificial metalloenzymes for lignin depolymerization, a metabolically engineered bacterium to upgrade xylose, and various tailored heterogeneous systems for a range of conversions. The contributions show the effect of introducing multiple functionalities and nanostructuring to attain catalytic materials displaying superior performance. Furthermore, cascade reactions are presented as a means of process intensification to address complex multistep transformations. Notably, these emerging catalytic technologies are investigated at different technology readiness levels on the path toward prospective implementation. Unconventional synthesis methods, such as mechanochemistry and aerosol processes, are put forward, and solvent effects are elucidated. The importance of innovating the characterization toolbox used, e.g., by adopting methods such as confocal microscopy that are established in other research fields, as well as the insights gained from theoretical studies to deepen molecular-level understanding are highlighted. Finally, process modeling and life-cycle analysis are demonstrated to be powerful not only to verify at an early stage the sustainability of individual routes and their integration into a single facility, but also to identify process parameters that can guide catalyst design and optimization.

We thank all the authors and reviewers whose timely efforts made it possible to produce this fine collection of papers and the editorial team of *ACS Sustainable Chemistry & Engineering* for their great support. We hope that the challenges, opportunities, and perspectives presented in this VSI with respect to feedstocks, routes, catalytic systems, and process solutions will inspire the many scientists engaged in sustainable biobased chemistry, thereby accelerating full feedstock utilization aimed at coproducing renewable fuels, chemicals, and materials in future biorefineries, ultimately fostering the establishment of a circular economy.

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Notes

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