

Editorial

# Editorial Catalysts: Special Issue on “Biomass Derived Heterogeneous and Homogeneous Catalysts”

José María Encinar  and Sergio Nogales-Delgado \* 

Department of Chemical Engineering and Physical-Chemistry, University of Extremadura, Av. De Elvas s/n, 06006 Badajoz, Spain; jencinar@unex.es

\* Correspondence: senogalesd@unex.es

Received: 27 November 2020; Accepted: 4 December 2020; Published: 8 December 2020



The replacement of petrol products for environmentally-friendly ones is a reality today, as many governments and international organizations are promoting the implementation of renewable energy sources and natural feedstocks in industrial activity. The multiple advantages of using bio-based products instead of their equivalent material of mineral origin are well known, like lower associated emissions, higher biodegradability, and a sustainable economic development of poor regions or developing countries, among others. In addition, the performance of these products, compared to the traditional ones, is acceptable, even showing some competitive advantages in certain cases. However, the implementation of technologies for environmentally-friendly production is sometimes worrisome, because it usually requires high costs. In these cases, the use of catalysts in order to improve the yield during production is vital to make green processes more competitive from an economic point of view.

In this special issue, we have tried to focus on the performance of homogeneous and heterogeneous catalysts applied in biomass processing, paying attention to the main advantages and challenges related to each kind of catalyst. Indeed, these challenges are opportunities to develop new research lines which can be fruitful in the near future. Thus, the use of homogeneous catalysts tends to be really useful to obtain acceptable product yields, whereas their management (including separation, among other steps) is generally difficult. On the other hand, heterogeneous catalysts can prevent this kind of problem, but their effectiveness compared to homogeneous ones is lower. That is, the yield is usually lower and therefore higher temperature or longer reaction times are required. In addition, their reusability is generally poor, not allowing many cycles.

Thus, we can note, in this special issue, the wide range of uses (or approaches) of homogeneous and heterogeneous catalysts, from the production of fatty acid amides [1] to the production of fatty acid esters for biodiesel or biolubricant use through different techniques and catalysts [2–4]. This fact points out that the use of homogeneous and, especially, heterogeneous catalysts has a wide range of possibilities in biomass processing, which will be a promising research line in the medium and long term.

Indeed, the role of enzymes as biocatalysts is important, even taking part in pre-harvest conditions of biomass. This way, soil respiration was studied under different irrigation levels (with and without aeration) in a greenhouse tomato system, showing differences in root length as well as dry biomass of leaf, stem or fruit [5].

This special issue has not only focused on the production of typical biofuels like biodiesel. As abovementioned, there were different and specific processes where the use of catalyst was vital to make the process feasible in a large-scale industry. For instance, the production of fatty acid amides from natural triglycerides through amidation was considered. Fatty acid amides have multiple uses (like surfactants, lubricants, and detergents) in various industries (in cosmetic industry, in biodiesel development technology, etc.), and the use of heterogeneous catalysts (Zn-doped CaO nanospheroids) for its production was studied by Kumar et al. [1], obtaining high efficiency and excellent reusability

without losing much catalytic activity (one of the main drawbacks related to the use of heterogeneous catalysts or enzymes).

On the other hand, Hameed et al. reviewed the use of metal-based catalysts for the catalytic aerobic oxidation of biomass to produce 2,5-furandicarboxylic acid (FDCA), which has multiple uses (especially the replacement for terephthalic acid, PTA). The main challenges are the improvement of selectivity for FDCA when non-noble metals were used, and the performance of the catalysts was dependent on properties like the support, the active phase, or particle size, among others [6].

Another application of catalysts in biomass could be upgrading bio-oils in order to improve their performance in engine fuels or as fuel additives. Xue et al. assessed the performance of an active trimetallic Ni-Cu-Co/Al<sub>2</sub>O<sub>3</sub> catalyst for hydrodeoxygenation of bio-derived phenol, showing a high catalytic activity compared to their monometallic and bimetallic equivalents and obtaining high cyclohexane yields (over 98%) [7].

On the other hand, the use of enzymes in many processes like food, bioremediation, and industrial biotechnology is also important. Gafar et al. studied the optimization of the production of keratinase using feathers as the only source of carbon and nitrogen, being the starting point for the treatment of other wastes like waste bagasse or palm mill oil effluent, among others [8].

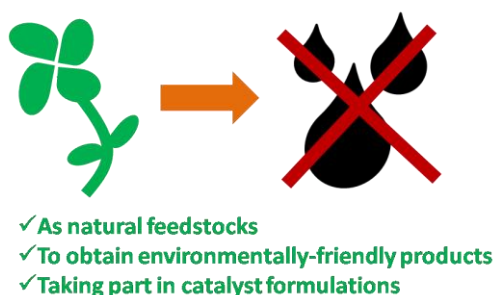
This way, another waste such as paper sludge is an attractive biomass feedstock for bioconversion to ethanol, and Malgas et al. used a recombinant cellulose cocktail for the saccharification of this waste to produce fermentable sugars. Thus, the enzymatic cocktail was optimized, and its performance was comparable to commercial preparations for paper sludge saccharification [9].

Searching natural replacements for synthetic nanofillers in order to reinforce polymeric matrices could be another important aspect to be covered. Pandurangan et al. studied the effect of cellulose nanofiber (CNF) from banana fibers on curing characteristics, structure, thermal, and mechanical properties in epoxy polymer matrix. This way, CNF could be a promising green nanofiller for the epoxy matrix, possibly acting as a curing catalyst during epoxy gelation [10].

Last, but not least, furfural is an intermediate step for the generation of many pharmaceutical and chemical products, mainly obtained from xylose in agricultural wastes. The use of lignin-based activated carbon-supported iron catalysts for that purpose was studied by Rusanen et al., being a feasible alternative for FeCl<sub>3</sub>, with furfural yields up to 57%, although their reusability should be improved [11].

As a conclusion, the use of homogeneous and heterogeneous catalysts contributed to the improvement of the performance of many different processes, in order to produce bio-fuels or bio-based materials. Indeed, new trends were observed, like the use of natural feedstocks to take part in the catalytic process. In any case, the improvement of the performance of these green processes seems to be a promising research line in the medium or long term. Thus, as pointed out in Figure 1, catalysts can play an important role in the replacement of fossil fuels and its derivatives for natural feedstocks (like the ones covered in this special issue).

### **Towards the complete replacement of fossil fuels and its derivatives for natural feedstocks**



**Figure 1.** Main prospects for the implementation of green technologies.

Thus, catalysts can contribute to the implementation of new feedstocks used in biorefineries in order to obtain environmentally-friendly products. Moreover, one of the main challenges would be the replacement of artificial catalysts for bio-based catalysts, which would make current technologies “greener”, if possible.

**Funding:** This research received no external funding.

**Acknowledgments:** The guest editors would like to thank the interest of the authors who have contributed to this special issue, and we are especially grateful for the assistance of Zerlinda Tian during this interesting and rewarding experience.

**Conflicts of Interest:** The authors declare no conflict of interest.

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