Biomass Platform Chemicals Catalyzed by Aqueous-Phase Catalysts

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Received: 3 October, 2022, Manuscript No.BBOA-22-80045; Editor Assigned: 5 October, 2022, PreQC No. BBOA-22-80045 (PQ); **Reviewed**: 20 October, 2022, QC No. BBOA-22-80045 (Q); **Revised**: 24 October, 2022, Manuscript No. BBOA-22-80045 (R); **Published**: 28 October, 2022, doi:10.37532/bboa.22.3.5.3.

Abstract

Through catalytic transformations such as dehydration, hydrogenation, oxidation, isomerization, reforming, ketonization, and aldol condensation over heterogeneous catalysts, a number of platform molecules derived from biomass, such as glucose, furans, levulinic acid, 5-hydroxymethylfurfural, and acetic acids, can be transformed into a variety of value-added chemicals. Given the high water content of the biomass and the creation of water during the catalytic conversion process, aqueous-phase processing is a significant concern and a major obstacle for the heterogeneous catalytic conversion of biobased compounds. Noble metal catalysts, non-noble metal catalysts, bimetallic catalysts, metal oxides, and zeolite are among the heterogeneous catalysts that are applicable to the aqueous-phase conversion process of biomass platform chemicals in this paper. A thorough evaluation of the catalyst performance, including the catalytic activity, stability, and regeneration performance of various types of heterogeneous catalysts, is also made. In addition, we emphasised the deactivation process in the aqueous phase and the impact of water on heterogeneous catalysts. To further aid in understanding the reaction process occurring on the surface of catalysts in the aqueous phase and to aid in the design of focused catalysts, a number of catalytic processes of aqueous-phase conversion over heterogeneous catalysts are presented. Finally, there is hope for biobased chemicals and energy.

Keywords: Ketonization • Dehydration • Isomerization • Biorefinery • Recyclability • Aldol

Introduction

Alternative energy sources that are environmentally friendly and have excellent renewability are becoming more important due to the depletion of traditional fossil fuels and their negative effects on the environment. Because of its enormous abundance and high sustainability, biomass is regarded as one of the most competitive potential resources, both as fuels and as chemical intermediates. The consideration of the conversion of biomass into biofuels is outside the scope of this study, despite the fact that biofuels are undeniably promising byproducts of the usage of biomass and have a considerable market demand. Despite the ease with which basic edible raw materials like starch and sugars may be transformed into valuable goods, this pathway is not seen as a promising one since it either directly or indirectly competes with food production. In contrast, despite it is rather challenging to prepare, lignocellulose, which is made up of cellulose, hemicellulose, and lignin, is edible. The biomass-based business can reach economic viability by creating chemical platform molecules via a variety of ways, and then further turning them into valuable chemicals through biorefinery, much like the petrifaction industry. These platform compounds frequently include a large proportion of oxygenated groups, which may have undesirable consequences when they are converted into fuels. However, due to their high oxygen content, they are water soluble and may be converted via aqueous-phase reactions at low temperatures and pressures. Additionally, waters are created either directly by biomass or by lowering the oxygen level; this has a positive impact on the conversion of biomass compounds to the aqueous phase.

Monomeric molecules like xylose and glucose are initially formed by the fermentation process during a general conversion pathway of lignocellulose. Following that, the dehydration of pentoses and hexoses might create the important intermediate products furfural and 5-hydroxymethylfurfural, respectivel. By hydrogenation or oxidation, these compounds can be further processed into a range of valuable platform chemicals, such as Levulinic Acid (LA) or 2,5-dimethylfuran. The following chemical reactions—isomerization, reforming, ketonization, esterification, and aldol condensation can transform these compounds into the required chemicals. The generated water has less of an impact on the conversion process in the aqueous phase. Due to their superior separation, heterogeneous catalysts have tremendous development potential. Catalyst stability and activity undoubtedly play a key part in the process. When it comes to heterogeneous catalysts, characteristics like activity and selectivity are influenced by surface area, pore structure, and acid sites, whereas stability and recycleability are influenced by water tolerance and hydrophobicity. Many reactions have been accomplished in the gas phase or the organic solvent phase in the past; however, most catalysts cannot play fully catalytic ability in the aqueous phase; the most common is deactivated rapidly, because the degradation of catalysts caused by the corrosive effects of H+ or OH- ions and dissolved organic carbon in water.

Conclusion

The development of enzymes for the production of biofuels has been the subject of extensive research in recent years. But laboratory tests are pricey and time-consuming. Computer simulations allow us to swiftly run millions of tests. Although computer discoveries can help scientists choose the lab tests that are most likely to produce useful results, they are not as accurate as the actual lab tests. It's not especially challenging to create algorithms for biological applications provided you have a firm grasp of the biological problem and are familiar with a programming language.

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Cite this article: Musa, A. Biomass Platform Chemicals Catalyzed by Aqueous-Phase Catalysts. Bioenergy Bioresour: Open Access. 2022, 03 (05), 03