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Mini Review

Advancements in Biorefinery Processing

Umenweke, Great*

Department of Chemical Engineering, Federal University of Technology, Owerri, Nigeria

***Corresponding author:** Umenweke, Great, Department of Chemical Engineering, Federal University of Technology, Owerri, Nigeria

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Abstract

Biorefinery processing is gradually taking over the conventional way of producing chemicals and fuels, and this novel approach is not without its own attendant difficulties. Biorefining comprehends the selection, chemistry and the technologies involved in the conversion of biomass into chemicals and fuels. The challenges faced in Biorefining ranges from catalyst issues, to energy-use severity and cost ineffectiveness. With a unique approach to the heterogeneous catalysts and optimization of parameters involved in the process, the biorefining process would be a successful venture.

Theory

The most prominent of the biorefinery processes includes biomass gasification, lignin depolymerization, lipids transesterification and catalytic fast pyrolysis. These processes utilize biomass efficiencies, ranges from an average 50% to 100%. The Biorefining utilizes not only the carbon in the biomass, but the whole biomass – carbon, oxygen, hydrogen and nitrogen. This is reflected in high biomass utilization efficiency (BUE) [1]. The progress thus far in the production of biofuels follows a trend that makes it less competitive with the feed consumed by both man and animals. The first generation biofuels sources produced much more of the fuels, but were food crops (e.g. maize), which was an issue. The same challenge was posed by the second generation biofuels, which compete with animal feed (lignocellulosic biomass-grass). The most acceptable, although with relatively less yield but novel approach to biofuels production is the third generation, which uses small plants that grow near water-algae. This generation biofuels seems acceptable, because it doesn't in any ways compete with food for both humans and animals. In the later years of its use, it became apparent that algae (microalgae) are advantageous to produce a very high yield, as it can produce oil that can be refined into diesel [2]. The lignin has a complex structure and low reactivity, which limits its application, hence the reason it's burned off as energy. However, the reactivity of the technical lignin is much lower than the lignin fragment due to the reactive site is blocked by the complex structure [3]. Biomass processing can result into several chemicals, which to a very large extent, resembles those obtained from a different source and pathway. These chemicals from biomass utilization can be classified as Drop-ins, Smart Drop-ins and Dedicated Chemicals. The process routes taken for the conversion are called pathways. While the conventional pathway follow the route taken to convert petroleum, natural gas and coal to useful products. Drop-in bio-based Examples of Drop-ins are Ethylene, Polyethylene, Polypropylene and Polyethylene terephthalate (PET) such chemicals are structurally identical to the petroleum based chemicals [4]. Drop-ins utilize the biomass as a feedstock, and enter the conventional pathway at an early stage. They are produced in larger quantities and hence, more expensive compared to the petroleum-based counterparts. The smart drop-ins are usually smaller in quantity. Examples are Acetic Acid, Acrylic acid, Adipic acid, butadiene and isoprene etc. Dedicated bio-based chemicals follow an entirely different pathway from the conventional pathway. They do not have identical fossil-based counterparts. They are used to obtain products that cannot be obtained through traditional chemical reactions [1].

Understanding the chemistry and reactions involved in the biomass upgrading process is paramount. Biomass products contain a large number of oxygenated functional groups, which poses a challenge and the number of these groups must be reduced by different reactions. To understand how to properly handle this situation, there is therefore a need to perform research in order to develop novel catalysts that are able to perform these reductions of oxygenated group reactions, in contrast to the oxidation reactions typical of the conventional chemical industry. Therefore, the development of bi- or even multi-functional catalysts is a critical issue. Further research needs to be focused on the development of catalysts that are capable of selectively transforming biomass-derived monomers (sugars, fatty acids, etc.) to platform molecules, or catalyzing the reaction from these intermediates to final products. Simultaneously, improved research should focus on the catalyst activities even in the presence of water and oxygenated compounds; the work should also focus on the possible modification of catalyst surface properties. Research & Development is a key component to understand catalyst functionality and to modify the morphological approach to catalyst development using new tools (such as process spectroscopy, etc.) [5].

Conclusion: Since biofuels are renewable, they cannot be completely depleted. This is an edge over the fossil fuels source. In algae technology for example, significant improvements must be done on the current economics of algae biofuels production, to increase its competitiveness in the market. The thermo-chemical processes, such as the biomass gasification and combustion technology has since 2005 gained preeminence in Asia, particularly China. To improve the bio-oils from biomass processing, the catalytic transformation has gained the attention of the government [6]. Other thermo-chemical processes like gasification and pyrolysis processes, research should focus on scaling up and integrating them into existing production units, together with end-product quality improvement (e.g., syngas purification for catalytic conversion and pyrolysis oil upgrading and fractionation). There is a need for proper optimization in burning, as high reactivity of biomass-derived molecules leads to catalyst coking issues (rapid deactivation of catalysts by accumulation of carbonaceous compounds on their surface) [5].

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