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Editorial

Economic feasibility of using agricultural wastes for catalyst development

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Resource recovery provides an opportunity to transform limited and abundant materials in form of waste into biobased products. In the production system, this technique could offer an economic means to utilize wastes to generate valuable products which are fundamental to a sustainable economy. Agricultural and industrial wastes play a crucial role in the realization of a circular economy as more attention shifts to ecosystem preservation [1]. In this light, agricultural wastes are positioned to make a substantial contribution to the production and manufacturing sectors. Indeed, the enormous potential of agricultural waste has been explored across the scientific community. However, motivation for the utilization of agro-waste varies across different levels and fields. To some degree, the argument for waste utilization is made to reduce costs and resources, preserve the environment and avoid depletion of finite non-renewable resources. The ease at which this resource can be converted and concentrated for use in different areas of application makes them appealing for use in agriculture, industrial and manufacturing sectors. Hence, these agricultural residues found applications in cement production, super capacitor development, fertilizer synthesis, paper making, catalyst development and supports, panel processing and adsorbent synthesis [1-4]. The vast resources and nutrients in agro-wastes are unlocked through a series of thermochemical treatments such as gasification, pyrolysis, torrefaction, carbonization, calcination, and even biological technological processes such as anaerobic digestion [5].

With concern for a sustainable environment, utilization of agricultural wastes presents a promising route to preserve the ecosystem as well as further socio-economic development. However, the extent to which agro-wastes benefit the environment is debatable due to the emission generated such as SO_x and NO_x during the production process. Though, the net advantage to the surroundings is believed to outweigh the demerits if properly implemented based on several assumptions [6]. It is obvious that different regions or countries potentially have the capacity to utilize this low-cost and abundant biomass material to scale up their manufacturing sectors. However, given the current status of biodiesel on its production, costs and pricing across the world, the industry has not shown a big leap. The biodiesel industry is projected to benefit enormously from agricultural wastes from triglycerides to catalysts, but recent data revealed that the progress is only at the laboratory scale [7]. Currently, biodiesel is one of the commodities being exchanged in the international market, particularly among developed countries such as the USA, Canada, France and Germany [8]. It is widely acknowledged that the development and use of renewable solid catalysts from agro-residues could lower the operating cost of biodiesel. For this reason, many studies had explored, formulated and synthesized several solid catalysts with each study stating the effectiveness and remarkable activity of the developed catalyst in biodiesel production [3,9].

The essence of this piece is to assess the current technology as relating to the economic feasibility of developing catalysts from biomass material and its application in biodiesel synthesis. This paper explored the existing results regarding catalyst yield and the adequacy of current technologies in producing cost-competitive biodiesel and seek to identify the factors limiting the commercialization of biodiesel produced in the presence of heterogeneous catalyst from agricultural biomass (wastes or residues). Are there other unidentified technical, economic and social barriers preventing the application of bio-catalysts in reducing biodiesel costs despite numerous claims? Three questions were raised in an attempt to highlight factors limiting the progressive shift from laboratory biodiesel production to a large scale. Firstly, are the resource recovery technologies in developing solid catalysts efficient? Secondly, is the adopted technique capable to produce a quantity large enough for commercialization? Lastly, is the whole process economically feasible for commercialization as claimed by several authors?

In the synthesis of solid catalysts from agricultural wastes, two products (biochar and ashes) are most likely to be produced through a series of several simple methods via the application of thermochemical techniques. Biochar can serve as a catalyst precursor due to its large surface area and highly rich functionalized surface. It can be activated through impregnation with other minerals as a potential catalyst while biomass ash can directly act as a catalyst for biodiesel production. Besides activating biochar, it can be used for soil amendment and energy recovery since the resource is rich in potassium and phosphorus. The yield of biochar depends on the nature of biomass as well as production technologies, though biochar yield can be extremely low as 15.7% - 17% [10]. The heating rate and reaction temperature are some of the prominent factors influencing the final nutrient content of biochar. The implication is that there is no guarantee that a sizeable amount can be recovered for the different biomass types. Even for the same biomass category, the yield would be varied owing to the technologies employed. Currently, no established technique or conditions has been provided that correlate to optimal nutrient content. James, et al. [10] expressed concern that the lack of regulation to standardize biochar production causes properties variation which consequently causes difficulty in commercialization. Considering that the synthesis of the final product (catalyst) involves a transfer from one stage to another, the overall process might not be as economical as projected.

Biomass ashes are a potential source of alkali metal oxides, commonly referred to as heterogeneous base catalysts. They are obtained from huge quantities of agricultural wastes through combustion [9]. Calcined biomass ashes are obtained at a temperature between 500 and 1200 °C, although ashes from animal biomass are generated at a temperature greater than the calcination temperature for plant biomass. Transesterification of vegetable oils to biodiesel had been achieved in the presence of synthesized biomass ash from different sources. The technique for the development of the base catalyst involves washing, drying, grinding and calcination. It can further be modified to improve the catalytic activity of the synthesized ashes. In practice, this technique is simple, straightforward and inexpensive. Moreover, many studies had combined different biomass materials to produce base catalysts. This concept was implemented to enhance the catalytic activity of the synthesized catalyst, thereby combining the physicochemical properties of each catalyst to generate a hybrid catalyst. Most works on catalyst development are done to demonstrate the applicability of the synthesized catalysts. However, there is no research data to determine the catalyst yield obtained from a unit (kg or ton) of agricultural waste. In addition, economic analysis in terms of monetized value of the process as well as the developed catalyst had not been carried out.

Despite enormous studies on catalyst development from biomass wastes, mineral catalysts such as potassium oxide, sodium hydroxide and sodium methoxide are still used to date. The Biodiesel industry's utilization of chemical catalysts in the production process would add to the net production cost. The challenges associated with minerals catalysts are conspicuous to be ignored. Ideally, industrial practitioners are expected by now to have adopted the green solid catalysts produced from agricultural wastes. In Science Direct, there are 6,396 articles on biodiesel production from solid acid developed from agro-wastes. Only 8 articles conducted lifecycle assessment or techno-assessment analysis on biodiesel from wastes and none of the articles specifically focus on the economic analysis of heterogeneous base catalysts developed from agricultural wastes. It is unclear why the attention of researchers was not given to that important aspect of biodiesel production, but it does suggest that the scientific community is more focused on providing solutions while implementation and execution were not given the same importance. On the other hand, economic analysis or techno-economic assessment of heterogeneous base catalysts from agricultural wastes does not produce sufficient returns to justify the adoption of base catalysts from agro-wastes. One noticeable point is the lack of integration between the biodiesel practitioners and the researchers, perhaps the disconnection between the two important stakeholders is the final barrier that needed to be removed. Further studies can explore realistic scenarios based on the cooperation between the biodiesel industry and the researchers. Also, research with a focus on the economic implication of heterogeneous catalysts on overall biodiesel costs can eliminate the doubt regarding the application of biowastes.

In conclusion, base catalysts development from agricultural wastes is a promising method to lower the net costs of biodiesel production and as well protect the environment. However, the failure to utilize this resource even at the commercial level could indicate that either the methodology and technology employed do not make economic sense or the percentage yield of the catalyst synthesized is small without significant correlation to the procedural steps. The lack of industrial data or recent insight into biodiesel industries already using biowaste catalysts if exist may be due to technical-economic concerns. Several questions to be answered regarding the commercialization of biodiesel using green catalysts from agricultural wastes may include; is the availability of agricultural biomass in large quantities limiting the commercialization or is the logistics system limiting the expansion or is the failure to adopt biomass catalyst due to techniques adopted or is the efficiency of the resource recovery worth the process? Future studies can explore some questions raised in this piece to further the development achieved in the biodiesel industry. If biomass catalysts for biodiesel production are going to be adopted at the commercial stage, the technologies must be able to efficiently recover the resources in the most economical way to ensure sustainability.

Authors contributions

Olayomi Falowo wrote the article and Babatunde Oladipo proofread the manuscript.

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