CAN LIGNOCELLULOSIC HYDROCARBON LIQUIDS RIVAL LIGNOCELLULOSE-DERIVED ETHANOL AS A FUTURE TRANSPORT FUEL?

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Although transport fuels are currently obtained mainly from petroleum, alternative fuels derived from lignocellulosic biomass (LB) have drawn much attention in recent years in light of the limited reserves of crude oil and the associated environmental issues. Lignocellulosic ethanol (LE) and lignocellulosic hydrocarbons (LH) are two typical representatives of the LB-derived transport fuels. This editorial systematically compares LE and LB from production to their application in transport fuels. It can be demonstrated that LH has many advantages over LE relative to such uses. However, most recent studies on the production of the LB-derived transport fuels have focused on LE production. Hence, it is strongly recommended that more research should be aimed at developing an efficient and economically viable process for industrial LH production.

Keywords: Lignocellulosic hydrocarbon; Lignocellulosic ethanol; Lignocellulosic biomass; Transport fuel

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Lignocellulosic Hydrocarbon: A Promising Future Transport Fuel

Petroleum is currently being used as a major source for transport fuels, but it poses great concerns in terms of its future utilization because of limitations in its supply, increasing costs, and the associated environmental issues. Lignocellulosic biomass (LB) is becoming a potential raw material source for transport fuels in place of petroleum. Production of the LB-derived transport fuels has drawn much attention in recent years because it can significantly reduce our dependence on petroleum, create new jobs, improve rural economy, and reduce greenhouse gas emissions. Lignocellulosic ethanol (LE) and lignocellulosic hydrocarbon (LH) are two typical representatives of the LB-derived transport fuels, and these are produced through biological and thermo-chemical pathways, respectively.

LE as a transport fuel is mainly used as an additive for E10 or E15 flex gasoline. By contrast, LH can be used in place of such transport fuels as gasoline, diesel, and jet fuel. In other words, the LH has wider uses as a transport fuel. In fact, LH is essentially the same as the hydrocarbons obtained currently from petroleum, except that it is from LB. Compared with LE, there are many advantages of LH as a transport fuel. It has higher energy density and it isn't necessary to modify such existing infrastructure as engines and pipelines. Moreover, the production of LH also has many potential advantages over that of LE. First, LH production can eliminate the energy-consuming distillation step, since LH is immiscible in water and it can be self-separated from the reaction mixtures. Second, the LH production can be carried out in concentrated water solutions, an approach that can greatly reduce water consumption relative to the ethanol fermentation process. Third, the LH production can be carried out at higher temperatures, which allows for faster conversion reactions in smaller reactors. Thus, LH production has a smaller economical scale, which leads to not only the lower equipment investment but also the lower LB collection cost. Therefore, the LH might be a more favourable future transport fuel in contrast with the LE.

LE production is a relatively mature technology that involves four sub-processes: pretreatment of LB, enzymatic hydrolysis of carbohydrates in LB into fermentable sugars, ethanol fermentation, and its separation by distillation. Current research work on LE production is concentrated on decreasing its cost and improving its process efficiency. Although LH production is relatively new and there are still some challenging technical problems, it is essential that more research should be carried out in developing an efficient and economical viable process for the industrial LH production.

Development of an Efficient and Economical Viable Process for the Lignocellulosic Hydrocarbon Production

Thermo-chemical conversion of LB to LH as a transport fuel can be realized through a wide range of processes. Based on the deconstruction methods of LB, these processes can be broadly lumped into four classes: gasification, liquefaction, fast pyrolysis, and hydrolysis. Among them, gasification of LB into syngas, followed by syngas clean-up, water-gas shift, and the Fischer-Tropsch synthesis is the best defined and technically proven process for the production of LH. This process has been widely studied, and it can be used to produce such transport fuels as gasoline, diesel, and jet fuel by using different catalysts and controlling different reaction conditions in the Fischer-Tropsch synthesis. In principle, this process is similar with the "coal to oil" process. Its major roadblocks are the cost-effective production of syngas from LB and the deactivation of catalysts in the Fischer-Tropsch synthesis. Liquefaction or fast pyrolysis of LB into bio-oil and then upgrading the bio-oil to such transport fuels as gasoline, diesel, and jet fuel by hydro-treating, hydro-cracking, catalytic cracking, and hydrodeoxygenation is another effective process for the production of LH. This is analogous to today's petroleum refining process, and its extraordinary advantage lies in utilizing the existing infrastructure and technologies of petroleum refining. The greatest challenge for this process is how to efficiently remove oxygen from bio-oil while minimizing the consumption of expensive hydrogen. Hydrolysis of LB into sugars, followed by dehydration, aldol-condensation, hydrogenation, and hydrogenolysis is a relatively mild thermo-chemical process for the production of LH as transport fuels. Increasing the reaction selectivity and simplifying its production procedures by choosing suitable catalysts and solvents is the key to improve this process. Although great progress has been made in thermo-chemical conversion LB to the LH as transport fuels, much effort is still needed to develop an efficient and economical-viable process for its industrial production.

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