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Review

Biogasoline: An out-of-the-box solution to the food-for-fuel and land-use competitions

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A B S T R A C T

Societal developments are hinged on the energy supplied by fossil fuels. However, the supply of these fuels is finite in the foreseeable future. This is aside the associated environmental degradation and economic sustainability of these fuels. These negative consequences and challenges spurred the search for sustainable energy sources such as biofuels. However, affordable feedstocks and efficient synthesis for renewable fuels remain indispensable and yet challenging line of research. Therefore, breakthroughs in plant biotechnology and mass production are essential prerequisites for ensuring the sustainability of biofuels as alternatives to petroleum-based energy. Conversely, public outcry concerning the food-for-fuel conflicts and land-use change hinder the popularity of such biofuel energy sources. Therefore, this paper reviewed the prospects of biogasoline production as sustainable alternative to ethanol and a compliment to biodiesel. Apart from reduction in greenhouse gas emissions, biogasoline promises to be cheaper and more environmental friendly. Further, inedible feedstocks such as microalgae and rubber seed oil would ensure higher net energy gain. Consequently, these will help resolve the food-for-fuel conflicts and land-use competitions. However, achieving the biofuel central policy depends on advances in processing the renewable energy sources.

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1. Introduction

Apprehensions over diminishing oil reserves, increasing oil prices, deteriorating health standards because of greenhouse gas (GHG) emissions and associated environmental impacts have made biodiesel emerge as the fastest growing industry worldwide [1]. It is the second most abundant combustible renewable fuel. This is because of the renewable and potentially inexhaustible sources of vegetable oils [2,3]. Also, the energy content obtained therefrom is comparable to that of diesel fuel (Fig. 1 and Tables 1 and 2). However, to remain sustainable, some argue that nonfood crops which require minimal cultivation should be the main sources for biofuel production. Such cultivation should not compete with other feedstocks over arable land or cause deforestation. These include bioethanol from fermentation of sugarcane juice and starch-based feedstocks and biodiesel from transesterification of vegetable oil triglycerides (TGs). These issues raised the questions of food availability and prices, land-use and land-use changes, environmental degradation and socio-economic implications [4]. The proponents of this view claim the extensive utilization of seed crops and vegetable oils may cause starvation especially in the developing countries. Further, a general issue that affects the global biofuel development is the high cost of feedstock which constitutes more than 88% of the overall costs [1].

Bioethanol and biodiesel are the two globally acclaimed liquid biofuels that have the potentials for replacing gasoline and diesel fuels respectively. However, numerous challenges await the ingenuity of the research community and economic leeway from the policymakers. Collaborative efforts from these communities are vital in achieving the biofuel central policy especially in replacing fossil fuels, protecting and creating jobs, and protecting the environment [6]. While the research communities need to provide solutions to the production technologies and transition from fossil to biofuels, tackling the implications of such transitions rests on the policymakers. Interestingly, the need for concerted efforts and cheaper feedstocks persists [6,7]. This is despite the numerous developmental strides achieved such as utilization of abundant, affordable, and sustainable sources since Rudolf Diesel's vegetable oil dream. These strides were facilitated by advances in rational catalyst design and biotechnology. These techniques facilitate strategies for designing optimal biocatalysts and engineering native and *de novo* pathways for the sustainable production of biofuels. Other strides include reduced GHG emissions by 78% [6] while the Mcgyan Process® [8] produces biodiesel within 4 s by utilizing inexpensive, non-food-grade and FFAs-containing feedstocks.

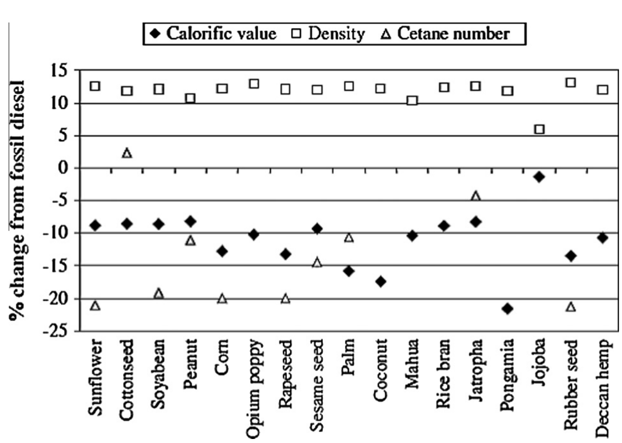

Fig. 1. Edible and inedible properties of plant oil compared to petrodiesel [5].

The challenge in rapidly and efficiently switching from utilizing the 'ready-to-use' energy sources (natural gas, coal and crude oil) to the renewable energy sources is an arduous one. This challenge is more pronounced especially when considering how to avoid deforestation while promoting bioenergy. Furthermore, the energy density of E85 (76,300–84,530 Btu/gal) is lower than that of gasoline (116,090–124,340 Btu/gal) based on location, time of year and political climate (Table 2). Additionally, this value equates to 73–83% the heat content of gasoline which gets lower in winter months in cold climates. Besides, the cost of bioethanol ($3.41/gal) is comparable to that of gasoline ($3.65/gal) [11,12]. Thus, spreading the perceived risks over wide range of renewable energy sources becomes appropriate. This will help provide a cocktail of energy sources which might appeal to the different needs of the consumers just like the fossil sources. Further, a diverse portfolio of energy is more likely to meet the high levels of future energy demands. Therefore, it is essential to understand and fully realize the causes that determine technological development. This is because process of developing a technology is not precise due to availability of different routes for such developmental stages. These include (a) minimal capital cost and investment, (b) utilization of affordable feedstocks, (c) environmental performance and (d) energy efficiency. Therefore, an out-of-the-box idea necessitates employing least-resistance-path approach in developing biogasoline expansion. This approach combines existing technologies and experiences with cheap resources. Though it might be below optimum initially, the approach ensures easy commercialization with minimum risks. This does not negate recognizing and promoting various 'nonbio' alternatives which are affordable, available, renewable and low-carbon alongside bioenergy [10]. Within this broader approach, bioalcohol (fermentation of sugars), biodiesel (transesterification of TGs) and bio-oil (pyrolysis of biomass) have received extensive experimentations. Similarly, the process that is gaining the attention of the academic and research communities is catalytic cracking of inedible oil to biogasoline.

Currently, ethanol is the available commercial biofuel. However, as mentioned earlier, because of sustainability, food security and economic competitiveness, it is imperative to find alternative sources. The present-day primary feedstocks such as starch

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