Minireview Article

Fuels for Automobiles; The Sustainable Future

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ABSTRACT (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

Unless clean fuels are available in commercial quantities, the future of internal combustion engine-powered automobiles hangs in the balance. Electricity-powered vehicles will displace them. However, electricity-powered vehicles are yet to meet some of the automobile demands. A paradigm shift with attendant infrastructural change is necessary for its adoption. Synthetic fuels promise to be the solution. Its invention dates back to the early twentieth century when the concern was not about climate change. The search for alternative fuels later metamorphosed to when fossil fuels reserve depletion and petroleum derivatives cost became a concern. The alternatives were made available in biofuels. The prevailing challenge is now climate change. It is the consequence of the emission of greenhouse gases from the combustion of petroleum derivatives in automobiles. Synthetic fuels show the potential of coming to the rescue despite the prevailing hurdles. The future holds a potential promise of converting greenhouse gas (CO_2) to liquid fuels that will allow little or no disruptions to the current transportation infrastructure network. It is, therefore, necessary to encourage further studies on the production of synthetic fuels. The environmental and economic benefits of commercially available synthetic fuels promise to be enormous.

Keywords: [Biofuels, Fossil fuels, Greenhouse gas, Renewables, Synthetic fuel}

1. INTRODUCTION

The development of internal combustion engines eased the movement from one place to the other. The engines find applications in automobiles, locomotives, aircraft, and marine vessels. Internal combustion engines face the threat of extinction because they emit greenhouse gases which contribute to climate change. Many nations' governments are looking at the electrification of vehicles to ensure clean transportation. However, demands like lightweight and short refueling periods still pose a challenge waiting to be surmounted [1]. The electricity-powered automobile can only be green if the source is green [2,3]. Hence, renewable energy sources like hydro, wind, solar, etc., need to be considered for electricity generation. Asides hydro generated electricity, wind and solar-generated electricity are the others with matured technology in the renewable energy mix [4]. They are, however, weather dependent and give out a fluctuating amount of electricity [4] thus, making the use of energy storage devices (batteries) a requirement. Electricity consumption relying on renewables requires augmenting with conventional generation during shortfalls, and for sole reliance on renewables, there has to be the introduction of redundancy.

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The peculiar demands of automobiles like lightweight and fast refueling make the use of batteries in electricity-powered vehicles an extra burden [1]. The batteries add to the weight of the automobile and need a relatively long time to recharge. While it's theoretically believed that all cars can be powered electrically, aircraft, ships, and heavy trucks still have to rely on internal combustion engines [5]. The importance of internal combustion to mobility led to the studies on alternative fuels as a means of reducing greenhouse emissions [6-7]. The use of biofuels can be a threat because it competes with available land for food production. However, leeway is the use of agricultural wastes to produce biofuels [8-10]. The level of greenhouse emission from biofuels in most cases is lower than for petroleum derivatives. However, not at the required level.

Scholars thus, suggest the utilization of the extra electricity generated from renewables above the mean during favourable weather for the production of synthetic fuels [1]. The process of production of synthetic fuels is by the hydrogenation of materials [11-12]. Synthetic fuels are carbon neutral when produced from renewable generated electricity [1-2,13]. With an economical production of synthetic fuels, our internal combustion engines can remain on the road with little or no net greenhouse gas emission contribution. The susceptibility of renewables to seasonal variation [4,14] will put further pressure on the system during the peak demand periods if electricity-powered automobiles are solely adopted. Thus, there is the need to have a fuel-based storage system to mitigate this challenge which will be critical to future energy systems [14]. This work thus reviews the literature on the development of alternative fuels for use in internal combustion engines. And the focus is made on synthetic fuels for the future.

2. ALTERNATIVE FUELS; THE PAST

The fuels of choice for the internal combustion engines used in automobiles are the Premium Motor Spirit (PMS) and the Automotive Gas Oil (AGO). These fuels are non-renewable. The fear of depletion of their reserves was the beginning of a search for alternative fuels [5,15-16]. Also, the requirement of high performance and lower emissions from the engines is a major driving force [2,6-7, 15-17].

The production of synthetic fuels dates back to the early twentieth century from fossil fuels. It contributed to the conception of the popular Fisher-Tropsch (FT) processes [18]. However, the push for alternative fuels during this period was not to reduce greenhouse emissions or improve engine performance. It was to make automotive fuels available without dependence on petroleum [18-19]. The inventors of the process faced the challenge of converting Germany's vast coal reserves for the best possible use. The automotive fuels exist in the liquid phase, and there was the challenge of getting a liquid fuel from the solid coals. This process was developed further and adopted by nations that sought fuel independence away from scarce petroleum reserves but with reserves rich in other fossils [19]. The technology of producing synthetic fuels from fossil fuels like coal and shale oil was conceived, implemented, and fully understood. However, what was lacking was its environmental impact [20]. Alcohol-based fuels referred to as “spirits” have also been used in the past to power internal combustion engines in automobiles [21]. These are alternative fuels to fossil fuels and qualifies as first-generation biofuels.

The reality of petroleum reserves getting depleted coupled with the insecure nature of its supplies [6,14,21] vis a vis fluctuating price soon became the pushing factor for the search for alternative mobility fuels. It forms the overlap between the past and the present. To overcome the challenge led to intensified studies on biofuels, which, unlike fossils, are renewable [6,16-17,21]. It is an undisputed fact that fossil fuels are great carriers of chemical energy. They can be used economically to meet demand within a short time frame [14]. Biofuels provided the needed alternative during this period. They have similar characteristic properties to that of petroleum-derived fuels [6,8-10,16,22-23]. Bioethanol found application in gasoline engines and biodiesels in diesel engines [21]. However, these biofuels come

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under the class of first-generation biofuels and compete with available resources for food production [16,21]. They thus became a subject of criticism; the production of ethanol is from sugarcane or corn that are food sources.

3. THE PRESENT AND THE FUTURE OF ALTERNATIVE FUELS

The search for alternative fuels originated from the need for motive fuel without dependence on petroleum but based on abundant coal reserves. The focus is now moving away from producing fuels from coal and crude-oil but other sources to end up with green fuels [19]. The competitive nature of the first-generation biofuels with food production [16,21] led to the push for producing biofuels from waste and other non-edible feedstock [21,24-25]. This class of biofuels forms the second-generation biofuels. In conjunction with the first-generation, they still find application in the present-day world as an alternative to fossil fuels for mobility.

Dimethyl Ether (DME) evolved as a substitute for AGO. It has properties similar to that of AGO with lower emissions making it a good choice for compression ignition engines [10,20]. It is a second-generation biofuel [21] but currently enjoys low patronage because of its adverse effects on the fuel system components and the need for a specialized fuel system design [11,21]. Moreover, it qualifies as a future fuel because of its potential as a hydrogen carrier for onboard fuel cells and its inclusion as a future potential fuel in EU nations [11].

Climate change is real. Studies have shown that global warming has gone to the extent of making average temperature about 1^0C above pre-industrial levels [2,26] and the reason for the push for greener fuels. An alternative to fossil fuels in terms of inherent energy with little or no greenhouse gas emissions is a task to be achieved.

Many nations' governments have joined the growing lists of countries making policies to adopt the use of electricity-powered vehicles over the internal combustion engines-powered ones [2-3] as a means of reducing global warming. However, while this might be possible if the source of electricity is green, some peculiar demands of automobiles are still waiting to be met with the design of electricity-powered vehicles [1]. The fact states that carbon-based liquid carrying fuels remains practically vital for mobility operations [5,12].

Electricity-based synthetic fuel production research is now enjoying patronage from nations' governments and big establishments. These gestures are to satisfy automobiles fuel need and for aircraft and marine vessels [27]. A plus that synthetic fuel is bringing-on is its compatibility with existing internal combustion engines. There is no gainsaying that the internal combustion engine technology is matured. The availability of compatible fuels that can meet the net zero-carbon emission requirement will be a dream come true. Keeping the infrastructures already on-ground for automobile manufacture will result in resource savings. Likewise, financial savings will come through the low cost of storage, transportation, and handling [14].

The Carbon Capture Storage (CCS) technology is fast developing, and the potential of producing synthetic fuels from the captured carbon is exciting [2,14,28]. The CCS technology currently relies on temperature swing adsorption using amine [29]. Studies, however, are on to advance the knowledge of cryogenics, membrane separation, and algae-based systems that can be adopted in the nearest future [28]. The disparity in the economics between fossil fuels and synthetic fuels is wide [29]. However, with significant investments, the gap will reduce. The technology of Carbon Capture and Utilization (CCU) is a potential boost for greenhouse gas reduction. It promises to provide the fuel of the future with zero contribution of greenhouse gas if rightly harnessed.

The high cost of producing synthetic fuels from Carbon IV Oxide (CO_2) is a consequence of its thermodynamic stability [28]. Studies have, however, shown possible mitigation of this with the development of non-thermal plasma technology that first reduces the CO_2 to Carbon II Oxide (CO) [30-31]. Technology for the absorption of CO_2 known as Pressure Swing Absorption (PSA) was proven to be feasible on a pilot scale. It is, however, required to conduct a techno-economic assessment of the process to determine its commercial

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feasibility [28]. Other studies have reported a cost reduction technology in direct capture-conversion, eliminating the high cost required for CO_2 purification [29].

The future looks bright for synthetic fuel production despite the constraints rearing its ugly head at the moment. The atmosphere has a vast amount of CO_2 that can be directly captured and utilized [27-29]. The water bodies (seawater) are also potential sources for synthetic fuel production [5,32] using artificial photosynthesis technology, and with committed studies can be developed to commercial scales. Synthetic fuel offers the potential of reducing carbon emissions from the transportation sector without disruptions to the existing infrastructures.

4. CONCLUSION

Having a clean fuel for the present and future with the twin advantage of being Carbon neutral and weather independent while perfectly fitting into the current liquid fuel infrastructures is a requirement. The utilization of CO_2 for synthetic fuel production will not only help in reducing greenhouse gases. It will also help to create an energy carrier from an environmental “toxic” product. The following are the deductions made from the study;

- The concept of synthetic fuel is not new; it was conceived in the early twentieth century, although due to different reasons from what is applicable today.
- The issue of cost and energy security became a cause of concern about petroleum fuels, and researchers came up with biofuels as an alternative. The concern about competition with food production led to a shift from the first to the second generation of biofuels.
- The dreaded effect caused by the emission of greenhouse gases from the combustion of petroleum derivatives became a cause of concern. It led to the call for the adoption of electric vehicles and the stop of the internal combustion engine-powered vehicle usage.
- Peculiar demands of automobiles cannot be fully met by electric-powered vehicles. Thus, the need for a Carbon neutral alternative to petroleum fuels. Synthetic fuels possess the potential to mitigate this challenge with little or no disruptions to existing transportation infrastructure.
- With the current state of technology development on synthetic fuels, the future of producing environmentally friendly fuels is bright.

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COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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