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Green diesel as sustainable alternative fuel

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ABSTRACT : *The increasing global demand for sustainable energy sources has driven significant interest in alternative fuels derived from renewable resources. Green diesel has emerged as a promising biofuel due to its high energy efficiency, low sulfur content, and compatibility with existing diesel engines and infrastructure. Unlike conventional biodiesel, green diesel is produced through hydroprocessing of vegetable oils, animal fats, and waste oils, resulting in a fuel with chemical properties similar to petroleum diesel. This study analyzes the production processes, environmental benefits, and economic potential of green diesel as a future alternative to fossil fuels. Additionally, its role in reducing greenhouse gas emissions and contributing to energy security is analyzed. The findings suggest that green diesel represents a viable and sustainable solution for the transition toward cleaner energy systems.*
KEYWORDS: Biofuels, green diesel, hydroprocessing, renewable energy, sustainable fuels.

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I. INTRODUCTION

Currently, meeting the high demand for fuels is a global challenge. According to the Organization of Petroleum Exporting Countries (**OPEC**), it is reported that less than 22 years of proven oil reserves remain, considering the current rate of production. Global crude oil consumption is approximately 76 MMb/d, which is an alarming figure, as more than 50% of the world's energy demand is derived from oil. However, although conventional crude oil can be obtained at relatively high rates and low cost, these reserves are declining worldwide.

Studies have shown serious environmental problems associated with the accumulation of harmful gases in the atmosphere, including emissions of carbon dioxide (**CO_2**), sulfur dioxide (**SO_2**), and nitrogen oxides (**NO_x**). These emissions are mainly generated by the extensive use of fossil fuels and contribute to global warming. This situation highlights the need to investigate alternative fuel sources with lower environmental impact. In this context, biomass represents a renewable and sustainable alternative of plant or animal origin.

II. WHAT IS A BIOFUEL?

Biofuels are fuels derived from biomass or organic matter, such as forest wood, agricultural and forestry residues, industrial waste, and animal waste. They represent a renewable source of energy and have the potential to create new and expanding markets for agricultural producers. Biofuels are commonly classified into four generations, depending on the type of biomass used in their production.

First-generation biofuels are produced mainly from agricultural products such as sugarcane, molasses, cereals, barley, corn, and other grains. However, there is significant opposition to this generation due to its impact on food security, particularly because of rising food prices. Second-generation fuels, also known as advanced biofuels, are produced from biomass such as agro-industrial waste, firewood, and used cooking oils.

Third-generation biofuels are derived from algae, which have the ability to grow under extreme conditions due to their metabolic adaptability. They offer significantly higher yields than first-generation fuels; however, their production requires nutrients and fertilizers, resulting in higher costs. Finally, fourth-generation

biofuels involve the use of genetically modified organisms, particularly algae. Although this approach shows promise, it is still under development and may pose potential risks to environmental health.

III. GREEN DIESEL AND ITS PROCESS OF OBTAINING

Green diesel, also known as green diesel or renewable diesel, is composed of fractions of long-chain hydrocarbons of carbon and hydrogen similar to conventional diesel obtained from oil. As shown in Figure 1, this fuel is usually free in its composition of oxygen (O), sulfur (S), nitrogen (N) and aromatic molecules

This can be produced from vegetable oil (palm, sunflower, jatropha, flaxseed, etc.) using hydroprocessing, consisting of subjecting the raw material to high temperature conditions and hydrogen pressure in the presence of a suitable catalyst. In addition, it is accompanied by the elimination of oxygen in the form of water and/or carbon dioxide from the molecules, these subprocesses are hydrodeoxygenation (HDO) and decarboxylation (DCO). These reactions produce green diesel, a mixture of long-chain saturated hydrocarbons that normally contain 15 to 18 carbon atoms per molecule. As a by-product, propane is formed, which could be used for energy purposes.

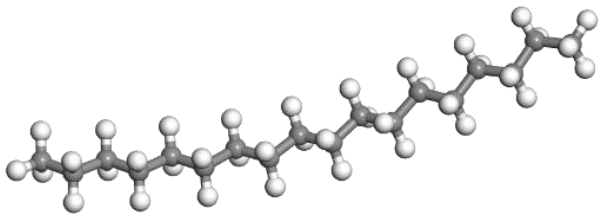

Fig. 1. Representation of the type of molecules of which green diesel is composed

IV. GREEN DIESEL AND ITS PRODUCTION PROCESS

The terms diesel, biodiesel, and green diesel can often be confusing; however, there are significant differences among these fuels, including their production processes, the products formed during the reactions, their molecular composition, and their physical properties. Conventional diesel is a non-renewable energy source that generates a large number of pollutants and carbon emissions into the atmosphere. In contrast, biodiesel is produced from triglycerides of plant or animal origin together with a solvent, usually methanol, through a transesterification process, generating glycerin as the main by-product of the reaction. Biodiesel is mainly composed of carbon, hydrogen, and oxygen.

On the other hand, green diesel is produced using the same raw materials; however, unlike biodiesel, no solvent is required. Instead, hydrogen is used under high pressure, producing propane gas as a by-product of the reaction. Unlike conventional diesel and biodiesel, green diesel does not contain oxygen, which improves engine performance, provides a higher cetane number, and increases its calorific value. These characteristics help reduce wear on engine components and allow for a more efficient combustion process with lower carbon dioxide emissions. The table below compares some key properties of the three types of diesels.

Property	Conventional diesel	Biodiesel	Green diesel
Feed stock	Petroleum	Vegetable oils/animal fat	Vegetable oils/animal fat
Oxigen content (%)	-0	10-12	0
Cetane number	40-55	50-65	70-90
Emission (Co_2)	High	Lower	Lower
Compatibility with engines	Excellent	Good (blends)	Good (drop-in fuel)

Fig. 2. Routes of the three types of diesels

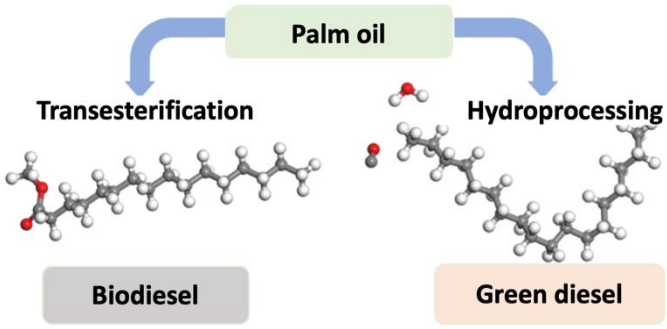

Fig. 3. Routes for obtaining biodiesel and green diesel

V. CONCLUSION

The production of green diesel is a viable and sustainable alternative to petroleum-derived fuels, as it is fully compatible with existing diesel engines and infrastructure. Its production from a wide range of biomass sources, such as vegetable oils, waste cooking oils, and animal fats, provides flexibility and supports the use of renewable resources. Additionally, its cleaner combustion profile, higher cetane number, and low sulfur content contribute to reduced greenhouse gas emissions and overall environmental impact.

Despite its advantages, some challenges remain, including high production costs, feedstock availability, and the need for further optimization of industrial processes. However, continuous advancements in catalytic technologies and process efficiency are helping to overcome these limitations. In this context, green diesel stands out as a key component in the transition toward more sustainable and environmentally responsible energy systems.

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