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Why hydrogen is an essential processing agent for biofuels

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Hydrogen enables chemical conversions which increase the usability, product yields and profitability of HVO and HEFA biofuels. This 'champagne' application elevates expensive hydrogen molecules to their highest value: as a chemical reagent to enable the use of affordable liquid biofuels.

HVO and HEFA

The term HVO refers to hydro-treated vegetable oil. HVO is a broad classification of liquid fuels which may include bio-diesel or sustainable aviation fuel. HEFA means hydro-processed esters and fatty acids. In addition to plant-based oils, treated animal fats such as beef tallow or poultry fat can be included within the HEFA definition.

Fatty acids and esters are hydrocarbon molecules which contain oxygen atoms. These oxygen atoms must be removed to increase the cetane value of the fuel. Removal of the [illegible]n also reduces the corrosive potential and ensures that the resultant biofuel is a [illegible] replacement for conventional fossil diesel or kerosene.

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The chemical conversion to remove the oxygen is known as hydrodeoxygenation. On the bio-refinery, it may take place by reacting the feedstock with hydrogen at around 30 bar pressure at a temperature close to 300 °C. Various metal catalysts combined with acidic promoters are known to enhance the reaction. Cobalt-molybdenum or nickel-molybdenum catalysts have been shown to be effective.

Unsaturated hydrocarbons can be unstable and polymerise over time, especially if traces of oxygen are present. This could transform the property of the fuel to be outside the appropriate specification for cloud point and pour point.

In turn, this would make the fuel highly viscous at low temperatures experienced during flight or when driving a truck in winter. Viscous fuel is hard to pump to the engine, and in the worst case may freeze, preventing fuel from reaching the engine and stalling the aircraft or truck.

The hydrogenation reaction targets double bonds between unsaturated carbon atoms. Hydrogen splits the double bond and joins the hydrocarbon molecule. Hydrogen, therefore, plays an essential role in ensuring driver and passenger safety in biofuels.

Moving hydrogen in bulk to biorefineries

The city of Los Angeles in California is home to a circa 12 mile hydrogen pipeline. It has been built by Air Products, largely through re-purposing crude oil, natural gas and refined products pipelines. The south west end of the pipeline is in the industrialised City of Carson, where hydrogen is produced on a steam methane reformer at a large petroleum refinery.

Hydrogen travels through the pipeline and heads to north and east. It traverses the cities of Los Angeles, Long Beach, Lakewood and Bellflower. The final offtake point is at the World Energy's biorefinery, in the City of Paramount.

World Energy uses 20 tonnes per day of hydrogen to convert up to 3,500 barrels per day of non-edible vegetable oils and beef tallow into renewable fuels. The bio-fuel products include aviation kerosene, diesel, gasoline and fuel gas.

If the pipeline did not exist, more than 20 compressed hydrogen truck deliveries would be required each day to deliver hydrogen to World Energy's Paramount Refinery. Avoidance of these truck movements improves urban safety in addition to reducing traffic congestion and air pollution from the vehicle emissions.

Food versus fuel

Without synthetic fertilisers the available fertile land on our planet may sustain only half the people that it can feed today. This emphasises the importance of land usage for the most essential purposes and re-allocation of land from food crops to energy crops must therefore be considered carefully.

In Europe, there have been restrictions placed on the amount of agricultural land that can be diverted from food production to fuel crops. Some years ago there was concern that many farmers were growing crops for biogas production rather than marketing their

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'Food versus fuel' considerations have led to a preference for waste oils as the input to HEFA processing facilities. However, there are only so many chips that get fried around the world. Waste oils are not produced for fuel, they are a secondary result of food preparation. Biofuels from waste vegetable oils therefore have a limited scalability.

Preservation of Asian forests

To prevent the use of virgin palm oil in biofuels and Sustainable Aviation Fuel (SAF), the European Union has implemented a regulatory squeeze using three legislative pillars.

1) Preventing Indirect Land Use Change (ILUC)

The Renewable Energy Directive (RED III) targets palm oil because of its high risk of ILUC, where agricultural land is cleared for fuel crops, leading to deforestation elsewhere to increase the available agricultural land. For road transport applications, as of 2023, the amount of palm-based biofuel that EU countries can count toward their renewable energy targets was frozen at 2019 levels. Since 2024, this allowance has been progressively reduced. By 2030, virgin palm oil use will be phased out completely.

2) Exclusion from Sustainable Aviation Fuel

The ReFuelEU Aviation regulation, which began its mandates in 2025, declares that food and feed-based biofuels, including virgin palm oil, are excluded from the SAF mandate. It also excludes Palm Fatty Acid Distillate (PFAD), a by-product of palm oil refining that was previously used as a "waste" feedstock, to close any loopholes and prevent palm oil entering the supply chain under a different name.

3) The EU Deforestation Regulation (EUDR)

this regulation controls imports of virgin palm oil. It entered into effect for large importers in 2025 and obliges them to prove that their palm oil was not produced on land deforested after 31st December, 2020. Furthermore, importers must provide precise coordinates of the farm on which the palm was grown. If the origin cannot be traced, the palm oil cannot be sold in the EU.

Second-generation biofuels

With recognition of the scalability limitations of first generation biofuels and their potential to result in food scarcity and environmental habitat loss, so-called second generation biofuels have emerged. They are produced from non-food crops and post-harvest waste.

Algae is also a source of esterified lipids which can be extracted from the algae to be processed in a similar manner to the HEFA products. Pyrolysis oils derived from waste lignocellulosic biomass, such as straw can also be processed in this way.

Gasification of forestry waste can also yield syngas for Fischer-Tropsch fuel production. In these cases, no land must be diverted from food production to generate clean biofuels. Biofuels generated through this pathways are currently being considered for new large-scale SAF production plants in Europe and the USA.

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