Algae-derived Biofuels as an Alternative to Petroleum-based Fuels for the Airline Industry

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Introduction

The need for replacing petroleum-based aircraft fuel continues to plague the airline industry as the threat of greenhouse gases produced by such machines contribute to global climate change. Even though the aviation sector is not a leading carbon emission producer, it is still a rapidly growing, fossil fuel dependent industry. For decades there has not been enough scientific research done to find economic and efficient alternatives to petroleum-based fuels that would make it worth the cost of using a substitute until now. The advances in science have allowed for the discovery and introduction of biofuels to the aviation industry as an almost promising potential candidates that have well rounded characteristics, such as their oil content, of becoming efficient biofuel materials.

Potential Impact Eco. Services

Jet fuel
- Already heavily relied upon
- Cheap to produce
- Disrupts ecological habitats and produces GHG (namely carbon) emissions

Biofuels
- Cannot compete with price or scale of jet fuels
- Compromised by cold weather
- Can greatly impact the reduction of oil dependence but it would take time

Algae can be grown in open ponds, which have cheaper production costs but a low yield and a high risk of contamination. Algae growth can also occur in closed photobioreactor systems that are more expensive than open ponds but have higher productivity and a larger yield. Algae are harvested in bulk then dehydrated to preserve the lipids in the cells. Dried algae oil extraction can occur either chemically or mechanically. Chemical extraction uses a variety of organic solvents. Modifications have been made to try and optimize the extraction time and lipid yield, including changing solvents and ratios of those solvents. Extracting oils mechanically from algae requires different press configurations, such as screw, expeller, or piston, that crush and break the cell to release oil.

There are two main methods to convert algae oil to jet fuel that is drop in ready. Hydroprocessed renewable jet (HRJ) conversion technology, as depicted in Figure 5, produces fuel with the same conventional properties of petroleum-based fuel.

Process Description

The current use of jet fuels releases carbon emissions and other dangerous chemicals directly into the atmosphere which aids in the continuation of climate change. As depicted in Figure 3, climate change directly affects our health. For example, many of life's necessities such as food, water, air and our habitats, are directly impacted. Along with this, the rises in temperature also affect lives due to its relation to viruses and how they are more susceptible to spreading under these conditions.

Despite the evidence against the use of biofuels, specifically its inability to meet the commercial demands. Integrating biofuels into the airline industry is not as difficult as it may appear as depicted in Figure 4. In fact, "more than 150,000 flights have used biofuel..." in 2018 alone. Which proves that it isn't impossible but there is a long way to go. The introduction of biofuels would positively impact the environment in various ways but most notably in the reduction of GHG emissions.

Research

Hypothesis: If algae is used to produce biofuel, it will be a viable and sustainable substitute to petroleum jet fuel.

Objectives:
1. Evaluate algae vs petroleum
2. Evaluate the effectiveness of different types of algae

Tasks:
1. Grow algae
2. Convert it to biofuel
3. Test its performance

Data Analysis: Biofuel conversion will be used to convert from weight and volume of algae into volume of biofuel. Other factors such as type of algae, method of production, and location will be important. An example of algae propagation is depicted in Figure 7.

Figure 1: Microalgae chlorella sp. is shown above with an oil content (weight % of dry basis) of 28.32

Figure 2: Microalgae dunaliella primolecta is shown above with an oil content (weight % of dry basis) of 23.73

The microalgae depicted in Figures 1-2 are promising potential candidates that have well rounded characteristics, such as their oil content, of becoming efficient biofuel materials.

Figure 3: Environmental Impacts

Biofuels

Figure 4: Biofuel Production

The catalytic hydrothermalysis (CH) produces jet fuel through a series of reactions, as depicted in Figure 6. These processes turn triglycerides into a mixture of hydrocarbons that can be isolated to jet fuel. The jet fuel produced from CH is drop in ready and has great combustion capacities.

Figure 4: Biofuel Production

Figure 5: HRJ Conversion Process

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Figure 6: CH Conversion Process

Figure 7: Commercial production-scale algae cultivation ponds.

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References

3. Dr. Safferman