CATALYTIC UPGRADING OF MICROALGAL HYDROTHERMAL OIL: IMPACT OF ALGAE SPECIES AND CATALYST FOR BIOFUEL PRODUCTION

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Global energy demand and environmental concerns to limit emissions have been growing steadily in recent years. As a result, fuel production from renewable resources has become an indispensable alternative to fossil fuels and microalgae are a potential raw material for third-generation fuel production due to their high growth rate, potential for CO_2 fixation, and high lipid content that can provide a significant biofuel yield. Hydrothermal liquefaction (HTL) is a thermochemical process successfully used to convert microalgae into bio-oil, avoiding an expensive additional drying step. However, the HTL algal oil contains a high amount of heteroatoms such as N, O, and sometimes S, which causes harmful emissions upon combustion and reduces fuel quality. Therefore, an upgrading step is required to reach transportation fuel specifications. Catalytic hydrotreatment (HDT) is the typical process for upgrading petroleum feeds and can be used to convert HTL algal oil into biofuel. In this context, two types of Chlorella microalgae (sorokiniana and vulgaris) with different biochemical compositions were cultivated at CEA Cadarache [1]. The algae were liquefied at CEA Grenoble, using a continuous HTL process to obtain HTL oils. Then, at IRCELYON, the algal HTL oils were transformed by hydrotreatment over various metal sulfide, nitride, and phosphide catalysts using different operating conditions [2]. Advanced characterization of HTL and HDT algal oils was employed to better understand the feedstock and catalyst effect during the HDT stage. Analysis of bio-oils showed C16 and C18 fatty acids, as the main compounds, that can be converted rapidly into C15-C18 aliphatics during the HDT stage. Besides, fatty amides and cyclic oxygen and nitrogen compounds such as phenols, indoles, pyrroles, and carbazoles were also identified and quantified. Catalytic hydrotreatment was efficient in improving the bio-oil quality, and it was confirmed that the bio-oil from lipid-rich microalga was easier to upgrade than the bio-oil from carbohydrate-rich microalga. Besides, the HDT oil yield was directly related to the biomass lipid content. The nature of the HDT catalyst greatly impacted the yield and selectivity. The tungsten sulfide-supported catalyst was more efficient than Mo nitride and Ni phosphide-supported catalysts, resulting in an HDT oil that felt primarily in the diesel range and then in the jet fuel range, as shown by SimDist. Thus, a second refining stage could promote cracking/isomerization reactions to increase the light fraction, which can be added to the sustainable aviation fuel (SAF) pool.

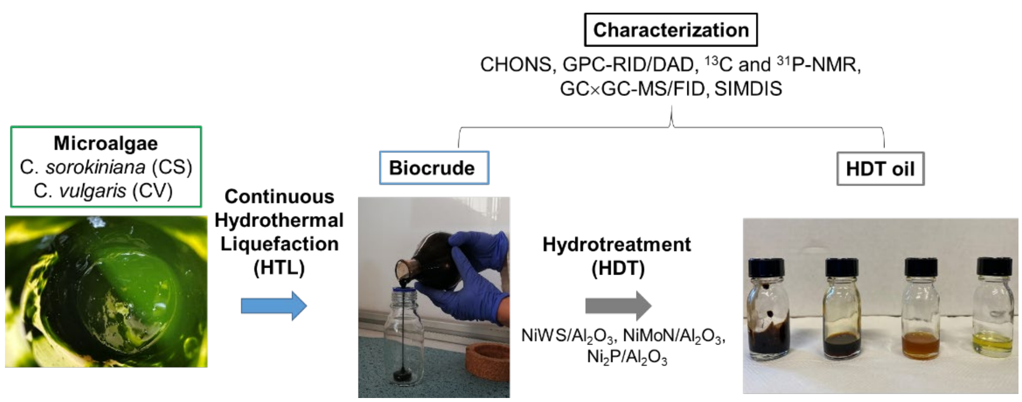

Figure 1 – Catalytic hydrotreatment of continuous HTL algal oil for biofuel production.

[1] Ramírez-Romero, A. et al., *Chlorellaceae* Feedstock Selection under Balanced Nutrient Limitation. *Fermentation* **2022**, *8*, 554. https://doi.org/10.3390/fermentation8100554
[2] da Costa Magalhães, B. et al., Catalytic Hydrotreatment of Bio-Oil from Continuous HTL of Chlorella Sorokiniana and Chlorella Vulgaris Microalgae for Biofuel Production. http://dx.doi.org/10.2139/ssrn.4239641