3rd Generation green fuels via hydrogenation of microalgae oil

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The depletion of fossil fuels and the resulting climate change have led the research community to investigate new cleaner technologies and high sustainability products based on renewable raw materials. Today, transportation accounts for about one-sixth of greenhouse gas (GHG) emissions in the world. Bio-based fuels are considered sustainable and constitute key alternatives to fossil-derived fuels. In this context, microalgal biorefineries pave the way towards the production of renewable fuels, provided that they are cultivated via methods aiming at the rational management of water resources and are exploited through state-of-the-art technologies with high yields. The current research aims to present a new technology for the production of green fuels via catalytic hydrotreatment exploiting microalgae cultivated in drainage water of greenhouse. The main target of this study is to investigate and optimize the hydrotreatment process of microalgae oil to 3rd generation green transportation fuels (diesel, gasoline and kerosene) based on fuel quality and process performance in terms of hydrogen consumption and product yields. Furthermore, life cycle assessment (LCA) was applied to evaluate the environmental impacts of the investigated biorefinery assessing the GHG emissions and energy efficiency.

More specifically, the current work targets to investigate the catalytic hydrotreatment upgrading of microalgal oil to green transportation fuels, employing the hydrotreatment pilot plant VB-01 of CPERI/CERTH. In particular, this TRL 3 pilot plant is a small industrial system which is operated to generate information about the behaviour of the system for use in design of larger facilities. The effect of the key hydrotreating parameters during the upgrading of microalgae oil in terms of product quality and catalyst performance were investigated, via testing three reaction temperatures, two hydrogen to oil ratio and two reactor pressures utilizing a commercial NiMo catalyst [1] [2]. A simplified diagram of the TRL 3 HDT unit is presented in Fig. 1.

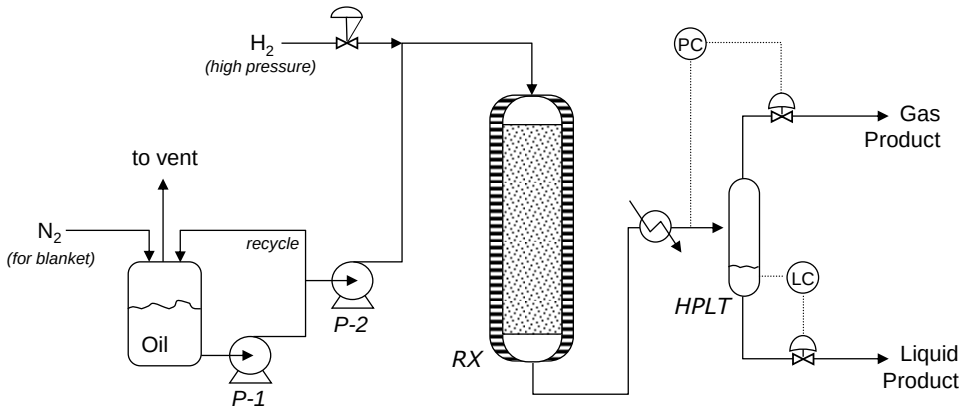

Figure 1 Simplified diagram of the VB01 TRL 3 hydroprocessing pilot plant

As aforementioned this study also attempts to perform a "cradle to gate" analysis evaluating the environmental profile of a biorefinery producing green transportation fuels. The system boundaries of the examined biorefinery are shown in Figure 2, presenting an overview of the encompassed subsystems.

According to the results, reaction temperature strongly influences the product yields as higher temperatures promote cracking reactions leading to lighter hydrocarbons in the kerosene and gasoline range. However, higher temperatures lead to higher hydrogen consumption due to more cracking reactions. The effect of pressure is not as strong as that of temperature, however higher-pressure favours hydrogenation reaction at the expense of hydrogen consumption. In general, it was observed that the choice of the operating window is very important and affects the product hydrocarbon range. Therefore, reaction temperature and pressure should be carefully selected based on the targeted products.

The LCA study evidenced that microalgae cultivated in drainage water constitute a potential feedstock for the production of renewable fuels via catalytic hydrotreatment rendering significant environmental advantages. In particular, the hydrogen consumption and the energy requirements were found to be the core sources of GHG emissions in the biorefinery.

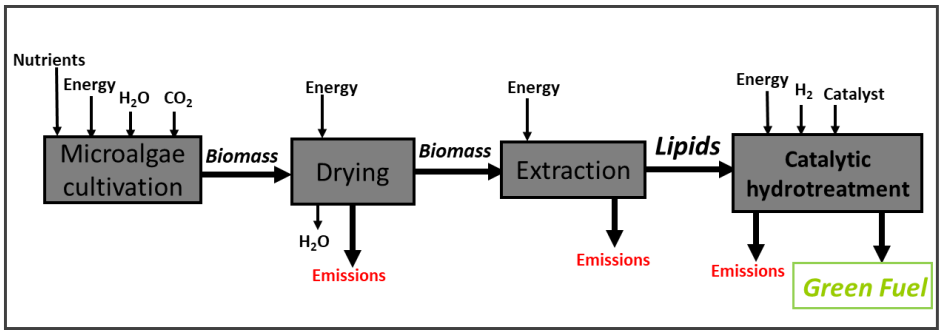

Figure 2 System boundaries of the examined process

Consequently, the current study aimed to explore the production of 3rd generation green fuels via catalytic hydrotreatment of microalgae oil cultivated in drainage water of greenhouse, evaluating its environmental impacts, as well. The results highlight that the investigated biorefinery approach constitutes a beneficial production process, thus enforcing research studies in this direction. Future actions could be guided towards the application of hydrogen originating from renewable sources in order to further reduce the environmental impacts of the production processes.

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