Simulation, Optimization and Economic Evaluation of Hydrothermal Liquefaction Process for Biofuel Production

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***Abstract*— Excessive use of fossil fuels has resulted in many global issues, such as environmental pollution, the energy crisis and global warming. As energy consumption rises and supply does not keep pace, alternative solutions must be developed to meet society's current expectations. Sustainable, energy-secure, and global warming-reducing alternatives to traditional fossil fuels are highly desirable. The study evaluates the microalgae hydrothermal liquefaction (HTL) and subsequent biocrude upgrading system with alternative aqueous phase treatment methods. The economic performance of three production pathways for large-scale processing of microalgae into biofuels was conducted in South Africa. The algal biorefineries produce primarily diesel fraction and naphtha co-product liquid fuels. Production scenarios were simulated using Aspen Plus® software. Using a discounted cash flow analysis, the resulting mass and energy flows were used to estimate the minimum selling fuel price (MFSP). The three scenarios that were evaluated are: (A) Biofuels production through HTL and Upgrading of microalgae grown in large-scale farms (Using freshwater), (B) Biofuels production through HTL and Upgrading of Wastewater primary effluent-grown algae with anaerobic digestion (AD) for the production of biogas and compost and, (C) Biofuels production through HTL and Upgrading of Wastewater primary effluent-grown algae without AD (Aqueous waste recycled back to algae farm). Scenario C was the most profitable with an MFSP of 0.91 US$/L, and scenario A was the least profitable with an MFSP of 3.11 US$/L with the feedstock costs contributing 88% of the operational expenditure. Scenario B had an MFSP of 1.47 US$/L. Scenario C was profitable due to its feedstock cost being zero because the wastewater treatment works (WWTW) assume the feedstock delivery costs. It is assumed that algae cultivation removes some nitrogen (N) and phosphorus (P), reducing the WWTW's nutrient removal costs. As a secondary benefit of algae treatment, some organic waste components can be broken down by bacteria, which are readily absorbed by algae, thereby reducing solid removal costs for the WWTW. Sensitivity analysis showed the process to be sensitive to feedstock cost, capital expenditure, operation time, bio-crude yield, the addition of the AD section and operational expenditure. Recycling the aqueous phase wastes to the algae farm offers more significant cost savings than generating biogas and compost from the AD section. The construction of biorefineries will lead to the creation of additional jobs in the country.**

***Keywords*— Biofuels Production, Wastewater treatment, Algae.**

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