Techno-economic analysis of biojet fuel production from wastes of the palm industry

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1. Introduction – The increasing demand for jet fuel and the concern about climate change make necessary to reduce the dependence of petroleum products and search for alternatives like the use of biojet fuel. This work studies, through a techno-economic analysis, three processes to produce biojet fuel, using the waste from the palm industry as a feedstock including palm kernel oil, palm fatty acid distillates (PFAD) and lignocellulose from palm biomass. Physico-chemical properties were estimated to determine if the final product of each process met with the technical requirements established in the ASTM standards. Mass and energy balances considered the energetic self-sufficiency of the processes simulations in ASPEN Plus®, preventing the use of fossil energy sources. Palm kernel oil and PFAD were converted to hydro-processed esters and fatty acids (HEFA) by esterification followed by upgrading to biojet fuel while the lignocellulose was converted into biojet fuel using a thermochemical conversion process composed by fermentation, dehydration, oligomerization and hydroprocessing (L-ETH-J). 2. Experimental – The NRTL method was chosen for the three simulations in ASPEN Plus® software. The physico-chemical properties estimation was based on the Joback group contribution method (1) and Rackett method (2). On one hand, the palm kernel oil was deoxygenated to hydrocarbons during the HEFA process by catalytic hydrotreating (3). The hydrocarbon products (mainly C15–C18) were subsequently cracked and isomerised by the addition of H2. The PFAD process was performed by updating a simulation reported previously by Yujaroen D. et al. (4). On the other hand, during the L-ETHJ process, the lignocellulose was pre-treated using SO2 and then hydrolysed enzymatically, with a cellulose to glucose of 87% (5). Continuous fermentation using a promising co-fermenting strain of Saccharomyces cerevisiae was subsequently employed, which had conversions of xylose to ethanol of 44% and glucose to ethanol of 88%, upgrading ethanol to biojet fuel by dehydration, oligomerization and hydroprocessing. The economic investigation was performed based on the complete mass and energy balances from the ASPEN Plus® process simulations. 3. Results and Discussion - The results of the comparison between the reference values of the ASTM D1655 and the estimated physico-chemical properties show how the biojet fuels obtained from the three processes qualify as a good quality jet fuels. The economic analysis shows how the cost of the raw material has a high impact on the final cost of the biojet fuel, however, a significant reduction of operation costs can be achieved thanks to energetic optimizations of the process. 4. Conclusions The physical properties of aviation fuel obtained in the three processes met with the ASTM technical standards. Energy optimization of the processes has a significant impact reducing the production costs of the biojet fuel, but the final price is still too high compared to Jet A-1, mainly due to the raw material. 5. References 1. Joback, K. G., & Reid, R. C. (1987). Estimation of pure-component properties from group-contributions. Chemical Engineering Communications, 57(1-6), 233-243. 2. Rackett, H. G. (1970). Equation of state for saturated liquids. Journal of Chemical and Engineering Data, 15(4), 514-517. 3. Gong, S., Shinozaki, A., Shi, M., & Qian, E. W. (2012). Hydrotreating of jatropha oil over alumina based catalysts. Energy & Fuels, 26(4), 2394-2399. 4. Yujaroen, D., Goto, M., Sasaki, M., & Shotipruk, A. (2009). Esterification of palm fatty acid distillate (PFAD) in supercritical methanol: Effect of hydrolysis on reaction reactivity. Fuel, 88(10), 2011-2016. 5. Carrasco, C., Baudel, H. M., Sendelius, J., Modig, T., Roslander, C., Galbe, M., & Lidén, G. (2010). SO2catalyzed steam pretreatment and fermentation of enzymatically hydrolyzed sugarcane bagasse. Enzyme and Microbial Technology, 46(2), 64-73.