Techno-economic evaluation of bio-hydrogenated diesel production from palm fatty acid distillate and refined palm stearin using recycled stream of alkane product as solvent.

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Highlights

- Production of bio-hydrogenated diesel production from palm fatty acid distillate and refined palm stearin were compared under the same production process.
- Alkane products from the process were recycled to be used as solvent in reactor.
- An economic evaluation of using recycled stream of alkane products was carried out.
- Using recycle stream as energy carrier and solvent has insignificant impact on cost reduction.

1. Introduction

Bio-hydrogenated diesel (BHD, alternatively named as green diesel, is one of the renewable liquid fuels, which can be produced from vegetable oil, animal fats, and waste cooking oil, having similar liquid fuel properties to conventional diesel. Palm fatty acid distillate (PFAD) and refined palm stearin (RPS) are by-products from the refining palm oil industry, having main fatty acid groups of palmitic acid (PA) and oleic acid (OA). Production of BHD can be carried out via three main catalytic reactions known as hydrodeoxygenation, decarbonylation, and decarboxylation with hydrogen gas. BHD production in a laboratory scale often uses solvents in the reaction with high hydrogen to oil ratio and dodecane is one of the most solvent selected. The main purpose of using solvent in the reaction is to reduce operating pressure compared with that of solvent-free process, which usually requires high operating pressures. It anticipates that solvents play a role in mass-transfer resistance reduction assisting the contact of hydrogen and reactants at catalyst surface. Dodecane is high cost so that other alkane-based solvents may be an interesting choice. As for the industrial scale of BHD production, alkane products from the production process may be recycled back and mixed with the main feedstocks prior to being fed to the reactor. Thus, it is anticipated that alkane products in a diesel range can be used as a solvent. Thus, it is worthwhile to investigate the economic benefit of BHD production. This work aims to study the feasibility of bio-hydrogenated diesel (BHD) process using recycled solvents by using the by-product from the crude palm oil refining process, PFAD and RPS, at a capacity of 50 tons/day. The study was conducted on chemical process design software, Aspen Plus, with four cases consisting of BHD production from PFAD and RPS both with and without using recycled stream of solvent. Material and energy balance calculations were performed prior to economic evaluation and comparison of the four cases.

2. Methods

Process flow diagrams of the BHD production from PFAD and RPS without solvent-recycled stream can be shown in Figure 1, while that of the process with solvent recycled stream can be shown in Figure 2. Reaction performances without using solvent were based on experimental data reported by Thongkumkoon et al. [1], while those with solvent were based on experimental results from our research group. Oil to solvent volume ratio for PFAD and RPS were set approximately at 1:0.785 and 1:1 respectively, while hydrogen to oil ratio was set at stoichiometric proportion.

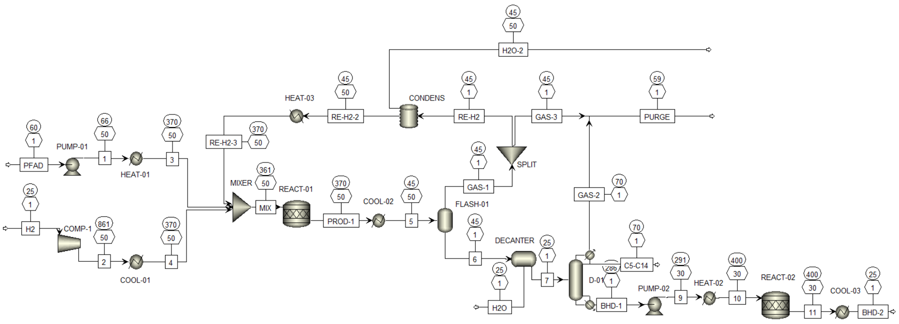

Figure 1. BHD production process from PFAD and RPS without solvent recycled stream.

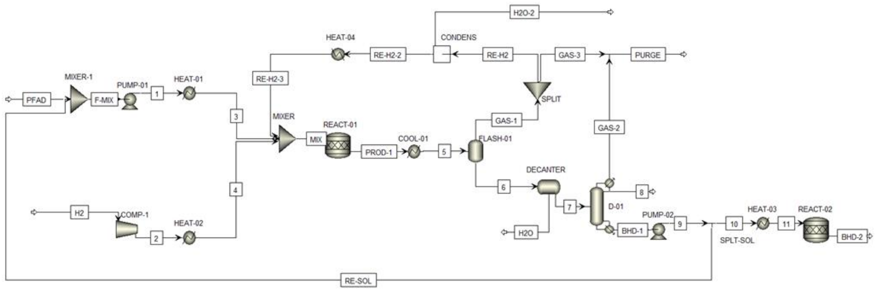

Figure 2. BHD production process from PFAD and RPS with solvent recycled stream.

3. Results and discussion

From process simulation calculation with the capacity of 50 tons/day of PFAD and RPS, when using PFAD as a feedstock, operating condition were changed from 50 to 17 bar and product yield at the hydro-processing section was changed from 81.53% to 96.02%, whereas that with RPS was changed from 50 to 34 bar and the yield was 81.83% and 96.09% respectively. After designing the process with energy recovery and heat integration, while energy used at the reactor was insignificantly changed due to energy recovery in the process and the energy used without considering separation part were decreased because lower pressure leading to lower energy required at pressure changer units. However, the overall energy used for the cases of using recycled solvent were increased due to more energy required at distillation column approximately two folds as the feed to the column increased.

4. Conclusions

Techno-economic evaluation for BHD production from PFAD and RPS were investigated in the case of using solvent compared to that of non-solvent ones. While operating condition at the reactor can be reduced leading to lower energy required, the overall production process required more energy as the capacity at distillation column was almost double. The process will require modification probably by recycling all the liquid products coming out from the reactor instead of recycling after passing the separation column.

References

[1] S. Thongkumkoon, W. Kiatkittipong, U. W. Hartley. N. Laosiripojana. P. Daorattanachai, Renew. Energy. 140 (2019) 111–123

Keywords

Bio-hydrogenated diesel; palm fatty acid distillate; refined palm stearin; alternative fuel.