Chapter 9

Conclusions and Future Perspectives

9.1 Conclusions

General conclusions can be drawn are room temperature, a closed container, and dark circumstances are the best conditions for long-term storage of biodiesel. The testing parameters of methyl ester content, density, acid value, and total glycerol in the multi-feedstock biodiesel met the quality standards of ASTM D 6751, EN 14214, and SNI 7182-2015. Palm oil biodiesel is still better from an environmental and energy perspective for Indonesia than multi-feedstock biodiesel. However, prudent practice is required; deforestation for land clearing for oil palm plantations must be prohibited. More detailed conclusions for each research chapter are in the following paragraph.

All POB and COB test parameters were impacted by storage duration in this research. POB exhibited increases in density of 51.52 kg/m^3, kinematic viscosity of 0.67 mm^2/s, acid value of 0.27 mg-KOH/g, total glycerol of 0.58 %-mass, and peroxide value of 48 meq-O_2/kg after 12 months in a closed container at 22 °C in the dark, as well as a decrease in FAMEs of 7.11 %-mass. Meanwhile, COB increased its density to 17.52 kg/m^3, its kinematic viscosity to 0.32 mm^2/s, its acid value to 0.25 mg-KOH/g, its total glycerol to 0.60 %-mass, and its peroxide value to 54 meq-O_2/kg, while decreasing its FAMEs to 9.36 %-mass. The GCMS data for POB and COB indicated decreases in 9-octadecenoic acid methyl ester and 9,12-octadecadienoic acid (Z, Z)-methyl ester, but increases in 9-octadecenoic acid and 9,12-octadecadienoic acid (Z, Z)-methyl ester (Z, Z). The FTIR data indicated peaks indicating little ketone and aldehyde group production during the biodiesel oxidation process during storage. Based on these findings, the quality of POB and COB after storage was satisfactory. Room temperature, a closed container, and dark circumstances are the best conditions for long-term storage of biodiesel. The storage of biodiesel under these circumstances aids in the reduction of oxidation.

In this study on the carbon footprint, human health damage, ecosystem diversity damage, and resource availability damage caused by biodiesel production from palm oil in Indonesia, it concluded that the environmental hotspot can be found within the palm oil biodiesel production life cycle in the oil palm plantation processing unit. The major culprit for the high figures in the fossil CO_2 eq effect category was N_2O gas, which originated from the oil palm plantation processing facility. The LCA study revealed that the damage to human health was severe. The oil palm plantation processing facility has the highest carbon footprint and the greatest impact on human health and ecological diversity as a result of peatland destruction and excessive urea usage. Due to the high consumption of methanol and power, the biodiesel production processing unit caused the most damage to resource availability. If operations in the oil palm plantation processing facility are carried out more conscientiously, the life cycle of biodiesel production may be made more ecologically friendly. That is, a focus on avoiding destroying peatlands and minimising urea fertiliser usage, as well as controlling the use of methanol and power in the biodiesel production processing unit.

This research successfully produced multi-feedstock biodiesel from a blend of five oils, which is acceptable for industrial-scale applications. All of the methyl ester content, density, acid value, and total glycerol testing parameters in the multi-feedstock biodiesel exceeded the quality criteria of ASTM D 6751, EN 14214, and SNI 7182-2015. The methyl ester content of the multi-feedstock biodiesel of all moles of methanol variants was greater than 98 %. This study also discovered that at a 1:3 ratio, 3 moles of methanol per mole of oil may be utilised to make multi-feedstock biodiesel with a methyl ester concentration of 99.12 % mass and 81.96 % yield. Similarly, with a 1:6 ratio, 6 moles of methanol per mole of oil might be used to produce multi-feedstock biodiesel with a methyl ester concentration of 99.58 % mass and 92.99 % yield. Multi-feedstock biodiesel at 1:3 and 1:6 ratios might be an option to decrease methanol consumption in industrial-scale biodiesel production. The maximum yield was obtained using a 1:6 ratio. According to the GCMS data, all mole variants showed methyl ester percentages that above 98 % area. In multi-feedstock biodiesel, the methyl ester with the greatest proportion was 9,12-octadecadienoic acid (Z,Z)-methyl ester. The existence of a methyl ester functional group and its long-chain (–R) was established by FTIR findings. As a result, our study created multi-feedstock biodiesel with industrial-scale application potential. Future research should focus on the kinetics of multi-feedstock biodiesel generation. Actually, each oil has a varied reaction time, therefore the production and conversion of biodiesel are governed by each oil reaction. We will be able to determine which oil is the most decisive in the process by assessing each kinetic of oil. Furthermore, the storage term will have an impact on biodiesel stability. As a result, the stability test is also important for future research.

The multi-feedstock biodiesel plant is operable based on the energy balance calculations. Multi-feedstock biodiesel has a lower energy content than palm oil biodiesel, 86,159 MJ compared to 110,350 MJ for palm oil biodiesel; hence, the energy balance of palm oil biodiesel is superior. This is because the energy input necessary to generate biodiesel from palm oil is much less than that required to make biodiesel from several feedstocks, such as sunflower, canola, soybean, palm oil, and spent cooking oil. The energy requirements for the manufacturing of biodiesel from diverse feedstocks are $35x10^3$ MJ, whereas those for biodiesel from palm oil are $23x10^3$ MJ. Thus, palm oil biodiesel has a better renewability than multi-feedstock biodiesel, which only has a renewability of 2.62. In terms of the energy balance of Indonesia, palm oil biodiesel remains better. Nonetheless, efforts must be made to improve energy management techniques throughout the entire life cycle of palm oil biodiesel. The majority of the energy needed in the manufacture of palm oil biodiesel is coal-based fossil fuel energy. Consequently, the dependence on hard coal as a fuel source must be reduced. Expanding the use of agricultural biomass as a replacement for hard coal is possible.

The potential environmental consequences of multi-feedstock biodiesel production from soybean, canola, sunflower, oil palm, and used cooking oil on the life cycle are greater than those of palm oil biodiesel production, particularly during the plantation stage. Oil palm has more carbon than soybean, canola, and sunflower. As a result, converting oil palm farms into multi-crop plantations is not advised since it creates an environmental burden. The conversion of scrubland into various crop plantations, with a CO_2 effect of 9.89 tCO_2. Meanwhile, the conversion of scrubland to oil palm plantations results in a CO_2 sequestration of -3.43 tCO_2. Many of the environmental consequences of plantation activities, notably the usage of fertilisers, include ecotoxicity, eutrophication, acidification, and global warming. The primary contributors to ecotoxicity include urea, phosphate, and potassium fertiliser production, eutrophication from phosphate and nitrate emissions into water, acidification from fertiliser production and nitrate emissions into water, and global warming from N_2O emissions from urea application. The greater use of urea and phosphate fertilisers on multi-crop plantations than on oil palm farms is the fundamental source of the former's higher environmental repercussions. From an environmental standpoint, palm oil biodiesel is still preferable in Indonesia. However, caution is essential; deforestation for the purpose of clearing land for oil palm plantations must be prevented. Biopore infiltration holes can be drilled in oil palm fields to boost groundwater reserves. Hydrocracking and hydroisomerisation using zeolites as a heterogeneous catalyst are effective ways for changing the chemical structure of fatty acid methyl esters in order to enhance cold flow parameters such as cloud point, pour point, and cold filter clogging in palm oil biodiesel.

The potential environmental damages associated with multi-feedstock biodiesel production from soybean, canola, sunflower, oil palm, and spent cooking oil are greater than those associated with palm oil biodiesel production, particularly during the plantation stage. Plantation operations, notably the use of fertilisers, cause environmental damage to human health, ecosystem variety, and resource availability. Urea production and the emissions of N_2O and CO_2 into the atmosphere are the primary contributors to human health; urea production and the emissions of nitrates into the water are the primary contributors to ecosystem diversity; and urea and diesel production are the primary contributors to resource availability. The greater use of urea and diesel on multi-crop plantations than on oil palm farms is the fundamental source of the former's higher environmental repercussions. The cost of multi-feedstock biodiesel is 126 $. The availability of resources for multi-feedstock biodiesel is more than that of palm oil biodiesel, which was 79.7 $. In terms of the ecology, palm oil biodiesel is still preferred in Indonesia. However, extreme caution is required; deforestation to clear land for oil palm crops must be avoided. To increase groundwater reserves, guludan, rorak, and infiltration holes can be constructed in oil palm fields. Hydrocracking and hydroisomerisation employing zeolites as a heterogeneous catalyst are efficient methods of modifying the chemical structure of fatty acid methyl esters to improve cold flow characteristics such as cloud point, pour point, and cold filter clogging in palm oil biodiesel.

9.2 Future Perspectives

Future works should be done on the kinetics of the use of the modified zeolites as heterogeneous catalysts which serve as hydrocracking and hydroisomerisation to transform the carbon chain of fatty acid methyl esters on palm oil biodiesel production. Then, the study of life cycle assessment of hydrocracking and hydroisomerisation of palm oil biodiesel production is also necessary to conduct in the future. It is to investigate whether this process is better or not from an environmental and energy perspective compared to palm oil biodiesel production in Indonesia, which currently still use potassium hydroxide or sodium oxide as homogeneous catalysts.