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Biodiesel Production with Immobilized Enzyme and Effect of Alcohol on the Result

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Abstract. Finding alternative sources of energy is an important issue. Various sources of alternative energy exist; among those available now, biodiesel is given more attention than the others. Between the different methods for biodiesel production, transesterification which is employed in this study is the most common one. In this reaction, alcohol existence is very important, thus finding the optimum amount of that in reaction is so helpful for catching the best results. Optimal alcohol ratio is studied in this work and finally the best result obtained at the alcohol/oil ratio of 5%.

Keywords: Biodiesel, Biocatalyst, Transesterification

1. Introduction

As time goes by, the world population is growing. As the result, energy demands are gradually escalating [1]. On the other hand, the World Energy Forum has predicted the exhaustion of fossil based fuel reserves such as natural gas, coal and oil which are the most common resources of energy and this issue causes the price of energies which are produced from fossil fuels to increase [1, 3]. In addition, fossil fuel utilization has led to many problems, and the most important one is an environmental problem such as air pollution. The solution for this crisis is to find an economically feasible and renewable source of energy. There are many alternative sources of energy like solar, wind, geothermal and biomass, among others. The first option which is acceptable in both economical and environmental aspects is biofuel that is produced from available biomass feedstock [3]. Biomass is the product of photosynthesis by vegetable matter. Nowadays, biomass is considered as the largest source of renewable energy by supplying 10.4% of total principal energy or in other words, by supporting 77.4% of world renewable energy [4]. Biofuels are gaseous or liquid fuels which are produced from biomass. Many different biofuels exist, which include biohydrogen, bioethanol, biomethanol and biodiesel. Among these, biodiesel has attracted great attention because of its energy content and also its similarity to common diesel. Biodiesel production was developed by Rudolph Diesel in the 1890s. He worked on vegetable oil fuels and showed that pure vegetable oils could be used as fuel for early diesel engines in agriculture and some areas of world where, at that time, did not have access to the petroleum. Biodiesel has many advantages: it is sustainable and renewable, nontoxic and environment-friendly. Furthermore, to utilize biodiesel, no engine modification is needed [1].

2. Biodiesel Production

2.1. Different methods of biodiesel production

Biodiesel is produced by the conversion of oils such as vegetable oils and animal fats into Fatty Acid Methyl Ester (FAME). Different methods exist for producing biodiesel including micro-emulsification, transesterification and pyrolysis. Pyrolysis means a chemical reaction caused by using heat to get simpler compounds from a complex compound. This process is known as cracking. Vegetable oils can be cracked to

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improve cetane number and to decrease viscosity. Cracking products include carboxylic acids, alkenes and alkanes. Different types of oils like cottonseed, rapeseed and soybean oil are cracked successfully with suitable catalysts for biodiesel production [5]. Cracked products will have good flow characteristics because of viscosity minimization. Drawbacks of this technique are high cost of equipment and also separate equipments are needed for various fractions separation. Plus, the product that is produced is akin to gasoline and they contain sulphur and this causes the product to be less environment-friendly.

Another technique for biodiesel production is micro-emulsification that has been suggested for biodiesel production. Micro-emulsion biodiesel components include vegetable oil, diesel fuel, alcohol, cetane and surfactant improver, all in appropriate proportions. Some alcohols like ethanol, propanol and methanol are used as additives to reduce the viscosity of the surfactants, higher alcohols are implied and as the cetane improvers alkyl nitrates are added. Reducing viscosity, good spray and cetane number increasing characters promote the use of micro-emulsions; on the other hand, prolonged usage causes problems such as carbon deposit formation, partial combustion and injector needle sticking.

Transesterification of vegetable oils is the most common method in biodiesel manufacturing. Biodiesel that is produced by transesterification is a liquid mixture of mono-alkyl esters of higher fatty acids. Removing high viscosity components and glycerol results in reduced product viscosity, making it similar to fossil fuels. Biodiesel fuel which is produced by transesterification, also named alcoholysis, is the substitution of ester alcohol by another alcohol in a technique not unlike hydrolysis, except that instead of water, alcohol is used. Ethanol and methanol are the most ordinarily used alcohols, notably methanol because of its chemical and physical advantages and its low cost. This method has been widely used to decrease the viscosity of triglycerides, thereby improving the physical properties of renewable diesel to enhance engine performance. The chemical structure of transesterification process is illustrated in Figure 1 [6].

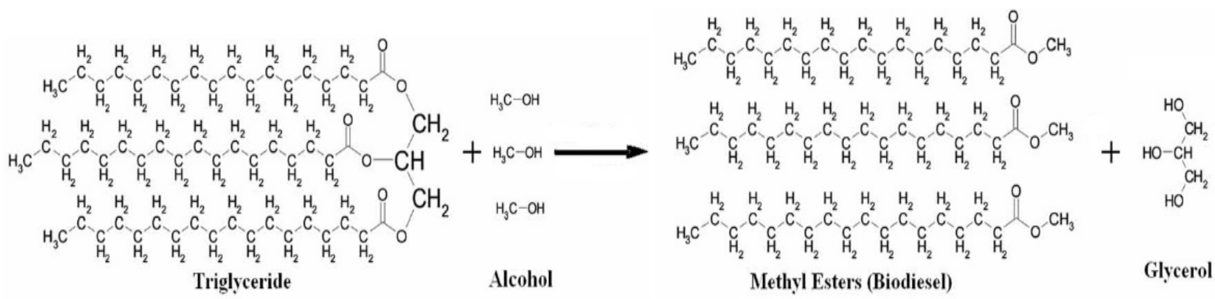

Fig. 1: Alcoholysis process

2.2. Biodiesel feedstock

As mentioned, there are various oils that can be used as feedstock for biodiesel production. In this study, jatropha curcas oil which is inedible oil was employed for alcoholysis. Jatropha curcas belongs to the Euphorbiaceous category. Jatropha name comes from Latin words jatros that means doctor, and trophe which means food because it has so many medicinal values. The jatropha plants, natively, are from the American tropics, but they usually grow in subtropical and tropical countries such as South East Asia, sub Saharan Africa, China and India. Jatropha seeds mature 3 to 4 months after flowering and when the plant matures, it will produce seeds for 50 years and about 40% of the seed content is oil [7]. As a plant that is resistant against drought, jatropha is a good candidate for feedstock and also it is good for eco-restoration in wastelands. In addition, cultivation of jatropha in wastelands will assist the soil to recover and would be able to help in carbon sequestration.

2.3. Experimental work and results

In this work, the transesterification method was chosen to methanolysis of jatropha oil under ambient condition. A screw-capped vial was used as the reactor vessel and in order to warm and shake the incubator shaker was employed. Immobilized enzyme (Rhizopus oryzae lipase) was utilized as the catalyst and it reacts with jatropha oil in the reactor vessel with the presence of water and methanol, while the mixture was continuously mixed and warmed. Water was added to the reaction mixture to prevent the enzyme from denaturing. Biodiesel was produced under different conditions and the maximum yield was achieved, with 87.1%. The conditions for this reaction were as follows: temperature: 42°C, water content: 70 % (based on weight of oil), methanol/oil molar ratio: 5%, time: 15.5 hr.

2.4. Effect of methanol on reaction

In enzymatic biodiesel production, alcohol/oil ratio plays an important role during the reaction. Based on the stoichiometry of the transesterification reaction, at least three moles of alcohol are required to produce three moles of ester for a reaction with one mole of oil. Despite the expectation that higher amounts of alcohol ends to higher yield of biodiesel, in enzymatic manufacturing of biodiesel, if the alcohol/oil ratio exceed more than specific amount it leads to reduction of our product due to enzyme deactivation. So finding the optimum amount of this reactant is important in transesterification reaction. The following graphs depict the effect of methanol under different conditions on the biodiesel yield. In both cases can be seen that yield of biodiesel is increased to the maximum amount (87.1) in optimum amount of alcohol (5% alcohol/oil molar ratio) and after adding more alcohol, the biodiesel yield is decreased.

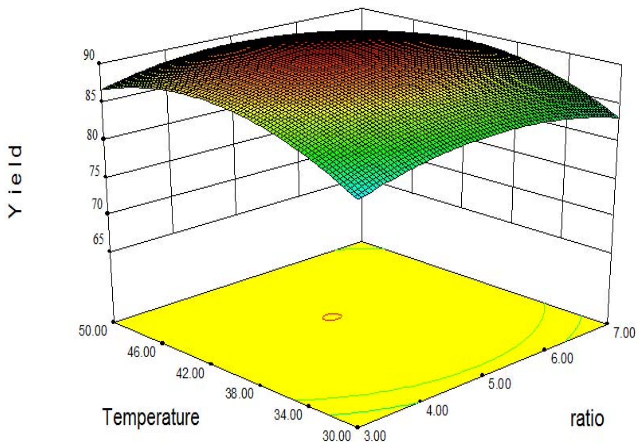

Fig. 2: Effect of methanol ratio and temperature on Yield

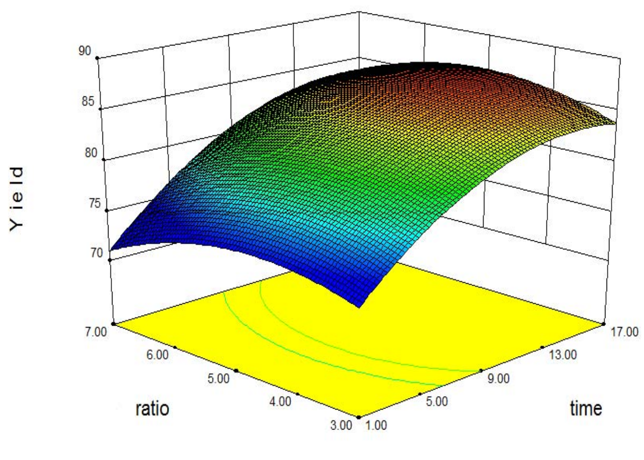

Fig. 3: Effect of methanol ratio and time on Yield

2.5. Conclusion

Different kinds of biofuels such as biohydrogen, biomethanol, bioethanol and biodiesel are considered alternative sources of energy. Among these, biodiesel garners more attention than the others, owing to its characteristics and advantages. Jatropha oil is one of the best options for biodiesel manufacturing, because it is inedible, the plant is resistance against drought and its cultivation on wastelands will assist soil recovery. Transesterification is the most common method in biodiesel production and this reaction strongly depends on alcohol existence. On the other hand, in enzymatic transesterification, alcohol has a negative effect on catalyst, thus the optimum amount of alcohol should be determined for this kind of reaction. This research has found that 5% alcohol/oil is the best ratio.

3. Acknowledgements

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4. References

[1] N. N. A. N. Yusuf, S. K. Kamarudin, Z. Yaakub. Overview on the current trends in biodiesel production. Energy Conversion and Management 2011, 52:2741–2751

[2] M. M. Gui, K. T. Lee, S. Bhatia. Feasibility of edible oil vs. waste edible oil as biodiesel feedstock. Energy 2008, 33:1646–53.

[3] M. K. Lam, K. T. Tan, K. T. Lee, A. R. Mohamed. Malaysian palm oil: surviving the food versus fuel dispute for a sustainable future. Renew. Sustain. Energy 2009, 13:1456–64.

[4] R. M. Carlos, D. B. Khang. Characterization of biomass energy projects in Southeast Asia. Biomass Bioenergy 2008, 32:525–32.

[5] S. V. Ranganathan, S. L. Narasimhan, K. Muthukumar. An overview of enzymatic production of biodiesel. Bioresour. Technol. 2008, 99, 3975–3981.

[6] M. Rajendra, P. C. Jena, H. Raheman. Prediction of optimized pretreatment process parameters for biodiesel production using ANN and GA. Fuel 2009, 88: 868–875

[7] J. Ch. Juan, D. A. Kartika , T. Y. Wub, T. Y. Hin. Biodiesel production from jatropha oil by catalytic and non-catalytic approaches: An overview. Bioresour. Technol. 2011, 102: 452–460.