Kinetic study of the transesterification reaction of African palm, rapeseed and sunflower oils for biodiesel production.

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Abstract

This paper aims to obtain apparent kinetics of the transesterification reaction of refined palm oil (Elaeis Guineensis) and a mixture of palm-sunflower and palm-rapeseed oils to produce biodiesel with methanol using a catalytic medium with homogeneous basic sodium hydroxide. Statistical analyzes were performed varying the concentrations of catalyst and methanol's molar ratios in the reaction and the yield obtained experimentally was measured for each one. The kinetic study of the reaction was performed with the best conditions found and experimentally measured concentrations of each component in the mixture at different times. The final product was analyzed for quality variables and compared with ASTM D6751 in order to ensure proper functioning of it in diesel engines. The results show that biodiesel produced through a mixture of palm oil and sunflower oil, requires less reaction time and that adding sunflower oil to the palm becomes kinetics faster as bigger is the concentration of saturated fatty acids in the mixture.

Keywords: Biodiesel, Kinetics, Simulation, Transesterification.

Introduction

Activities done today are constantly growing up with population increase and demand the processing of thousands tons of crude oil to be supplied. The shortage of fossil fuels, increasing in the pollutant emissions generated by combustion and their high costs will do of biomass sources a more attractive resource [1]. Biodiesel is nowadays one of the most important transition energies in the world. It's a synthetic liquid biofuel obtained from vegetable oils or natural fats, new or used, by industrial processes of esterification and transesterification, and applied in total or partial substitutes of gasoil derived from petroleum. There are few jobs about kinetics of transesterification of current used oils, because of these parameters change depending on the selected conditions of catalyst and alcohol and their fatty acids composition [2].

Refined vegetable oils or animal fats with low acidity are available to be used as fuel in combustion engines. However, the high viscosity of these raw materials decreases the atomization in the combustion chamber, and lead to have problems in the operation. To solve it some studies have been made to obtain fuel from vegetable oils, including hydrogenation. The way of obtaining simple alkyl esters from triglycerides by transesterification reactions with alcohols such as methanol or ethanol was early recognized [3].

The choice of the raw material used for the biodiesel production in the actually commercial plants depends mainly on geographic location, dominating the rapeseed oil in the EU, soybean oil in the US and Latin American, and palm oil in Asia. The use of virgin, edible oils for fuel production is controversial, and with the increasing prices, there is a growing interest in alternative feedstocks. This includes high-yielding, non-edible tropical crops such as Jatropha curcas. On a longer term, oil from marine microalgae has been proposed. Algae have oil productivities (L/ha/year) that far exceed that of any land-based crops, which is indisputably needed if we imagine biofuels to fully meet our global demand for transport fuels [4].

A selected group of alcohols and esters have been investigated for biodiesel synthesis in the literature. Some examples of these special compounds are the alcohols with small alkyl chains as methanol, ethanol, 1- and 2-propanol, and butanol isomers. Nowadays, the name of commercial biodiesel is FAME (Fatty Acid Methyl Esters), formed by oil's transesterification with methanol, due to this compound reacts successfully in alkaline conditions and, in some regions, it is the cheapest alcohol. With increasing oil/gas prices and increasing production of bioethanol, the price structure could, however, change in the future. Part of the added cost of a heavier alcohol is also compensated by the increased mass (and volumetric) gain of biodiesel. With ethanol vs. methanol, the increased weight is that of one methylene group, corresponding to approx. 5% of the biodiesel weight. However, alcohols with larger chains are reported to produce biodiesel with superior low temperature and crystallization properties [5].

Kinetics of transesterification reaction has been studied for different raw materials using complex and very expensive techniques of gas chromatography to follow the disappearance of triglycerides and each one of their steps to the formation of FAME's in a basic catalytic way. Formation of FAME's versus time has been reported for African palm oil using potassium hydroxide. However the use of alkaline catalyst during reaction has the disadvantage of soaps formation on which kinetics represents a big impact factor for the process.

Due to the availability and recent costs of some raw materials for biofuels in Mexico, the current study focuses in biodiesel production from African Palm, rapeseed and Sunflower oils.

Citation: *Barrera DA. Kinetic study of the transesterification reaction of African palm, rapeseed and sunflower oils for biodiesel production. J Ind Environ Chem 2021;5(4):1-2.*

Results

Since different rates of catalysts and methanol were analyzed for the interest cases, was demonstrated that the trans esterification reaction of African palm oil is favored mainly with a w/w rate of 0.6% for sodium hydroxide and a molar rate of 5/1 for methanol, while for the case of a mixture African palm- sunflower and African palm-rapeseed oils, the respective rates of catalyst and alcohol were 1% w/w-5/1 and 1% w/w-7/1. The studied oil's compositions are reported in Table 1.

Table 1. *Fatty acids composition in the studied oils.*

Fatty acid	African Palm Oil	Sunflower Oil	Rapeseed Oil
Lauric	0.44	0	0
Myrístic	2.33	0	1.8
Palmític	41.53	16.92	4.84
Stearic	4.74	73.62	0.93
Oleic	38.22	3.26	61.52
Linoleic	12.79	6.2	23.18
Linolenic	0.15	0	7.73

Conclusions

It is possible to carry out the transesterification reaction of the fatty acids contained in the African palm oil alone and in a mixture with sunflower using a basic catalytic medium obtaining yields above 90% in a reaction time under 30 minutes due to the found values of the kinetic constant and that allows to satisfy the quality variables of the obtained product.

A significant change of the oil's composition of an oil's mixture can modify the value of the kinetic variables becoming the reaction faster or slower according to the saturated and unsaturated fatty acids profile.

References

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