STUDY REGARDING THE TRANSESTERIFICATION OF PALM OIL

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Keywords: palm oil, transesterification, biodiesel;

Abstract. In this paper the transesterification of palm oil with methanol in the presence of NaOH as a catalyst was conducted in an experimental biodiesel installation. The kinetics of base-catalyzed transesterification of palm oil based on parameters such as oil and alcohol ratio, catalyst concentration and temperature were investigated to optimize the biodiesel production rate. Although, transesterification of palm oil consisted of three stepwise and reversible reactions, the reaction rate constants revealed that the forward reactions were the most important. The researches showed that both sodium hydroxide and sodium methoxide had high kinetic constants depicting fast formation of palm oil methyl esters with conversions above 90%.

1. INTRODUCTION

Methyl esters produced by methanololysis of triglyceride such as animal fats and plant oils, which are collectively named biodiesel, are viewed as promising renewable resources of fuel [4]. The use of biodiesel is becoming increasingly important due to diminishing petroleum reserves and environment regulations of our country. However, biodiesel is expensive in comparison with petroleum based fuel due to the high price of raw material which consist 80% of the total cost of production. However, nowadays, the complete substitution for diesel is not possible due to its high cost and also due to the fact that it does not have complete adaptation of its use to the conventional diesel motors [3]. Its immediate application would be in the blend with diesel, with values that can reach up to 30%. Among vegetable oils, palm oil ranks among the best in terms of availability and cost. In addition, it is a rich source of valuable neutraceutical compounds such as vitamin E, carotene, phetosterol and squalene [4]. Biodiesel is industrially produced via chemical catalysis using strong bases as a catalyst. Such industrial processes have a production scale of hundreds of thousand of tons. Even so, a strong base process suffers from several drawbacks such as difficulty in recovery of glycerol in the final product, the need for removal of base catalyst from product and the treatment of alkaline wastewater [5]. Any alternative fuel for an internal combustion engine should satisfy certain criteria, such as requiring minimum engine modification, offering uncompromised engine life and being not hazardous to human health and the environment during production, transportation, storage and utilization [1]. It's content of oxygen helps improve its combustion efficiency and is a clean burning fuel that does not contribute to the net increase of carbon dioxide. The fuel also must be low cost, renewable and in abundant and stable supply. In the present study, the optimum conditions to produce palm oil methyl esters by transesterification of crude palm oil with methanol using as catalyst sodium hydroxide (NaOH) were investigated. With the new trend and depth in the development in the biofuel industry, it is hoped to establish the optimum reaction conditions for good yields in the minimum reaction time and material consumption. In this context, experiments were done to an experimental biodiesel installation with the varying of reaction parameters.

2. MATERIALS AND METHODS

The research on the reaction condition for biodiesel production was performed using an installation with a capacity of 30 L per batch. In the Laboratories of Thermodynamics and Thermal Machines of the Faculty of Mechanical Engineering, University of Craiova, it was conceived and built a small experimental installation for biodiesel production [5] using palm oil as raw material (Fig.1). The installation presented in Fig.2 is composed by a reactor (were the reaction take place), a command panel to establish the reaction condition, an electrical resistance to heat the blend, a system for methanol recovery and different barrels for the reactants. The reactants mixing are done in three different ways: by the electric mixer, through the mix of the blend with the pump and to the use in the same time of the electric mixer and the pump. In the experiments was used a base catalyst, NaOH with a purity of 99% purchased from S.C. Laborex Romania. The quantity of catalyst used was measured with a precision balance model PGW 153e. For the experiments was used crude palm oil bought from a local supermarket. The conversion of sunflower oil into its methyl ester was determined using Gas Chromatograph on a HP-INNOWax (cross-linked PEG) capillary column, with flame ionization detection. The percentages of each peaks of methyl esters were calculated and based on these values, ester conversion was calculated.

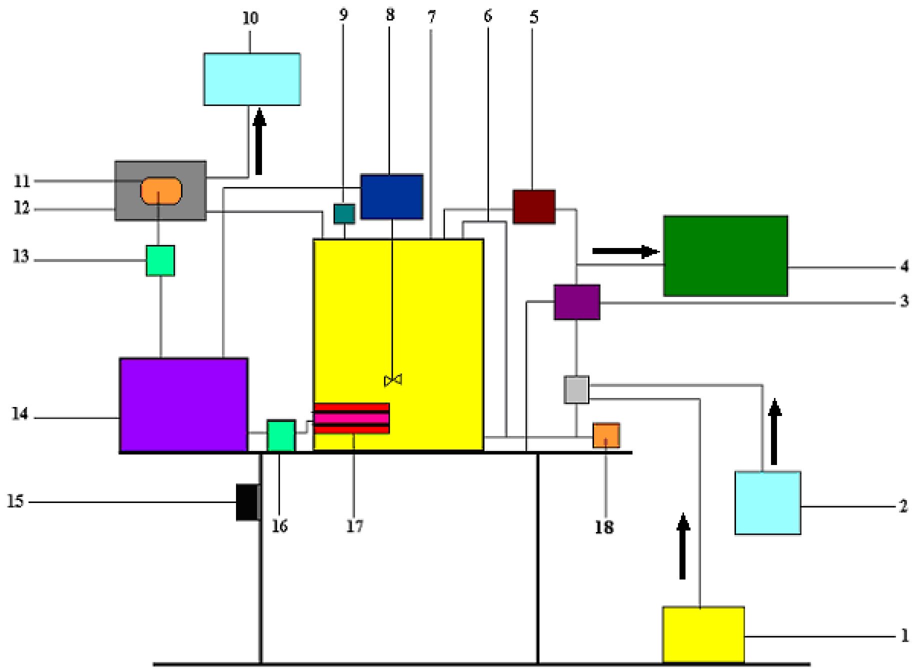

Fig.1 Scheme of principle for biodiesel installation
1- tank of vegetable oil; 2- methoxid barrel; 3- pump; 4- tank of biodiesel; 5- meter; 6- level pipe; 7- reactor; 8- electric mixer; 9- manometer; 10- methanol tank; 11- fan; 12- heat exchanger; 13- variable voltage control; 14- command panel; 15- meter electric power; 16- variable voltage control; 17- 2000W electrical resistance; 18- thermometer;

Fig.2 Experimantal installation for biodiesel production

3. RESULTS AND DISCUSSION

Molar ratio of alcohol to vegetable oil is an important parameter in biodiesel production affecting the final product. The stoichiometric ratio of transesterification reaction requires three moles of alcohol per mole of triglyceride to produce three moles of methyl esters and one mole of glycerol. Because it is a reversible reaction to obtain alkyl esters is necessary to work with excess alcohol. In this paper, the effect of methanol was investigated in the range of 3:1 to 6:1 (molar ratio), keeping other process parameters constant. Tests were performed on a volume of 20 liters of palm oil with a stirring speed of 250 rpm remaining constant throughout the experiments, a temperature of 60^0C and a catalyst concentration of 1.5% (w/w_{oil}).

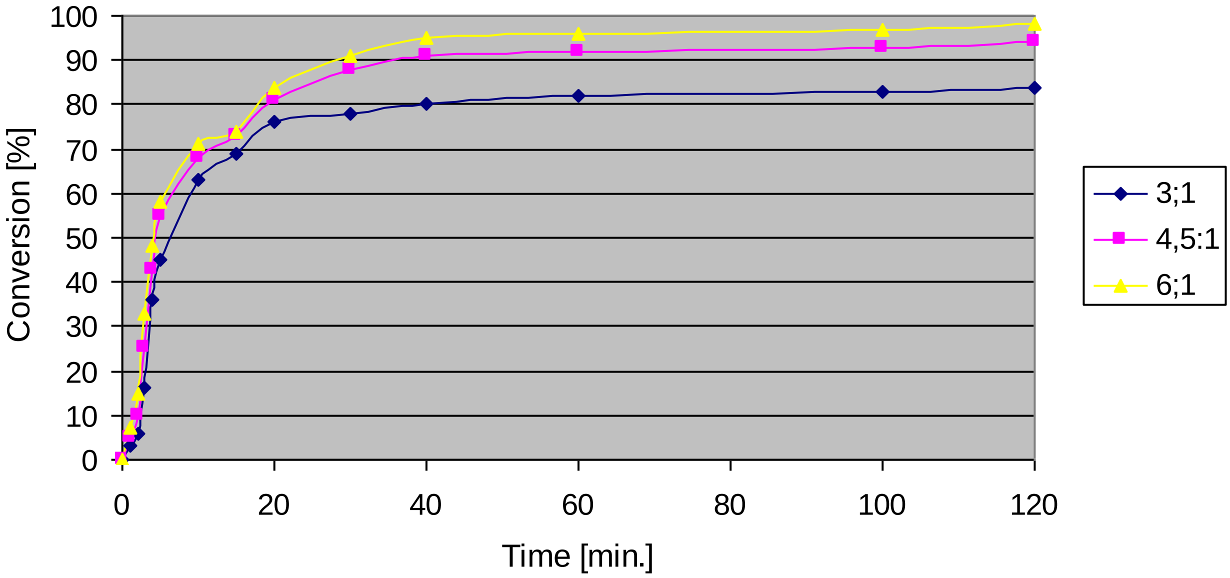

Fig.3 Effect of molar ratio of alcohol to vegetable oil on biodiesel conversion

The conversion rate of the vegetable oil increases with molar rapport methanol: vegetable oil. According to the results obtained (Fig.3) the reaction is carried out at high reaction rate in the first 20 minutes, then evolves slowly approaching equilibrium which it will reach in about 2 hours depending on the molar ratio used. Optimal molar ratio was found at a value of 6:1 with a total conversion of 98% in biodiesel. In general the reaction products of the reaction are separated into two layers, the upper layer containing alkyl esters with mono and diglycerides, traces of methanol, catalyst and glycerin and lower layer composed by glycerin, alcohol excess, catalyst mono and diglycerides. However, the increase of molar ratio to higher values did not result in higher conversions. The improvement of conversion is due to the change of the transesterification reaction to the right. Superior molar conversion reports not increase the conversion, but only interfere in the separation of glycerol by decreasing density of the upper and lower layers. This makes the separation of different layers to be more difficult in the end. If we use large rapports of methanol in biodiesel production in the reactor can form a third layer formed only from excess methanol which leads to great difficulties in the separation process. Effect of alkaline catalyst concentration was studied using palm oil and methanol with various amounts of NaOH varying from 0.5 to 5% (weight of NaOH/weight of oil). The molar ratio of alcohol to vegetable oil 6:1, stirring speed, reaction temperature 60^0C and 2 hour time is kept constant during the experiments. The results for different catalyst concentration are shown in Fig. 4.

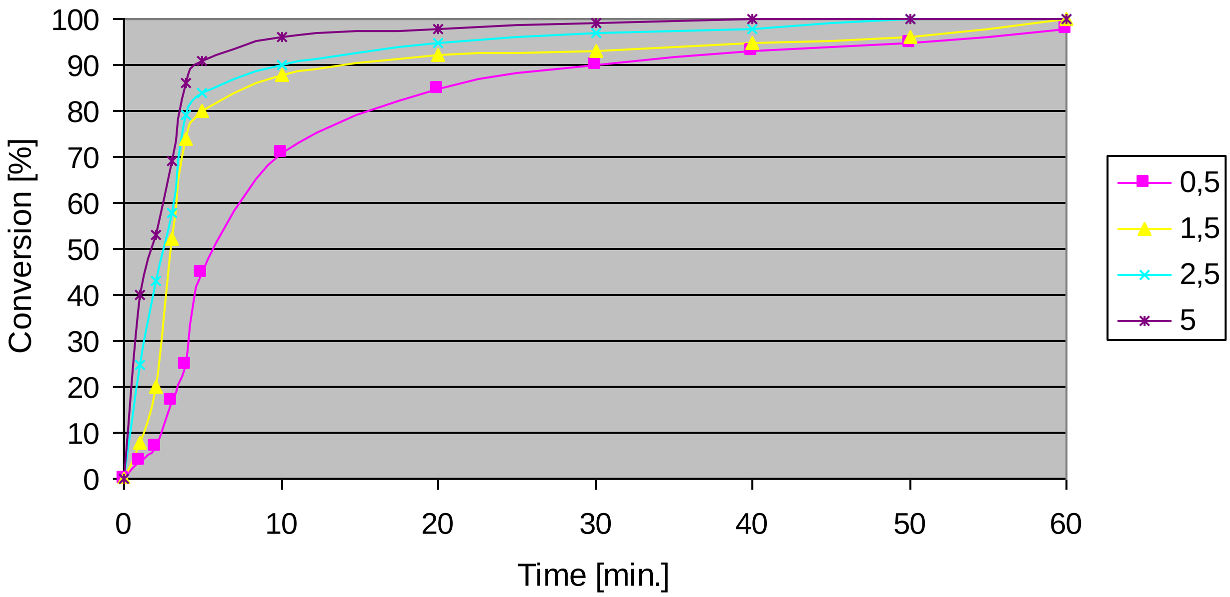

Fig.4 Effect of catalyst concentration on biodiesel conversion

An increasing amount of catalyst do not increase conversion rate but increase the cost of production due to the high soap formation and is necessary to remove the catalyst from the reaction products. It is noted that the reaction is carried out at high reaction rate in the first 10 minutes for the higher concentrations of NaOH, and then slowly evolves according to the proportion of catalyst used. Effect of reaction temperature was studied at 45, 55, 65^{0}C while all other parameters, molar ratio, catalyst concentration and time reaction were kept constant at 6:1, 1.5 % and 2 hour. The effect of reaction temperature on the ester conversion is shown in Fig. 5.

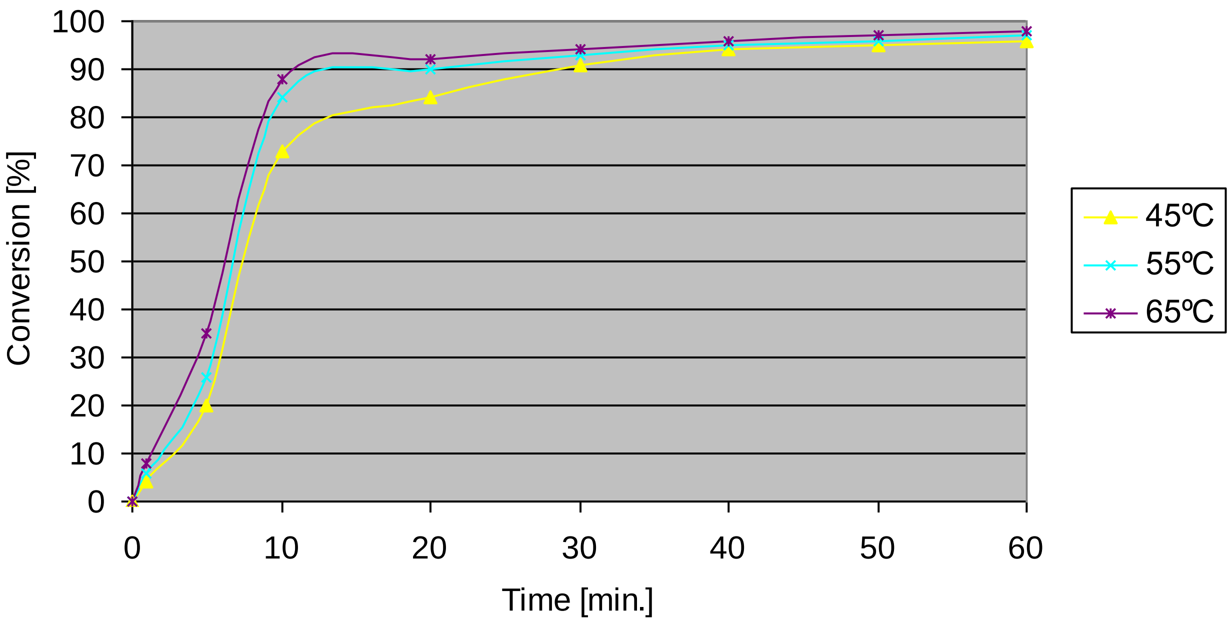

Fig.5 Effect of temperature on biodiesel conversion

It can be seen that the conversion rate increase with the rise of the temperature in the reactor. After 60 minutes, the transesterification reaction has reached equilibrium with a value of 98% to an average temperature of 65^{0}C. Since the transesterification reaction is a moderate exothermic reaction temperatures higher of 65….70^{0}C, can lead to a decrease in biodiesel conversion. Also was investigated the separation of byproducts from biodiesel (Fig.6). At the separation of biodisel from the wash an emulsion is formed during the tests.

Fig.6. Washing biodiesel

Is noticed that a strong base process suffers from several drawbacks such are the difficulty in recovery of glycerol in the final product and the need for removal of base catalyst.

4. CONCLUSION

In this study, an experimental installation for biodiesel production was build and tested in different working condition. Biodiesel production from palm oil using NaOH as catalyst was analyzed and was found that NaOH can be utilized as a catalyst for biodiesel production without any difficulty. According to the data obtained in the tests, the formation of the methyl esters is affected by the molar ratio of glycerides to alcohol, catalyst, reaction temperature and reaction time. It is noticed that a high molar ratio of alcohol to vegetable oil interferes with the separation of glycerin because it is an increase in solubility of the mixture. Due to the fact that triglycerides and methanol are not miscible at ambient temperature the reactants needs to be blended through mechanical agitation to improve the mass transfer in the reaction. The rise of reaction temperature and base concentration lead to the increases of biodiesel conversion.

ACKNOWLEDGEMENT

This work was supported by the strategic grant POSDRU/89/1.5/S/61968, Project ID61968 (2009), co-financed by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007-2013.

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