ULTRASOUND ASSISTED TRANSESTERIFICATION OF CORN OIL WITH ETHANOL

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Abstract — This paper evaluates the production of fatty acids ethyl esters from corn oil and ethanol. The reaction was carried out applying low-frequency high-intensity ultrasound (25 kHz) under atmospheric pressure and ambient temperature. Response surface methodology (RSM) was used to evaluate the influence of alcohol to oil molar ratio and catalyst concentration (sodium hydroxide) on the yield of corn oil into ethyl esters. Analysis of the operating conditions by RSM showed that the most important operating condition affecting the reaction was the ethanol to oil molar ratio. Results showed low yield of corn oil into ethyl esters. The highest yield observed was of 62.9% after 30 minutes of reaction. The best operating condition was obtained applying an alcohol to oil molar ratio of 4.5 and a catalyst to oil molar ratio of 0.010.

Keywords — biodiesel; ethyl esters; ultrasound; corn oil; transesterification; ethanolysis.

1. INTRODUCTION

Methyl and ethyl esters derived from vegetable oil or animal fat, known as biodiesel, have good potential as an alternative to diesel fuel. Cetane number, energy content, and phase changes of biodiesel are similar to those of petroleum-based diesel fuel (Munyappa et al., 1996; Darnoko and Cheryan, 2000). Biodiesel fuels have some advantages over petroleum based diesel fuels. Biodiesel fuels are biodegradable, non-toxic and produce less particles, smoke and carbon monoxide.

The conventional mechanical process for biodiesel production is generally carried out in batch reactors. Alcohol, vegetable oil and catalyst are fed and subjected to vigorous agitation and heated to achieve temperatures between 50°C and the boiling point of the alcohol. The time required to achieve total consumption of the oil is about 60 minutes. Alcohol in excess is used to speed up the reaction and to shift the equilibrium toward the formation of products. After the reaction period, the non-converted alcohol has to be separated, purified and recycled back to the reactor (Noureddini et al., 1998; Darnoko and Cheryan, 2000; Stavarache et al., 2005; Meher et al., 2006).

Alternative technologies to produce biodiesel have been studied by several researchers. Among the new technologies some may be suitable to large scale production: ultrasound technology, microwave technology (Mazo and Rios, 2010a) and heterogeneous catalyst technology (Mazo and Rios, 2010b).

Ultrasonic irradiation causes cavitation of bubbles near the phase boundary between the alcohol and oil phases. As a result, micro fine bubbles are formed. The asymmetric collapse of the cavitation bubbles disrupts the phase boundary. Impinging of the liquids creates micro jets leading to intensive mixing of the system near the phase boundary. The cavitation may also lead to a localized increase in temperature at the phase boundary enhancing the transesterification reaction. Neither agitation nor heating are required to produce biodiesel by ultrasound application because of the formation of micro jets and localized temperature increase (Stavarache et al., 2005; Stavarache et al., 2006).

The production of biodiesel using ultrasound has been studied by some researchers. Siatis et al. (2006) have studied the methanolsysis of cotton, sunflower and sesame oils obtaining yields into biodiesel ranging from 43 to 93%, which were higher than when the the traditional mechanical process was applied. Colucci et al. (2005) and Santos et al. (2009) have studied the methanolysis of soybean obtaining yields from 69 to 100%. Methanolysis of fish oil was also studied by Santos et al. (2010) and the results showed yields up to 98%.

Stavarache et al. (2005) have studied the production of biodiesel using several types of alcohols and found that increasing the length of the chain of the alcohol reduced the yield into biodiesel. Transesterification using methanol resulted in yields from 68 to 98%, while using n-propanol the yield reduced to 92% under the best operating condition.

The amount of catalyst used in the process has a great environmental impact. Large amounts of catalyst tend to produce a larger amount of soap (undesired product) and part of the catalyst remains in the biodiesel increasing its pH. After the end of the transesterification reaction biodiesel is separated from the alcohol phase and then it is washed with water to remove excess catalyst, soap and glycerin, generating large amounts of waste water that needs to be treated.

In this work we have studied the use of low-frequency high-intensity ultrasonic waves to promote the transesterification reaction of corn oil and ethyl alcohol. The reaction was carried out in a batch reactor at ambient temperature using sodium hydroxide as cata-