Biodiesel Synthesis Assisted by Ultrasound, Microwave and Hydrodynamic Cavitation – A Comparative Study

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Introduction

In recent years, the alkali catalyzed methanolysis and ethanolysis of vegetable or waste oils have been extensively studied [1, 2], most of the existing studies focusing on investigation and optimization of process variables, namely, oil to alcohol ratio, catalyst concentration, reaction temperature. Although there is a consensus regarding the influence of reaction parameters on the methanolysis process, in the case of ethanolysis there are greater discrepancies between published results [3]. The purpose of this paper was to study the production of biodiesel in continuous flow assisted processes, specifically a comparison between hydrocavitation, ultrasound, microwave and combined microwave – ultrasound assisted processes.

Materials and Methods

The feedstock used for this study was commercially available sunflower oil characterized by an acidity index of 0.2 mg KOH/g and a saponification index of 170 mg KOH/g. The transesterification processes were carried out with methanol, oil to alcohol molar ratio of 1:6, in the presence of KOH as catalyst (1% w of oil). Oil conversion to biodiesel was determined by gas chromatography analysis of Mono-, Di-, Triglycerides. The equipment used for this study consists of a "shear induced" hydrodynamic cavitation reactor with an electrical motor of 2.2 kW, similar devices being described in existing papers [4], a Vibracell 750 processor was used for the ultrasound assisted process, and for the MW – US assisted reaction a Miniflow 200SS provided with an ultrasonic bath of 200W was used.

Results

In the case of a hydrodynamic cavitation reactor, there are two driving forces which lead to high conversion rates in short reaction times, i.e. the cavitation effect and the mechanical mixing of the reactants. As seen in figure 1, when using a high intensity ultrasonic processor, the increase in either reaction time or ultrasonic intensity amplitude, leads to higher yields as the driving force is the acoustic cavitation phenomena, while the hydrodynamic cavitation process depends on the balance between cavitation assisted process and conventional process with better mixing of the reactants. Increasing the reaction time leads to the heating up of the reactants to a point where the generation and impact of cavitation is less significant.

In figure 2, the synergetic effect of microwave and ultrasound bath is visible, higher yields being attained when using the combined process over the microwave assisted process with mechanical stirring.

Specific energy consumption for each type of assisted process (HC, US, MW, MW+US) was calculated and compared.

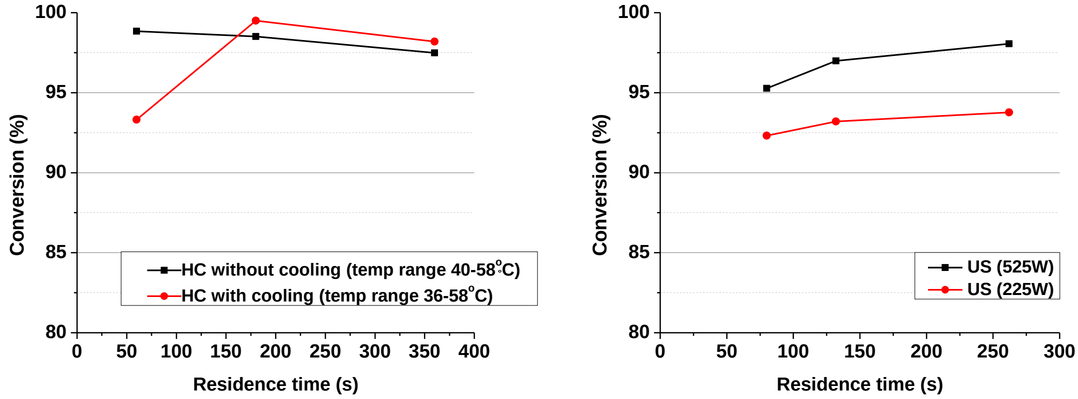

Figure 1. Comparison between hydrocavitation (left) and ultrasound (right) assisted biodiesel production

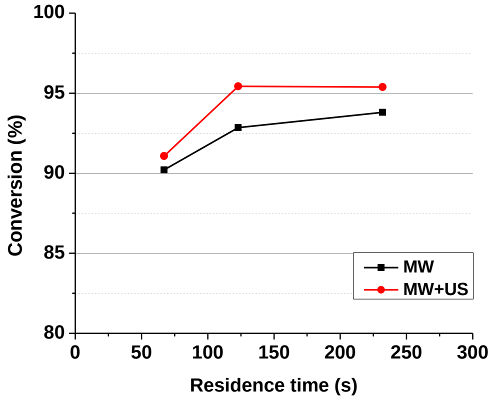

Figure 2. Comparison between microwave and combined microwave – ultrasound assisted processes

Conclusion

Several methods to intensify the process of biodiesel production were studied. Thus hydro-cavitation reactor produces significantly higher conversion of oil, but is more energetic. Probe system efficiency is power dependent higher power higher the oil conversion. The MW activation gives rather acceptable conversion, but it seems that combining US and MW is beneficial for FAME production. We are envisioning similar studies for ethyl esters of fatty acids, a task more difficult from post reaction processing point of view.

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