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ADSORPTIVE PRETREATMENT OF WASTE COOKING OIL USING QUICKLIME FOR TWO-STEP BIODIESEL PRODUCTION

***Lukic I.*[1], *Kesic Z.*[1], *Zdujic M.*[2], *Skala D.*[1]**

[1] *University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia*
[2] *Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Knez Mihailova 35, 11000 Belgrade, Serbia*

Corresponding author email: ilukic@tmf.bg.ac.rs

Abstract

Biodiesel, a mixture of fatty acid methyl esters (FAME), is an excellent non-toxic, and biodegradable substitute for mineral diesel fuels produced from crude oil. It is made from renewable sources by transesterification of triglycerides with methanol, or by a reaction usually defined as methanolysis. Usage of low-quality feedstock, such as waste cooking oil (WCO), is challenging due to the undesirable side reactions as a result of the presence of free fatty acids (FFA), and water, thus a pretreatment stage before subjecting it to the transesterification process is usually required. In the present study, a two-step approach based on an adsorptive pretreatment with quicklime in order to remove FFA from WCO, followed by methanolysis using CaO·ZnO as a heterogeneous catalyst was proposed. The first step was analyzed with the goal to define the optimal temperature of adsorption, the adsorbent particle size, calcination procedure, as well as the necessary amount of quicklime used. The analysis of adsorption kinetics was performed using pseudo-first and pseudo-second order kinetic models, and the efficiency of quicklime in the FFA removal from the WCO was also determined. The results showed that FFA from WCO could be successfully removed using quicklime as adsorbent at 30 °C for 1 h, with a removal efficiency of 72% and an adsorption capacity of 910 mg/g. The amount of Ca^{2+} ion present in the oil after the pretreatment was determined to be 12.64 mg/kg, showing that a very small amount of calcium from CaO was dissolved in treated WCO. The FTIR analysis of quicklime after the adsorption of FFA confirmed the interaction of the carboxyl group in FFA with the active site of the adsorbent. Adsorptive pretreatment had a positive effect on the rate of transesterification reaction with CaO·ZnO as a catalyst, enabling the achievement of over 96% of FAME yield in only 15 min at 60 °C. The present study showed that quicklime, being cheap, available, and efficient, has considerable potential for the removal of FFA from the WCO. Besides, both the adsorption and the heterogeneously catalyzed methanolysis are environmentally and economically acceptable processes.

Keywords: Biodiesel, Waste cooking oil; Adsorption; Quicklime; CaO·ZnO

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