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Enhanced Electro-Catalytic Process on the Synthesis of FAME Using CaO from Eggshell

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Abstract

The nature of the consumerist society of Indonesia with regard to the use of petroleum oil has increased. However, it is not comparable with the figures for petroleum reserves in natural deposits. Therefore, the problem has encouraged the Indonesia to be able to find an alternative new and renewable energy that is biodiesel. In this study, the biodiesel has been produced using electro-catalytic process that was enhanced by relatively high activity CaO catalyst made from eggshell, featured with high alkaline properties, large surface area and good cycling. The performance of CaO obtained from two types treatment of egg shell that was calcination (900 °C)–hydration (60 °C)–dehydration (600 °C) and calcined at 900 °C treatment were tested for its catalytic activity via electro-catalytic transesterification of soybean oil and used-cooking oil at room temperature. Scanning electron microscopy (SEM), X-ray diffraction (XRD) was performed to characterize the microstructures and chemical properties of as-prepared calcination-hydration-dehydration of eggshell material. The evaluation of the synthesis process of fatty acid methyl ester (FAME) was followed by GC-MS, determining the purity of FAME ratio at different operation variables. The results showed that for soybean as a feedstock, the FAME conversion was 97.35% for CaO-900-600 and it was 98.37% for CaO-900 in a 20 wt% catalyst loading (based on oil weight). However, a similar result of FAME quantity for both catalysts was obtained when using used-cooking oil as a feedstock in the experiment. In addition, a 10% catalyst loading was also tested in the synthesis with FAME yield as much as 98.99%.

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Keywords : Biodiesel; CaO; Electro-catalytic; Eggshell

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Nomenclature

Ø	symbol of diameter
mins	minutes
wt.%	percentage of weight
h	hour
V	symbol of voltage
θ	symbol of theta

1. Introduction

The depletion of fossil fuels and increasing ecological awareness have led modern societies to a search for alternative fuels made from renewable sources such as plant biomass. Due to its functional similarity with petroleum-based fuel, biodiesel has become a very attractive alternative for use in diesel engines. Biodiesel is usually synthesized by transesterification of triacylglycerides with methanol, yielding Fatty Acid Methyl Esters (FAMEs) and glycerol as by-products [1]. Typically, conventional biodiesel is straight forwardly produces by means of homogeneous alkaline catalyst, e.g NaOH and KOH and high temperature [2-3]. For low quality used-cooking oil containing a high proportion of free fatty acid (FFA) and water, homogeneous alkaline catalyst are markedly sensitive to FFA, leading to saponification problem, catalyst losses, lowering the efficiency and economics of the overall process [4-6]. Nidju *et al.* [7] had been used heterogeneous catalyst that is egg shells were subjected to calcination–hydration–dehydration treatment to obtain CaO with high activity for the conversion of biodiesel from used-cooking oil. The results showed that the methyl ester conversion was 94.52% at a reaction temperature of 65 °C in 1 h process. The synthesis of biodiesel at room temperature using electro-catalytic method had been reported first by Guan and Kusakabe [1] with the yield > 97%. Simplify process of these methods using Pt electrode have some advantages to produce biodiesel from used-cooking oil. For example, high water content in the feedstock can be directly used in electrolysis process i.e. the electron transfer emerged by the formation of H^+ and OH^- ions in the mixture was derived indirectly as a catalyst of transesterification process of oil. Putra *et al*. [8] had been reported the enhancement of electro-catalytic method using alkaline chitosan powder to produce biodiesel with the yield of 59.05%. Low yield on these synthesis processes due to lack of chitosan basicity, low surface area of chitosan material and low electric conductivity of graphite electrode that was used in the experiment. Fu *et al.* [9] had been immobilized CaO onto chitosan beads to increase the catalytic basicity in the production of biodiesel with the results 97%. Therefore, it is needed further study on the enhancement of electro-catalytic process to produce biodiesel using graphite electrode. In this study, the calcined CaO is proposed as an alkaline catalyst to enhance the biodiesel production using electro-catalytic method with a cheap graphite electrode.

2. Material and Method

2.1 Chemical and equipment

Soybean oil was obtained from local supermarket. The chicken eggshells and used-cooking oil were collected as wastes from culinary sellers in the street. The eggshell was rinsed with water to remove dust and impurities, and was then dried in an under static air at room temperature before reduced to small pieces. All chemicals were analytical-grade reagents (Merck, >99% purity) and were used as received. As