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Partial hydrogenation of polyunsaturated fatty acid methyl esters over Pd/activated carbon: Effect of type of reactor

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HIGHLIGHTS

- Oxidative stability of biodiesel was improved by partial hydrogenation.
- Type of reactor had an important effect on the conversion and selectivity of C18:1.
- Flow reactor provided hydrogenation rates 4–5 times higher than batch reactor.
- At high conversion, batch reactor provided higher C18:1 selectivity.

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ABSTRACT

Partial hydrogenation of polyunsaturated FAMEs has been investigated on a Pd/C catalyst. The effect of type of reactor: batch and continuous flow reactors, on the FAME composition and properties of a biodiesel product were studied. In addition, many characterization techniques such as XRD, BET, FE-SEM, and CO-chemisorption were used to examine the prepared catalysts. The result showed that the partial hydrogenation of polyunsaturated FAMEs in a batch-type reactor provides higher selectivity towards C18:1 than that of a continuous-flow reactor. However, at the low conversion (78%); selectivity of C18:1 obtained from both types of reactors were almost the same.

1. Introduction

Biodiesel or fatty acid methyl ester (FAME) is known to be one of the most promising alternative fuels due to its biodegradability, lower emissions of SO_2, CO, un-burnt hydrocarbon and particulate matters, and higher cetane number as compared to petroleum-based diesel [1,2]. However, some biodiesel properties such as oxidative stability and cold flow properties depend on the natural characteristics of the starting oil [3]. Biodiesel produced from material that contains higher unsaturated fatty acid composition has a lower oxidative stability. In contrast, the higher the saturated fatty acid composition, the worse the cold flow property becomes. The oxidation of the unsaturated FAMEs produces peroxides, aldehydes, ketones, and acids that change biodiesel properties and affect the combustion process [4]. Therefore, the saturation of polyunsaturated FAMEs by partial hydrogenation is a promising way to improve its stability and enhance its utilization potential.

The catalysts used in commercial hydrogenation of triglycerides are usually Ni catalysts supported on silica or alumina, and mostly used in the slurry phases. These Ni catalysts are active in hydrogenation and cheaper than noble metal catalysts, but more severe hydrogenation pressure is required [5,6]. In this respect, noble metal catalysts such as Pd seem to be the most promising [7]. Pd supported on carbon materials has been extensively employed as a catalyst for hydrogenation reaction because of its advantages, e.g., high activity, mild process condition [8], availability of carbon support, and simplicity of recovery of Pd metal by just burning off the carbon component [9]. Several recent publications have addressed the activity of Pd supported on various types of carbon materials such as activated carbon [9–13], nanocomposite carbon [14], carbon nanofibers [15–17], and carbon nanotube [18]. Of

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