



Non-catalytic heterogeneous biodiesel production via a continuous flow system

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ABSTRACT

This study provides a novel methodology for biodiesel (FAME) production under ambient pressure, which resolves most drawbacks of current commercialized biodiesel conversion via the transesterification reaction. This has been achieved by means of a thermo-chemical process and a true continuous flow system. This also enables combination of esterification of free fatty acids (FFAs) and transesterification of triglycerides into a single process without utilizing a catalyst, and leads to a 98–99 ± 0.5 % conversion efficiency of FAME within 1 min in the temperature range of 350–500 °C. High FFA content in oil feedstock is not a matter of the new process, which enables the use of a broader variety of feedstocks, including all edible and inedible fats. Another feature of this novel method is that it does not produce wastewater. Thus, the new process has potential to spur a breakthrough in the lowest cost of biodiesel production. Moreover, this method also requires utilization of carbon dioxide during biodiesel production, an additional environmental benefit.

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1. Introduction

During the past 10 years, fossil fuel depletion and global warming issues have strongly motivated research on fuel production from biomass (Lardon et al., 2009). In particular, biofuels based on vegetable oil have the key advantage of being able to utilize existing distribution networks and current engine technology for diesel fuel (Lardon et al., 2009). Moreover, utilizing biodiesel enhances energy security because it is derived from a renewable and domestic resource (Kiwjaroun et al., 2009). Compared to petroleum-derived diesel, biodiesel has a more favorable combustion emission profile (Di et al., 2009) including low carbon monoxide (CO), particulate matter (PM) and unburned hydrocarbon (UHC) emissions. Carbon dioxide (CO₂) generated by combustion of BD can be carbon neutral (Sahoo and Das, 2009).

The American Society for Testing and Materials (ASTM) defines biodiesel as mono-alkyl esters of long chain fatty acids derived from a renewable lipid feedstock. Biodiesel is generally produced in homogeneous and heterogeneous reaction systems at atmospheric pressure (Murugesan et al., 2009). Recently, the non-catalytic reaction, using only alcohol under supercritical conditions (~400 °C and 80–200 bar) has been investigated as an alternative method for biodiesel production (Demirbas, 2005; Tan et al., 2009). However, the non-catalytic approach (Ilham and Saka, 2009; Juan et al., 2011; Liu et al., 2011; Quesada-Medina and Olivares-Carrillo, 2011; Sawangkeaw et al., 2011; Yin et al., 2008) has not been economically viable due to high operational and equip-

ment cost (Balat and Balat, 2008; Basha et al., 2009; Ma and Hanna, 1999).

In practice, biodiesel can be commercially obtained by a free fatty acid (FFA) esterification reaction, either from vegetable oil hydrolysis followed by the fatty acid esterification (Alonso et al., 2009; Chongkhong et al., 2007, 2009), or directly from vegetable oils via the transesterification reaction (Azcan and Danisman, 2007; Demirbas, 2002; Patil and Deng, 2009). This has been done via batch or semi-batch (cascade) systems (De Paola et al., 2009; Gerpen, 2005). These refer to a catalyzed chemical reaction involving vegetable oil and an alcohol to yield biodiesel and glycerol.

The main goal of this study is to provide a novel methodology for biodiesel (FAME) production under ambient pressure, which resolves all drawbacks of current commercialized biodiesel conversion via the transesterification reaction.

2. Methods

2.1. Sample preparation and material purchase

Used cooking oil collected from a local restaurant was used for the experiment. Beef tallow and lard were purchased from the local slaughterhouse and their lipids were extracted using non-polar solvent (hexane). Soybean oil was purchased from local market of Kwang-yang city. Jatropha oil was imported from Laos and purchased from a local vendor.

Activated alumina (297.35 g m⁻³) was purchased from Daejung Chemicals and Metals Co., Ltd. Its diameter was ~0.5 cm. Cordierite honeycomb ceramic for catalyst support (Magnesium Aluminum Silicate) was purchased from SentroTech Co. (USA). Charcoal was

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