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Application of RSM and Taguchi methods for optimizing the transesterification of waste cooking oil catalyzed by solid ostrich and chicken-eggshell derived CaO

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A B S T R A C T

This paper reported the optimization of biodiesel production from waste cooking oil catalyzed by solid ostrich-eggshell and chicken-eggshell derived CaO via transesterification process using response surface methodology (RSM) and Taguchi method. Quadratic polynomial equations were obtained for transesterification reaction. Independent variables i.e. molar ratio of methanol to oil (M:O), catalyst concentration, reaction temperature and reaction time were investigated. It was found that the most influential parameter on the biodiesel production was reaction temperature based on both RSM and Taguchi method. The optimum biodiesel yield of ~98% (ostrich eggshell) and ~96% (chicken eggshell) were achieved at M:O of ~10:1; catalyst concentration of ~1.5 %w/v; reaction temperature of 65 °C; and reaction time of ~2 h for RSM and Taguchi method, respectively.

1. Introduction

Our world primary sources of energy are mainly conventional which are non-renewable: petroleum, natural gas, coal, and peat. In order to address the increasing energy demand issue alongside with the environmental and socio-economic concerns, the findings of new alternative sources are urgently needed. There are several types of alternative energy sources, including the traditional wood, hydro power, geothermal sources, solar, wind, wave energy and biofuel. Biofuel can mainly be divided into biodiesel and bioethanol. Biodiesel is produced from the renewable biological sources, usually from plant derived materials such as vegetable oils which can be generally divided into two groups i.e. edible and non-edible oils, animal fats, algae, as well as waste cooking oil from households [1]. Nowadays, biodiesel is usually use together with other conventional diesel. It can be used unblended (100% biodiesel, otherwise known as B100), or blended with conventional petroleum diesel as B5 (5% blend of biodiesel), B10 (10% biodiesel), B20 (20% biodiesel) [1] and so forth. In Europe, B100 is defined as an alternative fuel under the Energy Policy Act of 1992 (EPAct) [2]. As a greener fuel alternative, biodiesel may have many advantages including: low toxicity, biodegradability, high-lubricity, good combustion efficiency due to high oxygen content (10–11%) and free from sulfur and aromatic compounds [3].

Nowadays, the dominant industrial biodiesel production process involves the homogeneous chemical reaction of an alcohol (usually methanol) with a long chain alkyl ester in the presence of a catalyst to produce mono-alkyl esters (biodiesel) [4]. The biggest challenge is higher production cost as compared to the conventional diesel production [5]. This is mainly because commercial sectors mostly opted homogeneous base catalyzed technologies which employing low free fatty acid (FFA) raw oils. These pure refined vegetable oils are costly thus causing extra high purification cost to the total production cost [6]. To minimize the biodiesel production cost, low cost feedstock such as waste cooking oils could be a good replacement. Waste cooking oil generated by restaurant needs to be properly discharged which usually incur an additional cost. Therefore, waste cooking oils are a more economically viable

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