Prospect of Biodiesel from Sludge Palm Oil in Malaysia

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Abstract

High feedstock costs make biodiesel production impractical and economically unfeasible, particularly as most feedstocks are unknown for performance. Waste oil, such as sludge palm oil (SPO), may be used to produce biodiesel. This study examined the efficiency and prospect of Sludge Palm Oil Biodiesel (SPOB) production from SPO through transesterification. One-step and two-step transesterification methods were performed for SPOB conversion. However, only a two-step method was effective in converting SPO into SPOB. SPO's high free fatty acid (FFA) content necessitated a two-step process to reduce FFAs to less than 4% before SPOB conversion. Step 1 yielded 78% SPOB at 2 hours, 0.03:1 acid catalyst–to–oil, and 8:1 alcohol–to–oil. The optimal SPOB yield for step 2 at 4 hours, 0.01:1 alkaline catalyst–to–oil, and 9:1 alcohol–to–oil was 78%. SPOB components were analyzed using FTIR with SPOB having a 1435.04 cm-1 methyl peak. The diesel engine performance test mixed SPOB with mineral diesel at different concentrations with 30% SPOB blends in mineral diesel offers the lowest fuel consumption (0.1089 ml/s), maximum braking horsepower (24.9266 rpm), and best mechanical efficiency. Density, flash point, and heating value were also tested to identify SPOB's physical characteristics and discussed in detail.

Keywords: *Sludge Palm Oil, Free Fatty Acids, Transesterification, Fourier Transform Infrared Spectrometer, Diesel Engines*

1. Introduction

Growth in oil consumption, rapid diminishing of oil reserves, and the high price of oil are mainly due to rapid population and massive global industrial growth [1]. Furthermore, massive global industrial growth and political problems between countries resulted in soaring oil prices with low resources [2]. On the other hand, biodiesel is biodegradable and non-hazardous, with low sulfur content that is environmentally feasible [3]. Thus, biodiesel is identified as a potentially clean and

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renewable energy resource. Not only that, using biodiesel increases energy security, improves air quality and the environment, and provides safety benefits [4].

Biodiesel is a monoalkyl ester of fatty acids derived from renewable feedstocks, such as vegetable oils, animal fats, waste oils, or other greases [5]. It is a clean and biodegradable alternative fuel. Biodiesel is a renewable energy resource produced through the transesterification process with mono-hydric alcohol, which converts fats and oils into biodiesel. It is an environmentally friendly, non-hazardous, non-toxic fuel with low sulfur content [6].

A tropical crop called oil palm is farmed primarily for palm oil extraction. It is the world's highest-yielding and least cheap vegetable oil, making it a source of biodiesel and the preferred cooking oil for millions worldwide [7]. In addition, numerous packaged and fast meals, personal care and cosmetic items, and home cleansers frequently include palm oil and its derivatives [8]. Palm oil output increased twofold between 2003 and 2013 due to the demand for these goods, which is expected to continue [9-11]. When considering both production and trade, palm oil ranks as the world's most significant tropical vegetable oil, making up one-third of vegetable oil output in 2009 [12, 13]. The dominance of palm oil may be attributed to several factors, including its low cost and adaptability as a component in many processed goods [14], as well as its yield, nearly four times that of other oil crops [15].

The utilization of waste oils, such as sludge palm oil (SPO), presents a promising avenue for sustainable biodiesel production. However, challenges such as high feedstock costs and performance uncertainties have hindered its economic feasibility. This research explores the novel approach of producing Sludge Palm Oil Biodiesel (SPOB) through transesterification, focusing on efficiency, performance, and prospects. Two distinct transesterification methods, namely one-step and two-step processes, were evaluated to convert SPO into biodiesel. The study found that the two-step method was essential due to SPO's high free fatty acid (FFA) content, necessitating FFA reduction before conversion. The objectives of this research are to assess the efficiency of SPOB production through transesterification, analyze its chemical composition, evaluate its performance in diesel engines, and characterize its physical properties.

Therefore, an investigation was conducted into the efficiency and feasibility of Sludge Palm Oil Biodiesel (SPOB) production from sludge palm oil (SPO) through transesterification. Comparison and evaluation of one-step and two-step transesterification methods for SPOB conversion were undertaken, focusing on yield and purity. The chemical composition of SPOB was analyzed using Fourier Transform Infrared Spectroscopy (FTIR), with emphasis on characteristic peaks indicative of biodiesel. Diesel engine performance tests were conducted to assess the combustion characteristics and efficiency of SPOB blends with mineral diesel at various concentrations. The physical properties of SPOB, including density, flash point, and heating value, were determined to understand its suitability as a viable alternative fuel. By addressing these aims and objectives, this research contributed to the advancement of sustainable biodiesel production by offering insights into the efficient utilization of waste oils and enhancing the understanding of Sludge Palm Oil Biodiesel (SPOB) as a viable alternative to conventional diesel fuels.

2. Sludge Palm Oil (SPO) as biodiesel and its prospect

SPO is a by-product of the palm oil milling process or, in simpler words, a waste product of the palm oil mill [16]. This by-product contains high amounts of oil, dirt, and impurities, as shown in Figure 1. Sludge palm oil, also known as palm oil mill effluent (POME), is a brown slurry of roughly 95 % water, 0.5 to 1 % residual oil, and 4 to 5 % particles, mostly organic [17]. Additionally, there are significant levels of organic nitrogen in the effluent. However, many low-grade oils from the palm oil industry can be converted into biodiesel [18]. The considerable amount of fatty acids by weight percentage is commonly palmitic acid, oleic acid, and stearic acid [16]. The highest percentage of composition is palmitic acid at 42.84 wt%, while the lowest percentage of composition is caproic acid