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Effect of bio-polymer additive on the fuel properties of palm biodiesel and on engine performance analysis and exhaust emission

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Abstract

Biodiesel fuel produced from palm oil is becoming cost competitive with fossil fuels due to the massive resource on Southeast Asia and biodegradable, and environmental friendliness over fossil fuels. The aim of this work was to seek and improve the palm biodiesel fuel blends as possibly high fraction for supplying diesel engine based on modified bio-fuels with bio-polymer additive. This investigation considered simultaneously about the engine performance, the reduction of gas exhaust emissions and also compliance with the main regulation standards of ASTM and SEA. The use of bio-polymer additive in palm biodiesel blends effects on engine performance and reduction of carbon monoxide (CO), carbon dioxide (CO_2) and nitric oxide (NO_x) emissions. A chassis dynamometer used under the simulation of road load conditions with eddy current brake was used to measure engine brake power, engine torque, wheel power, and specific fuel consumption. Exhaust emission values were measured directly by sampling from exhaust pipe with a probe of the analyzers. The experimental results show that the B40 blend with 0.1g bio-polymer additive the most effective improvement of properties included kinematic viscosity, specific gravity, flash point, and midpoint boiling temperature under criterion of ASTM D445, ASTM D1298, ASTM D93, and ASTM D86, respectively. Therefore, modified B40 fuel is strongly possible to be an alternative fuel for a diesel engine. In the term of engine performance, average brake power and engine torque under engine speed tests from 1500 rpm to 4000 rpm slightly decreased by 2.80% and 2.97%, respectively as compared to B2 reference test even though brake specific fuel consumption increased by 20.46%. However, it was found that gas exhaust emissions obviously decreased in diesel engine fuelled palm biodiesel blends additive. As compared to B2 reference test, B40 with 0.1g dosage obtains the great reduction in NO_x, CO, and CO_2 emissions by 63.17%, 14.33%, and 53.25%, respectively under the engine speed at 3000 rpm. The study suggests that B40 or other less palm biodiesel fractions with bio-polymer additive has the high potentiality for as a clean and alternative fuel.

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1. Introduction

Exhaust emissions from diesel engine combustion such as hydrocarbons (HC_S), carbon monoxide (CO), carbon dioxide (CO_2), nitric oxide (NO_x), and particulate matter have a significant cause of high air pollution green-house effect. Therefore, alternative diesel fuel supported with no modifying engine has become important issue. Palm methyl-ester fuel is a kind of biodiesel fuel as an alternative fuels for diesel engines due to its various advantages, such as abundant biomass resources, biodegradable and environmental friendliness over fossil fuel [1], as the major conventional energy sources are gradually depleted. The ways to contribute palm biodiesel blend in diesel fuel safely adopted in diesel engine are widely researched and developed.

Many previous literatures were noted that biodiesel used in diesel engines can reduce exhaust emissions of CO, CO_2, HC_S, and volatile organic compounds [2-4]. Due to containing high oxygen, biodiesel is biodegradable through antioxidants and contributes it to burn more fully, whereas petroleum has essentially none [1]. Nonetheless, the physicochemical properties of pure palm biodiesel fuel may cause some operability problems from the lower fuel quality than the traditional diesel, such as lower cetane index, higher viscosity, higher density and extremely higher flash point for palm biodiesel fuel. The lower cetane index affects the decrease of particulate at high load of automobile [5]. Moreover, higher density and viscosity of biodiesel can affect the volatility and poorer atomization of the fuel spray and, subsequently less accurate operation of the fuel injectors. Finally, the combustion suddenly deteriorates in chamber [6]. Therefore, there are many researchers to study the optimal fraction of biodiesel blends in conventional diesel fuel and develop the new additives for the improvement of its properties [3,7-9].

Additives mixed in biodiesel fuel blends act as combined antioxidants and as dispersants. Some demonstrations showed the fuel consumption slightly increases with a significant decrease in engine power that relates to increasing biodiesel with additive content used [10-13], whereas the role of additives for biodiesel blended fuels on the reduced emissions of engine test has been critically reviewed. However, the physicochemical properties of biodiesel blends with additive in various fractions and effective reaction of the blended biodiesel with additive are concerned because its properties hardly effect on the engine performances and the exhaust emissions.

Several works have succeeded in the synthesis of additive formulations based on bio-solution for biodiesel oil blends, for example, mixing 4-Nonyl phenoxy acetic acid (NPAA: C_{17} $H_{27}O_3$)[14-15], ethers based (ETBE: $C_6H_{14}O$ and TAEE: $C_7H_{16}O$ etc.) [16], ethanol based (C_2H_5OH) [17] or glycerol based ($C_3H_8O_3$) [18] in palm biodiesel. In addition, the commercial multi-functional fuel additives have been claimed that they can enhance the combustion performance and also reduce exhaust gas after being dosed in commercial biodiesel fuel. However, perfective oil additives have not been found. Improvements of additive blends for increasing palm biodiesel quality are always needed.

This work is concerned with fuel quality improvements of the modified palm methyl-ester fuel by adding the commercial copolymer material as a fuel additive because of its reaction at low temperature with higher oxygen composition, based a block copolymer of 2-ethy-hexylmethacrylate and dimethyl aminoethyl methacrylate. In addition, the testes of comparative engine performances were conducted on a diesel engine without modifying under using the different additive levels in the various fractions of palm biodiesel blends in standard diesel fuel. The physical property tests of the blended palm methyl ester fuels were performed in this study including viscosity, specific gravity, flash point, fire point, and carbon residue which were evaluated under the ASTM standard. Moreover, an IDI pick-up diesel engine was tested on a FPS 2700 chassis dynamometer. All tests were performed without any modifying engine. NO_x, CO and CO_2 emissions from the engine were measured by Testo 350 gas analyzer. Moreover, the effects of the additive levels with various palm biodiesel blends were investigated on exhaust emissions.