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Effect of Biodiesel-Diesel Blending on Physico-Chemical Properties of Biodiesel produced from *Moringa oleifera*

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Abstract

The aim of this paper is to study the physical and chemical properties of *Moringa oleifera* biodiesel and its blends of 10%-90% by volume with petro-diesel according to the American society for testing and materials (ASTM D6751) standards and European standards (EN 14214). It was found that when *Moringa* biodiesel is blended with diesel fuel, all its fuel properties such as kinematic viscosity (KV), density (D), calorific value (CV), flash point (FP), cloud point (CP), pour point (PP), and cold filter plugging point (CFPP). For example, B10 reduce the viscosity of B100 from 5.05 mm²/s to 3.54 mm²/s (1.4:1). Then developed empirical models of properties are show high regression value (R^2) between properties and MOME-diesel blend. It is believed that the results obtained and empirical model proposed in this study will help the researchers to predict the properties of biodiesel-diesel blend which are important parameters to design the fuel system of biodiesel engine.

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1. Introduction

As the reserves of fossil energy resources are limited and decreasing day by day, discovering alternative energy sources has become one of the global agenda now a day. Biodiesel has gained popularity among the researchers as one of the alternative energy sources due to potential possession of reducing dependency on fossil diesel fuel, environmental pollutants, etc. [1-4]. Biodiesel can be obtained by employing the transesterification process of vegetable oils, animal fats, waste cooking oil and waste restaurant greases. The most common biodiesel sources from edible oils are palm oil, rapeseed oil, sunflower oil, coconut oil, peanut oil, *Jatropha curcas*, neem, cotton, jojoba, rubber, *Moringa oleifera*, Mahua, castor and animal tallow [5-7].

Recently, investigations have been carried out by numerous researchers [3, 8, 9] regarding the potential of biodiesel production from edible oil and non-edible oil sources and their utilization in a diesel engine. A few authors [9-13] have reported on the potential of biodiesel production from *Moringa oleifera*, a non-edible oil source but there is no extensive report on the characterization of *Moringa oleifera* biodiesel blend. *Moringa oleifera* is a member of the *Moringaceae* family, mainly grows in tropical countries. It is drought-tolerant pioneer species. The *Moringa oleifera* are most available in northwest India, Malaysia, Bangladesh, Africa, South America and Arabia, etc. [14]. It can grow up to 5 to 10 m. The plant starts bearing Pods 6-8 months after planting and reaches an average of 3 t of seed per hectare per year [15, 16]. The seeds of *Moringa oleifera* are triangular in shape which contains about 40% of oil by weight. The oil produced from the seed kernel of *Moringa oleifera* is golden yellow in color. It has been reported that *Moringa oleifera* oil contains higher amount of oleic acid and it is almost 74.41% of the entire fatty acid profile. Among all feedstocks, *Moringa oleifera* oil has a good potential to be converted into biodiesel and being non-edible oil source, it will not create the food versus fuel conflict. Thus the aim of this paper is to study the physical and chemical properties of *Moringa oleifera* biodiesel and its blends of 10%-90% by volume with petrodiesel according to the American society for testing and materials (ASTM D6751) standards and European standards (EN 14214).

Table 1: List of equipment used for properties test

Property	Equipment	Manufacturer	Test method
Kinematic viscosity	SVM 3000	(Anton Paar, UK)	ASTM D445
Density	SVM 3000	(Anton Paar, UK)	ASTM D1298
Oxidation stability	873 Rancimat	(Metrohm, Switzerland)	EN ISO 14112
Flash Point	Pensky-martens flash point - automatic NPM 440	(Norma lab, France)	ASTM D93
Cloud and Pour point	Cloud and Pour point tester - automatic NTE 450	(Norma lab, France)	ASTMD2500, ASTM D97
Cold filter plugging point	Cold filter plugging point tester - automatic NTL 450	(Norma lab, France)	ASTM D6371
Caloric value	C2000 basic calorimeter	(IKA, UK)	ASTM D240

2. Materials and methods

2.1 Materials

Crude *Moringa oleifera* oil (CMOO) was collected through a personal communication. All other chemicals, reagents and accessories were purchased from LGC Scientific Sdn Bhd. Table 1 shows the list of equipment that used for properties test.

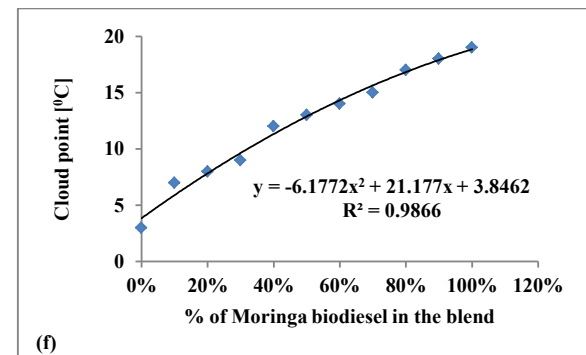
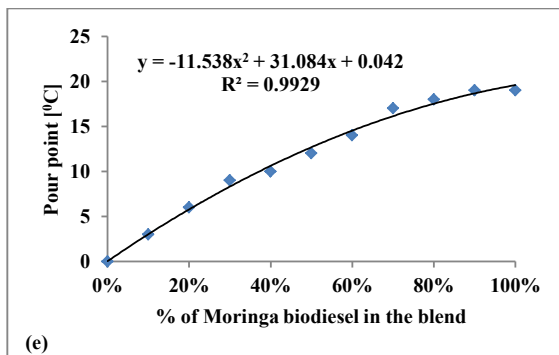
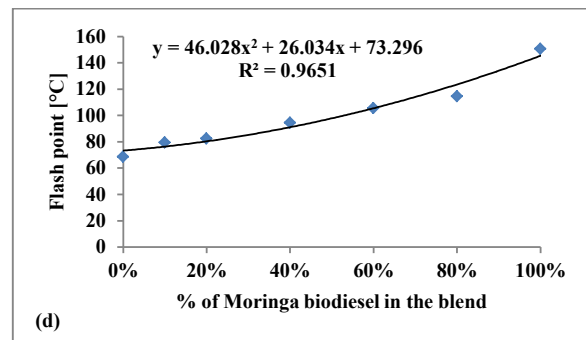
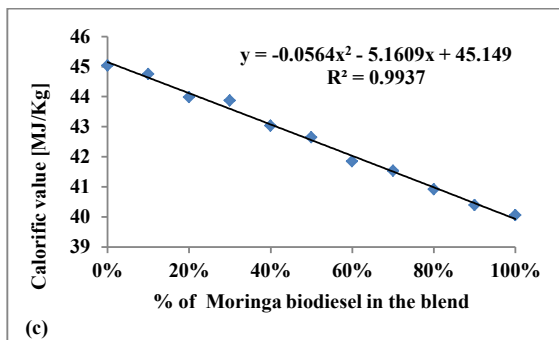
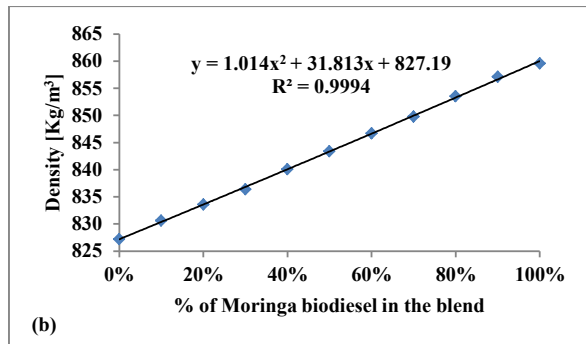
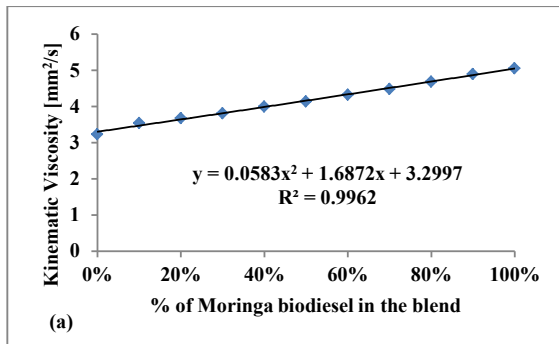
Table 2 Physico-chemical properties of CMOO

Properties	Unit	CMOO	MOME	Diesel
Kinematic viscosity at 40 °C	mm ² /s	43.33	5.05	3.23
Flash point	°C	268.5	150.5	68
CFPP	°C	18	18	5
Pour Point	°C	11	19	0

Cloud point	°C	10	19	0
Density	kg/m ³	897.5	869.6	827.2
Acid value	mg KOH/g oil	8.62	0.22	-
Calorific value	MJ/kg	38.05	40.05	45.30

2.2 Production of MOME

Biodiesel was produced using 1L batch reactor, a reflux condenser, magnetic stirrer, and thermometer and sampling outlet. Before starting the esterification process the crude oil was heated to 60 °C inside the control rotary evaporator (IKA) under vacuum conditions to remove moisture. For esterification of the crude oil, a molar ratio of 12:1 of methanol to crude *Moringa oleifera* oil (CMOO) and 1% (v/v) oil of sulphuric acid (H₂SO₄) were added to the preheated oil and stirred at 600 rpm and at 60 °C temperature for 3 hours. Later, the esterified oil was separated from the excess alcohol, sulphuric acid, and impurities by using separating funnel. Again the separated esterified oil was



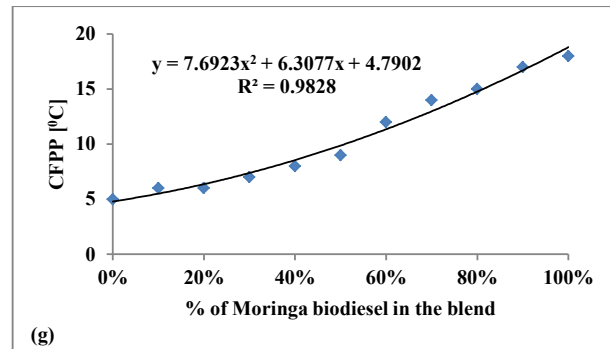


Fig.1 MOME-diesel blending effect on (a) KV (b) density (c) CV (d) FP (e) PP (f) CP (g) CFPP

heated to 60°C inside the control rotary evaporator for 1 hour to remove methanol and water. Then for transesterification purpose, a molar ratio 6:1 methanol to oil and 1% (m/m oil) of potassium hydroxide (KOH) were mixed with the preheated esterified *Moringa oleifera* oil (EMOO) and stirred at constant 600 rpm and at 60°C temperature for 2 hours. Once the reaction is finished, the produced methyl ester was kept in a separation funnel for 16 hours. Then the separated glycerol was drained out and methyl ester was filtered using qualitative filter paper to get final product.

3. Results and discussion

The physico-chemical properties of the produced methyl ester were characterized according to the ASTM D6751 and EN 14214 standards. The major fuel properties of CMOO and MOME are analyzed and presented in **Table 2**. It is found that the KV, FP, CFPP, PP, CP, D, acid value (AV) and CV of CMOO are 43.33 mm²/s, 268.5°C, 18°C, 11°C, 10°C, 897.5 kg/m³, 8.62 mg KOH/g oil and 38.05 MJ/kg respectively. The main findings from properties test is that MOME possesses the better fuel properties such as KV, FP, D, CV and AV but worse cold flow properties (CP, PP and CFPP) compared to CMOO.

Biodiesel can be blended with petro-diesel at any ratios [17]. Then the key fuel properties such as viscosity, density (D), calorific value (CV), flash point (FP), cloud point (CP), pour point (PP), and cold filter plugging point (CFPP) of different blend samples were determined. The effect of MOME-diesel blending on fuel properties are shown in Figs. 2a-g.

The following empirical equations have been developed from Figs. 1a-g to predict the viscosity, density, calorific value, flash point, cloud point, pour point and CFPP of any MOME-diesel blend. Where, (x denotes % of MOME in the blend).

KV	$= 0.0583x^2 + 1.6872x + 3.2997$	$0 \leq x \leq 100$	$R^2=0.9962$	(1)
D	$= 1.014x^2 + 31.813x + 827.19$	$0 \leq x \leq 100$	$R^2=0.9994$	(2)
CV	$= -0.0564x^2 - 5.1609x + 45.149$	$0 \leq x \leq 100$	$R^2=0.9937$	(3)
FP	$= 46.028x^2 + 26.034x + 73.296$	$0 \leq x \leq 100$	$R^2=0.9651$	(4)
PP	$= -11.538x^2 + 31.084x + 0.042$	$0 \leq x \leq 100$	$R^2=0.9929$	(5)
CP	$= -6.1772x^2 + 21.177x + 3.8462$	$0 \leq x \leq 100$	$R^2=0.9866$	(6)
CFPP	$= 7.6923x^2 + 6.3077x + 4.7902$	$0 \leq x \leq 100$	$R^2=0.9828$	(7)

It is seen that the D, KV, FP, CP, PP and CFPP increases as the percentages of biodiesel in the blends increases but the CV decreases as the percentages of biodiesel increases in the blends as expected. It is clear that MOME-diesel blend improves the KV, D, CV, CP, PP and CFPP of biodiesel.

Conclusions

In this paper biodiesel from CMOO was produced through transesterification process. Then the physico-chemical properties of biodiesel-diesel blending of 10-90% by volume are determined. It was found that the fuel properties such as KV, D, CV, CP, PP, CFPP and FP increases with blending ratio either linearly or exponentially as applicable & CV decreases with blending ratio. Finally, the empirical models of fuel properties are proposed. The outcome of the study will help to predict the properties of biodiesel-diesel blend at any blend ration which will be a substantial assistance to design the fuel system of biodiesel engine.

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