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Isolation and Fuel Characterisation of Mahua *(Madhuca Indica)* Biodiesel found in Bihar, India

Biological Science

KEYWORDS: Mahua seed oil, Biodiesel, Transesterification, FAME, Fuel characteristics, Cetane number, Flash point, Density, Pour point.

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ABSTRACT

With the increase in population, industrialization and development of countries, the demands of fossil fuels for power generation and transportation increases continuously in all over the world. The fossil fuels limited source, their shortages, and environmental concern have led to look for alternative fuels, among which biodiesel from vegetable oil feedstocks are widely practiced. Being biodegradable and renewable, biodiesel is chemically fatty acid alkyl ester (FAME/FAEE), which can be derived from vegetable oil/fat by transesterification. In this study, biodiesel production from locally purchased (from Bihar state of India) seeds of Mahua (Madhuca indica) and some of its fuel characteristics were investigated. Mahua seed oil was transesterified with sodium methoxide as homogenous base catalyst to obtain fatty acid methyl ester of Mahua seed oil. The density, flash point, pour point, and cetane number were calculated by standard test methods (ASTM & EN specification for biodiesel) which showed that Mahua oil biodiesel can be used as alternative fuel in diesel engine with regard to Indian conditions.

1.Introduction

Due to limited reservoir of fossil fuels and their increasing use, the fossil fuel will be exhausted one day. Thus, it is important to obtain the solution so that the progress of our nation can't be barricaded. For this reason, the whole world is using biodiesel as an alternative, biodegradable, environmentally friendly fuel as a neat form (B100) or blended (B5, B10, B20) with conventional diesel. These days, India has become the fastest growing economy among developing countries of the world. However, in order to sustain such development, India will throw to reduce fossil fuel dependency. India produces only 22% of total crude oil for domestic expenditure and the rest demand (72%), accomplished by importing crude oil from other countries [1]. The diesel makes up about 44% of total consumption of petroleum products in India whereas petrol accounts for approximately 10% [2]. To tackle such increasing demands of petroleum based fuel and there shortages, the Planning Commission of India established the Committee on Development of Biofuel in 2003. The Indian government approved the National Policy on Biofuel on December 24, 2009, which proposed the biofuel as alternative fuel. The goal of this policy was 20% blending of biofuel (biodiesel or bioethanol) by the end of 2017 [3]. For any country, biodiesel production from edible oil seeds can compete with agricultural food crops, so non-edible oil seeds are most suited for this purpose [4].

Among non-edible seed oils in India, *Jatropha curcas* seed oil valued mostly for biodiesel production. However, other non- edible seed oil can also be utilized to change fuel economy in India, of which Mahua seed oil biodiesel may be next popular alternative, due to its large availability, potential growth and link to Tribal economy. The Mahua tree is well known for its flowers, which are used to brew country liquor and are consumed as food. It also has socioeconomic values as it contributes maximum (55%) to total NTFP (Non Timber Forest Products) income for tribal families in India [5]. Ranchi (Jharkhand) is the biggest trading center for Mahua in India [6]. However, Mahua seed (*Madhuca Indica*) for biodiesel production, is less appreciated, but it can be a safer option as a number of researches suggested it as good alternative fuel. According to Hifjur Raheman et.al, the Mahua oil has more Oleic acid content (41.0-51.0 mass %) but the minimum Arachidic acid content (0.0-3.3 mass %) among other fatty acids [7].

Chemically, Biodiesel is a mixture of monoalkyl esters of long chain carboxylic acid (fatty acids) (ASTM D6751). It is renewable, non toxic, biodegradable, environmentally friendly with a usually high cetane number (a combustion quality parameter), negligible sulfur content, and oxygenated [8]. Since, it has agriculture based production, so it can generate employment opportunity, especially in the rural sectors of developing countries [9]. Important disadvantages of biodiesel include high biomass feedstock cost, poor oxidative stability, poor storage and lower fuel energy content & low-temperature operability [10]. It is unsaturated fatty acids in seed oils, which impart better fuel characteristics to its biodiesel. The major fatty acids of vegetable feedstocks for biodiesel are Linoleic (18:2) followed by Oleic (18:1) and Estearic acid [11].

Transesterification of a vegetable is the reaction between a triglyceride molecule of oil and an alcohol in the presence of a strong acid or base (as a catalyst), which result a mixture of fatty acid alkyl esters (like FAME) and glycerol. The base catalyzed transesterification results better yield in terms of a rate of reaction than acid catalyzed transesterification of vegetable oils [12]. The choice of alcohol in alcohol/oil molar ratio also affects the transesterification yields. It has been reported that methyl alcohol (6:1) is better for good yield (more than 98%) in transesterification than ethyl alcohol (9:1) because of the less molar ratio and efficiency [13].

The objectives of our study were to produce biodiesel from the locally purchased (from Bihar, India), soxhlet extracted *Madhuca Indica* seed oils with alkali (sodium methoxide) catalyzed transesterification and to determine some important fuel characteristics of the Mahua biodiesel.

2. Material and methods

Mahua seeds were collected from the Samastipur District of North Bihar (India). The oil from dried, grounded, and properly weighed seed kernels, were extracted by means of solvent extraction technique using n-hexane as solvent, by Soxhlet apparatus of 500 ml capacity followed by further heating at low temperature for complete evaporation of residual solvent [14].

2.1. Transesterfication:
The transesterification process of pure Mahua oil was carried out in 500 ml round bottom flask supported with water condenser, containing 16.5 ml of methanol and 100 ml of oil, and 0.82g NaOH (as A catalyst) at 600C for half an hour. The mixture was allowed to settle for 24 hours before removing the glycerol layer from the bottom in a separating funnel to get the fatty acid methyl ester (biodiesel) layer on the top. The fuel characteristics like density at 150C, Flash point, Pour point, Cetane number and sulfur content were determined by ASTM D 287, ASTM D 93, ASTM D 97, ASTM 613 and ASTM D 5453 methods respectively. The value of fuel characteristics, thus obtained were compared with standard value prescribed in ASTM D6751 & EN I4214 for biodiesel and as well as ASTM D975 for HSD [14].

3. Result and discussion
3.1. Isolation of Mahua oil
The 41.58 % by mass of Mahua seed oil was obtained through solvent extraction method. Such yield might be depends on geographical conditions from where the seeds were collected.

3.2. Fuel characteristics
The fuel characteristics of Mahua biodiesel are given in Table 1. It was observed that that Mahua biodiesel fuel property was in agreement with those of the prescribed for petrodiesel, and within the limits prescribed in the ASTM and EN standards for biodiesel.

Table-1 Fuel characteristics of Mahua oil, Mahua biodiesel and Diesel

				Biodiesel standards	
Property	Unit	Mahua biodiesel	HSD Limits (ASTM D975)	ASTM D6751	EN 14214
Density at 15^0C	kg/m^3	840	820-845	870-900	860-900
Cetane no.	^{0}C	61.5	51	47 min	51 min
Pour point	^{0}C	21.0	3-15	_	0 max
Flash point	^{0}C	>110	35	>130	>120
Sulfur content	mg/kg	150	350	15	10

4. Conclusions
The sodium methoxide (a base) catalyzed transesterification of pure Mahua oil is effective for better yield of Mahua biodiesel. The higher Sulfur content in Mahua biodiesel is alarming, but the very high Pour point positively reflects its suitability in cold climate. Therefore, the Mahua biodiesel has improved Cold flow property. The High value of Cetane number (an indicative of ignition quality) than petrodiesel limit may affect diesel engine performance. The observed Flash point value showed that Mahua oil biodiesel is safer than diesel in terms of its storage and handling.

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