International Conference on Recent Trend and Practices in Science,
Technology, Management and Humanities for
Sustainable Rural Development
(STMH - 2019)

Production and Characterization of Biodiesel from *Citrus Maxima* and *Thevetia Peruviana* Seed oil

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Abstract—*Biodiesel is a renewable option in conventional CI engines to standard diesel. The current investigation deals with the production of biodiesel or methyl esters from Citrus maxima & Thevetia peruviana seed oils. Locally in North East, India, these resources are available locally. The methyl esters from corresponding biodiesel have been prepared in a laboratory scale through transesterification process. Both the biodiesel's physical and chemical properties have been determined and compared to diesel. The physical and chemical characteristics of the two biodiesel resemble that of diesel. This shows that methyl esters or biodiesel from Citrus maxima & Thevetia peruviana can be used entirely or in blends in standard CI engines without any engine alteration.*

Introduction

The world is dependent on fossil fuels. The fossil fuel reserves are limited and nearing towards exhaustion. The fuel prices are no longer stable. This volatility is hurting the Indian economy very much. The dependence on imported fossil fuel is also posing a great threat to Indian energy security. The recent oil embargo on Iran which is a major oil supplier to India is a reminder of such eventuality. Therefore, it has become a necessity to invest time and money for development of a new kind of fuel which is sustainable, renewable and clean. In India, the transport sector is the major consumer of fossil fuel. Biodiesel could be a good substitute for diesel in transport sector. The physical and chemical characteristics of biodiesel resemble with that of diesel to a great extent. Biodiesel can be synthesized from any kind of vegetable oil resources [1]. The vegetable oil is also known as triglycerides. The triglycerides can be converted to monoalkyl esters by transesterification process. The transesterification is a chemical reaction process which can be either base-catalyzed or acid-catalyzed based on the feedstock [2]. The process brings down the viscosity of the vegetable oils or triglycerides and gives a less viscous monoalkyl ester which is at par with standard diesel in characteristics. This monoalkyl ester or biodiesel can be utilized in diesel engines either fully or in blends with much of a problem [3]. The study suggests that biodiesel has been successfully utilized in unmodified diesel engines [4]. But, the fuel economy is low for biodiesel fuelled diesel engines due to low calorific value, relatively higher viscosity and density on the part of the fuel. Apart from that biodiesel have many advantages. It is a clean renewable fuel. The biodiesel fuelled engines emit less carbon dioxide, carbon monoxide, & particulate matter and no oxides of sulfur at all [5]. Moreover, it lubricates the engines upon utilization [6]. Another most important thing is that biodiesel might contribute towards sustainable economic development of rural economy in near future from production to distribution. This might help to generate thousands of employment opportunity [7-10]. The present study aims to utilize locally available non-edible vegetable oil resources for biodiesel production. These are the seed oils of *Citrus maxima* and *Thevetia peruviana*.

Materials and Method

Biodiesel can be synthesized from any kind of vegetable oil resources. Due to issues regarding food security in India, the plant-based vegetable oils which are nonedible are preferred for biodiesel production. The seeds have been collected from farms in Dibrugarh and Jorhat from. Therefore, two locally available seed oils from *Citrus maxima* and *Thevetia peruviana* have been utilized. The *Citrus maxima* are the citrus fruits with large number of seeds owing to its large size. The seeds of *Citrus maxima* are with thin shells which need to be removed before processing. On the other hand, *Thevetia peruviana* is a flowering plant which bears hard-shelled seeds after flowering. The seeds need to be processed by removing the hard shells. Figure 1 and 2 shows the *Citrus maxima* and *Thevetia peruviana* seeds respectively. Table 1 shows the amounts of seed collected from various localities. The seeds have been processed in Mechanical Engineering laboratory, DUIET, Dibrugarh University. The processed seeds have been sundried to remove moisture. Then, these seeds are put through oil expellers. During vegetable oil extraction, both the mechanical and automatic oil expellers have been utilized. The extracted vegetable oils have been filtered properly to remove the sediments.

The *Citrus maxima* and Thevetia *peruviana* vegetable oils can be converted to their corresponding methyl esters or biodiesel by a very simple based catalyzed chemical reaction known as transesterfication in laboratory scale. First the vegetable oil is to be heated at 100°C to remove any moisture present in there. Otherwise, this will cause soap formation during chemical reaction. Then, the process involves the vegetable oil and 20% methanol of the vegetable oil in presence of KOH as the catalyst in reactor at 60°C (below boiling point of methanol) in a reactor for 90 minutes at 300 rpm. The transesterfication process is shown diagrammatically in figure 3. After the reaction, the mixture is placed in a partial distillation flask. The mixture is kept there for 12 hours or more. This settles the distinct layers of biodiesel at the top of the flask and glycerin layer at the bottom. Generally, the biodiesel layer at the top is light yellow and the glycerin layer is dark brown in color. The biodiesel and glycerin have been separated by gravity separation method. The separated biodiesel still contains traces amount of alcohol and catalyst. These are removed by warm water washes. After the washes, the biodiesel looks very light yellow in color. The transesterfication parameters utilized for the *Citrus maxima* and Thevetia *peruviana* vegetable oils are given in table 2.

Table 1: Collection of seeds

Seeds	Collection Place	Seeds Quantity (kg)
Citrus maxima	Dibrugarh & Jorhat, Assam	30
Thevetia peruviana	Pune, , Maharashtra	15

Figure 1: *Citrus maxima* seeds

Figure 2: *Thevetia peruviana* seeds

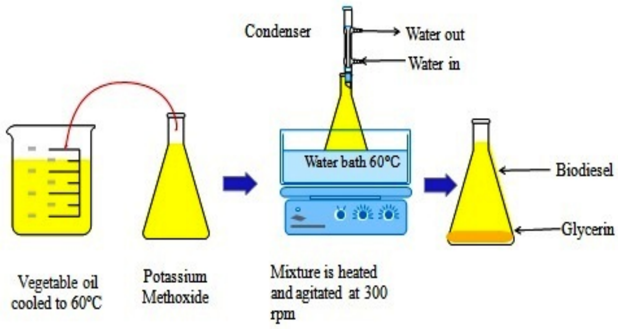

Figure 3: Transesterification process

Table 2. Transesterfication parameter

Feedstock	Oil (ml)	Methanol (ml)	KOH (gm)	Speed (rpm)	Time (mins)
Thevetia peruviana	1000	200	14.5	300	90
Citrus maxima	1000	200	14	300	90

Results and Discussions

The physical and chemical properties of methyl esters of *Citrus maxima* and *Thevetia peruviana* have been determined according to ASTM D625 standards and compared with standard diesel in table 3. It is observed that the methyl ester of *Citrus maxima* has the lowest density at 822 kg/cm^3 which is lower than that of the standard diesel. Kinematic viscosity values of the both of the methyl esters of *Citrus maxima* and *Thevetia peruviana* fall within the ASTM limit of 5cSt. In the diesel engine, the highly viscous fuels cannot be used as they can block the fuel supply lines and injectors during combustion. In addition, their atomization is difficult during fuel injection. As a result, combustion process gets hampered. Since the methyl esters of *Citrus maxima* and *Thevetia peruviana* have low viscosity; they can be utilized in conventional CI engine without any problem. The low viscosity of the fuels also indicates the successful transesterfication process. The calorific value refers simply to the energy released in MJ for combustion of 1kg of fuel.

Citrus maxima and *Thevetia peruviana* methyl esters' calorific values are 27.1 MJ / kg and 38 MJ / kg respectively. The calorific values of this two biodiesel are lower than that of diesel which is at 53.4 MJ/kg. As a consequence, the greater quantity of methyl esters would be consumed as opposed to diesel during combustion process. This leads to greater brake specific fuel consumption (BSFC) of the fuels in diesel engine relative to mineral diesel. Cetane number of diesel is a significant parameter to assess ignition quality. Higher cetane number in diesel implies that it will ignite readily. The methyl esters of *Citrus maxima* and *Thevetia peruviana* have been tested for cetane numbers which are 52 and 50 respectively. The values are well within the ASTM limits. The pour point and cloud point are the criteria for fuel to be utilized in cold areas. *Citrus maxima*'s methyl esters and *Thevetia peruviana's* pour point and cloud points are -15&-4 and 3&12 respectively. It shows that the methyl esters of *Citrus maxima* have good cold flow properties. Flashpoint is the parameter linked to safety and handling of fuel for storage and transport purposes. The methyl esters of *Citrus maxima* and *Thevetia peruviana* have 151℃ and 110℃ respectively. The flashpoints of both biodiesels are higher than that of diesel. The flashpoint of the methyl ester of *Thevetia peruviana* is well within ASTM limit but the methyl ester *Citrus maxima* above the limit. According to ASTM D6751, the acid value of biodiesel should not be more than 0.8mgKOH/g. A higher acid value in biodiesel causes increase in FFA. This ultimately leads to corrosion in engine parts. The acid values of the methyl esters of *Citrus maxima* and *Thevetia peruviana* are 1.875 mg KOH/g and 1.2 mg KOH/g respectively.

Table 3: Physical and chemical properties of biodiesel

Property	Methyl ester of Thevetia Peruvian	Methyl ester of Citrus maxima	Diesel
Density (kg/cm^3)	860	822	833
Kinematic viscosity(cSt)	1.27	1.92	2.6
Calorific Value (MJ/kg)	38	27.1	53.54
Cetane Number	50	52	46
Pour point (℃)	3	-15	-16
Cloud Point (℃)	12	-4	-4
Fire point (℃)	120	200	64
Flashpoint (℃)	110	151	66
Acid value (mg KOH/g)	1.2	1.875	-
FFA (%)	0.6	0.9375	-

Conclusions

The current research demonstrates the two prospective feedstock *Citrus maxima* and *Thevetia peruviana* seed oil for biodiesel production. Both biodiesels have physical and chemical properties well within ASTM limits for use in diesel engines as fuel. By mixing, this biodiesel can be used. Generally speaking, the diesel engine does not need to be modified but changes can be made to improve fuel economy, brake thermal efficiency, and reduced NOx emissions. These include redesign of engine combustion chamber, changes in injection pressures, changes in compression ratio, manipulation of ignition delay, etc. In the current study the methyl esters of Citrus *maxima*'s methyl esters and *Thevetia peruviana* have been utilized in diesel engine. The engine has run without any difficulty and vibration.

Acknowledgments

The author acknowledges the support from Mechanical Engineering laboratory, DUIET, Dibrugarh University, and Assam Engineering College, Guwahati as well.

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ISBN-978-93-85822-92-6