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Physico-Chemical Properties of Biodiesel Obtained from *Callophyllum innophyllum* Oil.

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ABSTRACT

The biodiesel obtained from the seeds of *Callophyllum innophyllum* has been analyzed for its physico chemical properties. The oil yield potential of *Callophyllum* seed and the biodiesel properties of the oil were studied in order to know the feasibility of the oil as a biofuel. The physico-chemical properties of the biodiesel produced by blending with the conventional diesel were evaluated and compared with that of diesel. The physico-chemical properties assessed includes, specific gravity, density, viscosity, flash point, fire point, cloud point, pour point, smoke point, pH, carbon residue, ultrasonic parameters, average molecular weight, saponification value, acid value, and iodine value. The results revealed that there is a significant difference between the physico-chemical properties of biodiesel and petro diesel.
Keywords: *Callophyllum innophyllum*, biodiesel, *Callophyllum* oil, fuel, ASTM

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INTRODUCTION

Biofuel is a nonpolluting, locally available, accessible, sustainable, and reliable fuel obtained from renewable sources. The liquid biofuel are from agricultural sources, like: lipids, simple sugars and polysaccharides sources. Biodiesel refers to vegetable oil or animal fat-based diesel fuel consisting of alkyl (methyl, propyl, or ethyl) esters obtained by chemical reaction of the lipids (vegetable oil, animal fat) with an alcohol[1]. Biodiesel is a clean burning alternative fuel to diesel. It is produced from domestically grown renewable resources. Chemically, most biodiesel consists of alkyl esters instead of the alkanes and aromatic hydrocarbons of petroleum derived diesel[2].

With the increase in the number of diesel vehicles in the World, the demand for the petroleum diesel fuel is going on increasing. But the depletion in the petroleum diesel fuel sources and the price escalation do not meet the demand of the country. Hence, there is a need for search for an alternative source for the petroleum diesel fuel. In this juncture, biodiesel can play a good role for substituting the petroleum diesel fuel. Biodiesel is made from vegetable oil (edible or non-edible) .and animal fats reacted with alcohol in the presence of a catalyst (NaOH/kOH). Biodiesel can be used in the pure form, or blended up to 20% with diesel fuel to obtain a biodiesel blended fuel for use in compression ignition engines[3],[4]. Bio-diesel can be used in diesel engines either as a standalone or blended with petro diesel[5]. In a country like India the yield of edible oil is found to be insufficient to meet the growing demand. Hence, the choice for the production of biodiesel falls on the non- edible oils. The biodiesel from non- edible oil will solve the problem of insufficient supply of diesel fuels, the price escalation and also it is safe to the environment. As a progressive step in the direction of alternate fuel, there is a need to identify suitable non-edible oil yielding tree[6]. In India a large scale program of biodiesel is being taken up in the country through the cultivation of selected oil bearing species like Jatropha and Pongamia[7]. But for the sustainable production of biodiesel there is a need for screening a large number of oil yielding trees. Among them *Callophyllum innophyllum* tree is one of the non-edible oil yielding tree, which can grow well along the river belts and coastal areas of Peninsular India with seeds productivity potential as high as 150 to 200 kg per tree per year[8]. Moreover, the oilcake obtained after the extraction of oil could be used as a bio-manure.

Botanical features

Callophyllum innophyllum L. (Family: Clusiaceae) is commonly known as Alexandrian laurel or Dilo or Sultanchampa or Nagachamba. The generic name is derived from the Greek. Kalos means beautiful, phyllon means leaf. *Callophyllum* L. has more than 200 species. It is introduced from Madagascar and naturalized in India and Sri Lanka and widely distributed in tropical South East Asia, Malaysia, Australia, American tropics, Eastern Africa, Pacific islands, West Indies, South America and Fiji Islands. Fourteen species are occurring in India[9, 10].
Callophyllum innophyllum L. is a medium-sized evergreen tree with a smooth, grey bark and cylindrical low-branching with a broad, spreading crown of irregular, gnarled branches attaining a height of 15 – 22 m. This species grows well in a wide range of habitats from ridges in mountain forests to coastal swamps, lowland forest and even coral clays. The tree is attractive for its large shining leaves which are 20 cm long and 10 cm broad. Leaves are

opposite, oblong or ovate, usually emarginated, thick leathery and glistening with numerous parallel veins. Flower buds are clothed with minute rusty hairs. Flowers are white, scented, with variable number of perianth parts and yellow anthers. Flowers are 2 cm in diameter occurs in auxiliary, racemose or paniculate inflorescence consisting of 4 – 15 flowers. Although, some flowering may occurred throughout the year, in most of the regions two distinct flowering periods occur, i.e. one in the late spring/early summer and another in late fall. The fruit (A drupe) is green in color, round and typically 2 – 4 cm diameter, including a thin (3 – 5 mm) layer of pulp, the shell and single large seed. Fully matured fruits are yellow or Red-brown and wrinkled seeds can be collected by picking individual fruits or looping of branches with pruning poles. Seeds are most readily available during April – June and October – December. One kilogram of seed contains about 100 – 150 of nuts. The kernel yields oil and it is about 70%. The plant is propagated by seeds. The cutting of half ripe shoot can be rooted under mist with bottom heat[11].

Cultivation aspects

This tropical evergreen tree grows well up to 1000 m above the sea level in all types of soil. It is primarily a tree of the seashore and adjacent lowland forests, although it occasionally grows at higher elevations and has been successfully planted in inland areas. It grows in areas with annual rainfall ranging from about 1000 – 5000 mm. The tree grows in a wide variety of soils, from nearly pure coastal sands to clay, and is capable of growth on degraded and poorly drained sites. It can be found right at the edge of the sea, where it may be exposed to high winds, sea spray and brackish water table. The descriptions of tree often emphasize its value as an ornamental because it as attractive leaves fragrant flowers and a pleasing canopy. Indeed, it is probably planted more for ornamental purposes than for other utilities. The species is commonly planted along the streets and roads and in urban areas throughout its native range.

Uses of *Callophyllum innophyllum*

All the parts of *Callophyllum innophyllum* are useful in one way or the other. From the fruit aromatic oil is prepared known as “Alexandrian laurel oil”[12]. The dark green oil extracted from the seeds is used in a number of products, including oil for lighting, medicines, soap making and hair grease. The oil is used to treat skin diseases and rheumatism. The oil has very high medicinal value; it is rubbed on the joints to cure rheumatism, skin diseases and used in massaging rheumatic aches. With high content of EFA, the oil is used in skin softening and moisturizing. It has immense regenerative and antiseptic properties. The oil can be used for dry and damaged hair which brings back and revives the brilliance of colored hairs. From the bark of this plant, an aromatic gum is excluded which is known as “tacamahac” and it is used as a perfume[13]. Wounds can be treated with the gum from the bark. The leaves are soaked in water to make an eye wash for removing foreign objects from the eyes. The eye wash is given for relieving eye pains. Leaves are softened by heating and then applied to sores and cuts. Boiled leaves are used to make a solution and are used for washing skin rashes. An infusion of the leaves is ingested for diarrhoea. Leaf litter is good feed for the earthworm and it makes good manure. Flower yield essential oil and are used in cosmetics and scents. Fragrant flowers are used for the treatment of syphilis, scabies and skin eruption, which has cooling effect. The trees have large hardwood, attaining 30 m in height and 0.8n m in diameter[14]. The bark is grey or white in color and decorticates in large thin strips. The wood is of light weight, pink-red or almost brown, while the sapwood varies from species to species, often from yellow, brown (often pink tints) to orange. The wood is hard, strong, moderately durable, and it has been used in general construction and boat-making and for flooring, furniture, musical instruments, handicrafts, honey bee shelves and a variety of other purposes. However, in the present context, seeds are considered economically important value as they contain 70% of oil content which can be used in the production of biodiesel. Up ‘to 20% of this oil can blended with petroleum diesel fuel. Biodiesel can be used in the conventional diesel engine without any modification[15]. The emission produces less pollution and it is safe to the environment.

The oil-cake, being rich in nitrogen, phosphorus and potash, is valuable organic manure. The shells can be pulverized and are used' in the compost since they also contain high NPK content[16]. Alexandrian laurel tree is an evergreen multipurpose, eco-friendly tree with well developed root system which can check soil erosion and environment degradation.

MATERIALS AND METHODS

Collection, extraction, purification and preparation of *Callophyllum innophyllum* seeds

The *Callophyllum innophyllum* fruits were collected in and around Kumaracoil, Tamilnadu state, India. The fruits were dried, dehulled to obtain the seed, the seed was separated from the seed coat and dried, undesired impurities were removed by hand-picking. The seed was prepared for extraction by grinding using a laboratory mortar and pestle to. The bulk of the oil was extracted using by soaking the grinded seed in a container with n-Hexane and left for 3 days, the extraction process was repeated 3 times for proper extraction. The diesel used was purchase at Indian oil Filling Station, Trivandrum Road, Thuckalay, Tamilnadu State, India.

Conversion and Preparation of *Callophyllum innophyllum* oil to biodiesel by blend method

In the present study, the *Callophyllum innophyllum* oil is mixed with the conventional diesel in two different proportions namely at BI0 (90% diesel and 10% *Callophyllum innophyllum* oil) and at B20 (80% diesel and 20% *Callophyllum innophyllum* oil). The ultrasonic studies and simple physico-chemical studies were carried out for the blended proportions of biodiesel.

Physico-chemical analysis

The specific gravity and density were determined using the specific gravity bottle and were estimated using the equations below

$$SG = \frac{Mass\ of\ Oil}{Mass\ of\ an\ equal\ volume\ of\ water}$$

$$Density = \frac{Mass\ of\ Oil}{Volume\ of\ Biodiesel}$$

The fire point, flash point, smoke point, carbon residue, cloud point, pour point were carried out. The fire point was carried out by using Clevenant open cup apparatus. The flash point was determined by using Pensky-Martens closed cup tester apparatus. The cloud point and pour point were obtained by using Deep vision Cloud point apparatus. Carbon residue was determined by using Conradson carbon residue apparatus. The smoke point was determined using Seta Smoke point apparatus. Viscosity was measured by using calibrated Owtwald Viscometer. The pH was determined by using Elico pH meter.

The econometric and acidimetric chemical properties were analyzed for the Callophyllum oil. The econometric constant namely the Iodine value was determined by Wijs method. The acidimetric constant namely the Acid value and saponification value were measured by AOAC method. The average molecular weight of the oil was determined by using their acidimetric chemical constant. The free glycerol was determined by ASTM D6584 method.

The ultrasonic parameters namely ultrasonic compressibility, relaxation time, acoustic impedance and intermolecular free length were studied for the blended proportions (B10 & B20) and diesel with the help of the Ultrasonic Interferometer. The frequency of measurement is 2 MHZ.

RESULTS AND DISCUSSION

The physical parameters of flash point, fire point, smoke point, cloud point, pour point, carbon residue, pH, Specific gravity, density and viscosity were measured for diesel and the Callophyllum oil biodiesel blended at 10 and 20 proportions. The results were compared with standard value and it is tabulated in Table 1. The iodine value, acid value, saponification value, average molecular weight and free glycerol (percentage) were measured for the Callophyllum biodiesel blends and the results are given in the table 2. The ultrasonic parameters namely ultrasonic velocity, ultrasonic compressibility, relaxation time, acoustic impedance and intermolecular free length were studied for diesel and the blends of Callophyllum oil with conventional diesel with B10 and B20 proportions are furnished in the table 3.

The flash point of biodiesel blends are almost equal to the petro diesel and the B20 value is slightly higher than the petro diesel and the flash point obtained for the diesel fuel and the biodiesel blends are within the standard specified for petro diesel[17]. The flash point of biodiesel I higher than that of fossil diesel therefore it could be said that biodiesel is safer to handle than fossil diesel[18]. Fire point of the blend B10 is almost equal and the B20 blend is slightly higher than the petro diesel, and which falls within the range of the ASTM Standard (American Society for Testing and Materials). This indicates the biodiesel blends are safer to use as that of fossil diesel. The smoke point of the biodiesel blends are less than the petro diesel but within the range of the ASTM standards. The carbon residue is slightly higher than the petro diesel. The high value of carbon residue may be due to the impurities in the biodiesel blends but it falls within the ASTM standard. The cloud point and pour point

Table: 1. Physical parameters of *Callophyllum innophyllum* Biodiesel blends and diesel

Parameters	Diesel	*Callophyllum innophyllum*	
		B10	**B20**
Flash point	47.2ºC	45.7ºC	56.0ºC
Fire point	54.0ºC	54.2ºC	58.3ºC
Smoke point	9mm	6mm	7mm
Carbon residue	0.2g	0.3g	0.4g
Cloud point	3 ºC	5 ºC	7 ºC
Pour Point	0 ºC	1 ºC	2 ºC
pH	6.8	5.7	4.2
Specific gravity	0.880	0.895	0.905
Density	0.804g/cm^3	0.848g/cm^3	0.864g/cm^3
Viscosity	3.5	3.6	4.1

Table: 2. Chemical parameters of *Callophyllum innophyllum* Biodiesel blends and diesel

Parameters	Diesel	*Callophyllum innophyllum*	
		B10	**B20**
Acid value	16.31	79.2	101.12
Iodine Value	6.838	1.92	5.62
Saponification value	109.41	61.72	33.66

Table: 3. Ultrasonic parameters of *Callophyllum innophyllum* Biodiesel blends and diesel

Parameters	Diesel	*Callophyllum innophyllum*	
		B10	**B20**
Ultrasonic velocity 10^6 m/s	1.380	1.324	1.356
Ultrasonic Compressibility × 10^{-12}kg^{-1}ms^{-2}	0.625	0.679	0.639
Relaxation Time × 10^{-12}s	2.917	3.259	3.493
Intermolecular free length × 10^{-12}m	1.620	1.689	1.638
Acoustic impedance × 10^6kgm^{-2}s^{-1}	1.059	1.112	1.153

Table: 4. Chemical parameters of *Callophyllum innophyllum* oil and ASTM standard for diesel

Parameters	ASTM standard value	*Callophyllum innophyllum* oil
Average molecular weight	-	196.15
Free glycerol (%)	<0.02	0.52

of the biodiesel blends are slightly higher than the petro diesel it is because of the fatty acids and the types of fatty acids present in the biodiesel blends. The pH of the biodiesel blends is slightly less than the petro diesel which also indicates the biodiesel are due to the presence of fatty acid. The density and viscosity and specific gravity are important when considering the spray characteristic of the fuel within the engine. Higher density and viscosity of the liquid fuels affects the flow properties of the fuel, such as spray atomization, subsequent vaporization and air-fuel mixing in the compression chamber. The change in spray can greatly alter the combustion properties of the fuel mixture. Specific gravity, Viscosity and density of vegetable oil are several times higher than that of diesel. By mixing the vegetable oil with the conventional diesel with B10 and B20 the specific gravity, density and viscosity were found to be slightly higher than that of diesel and it is also falls within the range of the ASTM standard value for the biodiesel.

The ultrasonic study is a novel method for screening the biodiesel. It is a cheap, quick and best method for the screening of vegetable oil for its potentiality for biodiesel[8].

The ultrasonic velocities, the intermolecular free length of the biodiesels were very close to that of diesel. The ultrasonic compressibility and the relaxation time of the biodiesel blends have a slight higher than the diesel because of the slight variation in their density with that of the petro diesel.

In chemical property, the acid value of the oil indicates that the amount of fatty acid present in the sample. The acid value of Callophyllum oil is slightly higher than that of the ASTM standard. The number of double bonds present in a vegetable oil is calculated by treating with iodine. The higher the iodine number, higher will the amount of iodine need to be saturate or break the double bonds and also higher the efficiency of that oil as biodiesel. From the result the iodine value biodiesel is lesser than the petro diesel and it is found to be within the range of ASTM standard for the biodiesel. The saponification value can indicate the non fatty impurity and the amount of alkali that would be required by the fat for its conversion to soap. In the biodiesel blends the saponification values are less than that of the petro diesel. However the saponification value is found to be within the acceptable range of biodiesel. The average molecular weights of the oil were determined by acidimetric chemical constant. The average molecular weight of the oil should be low to avoid the combustion problem when it is used as a biodiesel. The oil containing less viscosity has low molecular weight. Here the Callophyllum oil has less viscosity and low molecular weight. The free glycerol (percentage) result shows slightly greater than the ASTM standard value.

The present study on Callophyllum oil has shown that most of the physical properties, chemical properties and ultrasonic properties evaluated for the biodiesel blends (B10 and B20) falls within the range of ASTM and EN standard values and are very nearer to the petro diesel properties. It could be concluded from the study that the biodiesel blends produced from Callophyllum oil blend B20 is the potential replacement for fossil diesel while the production and effective usage of biodiesel blend B20 will help to reduce the cost of protecting the atmosphere form the hazards in using fossil diesel and also will boost the economy of the country.

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REFERENCES

[1] Fairless D. Nature 2007; 449: 652-5.

[2] Jongschaap REE, Blesgraaf RAR, Boogard TA, Van Loo EN, Savenije HHG. Proc Nat Acad Sci USA 2008; 106.

[3] Caio CS Macedo, Frederique R Abreu, André P Tavares, Melquizedeque B.Alves, Luiz F Zara, Joel C Rubim, Paulo AZ Suarez. J Braz Chem Soc 2006; 17: 1291-6.

[4] Edimar DeOliveira, Rafael L Quirino, Paulo A.Z. Suarez, Alexandre G.S. Prado. Thermochimica Acta 2006; 450: 87-90.

[5] Arumugam V, Sanjeevi R, Raguatha Rao D, Balakrishnan R, Shameem Banu IB. Indian J Pure Appl Phys 1998; 36: 578-83.

[6] Joshi, Syamasundar, Hiremath, Shantha. Curr Sci 2000; 78: 694-7.

[7] SK Chopra. *Energy Policy for India*ed. New Delhi: oxford and IBH publishing Co. Pvt. Ltd., 2005.

[8] Meena Devi VN, Vijayalakshmi GS, Nagendra Prasad P. Natl J Life Sci 2005;2: 54-9.

[9] Achten WMJ, Verchof L, Franken TJ, Mathius T, Sigh VP, Aert R. Biodiesel Production & use Biomass & Bioenergy 2005; 33: 1003-84.

[10] Bhattacharjee Supriya Kumar. *Handbook of Aromatic plants*ed.: Pointer Publisher, 2000.

[11] Prajapati, Narayan Das S, Purohit S, Arun Sharma K, Tarun Sharma. A Handbook of medicinal Plants, vol.: Agrobios (India), 2003.

[12] Achten WMJ, Mathijs E, Verchot L, Sjngh VP, Aerts R, Muys B. Biofuel Bioproducts Biorefining 2007; 1: 283-91.

[13] Vasudevan PT, Briggs M. J Ind Microbiol Biotechnol 2008; 35: 421-30.

[14] El Diwani G, Attia NK, Hawash SI. Int J Environ Sci Technol 2009; 6: 219-24.

[15] Belewu MA, Adekola FA, Adebayo GB, Ameen OM, Mohameed NO, Olaniyan AM, Adekola OF and Musa AK. Int J Biol Chem Sci 2010; 4: 524-9.

[16] Tint TK, Mya M. World Acad Sci Eng Technol 2009: 477-80.

[17] http://www.rix.co.uk. vol.

[18] Adebayo OL, Shallie PD, Adenuga GA. Asian J Clin Nutr 2011; 3: 71-7.