PRODUCTION OF BIODIESEL FROM *MELIA AZEDARACH* SEED OIL: A NON-EDIBLE FEEDSTOCK FOR BIODIESEL

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ABSTRACT: *Biodiesel (BD) is a first-generation biofuel that has emerged as a renewable alternative diesel fuel, obtained by the transesterification of vegetable oils and animals fats, using a short-chain alcohol and a catalyst that may be an acid, a base or an enzyme. BD can be used in the existing compression-ignition engines without any further modification. Presently, most of the BD production is being carried out using edible vegetable oil which has put a strain on the food supply and, hence, has led it into a competition with the food industry. It has also resulted in a rise in the prices of such feed stocks. Hence, search for the newer and non-edible feed stocks is becoming increasingly important. The objective of the present work is to explore the utility of Melia azedarach seed oil, a non-edible feedstock, for the preparation of BD. The oil was extracted by using n-hexane as a solvent and a oil content of 32% was obtained. As a result of transesterification using sodium hydroxide and methanol, 80% conversion of the oil into BD was obtained. Fatty acid profile of the oil and the BD were found to be almost the same. Different fuel properties of the BD prepared were studied including viscosity, iodine number, acid number, cold point and cetane number, and the values obtained are 4.7, 112, 0.45mg KOH/g, < -10^{o}C and 45, respectively. Although the oxidation stability is less than the required standard value by EN 14214, but it can be enhanced by introducing some additives into the final product. Other properties were found to be in agreement with the required specifications for BD by EN 14214, hence Melia azedarach seed oil is a suitable non-edible feedstock for the production of BD.*

Key words: Biodiesel, Transesterification, *Melia azedarach,* Vegetable oil

I. INTRODUCTION

Biodiesel (BD) is a first-generation biofuel that has emerged as a renewable alternative diesel fuel, obtained from vegetable oils and animal fats. Chemically, BD is obtained by the transesterification of oils and fats by using a short-chain alcohol and a catalyst that may be an acid, a base or an enzyme, as shown in fig. 1 [1].

BD has been found to be a simple and suitable alternative of the conventional diesel fuel in the light the research carried out in last three decades that can be used in the existing compression-ignition engines without any further modification [2]. BD is an environment-friendly fuel that bears a number of advantages over the fossil-based diesel fuel. Firstly, it is a rene wable fuel as it is produced from renewable source. Secondly, it possesses a higher oxygen content and lower sulphur content than that of petroleum diesel, as a result of which it shows reduced emission of different pollutants like particulate matter, carbon monoxide, sulphur dioxide etc. In addition to this, it is non-toxic as well as biodegradable [3]. Fuel properties of BD, on the other hand are similar and in some cases better than those of petroleum diesel, e.g., density, viscosity, cetane number, flash point etc. A rapid increase in the production of BD has been seen in last few years due to the concerns like over-riding use of the diesel fuel, followed by its depletion [4] and a corresponding increase in the prices of petroleum products. Various kinds of feed stocks have been utilized for the synthesis of BD so far like vegetable oils (for example soybean, canola/rapeseed, sunflower, corn, jatropha, palm etc.), animal fats (for example lard, fish oil etc.) and yellow grease. According to an estimate, the cost of BD production gets its major share from the cost of its feedstock, with the rest of it being dependent on the synthesis and refining procedures adopted [3].

The cost of the feedstock, on the other hand, depends upon its abundance and availability.

At present, most of the BD production is being carried out using edible vegetable oil which has put a strain on the food supply/economy and, hence, has led it into a competition with the food industry. An obvious result of this situation is a rise in the prices of such feed stocks/oil sources [5,6]. Keeping this situation in mind as well as the demand for the rapid and excessive BD production in order to confront the increasing energy crisis, search for the newer and non-edible feed stocks is becoming increasingly important [4]. Finding such feed stocks would help to overcome the production cost of BD as well as to lessen the strain on the food-value oilseed-crops especially for the oil-importing countries like Pakistan, where the domestic oil production is already far less than that of the required level.

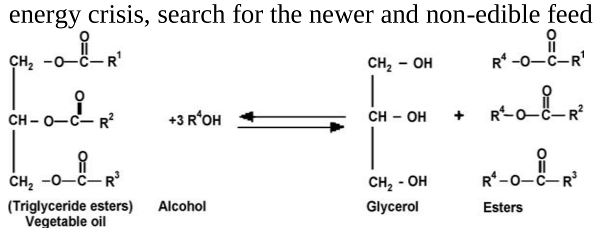

Fig.1. Transesterification of vegetable oil into mono-alkyl esters (biodiesel)

Various studies have been carried out in this regard for evaluating the use of different non-edible oils for the production of biodiesel like castor oil, jatropha oil, linseed oil, neem oil, pongamia oil, rice bran oil and many others [1].

Melia azedarach L., commonly known as chinaberry, bakain or umbrella tree, is an ornamental tree that belongs to meliaceae family [7-10]. It is seen commonly growing on the roadsides, near dwellings, open areas, marginal lands etc. both on dry as well as alkaline soil and is able to grow easily in the disturbed areas [11]. Although it grows wild and abundant in the sub-himalayan tract but is also cultivated for both medicinal and ornamental purpose in Pakistan as well as India [9,12]. Like those of neem tree, various parts of the chinaberry tree, like leaves, flowers, fruits and bark, are reputed to have therapeutic value [9], as they are used for curing different skin disorders that include ulcerative wounds, syphilitic ulcers, leprosy, eczema, scrofula etc. [10,12]. Although neem, that is also a member of the same family, has often been studied as a feedstock for producing biodiesel [1], *Melia azedarach* has not been given attention in this regard.

The objective of the present work is to explore the utility of *Melia azedarach* oil, a non-edible feedstock, for the preparation of BD, and to determine important fuel properties of *Melia azedarach* methyl esters.

II. EXPERIMENTAL PROCEDURES

A. Materials and Reagents

M. azedarach seeds were collected from the lawns of the University of Sargodha, Sargodha, Pakistan. n-hexane and methanol were purchased from LAB-SCAN Analytical sciences (Dublin, Ireland), sodium and potassium hydroxides, sodium thiosulphate and anhydrous magnesium sulphate were procured from Merck (Darmstadt, Germany) while glyceryl tripalmitate, glyceryl tristearate, glyceryl trioleate and glyceryl trilaurate (all ≈ 99%) were purchased from Fluka (Steinheim, Germany). The solvents that were of analytical grade were used without further purification.

B. Extraction of the oil

The *M. azedarach* seeds were cleaned, dried and crushed manually to separate the seed kernals. Oil was extracted using a soxhlet apparatus by employing n-hexane as a solvent (10hr). The hexane extract was then filtered and solvent was evaporated using a rotary evaporator. The *M. azedarach* seed oil was then degummed by using deionized water. This oil was then used for further processing.

C. Biodiesel production

Freshly obtained oil was heated up to 60^{o}C in a round bottom flask and specific amount of methanol and sodium hydroxide was added in it and it was refluxed for 1hr, along with stirring at 600rpm. After this the resulting mixture was allowed to stand for a few minutes in a separating funnel in order to separate two layers. The upper layer was that of BD and lower of glycerin. BD was separated from the lower layer and washed thrice with deionized water in order to purify it from the residual components and was then dried over magnesium sulphate and then in oven. This was then used for further characterization.

Determination of the general properties

Different properties of the BD including density, kinematic viscosity, acid number, cloud point, flash point and cetane number were determined by using the standard ASTM methods D445, D664, D2500, D93 and D130, respectively.

D. Fatty acid profile of oil and BD

The fatty acid profile of the *M. azedarach* oil and the BD sample was established by the help of a Shimadzu gas chromatograph, model 17-A, fitted with a flame ionization detector (FID) and a polar capillary column SP-2330 (Supelco, Inc., Bellefonte, PA, USA.). The temperature of column was ramped from 180^{o}C-220 ^{o}C, at a uniform rate of 5 ^{o}C/min., while the temperature of the injector and detector were maintained at 230 ^{o}C and 240 ^{o}C, respectively. Sample volume was kept 1.0µL that was injected in a split mode. All the quantitative measurements were made by Chromatography Station for Windows (CSW32) software. The fatty acid composition was given as a relative percentage of the total peak area.

TABLE 1: Properties Of The Biodiesel Produced

Property	**Biodiesel**	**EN 14214 limits**
Density, 15^{o}C (g/cm^3)	0.88	0.860-0.900
Viscosity, 40 ^{o}C(cSt)	4.7	3.5-5.0
Acid Value (mg KOH/g)	0.45	<0.5
Iodine Number	112	<120
Oxidation Stability, 110^{o}C(h)	4.8	>6
Cloud Point (^{o}C)	< -10^{o}C	-
Cetane Number	45	>51

III. RESULTS AND DISCUSSION

The oil content of the *M. azedarach* seeds was found to be about 32%, extracted using n-hexane as solvent, which is in accordance with that of Shahina *et al* [9]. About 80% conversion of the oil into methyl esters was obtained as a result of tranesterification with sodium hydroxide and methanol which shows that nearly 80g of the oil is converted into methyl esters that is BD. Different properties were determined for the characterization of *M. azedarach* methyl esters (MAME), and their comparison was made with EN 14214, that establishes the requirements of biodiesel quality, for its usage in the diesel engines [13].

Cetane number is concerned with the ignition of the BD such that a low value of cetane number shows that the combustion of the fuel is incomplete. For MAME, the value of cetane number was found to be 52 that is well agreed with its standard value according to ASTM and EU specifications.

TABLE 2: Fatty Acid Composition (%) of *M. Azedarach Seed Oil And Its Bd (Mame)*

Fatty acid	***M. Azedarach seed oil***	**MAME**
Palmitic acid (C 16:0)	9.54	9.5
Stearic acid (C 18:0)	4.35	4.32
Oliec acid (C18:1)	69.55	69.52
Linoliec acid (C 18:2)	16.53	16.11

Iodine number determines the level of unsaturation in the fuel that indicate its oxidation stability as well. For MAME, the iodine number was evaluated to be 104, that is within the upper limit by EN 14214. Similarly, the value of acid number is in agreement with its required value according to EN14214. This shows that the BD produced has a low free fatty acid content.

Fatty acid profile of the *M. azedarach* seed oil as well as the BD produced with it was found to be nearly the same, as shown in table 2. This indicates that transesterification does not affect the composition of the *M. azedarach* seed oil and hence no hydrogenation or isomerization is resulted from it. As shown in the table, the content of mono-unsaturated fatty acid is more than 69% that shown it to be susceptible to oxidation, but at the same time gives it a suitable value of viscosity as well as required low temperature properties.

IV. CONCLUSIONS

The oil content of *M. azedarach* seeds makes it a suitable source of BD feedstock, that is also confirmed by the properties of BD produced from it. Although, higher level of unsaturation makes it susceptible to oxidation, but the problem can be overcome by mixing some additives into the BD obtained from it [14]. *M. azedarach* is an oil producing tree whose fruit goes waste, as it has no other use, being unsuitable for human consumption [10]. Production of BD will help to its disposal in an economical way.

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