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PRODUCTION OF BIODIESEL FROM *SWIETENIA MACROPHYLLA* SEED

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Abstract- *Increasing demand of conventional source of fuel, which made people to consider an alternative source. Extraction of oil from the seeds of Swietenia macrophylla was carried out to determine its potential for bio-oil production. Experimental design was employed considering reaction time, catalyst loading and amount of methanol as operating variables in the production of biodiesel. The biodiesel production, produced via trans-esterification process using potassium hydroxide as catalyst. Essential characteristics of the seed, extracted oil and produced biodiesel were determined. The result shows that the seed has a moisture content of 0.272%. About 53.08% by weight of seed was elevated as bio-oil with 0.86gm/cm3density and 6.28 pH. After refining, 69.5% by weight of the extracted oil constitute the final biodiesel product. The FT-IR analysis identified the possible presence of alkanes, esters, aromatics, hydroxyl, and carbonyl in the biodiesel, compounds which are similar to the other biodiesel profile.*

Keywords: Bio-diesel; Swietenia macrophylla; trans-esterification; FT-IR.

1. INTRODUCTION

Due to the depletion of the world's petroleum reserves and the increasing environmental concerns, there is a great demand for alternative sources of petroleum–based fuel, including diesel and gasoline fuels. Biodiesel, a clean renewable fuel, has recently been considered as the best candidate for a diesel fuel substitution because it can be used in any compression ignition engine without the need for modification [1]. Chemically, biodiesel is a mixture of methyl esters with long-chain fatty acids and is typically made from nontoxic, biological resources such as vegetable (seed) oils [2-6], animal fats [7-10], or even used cooking oils [11]. Seed oils, are promising feedstocks for biodiesel production since they are renewable in nature, and can be produced in large scale which are environmentally beaign [13]. Vegetable oils include edible and non-edible oils. More than 95% of biodiesel production feedstocks come from edible oils since they are mainly produced in many regions and the properties of biodiesel produced from these oils are much suitable to be used as diesel fuel substitute [13]. However there is a composition between human consumption of edible oils and production of biodiesel from edible oils. The reason is that, many researchers focus their attention on the production of biodiesel from non-edible oils [14-18]. S. macrophylla (mahogany) is one of the tropical trees that could potentially provide biofuel products. Mahogany seed oil is inedible [19]. The fatty acid constituents of mahogany oils are: stearic acid (10.41%), palmitic acid (21.39%), oleic acid (64.62) and unidentifiable acid (3.58%) [19]. Mahogany oil does not contain certain essential fatty acids, hence it does not have nutritional value. Particularly, more than 50% of the components of the seed of the s. macrophylla are carbon (48.14%) and hydrogen (6.4%), the elements composing the biofuel products [20].

A number of methods are currently available and have been adopted for the production of biodiesel fuel. There are four primary ways to produce biodiesel: direct use and blending of raw oils [21-25], micro-emulsions process [26], thermal cracking [27-32], and transesterification [33]. The most commonly used method for converting oils to biodiesel is through transesterification of seed or vegetable oils. The objective of this paper is to describe various optimum condition and results of biodiesel production from S. macrophylla seed oil. The various factors which affecting the yield of biodiesel are also discussed.

2. Materials and Methods

2.1. Collection of *S. Macrophylla* seeds:

The S. *Macrophylla* capsules were collected from local area of Jessore, Bangladesh. The seeds were manually taken from the capsules and sun dried for 10 h. After that it was dried in oven at 180ºC for 5 minutes. By using a

moisture analyzer model MS-70(A and D company Ltd.) was used for moisture analysis. The moisture content of the dried seeds is calculated by using the following equation,

$$Mc = \frac{W_1 - W_2}{W_1} \times 100\%$$

Where,

If a Mc is the moisture content, W_1 and W_2 are the weight of raw seed and dry seed, respectively.

2.2 Oil Extraction method:

After blending, the dried seed become grind form. The grind sample (mahogany seed) which already prepared by blending is weighted. There are three well-known methods to extracting the oil from seed namely: (1) Expeller/press method, (2) Solvent extraction using chemicals method and (3) Supercritical fluid extraction method [34]. The most popular extraction method is the Soxlet extraction using hexane as a solvent. The extraction time range employed in this research was 3 to 6 h, [35] whereas the amount of hexane used was varied between 250 ml and 400 ml. The grind sample was taken in an extraction chamber. Then hexane (solvent) and sample with a ratio of 4:1 is poured into a round bottom flask.

2.3 Biodiesel Production through Trans-esterification by hot plate:

For biodiesel production was by base catalyzed trans-esterification method using hot plate. The reaction was performed at 60 ℃ and time was 1 hr with continuous stirring. 50 ml oil sample was placed in a two necked 250 ml round bottom flask equipped with a reflux condenser. The flask was transferred on an electric hot plate with a temperature controller and a thermometer. Sodium hydroxide and potassium hydroxide pellets were used as catalyst, which dissolved with required amount of methanol (99.8%) purity. Molar ratio of oil to methanol was taken as 1:5 and 1:4.

3. RESULT & DISCUSSION:

3.1.1: Effect of time on oil yield:

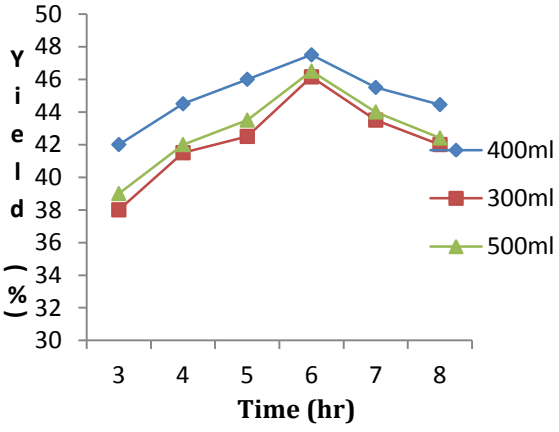

Fig- 1: Variation of oil yield (%) with time (hr). Condition: Sample 100 gm, T= 60℃

Figure 1 shows a clear idea about yield with various amounts of hexane and time. In every case yield of oil increases with time and maximum yield is obtained at 6 hr then attenuate. This figure depicts that increasing mixing time from 6 hr, the yield decreases. This result agrees to finding reported by Mani et al. (2007) [37] that any further increase passes 6 hours in extraction time did not increase the oil yield [37]. This phenomenon is due to low solvent density left in the sample after 6 hours [38]. However, the oil yield increased dramatically when the s. *macrophylla* seeds were heated from 1 hour until 6 hours because the diffusivities of the oil and solvent increases, which result in high oil yield. Therefore, the maximum yield could be achieved at a shorter retention time with an optimum temperature of 60^0C.

3.1.2: Effect of hexane on oil yield:

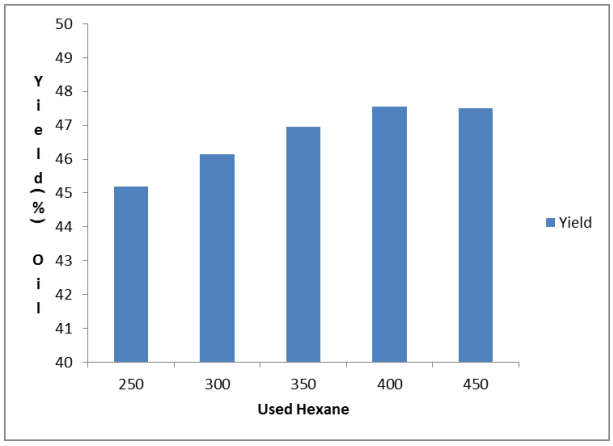

Fig- 2: Variation of oil yield (%) with different amount of hexane (ml). Condition: Sample 100 gm, time 6 hr, T= 60℃

The hexane is widely used solvent in oil extraction, because of its ideal functionality for maximum extraction (Swanson, 2009) [39]. It is nonpolar and apparently dissolved nonpolar compounds in the seeds following the chemistry rule that "like dissolves like." It means nonpolar compounds in the seeds were dissolved by hexane and became part of the filtrate after the solid residues were separated. Figure 2 shows that the maximum yield is 47.55%, which is obtained at hexane to sample ratio 4:1[40], where as 35% yield was reported by Elkhaleefa and Shigidi at hexane to oil ratio 4:1. Since a maximum yield was obtained at 4:1 ratio, this ratio was further used.

3.1.3: Effect of sample amount on oil yield:

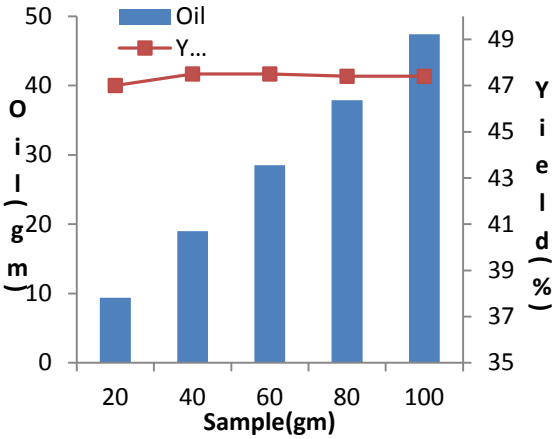

Fig- 3: Variation of oil amount (ml) and yield (%) with different sample (gm). Condition: time 6 (hr), hexane to sample 4:1, T= 60℃

Figure 3 shows how yield (%) of crude oil varies from different sample of s. *macrophylla*. Renato et al. (2016) found the crude oil yield of 30.36-48.44% by using S. *macrophylla* [20]. In this work, we found the yield of 47-47.5%, which is much better than that obtained by Renato et al. [20].

3.2.1: Effect of amount of catalyst (KOH) on biodiesel yield:

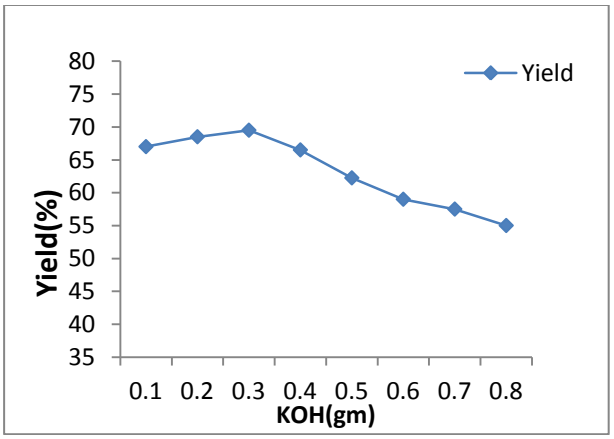

Fig-4: Effect of amount of catalyst (KOH) on biodiesel production at constant temperature (65℃) and sample oil.

Figure –4 shows the variation of amount of catalyst on bio-diesel conversion, where the catalyst was varied in the range of 0.1 g to 0.8 g. Fig. shows the conversion increased firstly with catalyst from 0.1 g to 0.2 g, then conversion decreased with catalyst. According to D. Kumar et al. [6] increase in the catalyst amount from 1.5% to farther, the conversion decreased due to soap formation. The yield of biodiesel from 36.10% - 84.30% is obtained by O. Renato et al. [20]. In our result the yield of biodiesel ranges from 55% to 69.5% which satisfies the result of O. Renato et al. [20]. So, the optimum catalyst (KOH) is 0.3 g for 20 g oil sample.

3.2.2: Effect of biodiesel and yield with variable Time:

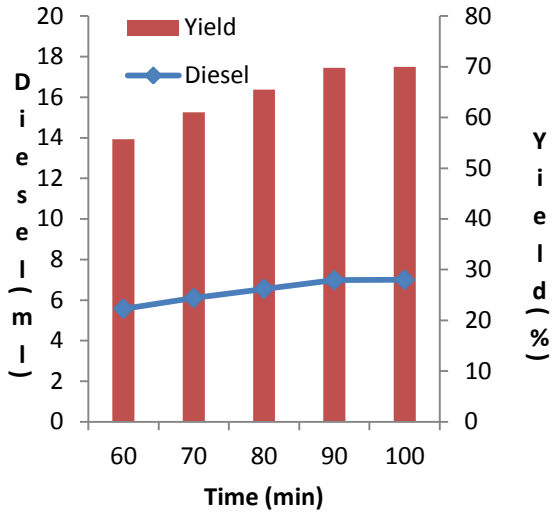

Fig-5: Variation of biodiesel and yield with variable Time (min) at constant temperature (65℃) and oil sample (10ml).

Figure: 5 give a concept of biodiesel as well as yield percentage with time. Biodiesel increases from 5.57 ml to 7.03 ml and yield varies from 55.7% to 70.3% where the time varies from 60 min to 100 min. Increasing time it get more time for reaction which increased yield percentage. For both 90 min and 100 min the yield percentage is approximately the same. So what optimum time is 90 min.

3.3: Table 2: Properties of Biodiesel:

Properties	Mahogany Biodiesel	ASTM D-6751,482,7467 standard
Viscosity	3.038mm^2/s	1.90 - 6.00
Density	880kg/m^3	860 – 900
Cloud Point	7℃	-3-12℃
Moisture Content	0.14mg/kg0	-500 mg/kg ASTM7467
Flash Point	165℃	100 - 170℃
Pour Point	9℃	-15 – 10℃
Acid Value	0.49	0.80 max
Free glycerol	0.005%	0.02% max
Net Calorific Value	39.87	39 MJ/Kg min

3.4: FTIR analysis:

Figure 11: Fourier Transform Infrared Radiation (FT-IR)

Spectrum of Biodiesel from *S.macrophylla* Seed Extract

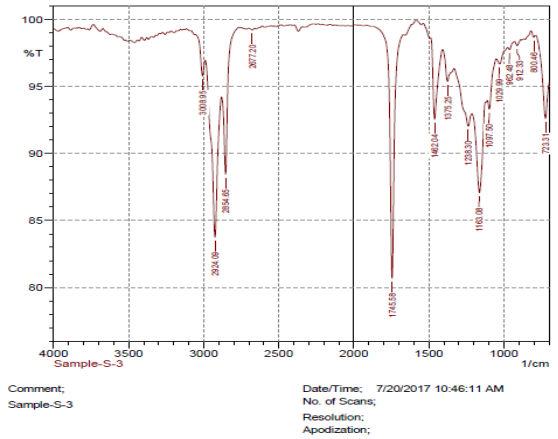

Fig-6: Fourier Transform Infrared Radiation (FT-IR) Spectrum of Biodiesel from *S.macrophylla* Seed Extract.

The functional groups present in the biodiesel extracted from the S. macrophylla seeds were identified via FT-IR analysis in the wavelength between 723-3008 cm-1 wavenumbers (Figure 6). The figure 6 Fourier Transform Infrared Radiation (FT-IR) spectrum of biodiesel from *s. macrophylla* seed extract. A broad absorption band observed between 3200-2700cm-1 is attributed to the O-H stretching of hydroxyl group from alcohols. The observed peak between 2800-3000cm-1 range and actually 2924 is caused by C-H stretch suggesting the presence of alkanes. The C=O stretching 1670-1820 and 1300-1000 cm-1 indicated presence of ether and carbonyl compound and another bond 790-995 cm-1 indicate bending aromatics compound. The range 1025-1070cm-1 indicate the possible presence of sulpoxide at stretching Sulphinyl (S=O) compound.

4. CONCLUSIONS

This work explored the potential of using the seeds of S. macrophylla in the production of biodiesel. The physicochemical characteristics of the seed oils from *S. mahagoni*can are helpful to identify the quality of oil and biodiesel products for possible industrial or commercial uses. The refining of crude mahogany oil leads to the reduction of specific gravity, moisture content, viscosity, and acid value. The reduction of these properties can be attributed to the removal of phospholipids via degumming with phosphoric acid followed by neutralization with potassium hydroxide solution, and adsorption of other impurities by activated charcoal. The S. macrophylla seeds, after sun drying, contain acceptable moisture content ready for oil extraction. The oil content of the S. macrophylla seed ranges from 38.3% to 47.05% by weight. The optimum condition for better yield for oil operating time 6 hr. sample to hexane ratio is 1:4, and for bio-diesel potassium hydroxide 0.2 gm, operating time is 90 min. The biodiesel product has the needed energy to run engines with a high heating value of 39.87 MJ/kg, a value higher than the 39.80 MJ/kg requirements of commercial biodiesel products. A ton of *S. macrophylla* (mahogany) seeds can produce 420 L bio-oil and 352L Biodiesel.

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