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Physicochemical Analysis, Elicitation and Characterisation of Bio-oil from *Aloe barbadensis*

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Abstract: Biodiesel from plants can compete economically with petroleum diesel fuels as a future prospective fuel. The bio-oil was extracted from the plant of *Aloe barbadensis* by soxhlet extractor using hexane as an organic solvent, and then further, the oil was analyzed for moisture content, pH, specific gravity, density, viscosity, saponification value, refractive index, peroxide value, acid number, free fatty acid, and iodine value. The results showed that four major fatty acids, like nonadecanoic acid, n-hexadecanoic acid, octadecadienoic acid and octadecenoic acid were present in the bio-oil of *Aloe barbadensis* and characterized by GC-MS, which showed that the bio-oil could be used for producing high quality of biodiesel. In future studies, converted crude biooil into biodiesel using heterogenous catalyst will be analysed for their engine characteristic studies.

Keywords: Physicochemical Analysis, Bio-oil, Biodiesel.

1. INTRODUCTION

The demand for energy around the world is influenced by many factors like urbanization, increased population, and better living standards. People have realized that the present energy reserves of fossil fuels have been declined with many environmental factors. An alternative of energy with a better economy which can provide a sustainable future in both domestic and industrial point is bio-diesel [1&2]. Bio diesel remarked as "Carbon dioxide neutral" since most of the carbon produced in combustion is retrieved during cultivation of crops is produced from plant and animal fats raw or used has methyl ester as its main chemical content. Biodiesel has favorable characteristics like non-toxic, biodegradable, regenerative, and does not pollute the water, which makes it an economically friendly product. Lower sulfate and particulate matters and lesser hydrocarbon emissions make it a future fuel to beat current petroleum fuels economically. Feedstock rich in fatty acids like food waste, animal fats, and vegetable oil both edible and inedible seeds and byproduct obtained in the refining process is much cheaper, thereby reducing the production cost and are more preferred [3]. The production of biodiesel from animal and plant fats and alcohol production by fermentation under microbes are the pronounced source of renewable energy [3]. The critical source of biodiesel is the oils extracted from plant seeds. While the edible seed oils met the demand as a source of food, the vegetable oil extracted from non-edible seeds acts as a secondary source of feedstock in biodiesel production [4]. Demand as food source and cost of producing the edible seed oil into fuel is higher. This is an added advantage of letting us prefer non-edible oilseed in the production of biodiesel. Aloe Vera, an herbaceous family plant, also called Aloe Barbadensis, Barbados Aloe, etc. has the scientific name Aloe Vulgarize. It is cultivated in many types of soil. It consumes less water and can be seen easily in places having a tropical climate. The leaves of the plant are thick, juicy, and green, which grows up to 30 to 60 cm long. A tasteless and colorless gel called aloe gel, which is highly viscous in nature, is found in the leaves of the plants. As the age of the leaves of the aloe vera increases, the viscosity increases too [6]. Enzymes, vitamins, minerals, sugar, saponins, lignin, amino acid, and salicylic acid are the constituents present about more than 98% along with water polysaccharides like cellulose, hemicellulose, acemannan, glucomannan, pectin, and mannose derivatives. The infection of fungal disease on the plant may affect the biomedical medicals mentioned above [9]. They were widely used in medical, skin related cosmetics, and agricultural purposes. It is also used in the production of bio-beverages and can be used in the treatment of polluted water [7&11]. Processing of the aloe vera for such purpose includes dehydration and heating, followed by grinding of the leaves. Pyrolysis treatment of aloe vera is found to be low cost, eco-friendly, manage biomass, and economically feasible by research studies [6]. Aloe vera farming has seen a commercial reputation in medicinal products [8]. A sample dehydrated at 70 and 80 when heated shows changes in average molecular weight in bioactive polysaccharide in fresh aloe with an increase from 45kDa to 75kDa [9]. Dirt and bacterial at surface level are removed when the leaves are washed with an antimicrobial agent. This process is then culled, trimmed, and the rind is removed. This final leaf material looked similar to a proceeded fillet fish and called as "fillet". This filleting can be done either manually or mechanically, which involves the removal of the tip of the leaf, top and bottom rinds, the lower part of the leaf



base, and the spines along the leaf margins. Water is used to rinse the inner part of the leaf fillets, followed by depulping and pasteurization. Further processing is treatment using enzymes, deaeration by filtration and using activated carbon to decolorize (see the aloe vera leaf processing section), and preservative addition [10 & 11]. Final purification includes filtration followed by the stabilization of liquid. The obtained final fluid is clean and is comparable to the organoleptic characteristic of inner leaf juice, but generally holding three times more bio-active constituents than juice produced by hand filleted as discussed in the next section of this document [12-16].

2. MATERIALS AND METHODS:

2.1 Collection of raw material and extraction of bio-oil from *Aloe barbadensis*

The fresh plant leaves were collected from VIT University, Tamil Nadu, and India. The leaves obtained from the *Aloe barbadensis* plant were washed properly and were cut into small pieces for drying purposes. For three weeks, the cut pieces of aloe vera leaves were air-dried in the shade so that loss of phytoconstituents from direct sunlight can be avoided. After proper drying, it was finely powdered using the pulverizer and sieved. It was then stored in an air-tight container after homogenization for further analysis as shown in the figure 1. The plant leaves were washed with water, and kernels were separated from leaves. The leaves were left for drying in the Hot-Air Oven for about 3 hours. After drying, grains were separated from leaves. The separated kernels were finely grounded. The extraction of bio-oil was done using Soxhlet extractor. The crude bio-oil is extracted with 200mL of hexane as a solvent for about 72 hours at 80 °C. Then the extract was concentrated using a rotary evaporator at 50°C. The extracted crude oil were stored for further use as shown in the figure 2.

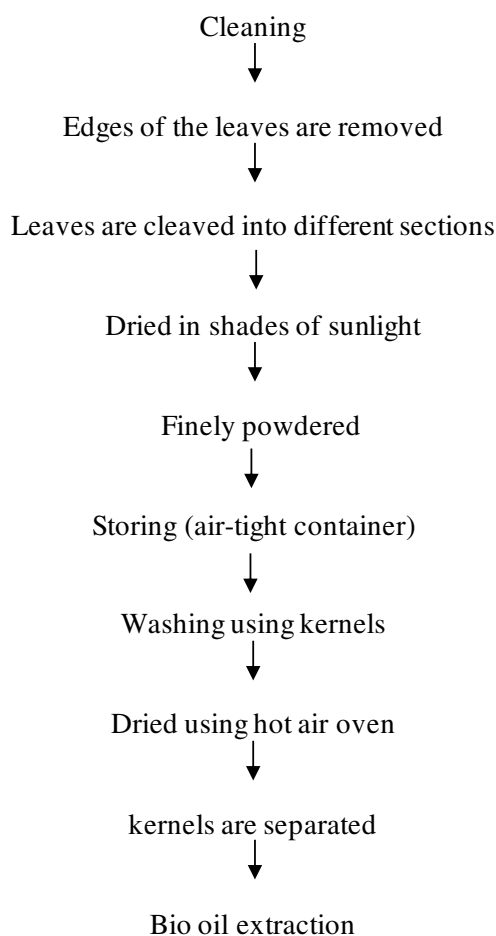


Fig 1. Process flow diagram for the extraction of bio-oil from *Aloe vera* leaves

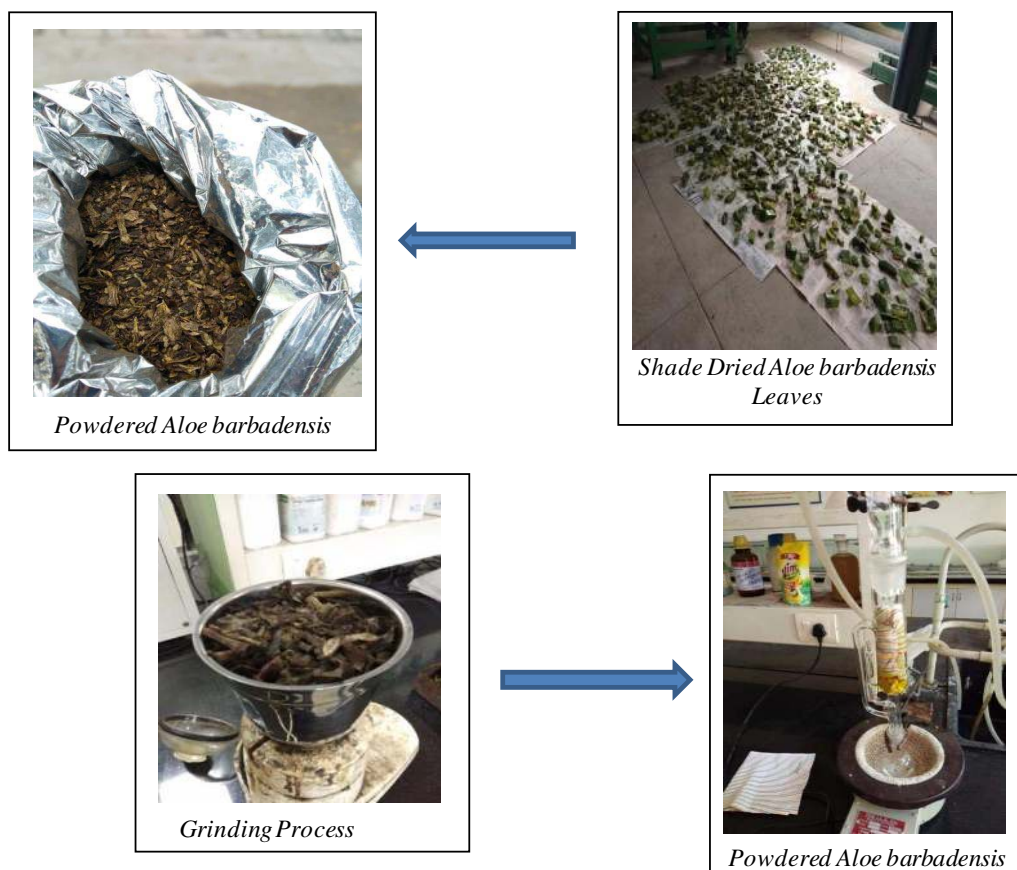


Figure 2: Extraction process of *Aloe barbadensis*

2.2 Characterization of Oil

The percentage (%) yield of the leaf oil was calculated gravimetrically. Odor, color, and physical state of the oil were estimated by sensory evaluation. They were characterized for specific gravity using specific gravity bottle, and P.H. was determined using pH meter, moisture content by the oven-dry method, ash content by heating to dryness in a furnace, refractive index using Abbe refractometer, kinematic viscosity using a viscometer [17]. Other properties analyzed were the saponification values determined by titrimetry method. Acid value, iodine value, and peroxide value were determined by titrimetry, according to FAO.

Gas Chromatography

An Agilent 6890 gas chromatograph was equipped with a straight deactivated 2 mm direct injector liner and had a 15m Alltech EC-5 column (250 μ I.D., 0.25 μ film thickness). For sample introduction, a split injection was used, and the split ratio was set to 10:1. The oven temperature program was programmed to begin at 35°C, hold for 2 minutes, then ramp at 20°C per minute to 300°C and hold for 5 minutes. The flow rate of helium carrier gas was set to 2 ml/minute(constant flow mode).

Mass Spectrometry

A JEOL GCmate II benchtop double-focusing magnetic sector mass spectrometer operating in electron ionization (E.I.) mode with TSS-2000¹ software was used for all analyses. Low-resolution mass spectra were acquired at a resolving power of 1000 (20% height definition) and scanning from m/z 25 to m/z 700 at 0.3 seconds per scan with a 0.2-second inter-scan delay. High-resolution mass spectra were acquired at a resolving power of 5000 (20% height definition) and scanning the magnet from m/z 65 to m/z 750 at 1 second per scan. Qualitative analyses were performed on an H.R.; high-resolution mass spectrometer Samples were introduced into the electron ionization source using a drawn micro capillary at a flow rate of 1 ml/min. The mass spectrometer was operated in positive ion mode with a spray voltage of 2.4 kV, a capillary temperature of 250,

a capillary voltage of 29.0 V, a 1.5-u ion isolation window, and a 100-ms maximum inject time. The average Scans of the M.S. spectra approximately 100 scans were averaged for the MS² and MS³ spectra.

Mass spectrometry library search

Identification of the components of the purified compound was matching their recorded spectra with the info bank mass spectra of NIST library V 11 provided by the instrument's software. Based on the GC-MS spectral data, six fatty acids were identified, and further, the bio-oil will be converted into biodiesel using the trans-esterification process. The Bio-oil from aloe vera was converted into biodiesel using the NaOH catalyst. The produced biodiesel yield was calculated gravimetrically.

3.RESULTS AND DISCUSSION:

The bio-oil content of *Aloe barbadensis* was calculated, and it can be used for biodiesel production would be highly economical. The oil content was found to be 21.57%. The oils had agreeably oily and very dark in color is an advantage to use as biodiesel feedstock. The physical state of the oil was liquid at room temperature. The specific gravity of the oil was 0.86, which is close to the standard range of 0.87–0.90 for biodiesel [18-21]. Density and gravity are other important parameters for diesel fuel injection systems. The values are supposed to be maintained within tolerable limits to permit optimal air to fuel ratios for complete combustion. The moisture content of the oil was in the limit to the ASTM Standards. The results of the physical properties are tabulated in Table 1.

Table 1: Physical properties of *Aloe barbadensis* leaf oils

| S.No | Chemical properties | <i>Aloe vera</i> |
|------|--------------------------------|------------------|
| 1. | pH | 4.5 |
| 2. | Iodine value (g/100g) | 105.02 |
| 3. | Acid value (mgKOH/g) | 0.05 |
| 4. | Saponification value (mgKOH/g) | 220 |
| 5. | Peroxide value (meq/kg) | 7.89 |
| 6. | Refractive index | 1.447 |

The results of the chemical properties are tabulated in Table 2. The pH value of the oil was acidic. A measure of the unsaturation of fats and oils is the Iodine value. High iodine value indicates the presence of highly unsaturated fats and oils. Aloe vera leaf oil iodine values are within the limits of standard. The saponification value is used in checking adulteration. The saponification values are lesser than the ASTM standard. The refractive index of oils depends on properties like molecular weight, fatty acid chain length, degree of unsaturation, and degree of conjugation. Triglycerols have a higher refractive index than do their constituent free acids. The values of the refractive index for different oils generally vary between 1.447 and 1.482 [22-24]. All these physicochemical properties suggest that the leaf oil adoptable for biodiesel production.

Table 2: Chemical properties of *Aloe barbadensis* leaf oil

| S.No | Physical properties | <i>Aloe vera</i> |
|------|---------------------------------|------------------|
| 1. | Colour | Light yellow |
| 2. | Odor | Agreeably Oily |
| 3. | Moisture (%) | 98.82 |
| 4. | Oil Content (%) | 42 % |
| 5. | Specific Gravity | 1.002 |
| 6. | Physical State at R.T. | oil |
| 7. | Density (g/cm ³) | 0.93 |
| 8. | Viscosity, at 40°C, centistokes | 28.4 |

The fatty acid composition of aloe vera leaf analyzed by GC-MS was shown in table 3. The fatty acid profile shows that the *Aloe barbadensis* leaf oil can be used for quality biodiesel. It was clear that most of the fatty acids like nonadecanoic acid, n-hexadecanoic acid, octadecadienoic acid and octadecenoic acid present were essential fatty acids that can be converted into biodiesel [25 & 26]. Biodiesel was produced using the oil extracted from *Aloe barbadensis*, and the yield was 82%.

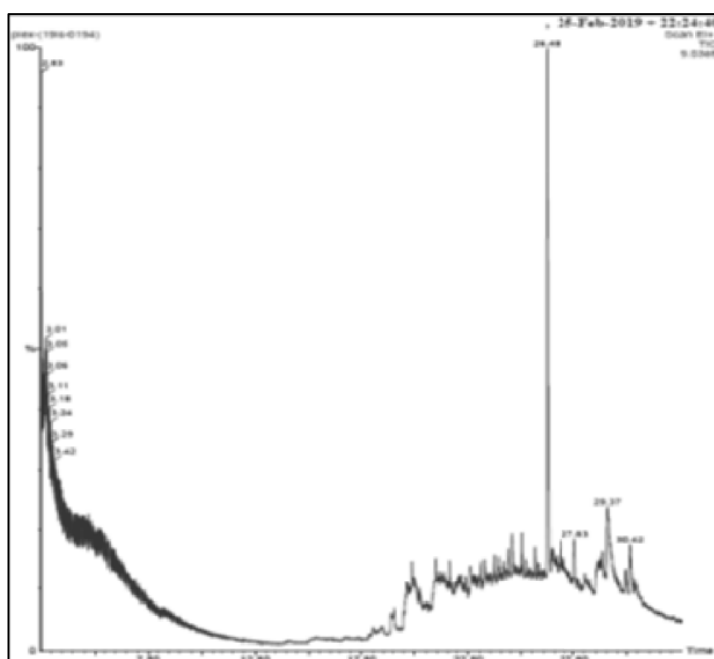


Figure 3: GC-MS Spectrum for crude oil obtained from *Aloe barbadensis*

| S.No | RETENTION TIME | FATTY ACIDS | STRUCTURE |
|------|----------------|----------------------|---------------------------------------|
| 1 | 26.48 | Nonadecanoic acid | <chem>CCCCCCCCCCCCCCCCCC(=O)O</chem> |
| 2 | 27.83 | n-Hexadecanoic acid | <chem>CCCCCCCCCCCCCC(=O)O</chem> |
| 3 | 29.37 | Octadecadienoic acid | <chem>CCCCCCCC=CCCCCCCCCC(=O)O</chem> |
| 4 | 30.42 | Octadecenoic acid | <chem>CCCCCCCC=CCCCCCCCCC(=O)O</chem> |

Table 3: Fatty acids composition of *Aloe barbadensis* leaf oil

CONCLUSION:

The following conclusions were made by biodiesel production; (i) The physicochemical properties of bio-oil distinctly confirmed that the bio-oil from *Aloe vera* was used for biodiesel production; (ii) Overall four fatty acids were identified as nonadecanoic acid, n-hexadecanoic acid, octadecadienoic acid and octadecenoic acid using GC-MS spectral data, and these fatty acids were only responsible for biodiesel production; (iii) The extracted crude oil was converted into biodiesel and achieved 82% yield using heterogeneous catalyst; (iv) Finally, the produced biodiesel will be used to check their performance and emission characteristics in diesel engine in future work.

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