Journal of Applied Science and Engineering Methodologies
Volume.2, No.3, (2016): Page.384-387
www.scientistlink.com/jasem

Bioenergy for Power Generation

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Abstract

Biomass is the most potential considering their quantitative availability. Prosopis juliflora a Mesquite is a shrub or small tree in the Fabaceae family. It is also one of the biomass which is available hundred hectares in our area. In order to characterize the physical and chemical properties of P. juliflora as feed stocks for energy conversion process, we developed a protocol. The particle size of sample was found to be 8nm from X-ray diffraction (XRD) technique. Surface morphology of the samples was studied by Scanning Electron Microscopy. Proximate, structural and elemental analyses showed that P. juliflora has lower moisture content and high fixed carbon indicates that it is appropriate to meet requirements of thermo chemical process. Also, considered as one of the strengths of biomass utilization for energy purposes in terms of contribution to environmental protection, P. juliflora contains very low level of Mg and Ca (0.39% & 2.32% respectively). Higher proportion of carbon and lower proportion of oxygen content in P. juliflora leads to high calorific value 3891Kcal/kg.

Keywords: *Calorific value, Elemental analysis, Gasifier efficiency, Prosopis juliflora, Proximate analysis*.

1. Introduction

Biomass constitutes the first energy source human has tamed. Biomass fuels continue to representing the primary source of energy for more than 50% of the world population and amount to about 14% of the total energy global consumption [1]. Amongst different sources of renewable energy, biomass residues hold special promise due to their inherent capability to store solar energy and amenability to subsequent conversion to convenient solid, liquid and gaseous fuels. Prosopis juliflora is one of the biomass residues which are used to generate electricity. P. juliflora has a negative impact on plant diversity [2]. The Mesquite tree grows to a height of up to 12 meters (39 ft.) and has a trunk with a diameter of up to 1.2 meters (3.9 ft.). However to use biomass efficiently for energy production a detailed knowledge of its physical and chemical properties are required. These properties more specifically average and variation in elemental compositions is also essential for modeling and analysis of energy conversion process [3]. Ash forming elements such as Si, Ca, Fe, K, Mg, Na, and P in biomass are important to be documented for any thermo chemical conversion process [4]. Actually, high contents of alkali are well-known to conduct to critical technical problems when biomass is used as feedstock for thermal power production, since they contribute to slagging, fouling and sintering formation. Actually, information on concentration and speciation of some elements is useful both for energy and environmental issues. Therefore the investigation of physico-chemical properties of biomass fuels would help finding for them suitable and appropriate energy conversion technologies. In the present work the physical chemical properties of P. juliflora has been investigated.

2. Materials and Methods

One to two kilograms of P. juliflora was collected from the plantation. They were oven dried at 70°C during 24h. The sample was then ground into powder.

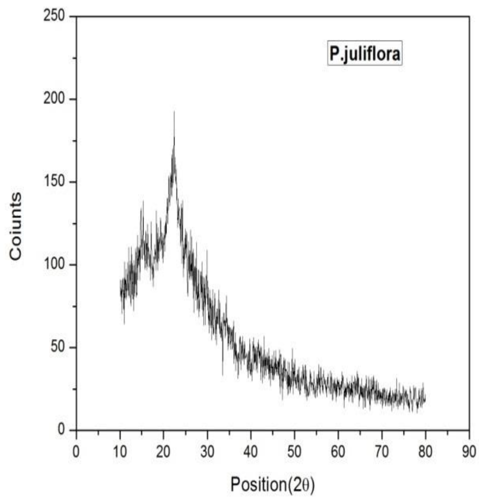
3. Material characterization

The particle size of the sample was determined using X-ray diffraction (XRD) in a wide range of Bragg angles 2θ ($10^{\circ}<2\theta<90^{\circ}$) with co-radiation (1.54054 Å). The surface morphology was recorded using field emission scanning electron microscope. The proximate analysis to measure moisture, volatile, fixed carbon and ash content was performed by ordinary oven and muffle furnace. The calorific value of the samples was measured using bomb calorimeter. Elements presented in the sample were identified using EDAX analysis. Gasifier efficiency of the woody material was calculated using updraft gasifier.

4. Results and Discussion

4.1. STRUCTURAL ANALYSIS

The XRD pattern of the samples was shown in Fig.1. The size of the samples was determined using the broadening of a few XRD peaks using Scherr's equation (C.A.Vincent, 2000) $D=.89\lambda/(\beta_{1/2}\cos\theta)$, where $\lambda= 1.54054$Å and $\beta_{1/2}$ is the peak width of the reflection at half intensity. The average particle size was found to be 8nm for P. juliflora. Fig.2 shows the Scanning Electron Micrograph of the sample at room temperature. Aggromolahar shaped texture was observed.



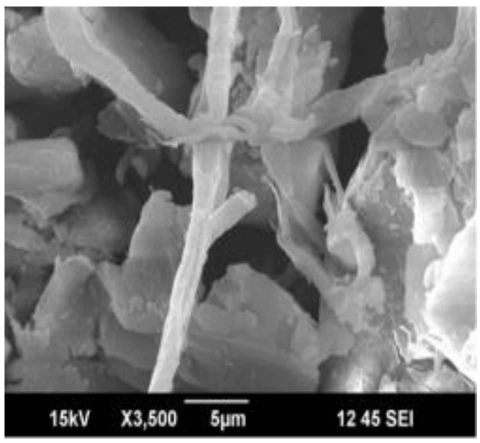


Fig. 1 XRD Pattern of P. juliflora **Fig. 2 SEM Micrograph of P. juliflora**

4.2. EDAX ANALYSIS

From the EDAX analysis P. juliflora has low concentration 0.39% of Mg 2.32% of Ca (Table.1). The good heat of combustion of P. juliflora is due to its higher proportion of carbon and lower proportion of oxygen [5]. Higher proportion of oxygen leads to calorific value reduction.

Table I: Elemental analysis of P. juliflora

Element (K)	*P. juliflora Mass(%)*
C	75.3
O	17.92
Mg	0.39
Ca	2.32
Cu	4.05

4.3. PROXIMATE ANALYSIS

Proximate analysis is reported in Table. 2. Moisture content is of important interest since it corresponds to one of the main criteria for the selection of energy conversion process technology. Thermal conversion technology requires biomass fuels with low moisture content, while those with high moisture content are more appropriate for biological-based process such as fermentation or anaerobic digestion [1]. From Table 2, it is noted that P. juliflora has moisture content of lesser than 10% and hence more suitable to serve as feedstock for thermal conversion technologies. The ash content of biomass influences the expenses related to handling and processing to be included in the overall conversion cost. On the other hand, the chemical composition of the ash is a determinant parameter to consider for the operation of a thermal conversion unit, since it gives rise to problems of slagging, fouling, sintering and corrosion. Higher proportion of carbon content leads to high calorific value 4200Kcal/kg [6].Since P. juliflora has low ash content, high volatile matter and low fixed carbon (8.17%) the woody biomass material is the best candidate for thermal conversion technologies.

Table II: Proximate analysis of P. juliflora

Species	*Moisture (%)*	*Ash (%)*	*Volatile matter (%)*	*Fixed Carbon (%)*	*Calorific value Kcal/kg*
P.juliflora	5.35	1.01	79.23	15.69	3891

4.4. GASIFIER EFFICIENCY

Gasifier efficiency and Thermal output result (Table.3) shows that the biomass material has considerable thermal output (6 to 11 kW/hr) and also better flame length [7]. Therefore this biomass material is the most suitable candidates for gasification.

Table III: Measured parameters used to calculate the Gasifier efficiency and Thermal output using updraft Gasifier

Samples	*CV of wood KJ/Kg*	*Gasifier running time (Hrs)*	*Wood consumption rate (Kg/hr)*	*Air flow rate (M^3/hr)*	*Gas production rate (M^3/hr)*	*Ash produced (Kg)*	*Gasifier efficiency (%)*	*Thermal output (KW/hr)*
P. juliflora	30055.48	1.30	8.0	12.00	20.00	0.20	37.30	11.0

5. Conclusion

Every type of energy generation or utilization process affects the environment to some extent, either directly or indirectly. Since biomass fuel is considered as carbon neutral in nature and the generated electricity is considered as a clear form of energy. By this way of power generation we can face the ‘three Es’ (Environment, Energy and Economic development) in a positive manner. One kilogram P. juliflora can generate one unit of electricity and the production cost to generate one unit of electricity is Rs.2.30. The installation cost of this biomass power is Rs.4 crore/MW. Using 330 tons of P. juliflora 240 MW electricity can be generated per day. This study could serve to establish a database of biomass fuels or feedstock that would support decision making in terms of energy conversion technology selection and operating conditions setting.

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