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ORIGINAL ARTICLE

Gliricidia sepium Bioenergy Resource for Power Generation

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ABSTRACT
Amongst different sources of renewable energy biomass residues hold special promise due to their inherent capability to store solar energy and amenability to subsequent convention to convenient solid, liquid and gaseous fuels. The specific production of biomass for fuel could occur on energy farms. Gliricidia sepiumis a medium size leguminous tree belonging to the family Fabaceae. We developed a protocol in order to characterize the bioenergy potential of G. sepium as a feed stock for energy conversion process. The combustion properties of the fuel wood like moisture content, percentage of fixed carbon, ash content, volatile matter, different modes of functional groups, elemental composition and thermal stability were determined. The rate of production of gas, thermal output and calorific value were also calculated using forced draft gasifier. The study on bioenergy potential of G. sepium indicates that lower proportion of oxygen leads to meet the requirement of thermochemical process. Since it possesses high thermal output it can serve as a feed stock for energy conversion process.
Key words: Gliricidia sepium, Proximate analysis, Calorific value, Bioenergy potential, Gasification.

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INTRODUCTION

Because of its ability to limit climate change from energy production, biomass is widely considered to be a major potential fuel and renewable resource for the future [1-8]. Biomass is the most potential candidate for their quantitative availability. *Gliricidia sepium* is one the biomass residue, grows to a height of 10 to 12 meters and has a trunk with a diameter up to 30 cm. Studies from Malawi have shown that *G. sepium* (*Gliricidia sepium* (Jacq) Walp, Rutta) , a fast growing tree species and a nitrogen fixer can yield over 5.4 t ha^{-1} $year^{-1}$ of copied biomass [9]. However to use biomass efficiently for energy production a detailed knowledge of its bioenergy potential is required. For that purpose well-known physical, chemical, thermal, and mineral studies were used for characterization of solid fuels. These properties more specifically average and variation in elemental composition is also essential for modeling and analysis of energy conversion process [10]. Ash forming elements such as Si, Ca, Fe, K, Mg, Na, and P in biomass are important to be documented for any thermochemical conversion process [11]. Actually, high contents of alkali are well –known to conduct to critical technical problems when biomass is used as feedstock for power production, since they contribute to slagging, fouling and sintering formation. This information on concentration and speciation of some elements is also 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 [12]. Biomass gasification is the process of converting solid into combustible gases; it is a thermo-chemical process in which the fuel gas is formed due to the partial combustion of biomass [13-15]. This technology was developed around 1920 and played an important role in generating motives power till other fuels made their appearance [16]. The use of biomass as an energy source has high economic viability, large potential and various social and environmental benefits. The main objective of the study is to determine the bioenergy potential of *G.sepium* for power generation.

MATERIALS AND METHODS

One to two kilograms of *G. sepium* was collected from the plantation. They were oven dried at 70˚C during 24h. Bomb calorimeter was used to determine the gasification related properties of biomass such as volatile, fixed carbon and ash content. Thermo gravimetric Analysis or TGA is a type of testing that is performed on samples to determine changes in weight in relation to change in temperature. *G. sepium* wood was subjected into the forced draft gasifier to determine the rate of production of the gas, thermal output, and calorific value of the sample.

Material characterization

The particle size of the sample was determined using X-ray diffraction (XRD) in a wide range of Bragg angles 2θ (10°<2θ<90°) with Co radiation (1.54054 Å). The surface morphology was recorded using scanning electron microscope (JEOL Model JSM-6390LV). The proximate analysis to measure moisture, volatile, fixed carbon and ash content was performed by ordinary oven and muffle furnace (GUNA Model TC141P). The calorific value of the sample was measured using bomb calorimeter. Elements presented in the sample were identified using EDAX (JEOL Model JED-2300) analysis. In order to analyze the presence of functional groups in the sample the Fourier transform infrared (FT-IR) spectrum was recorded in the range of 4000-400cm^{-1}. The thermal behaviour of *G. sepium* had been studied by thermo gravimetric analysis (TGA) and differential thermal analysis (DTA) The rate of production of gas, thermal output and calorific value were calculated using forced draft gasifier.

RESULTS AND DISCUSSION

Structural analysis

The structural analysis of biomass is particularly important in the development of processes for producing other fuels and chemicals and in the study of combustion phenomenon. The XRD pattern of the sample shown in Fig.1 reveals the amorphous nature of biomass material. The size of the sample was determined using Scherr's equation (17) $D=.89\lambda/(\beta_{1/2}\cos\theta)$, where λ= 1.54054Å and $\beta_{1/2}$ is the peak width of the reflection at half intensity. The average particle size was found to be 8nm.Fig.1 (inset) shows the scanning electron micrograph of the samples at room temperature. Needle shaped texture was observed.

EDAX Analysis

It is generally believed that alkali metals ae the main cause of slagging, fouling, and sintering. Ca, Fe, K, Mg, Na and P in biomass are especially important for any thermochemical conversion process. EDAX analysis of *G. sepium* shown in Fig.2 has 0.39% of Mg 2.32% of Ca. The good heat of combustion of *G. sepium* is due to its higher proportion of carbon and lower proportion of oxygen [18]. Thepercentage composition of elemental carbon was higher than that of elemental oxygen.

Proximate Analysis

Table 1 shows the result of proximate analysis of *G. sepium.* 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. The moisture content affects the value of biomass as a fuel; the basis on which the moisture content is measured must always be mentioned. This is particularly important because biomass materials exhibit a wide range of moisture content (on a wet basis), ranging from less than 10 percent for cereal grain straw up to 50 to 70 percent for forest residues [19] . It is noted from Table.1, that *G. sepiumhas* 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. Volatile matter refers to the part of the biomass that is released when the biomass is heated (up to 400 to 500°C). During this heating process the biomass decomposes into volatile gases and solid char. Biomass typically has a high volatile matter content (up to 80 percent), [19]. Biomass offers important advantages as a combustion feedstock because of the high volatility of the fuel and the high reactivity of both the fuel and the resulting char [20]. Higher proportion of carbon content leads to high calorific value 4200Kcal/kg [21]. The calorific value is one of the most important characteristics of a fuel, and it is useful for planning and control of the combustion plants. It indicates the amount of heat that develops from the mass (weight) in its complete combustion with oxygen in a calorimeter standardize. The wood substances of higher density species burns more slowly, thereby releasing heat energy at a slower rate for a longer time [22]. Wood with a high density and low moisture content is preferred as fuel because of high energy content per unit volume and slow burning rate [23].

FT-IR spectral analysis

A FT-IR spectrum for the *G. sepium* is shown in Fig.3. The O-H stretching appears at 3413cm^{-1}. The O-H stretch carboxylic acids appear at 2905 cm^{-1}. The N-H bend primary amines appear at 1648 cm^{-1}. The peak at 1374 cm^{-1} is assigned for C-N stretching of aromatic amino groups. 1160 cm^{-1}, 1119 cm^{-1} and 1058 cm^{-1} are assigned for C-N Stretching alcohols. The region from 1400-600 cm^{-1} is called finger print region because the pattern of absorptions in this region are unique to any particular compound, just as a person's fingerprints are unique. The observed wavenumbers and their assignments are presented in Table 2.

Thermal Analysis

The TGA thermo gram for *G. sepium* is given in Fig.4 which showed four distinct segments. The moisture removal last for 250°C. In this material release of lighter volatile initiated at 250°C and last up to 362.95°C. The lighter volatile noticed in the range of 50%. After release of lighter volatile, release of heavier volatile start at 362.95°C and continued up to 535.15°C. Oxidation temperature of *G. sepium* is found to be 370°C. In TGA and DTA curve implies that the observed weight loss is due to the presence of volatile materials. The presence of hydroxyl group and free hydrogen were responsible for the total reduction (above 800K), the obtained intermediate involves further decomposition there by the formation of residual products like tar and char.

Gasifier Efficiency and Thermal output Measurement

The temperature of the gasifier air inlet and outlet were measured using thermometer. The measurement of the temperature helps in determines the quality and heating capacity of the gas generated. The woody consumption rate is the amount of wood consumed by the gasifier per hour. Theoretically, we have to produce 2.5Kg of gas from 1 Kg of wood. At first measured quantity of wood chips were filled in the hopper. After gasifier operation the remaining wood was weighed and from this, wood consumption rate was calculated. The wood consumption rate is one of the crucial parameters that determine the rating of the gasifier. The calorific value, gasifier efficiency and the thermal output of *G.sepium* was analysed and the results are tabulated in Table 3.

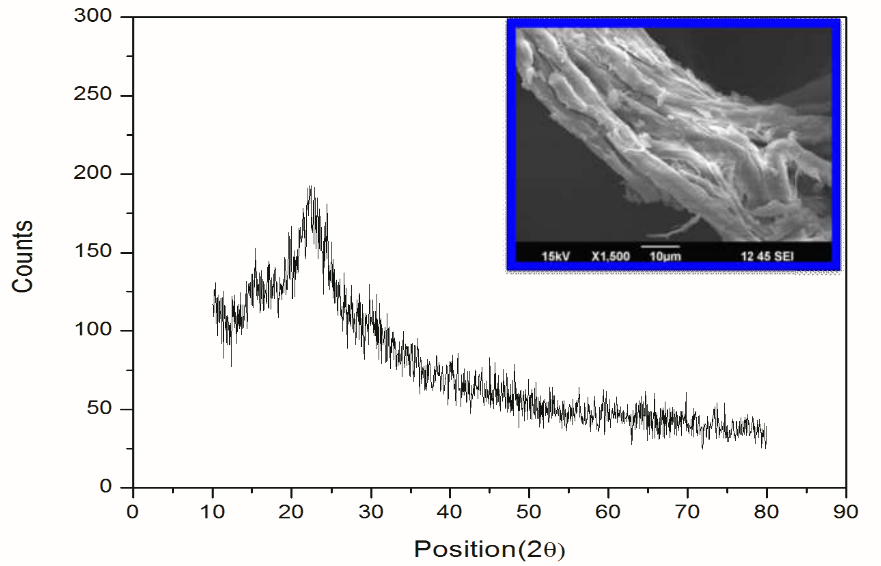

Fig.1 Room temperature XRD pattern and SEM of *G. sepium* wood

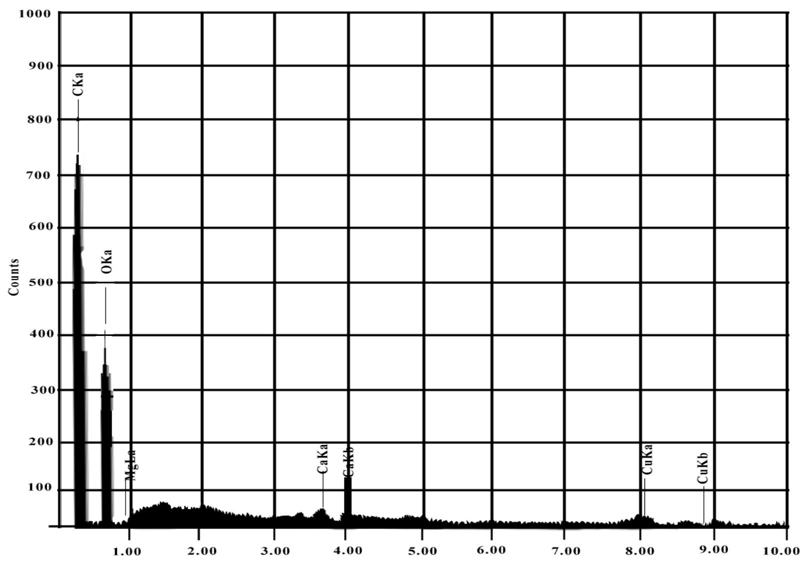

Fig.2 Elemental analysis of *G. sepium* wood

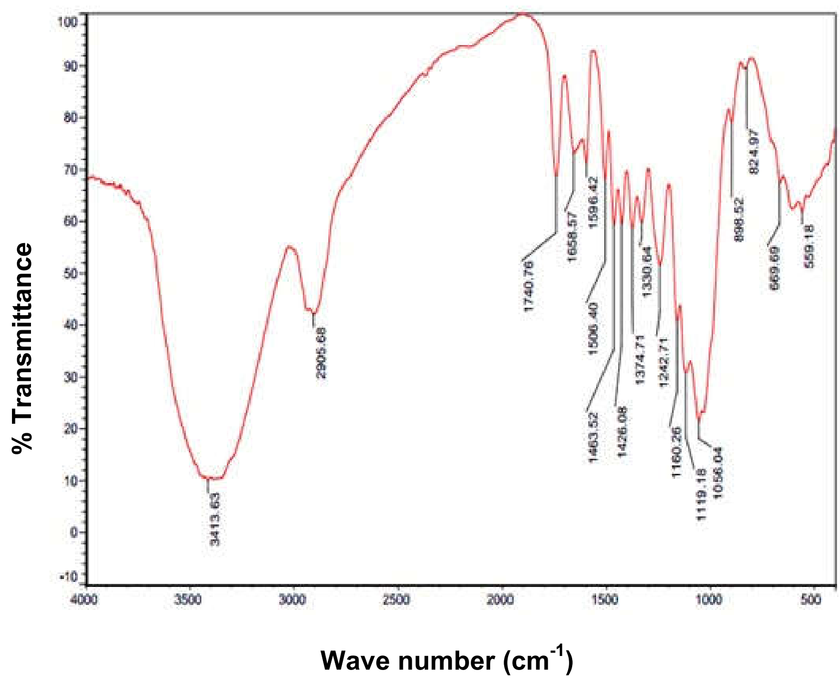

Fig 3.FT-IR spectrum of *G. sepium* wood

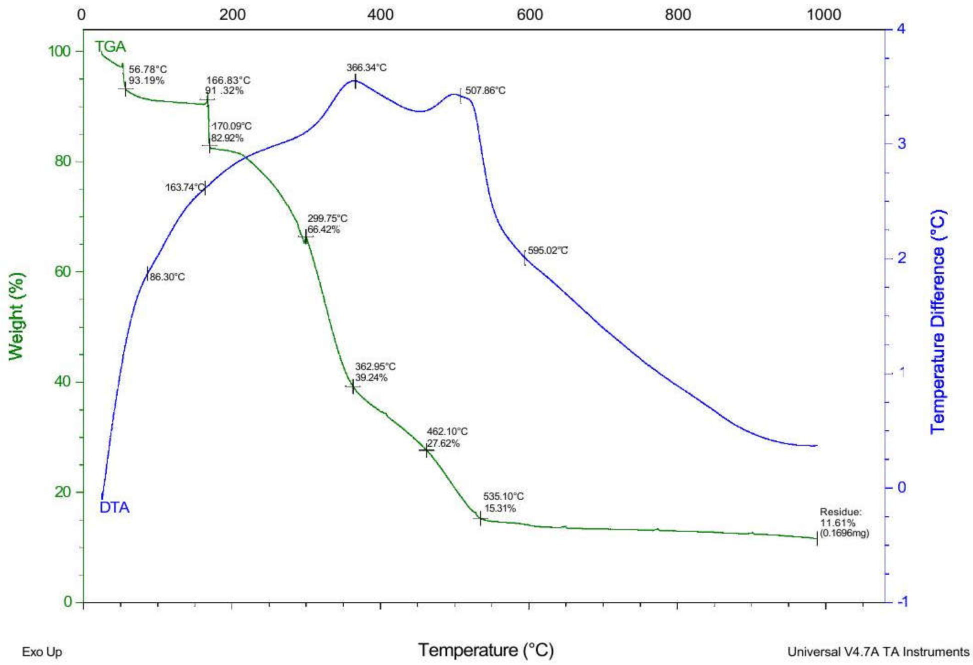

Fig.4 TG-DTA curve for *G. sepium* wood

Table 1. Proximate analysis of *G. sepium* wood

Moisture (%)	Ash (%)	Volatile matter (%)	Fixed Carbon (%)	Calorific value kcal/Kg
4.80	4.58	79.64	10.98	3540

Table 2.FT-IR spectral Data of *G. sepium*

Wave Number Cm^{-1} *G. sepium*	**Assignments**
3413	O-H Stretch
2905	O-H Stretch Carboxylic acids
1740	C=O Stretch
1658	N-H bend primary amines
1463	CH_2& CH_3 bend
1374	C-N Stretching of aromatic amino groups
1242	C-O Stretch
1160	C-N Stretching alcohols
1119	C-N Stretching alcohols
1056	C-N Stretching alcohols

Table 3. Measured parameter used to calculate the gasifier efficiency and thermal output

Calorific Value 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 (KWth/hr)
17937.01	2.10	5.0	04.25	12.75	0.25	59.39	5.5

CONCLUSION

Thermal and EDAX analysis showed that *G. sepium* is of low moisture content; low proportion of oxygen indicates it is appropriate to meet requirements of thermochemical process. The TGA and DTA studies indicate the decomposition of surface groups and formation of various gaseous products. Gasifier efficiency and thermal output analyses reveal that *G. sepium* possess high thermal output. 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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REFERENCES

1. Amutio M, Lopez G, Artetxe M, Elordi G, Olazar M, Bilbao J. Influence of temperature on biomass pyrolysis in a conical spouted bed reactor. ResourConservRecycl 2012; 59:23–31.
2. Bridgwater AV. The technical and economic feasibility of biomass gasification for power generation. Fuel 2005;74:631–53.
3. Caputo AC, Palumbo M, Pelagagge PM, Scacchia F. Economics of biomass energy utilization in combustion and gasification plants: effects of logistic variables. Biomass Bioenergy 2005; 28:35–51.
4. Hanaoka T, Inove S, Uno S, Ogi T, Minowa T. Effect of woody biomass components on air – steam gasification. Biomass Bioenergy2005; 28:69–76.
5. Hohenstein WG, Wright LL. Biomass energy production in the United States: an overview. Biomass Bioenergy 1994; 6:161–73.
6. Hustad J, Skreiberg, Sonju O. Biomass combustion research and utilizationin IEA countries. Biomass Bioenergy 1995; 9:235–55.
7. Panepinto D, Genon G, Brizio E, Russolillo D. Production of green energy from co-digestion: perspectives for the Province of Cuneo, energetic balance and environmental sustainability. Clean Technol Environ Policy 2013; 15:1055–62.
8. Van Den Broek R, FaaIj A, Van Wick A. Biomass combustion for power generation. Biomass Bioenergy 1996; 11:271–81.
9. Maghembe, J.A., Prins, H., 1994. Performance of multipurpose trees for agroforestry two years after planting at Makoka, Malawi. For. Ecol. Manag. 64, 171–182.
10. Nordin A (1994) Biomass and Bioenergy 6(5): 339-347.
11. Cuping L, Changzhi W, Yanyongijie and Haitao H (2004) Biomass and Bioenergy 27:119-130.
12. Obemberger I and Thek G (2004) Biomass and Bioenergy 27:653-669.

13. Tripathia AK, Iyera PVR, Kandpal TC. 1999. Biomass gasifier based institutional cooking in India: a preliminary financial evaluation. Biomass and Bioenergy. 17:165-173.
14. Pletka R, Brown RC, Smeek J. 2001. Indirectly heated biomass gasification using latent heat ballast. Part 1: experiments. Biomass and Bioenergy. 20; 297-305.
15. Dasappa S, Sridhar HV, Sridhar G, Paul PJ, Mulkunda HS. 2003. Biomass gasification – a substitute to fossil fuel for heat application. Biomass and Bioenergy. 25:637-649.
16. Rathore NS, Panwar NL, Kothari S. 2007. Biomass Production and Utilization Technology. A book published by Humanshu Publication, Udaipur ISBN 81-7906-139-6.
17. Vincent C A (2000) Solid State Ionics 134: 159-167.
18. Goel V L, Behl H M (1996) Biomass and Bioenergy, 10 (1): 57-61.
19. Jenkins BM (1980) Downdraft Gasification characteristics of a major California residue derived fuels. PhD Thesis, University of California, Davis.
20. Demirbas A. Potential applications of renewable energy sources, biomass combustion problems in boiler power systems and combustion related environmental issues. Prog Energy Combust Sci 2005;31:171–92.
21. Khan D, Ahmad R and Ismail S (1986) Pakistan Journal of Botany 19:131–138.
22. Groves, K. G. and Chivuya, A. M., Fuelwood evaluation of four Australian grown tree species. In *Trees for the Tropics,* ed. D. J. Boland, pp. 159-169. Etching Press, Brisbane, 1989.
23. Tietema TT, Dithogo M, Tibone C, Mathalaza N. Characteristics of eight firewood species of Botswana. Biomass and Bioenergyl(1), 41-46 (1991).

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