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Short Communication

A NOVEL APPROACH FOR RENEWABLE ENERGY GENERATION FROM BIOMASS USING *DELONIX REGIA*

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ABSTRACT

The rising costs of conventional fuels, as well as the negative impacts of burning on the environment, have resulted in a shift in demand for wood fuel. As a result, research into the possibility for some woody biomass to be used as a fossil fuel substitute has become important. *Delonix regia* is a widely grown tree species. These species produce large quantities of lignocellulosic biomass from the tree parts. This study examined the thermochemical characteristics and pyrolytic conversion behavior of these tree parts to assess the possibility of volarization to yield bioenergy. Proximate analysis of *Delonix regia* revealed low moisture content (6.5%), ash content (1.95%), fixed carbon (12.95%) and high volatile matter (78.6%) respectively. *Delonix regia* attained high calorific value 3611Kcal/Kg. In FTIR analysis, the biomass sample (*Delonix regia)* attained multiple functional groups is also discussed. In EDAX, the fuelwood property of elemental composition is determined. TGA analysis is done to examine the thermal behavior of biomass. The paper presents an innovative approach to the research of power generation from biomass by suggesting *Delonix regia* exhibited high energy properties.

Keywords: *Delonix regia*, FTIR, Proximate, EDAX, TGA.

1. INTRODUCTION

The use of fossil fuels has led to many environmental problems, including local air pollution and greenhouse gas emissions. Possible ways to solve these problems include developing cleaner and more renewable energy sources. Modern use of biomass is an interesting option because biomass is worldwide available, it can be used for power generation and bio-fuels production and it may be produced and consumed on a CO_2-neutral basis. However, to use biomass efficiently for energy production, a detailed knowledge of its physical and chemical properties is required. The characteristics of the wood *Delonix regia* for the thermochemical conversion process are under reported. *Delonix regia* is one of the most underutilized biomass materials in sub-Saharan Africa, often referred to as waste [1]. It is a leguminous plant that belongs to the family of leguminosae and is ranked as the second largest family among the dicotyledonous plants. It has the following common names; Pride of Barbados, Dwarf Poinciana, Bird of Paradise, flamboyant-de-jardin [2].

Since wood biomass is a versatile material, people have used it in many ways for a long time. It is, however, essential and important to provide further information on the utilization of some woody biomass for energy by examining their bioenergy properties, as this would further assist in understanding their suitability for use as an alternative energy source, which is the overall aim of this study.

2. MATERIAL AND METHODS

In this study, *Delonix regia* woody material has been used. In sample preparation stage, this woody material was kept in open trays for several days. We want to get dried materials sample to avoid biological decay of wet samples. The dried samples were then ground into powder form.

The proximate analysis (moisture, volatile matter, ash and fixed carbon contents) of the sample was performed by an ordinary oven and a muffle furnace. The Calorific value was measured using bomb calorimeter [3]. Elements presented in the sample were identified using EDAX analysis [4]. The FT-IR study was done to determine the functional groups present in the woody material [5], which are important for volatility. The thermal behaviour of *D.regia* has been studied by thermo gravimetric analysis (TGA) [6].

3. RESULTS AND DISCUSSION

3.1. Proximate Analysis

The proximate analysis explains composition of moisture, volatile matter, ash, fixed carbon and calorific value as a percentage of the sample weight. Moisture content represents the amount of water in biomass [7]. Here the moisture content of the *D. regia* value is 6.5%. While biomass with low moisture content, subjected to thermochemical conversion process [8]. Literature says that moisture content is less than 10%; it is suitable for pyrolysis and combustion [9].

Ash content is recorded as 1.95% for *D. regia* biomass material which leads to high calorific value as well as influences combustion behavior and thermal decom-position [10]. Braga et al. [11] reported that low ash content (less than 2%), in addition to an increase in volatile matter (78.6%) and a decrease in fixed carbon (12.95%), which is highly favorable for the biomass to use as a pyrolysis feedstock.

Another important parameter in proximate analysis is volatile matter that is released when biomass is heated at high temperature [12]. The volatile matter present in the (*D. regia*) sample range is 78.6%. Kumar et al. [13] reported that values of different species ranged between 65% -85%. However, the value of the selected sample is within the reported value. So, it is suitable for pyrolysis process.

Fixed carbon is responsible for the formation of char [14]. The fixed carbon value of *D. regia* woody material is 12.75%. Although, the fixed carbon content recommended for biomass is from 7.00 % to 35.00 % (6). Nasser et al. [15] showed that low fixed carbon content can be linked with a high volatile matter which engenders consumption of the bulk of the residues in the gaseous state during combustion.

The Calorific value for the selected woody material is 3611 Kcal/Kg, (Table 1) which is preferred for the gasification process and it can be supplied for the application of power generation [16].

3.2. FTIR Analysis

The FTIR spectrum of the biomass sample *(D. regia*) is shown in Fig. 1, while Table 2 presents the analysis of the peaks attained from the FTIR spectra based on the literature [17].

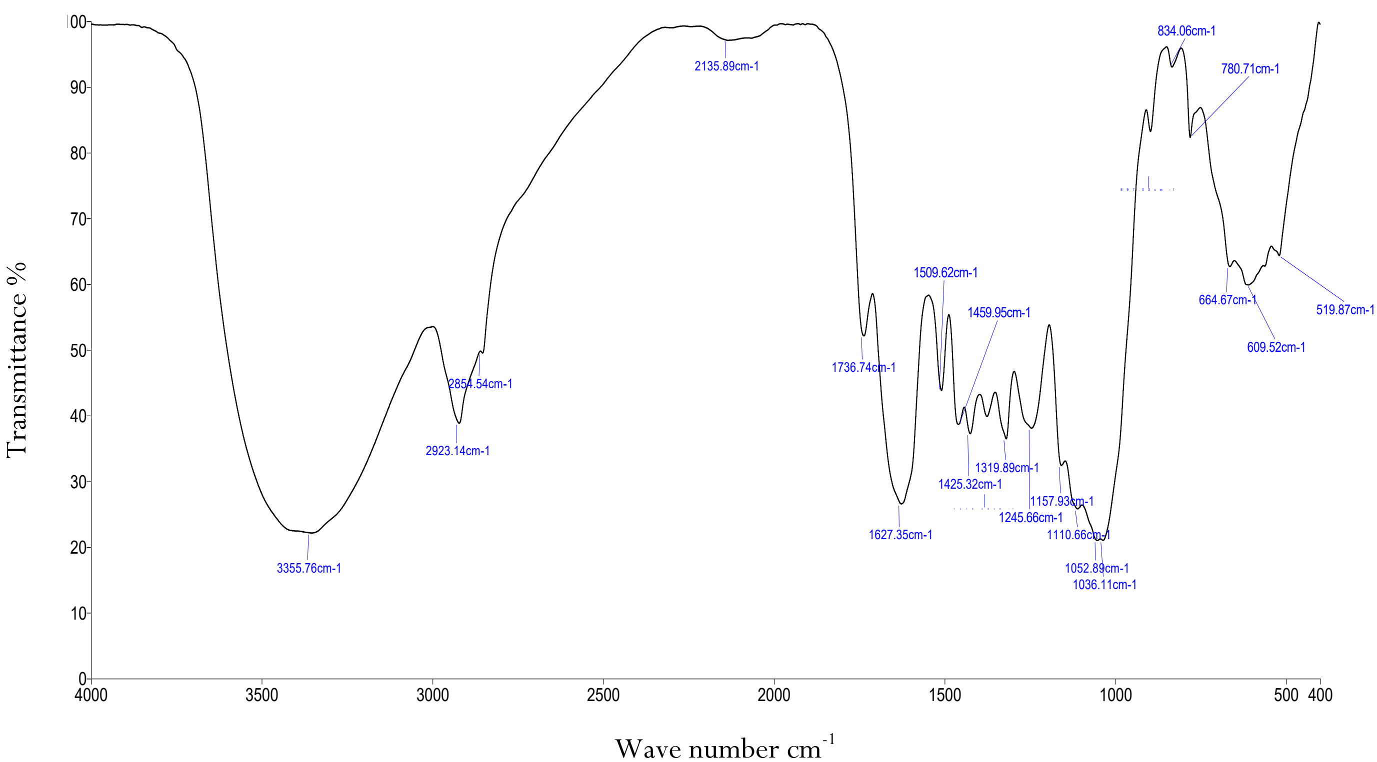

Fig. 1: FT-IR Spectrum of *D.regia* wood

Table 1: Proximate analysis of *Delonix regia*

Species	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed Carbon (%)	Calorific value Kcal/kg
Delonix regia	6.5	1.95	78.6	12.95	3611

Table 2: FT-IR spectral assignments for *Delonix regia*

Wave Number (cm^{-1}) *Delonix regia*	Assignments	References
3355	O-H Stretch	[17]
2923	O-H Stretch Carboxylic acids	[17]
1739	C=O Stretch	[17], [18]
1627	N-H bend primary amines	[17]
1425	CH_2 scissor vibration and CH_3 bending vibration	[19], [20]
1319	C-N stretching of aromatic amino group	[17], [18]
1245	C-O stretch	[18]
1052	C-N Stretching alcohols	[21]

The heterogeneous nature of the *D .regia* is confirmed by the identification of multiple functions present in the sample. The band 3355cm^{-1} is O-H stretching vibration. The band nature is broad. It confirms the presence of hydrogen bond. The O-H stretching carboxylic acid appears at 2923 cm^{-1}. The N-H bend primary amines appear at 1627cm^{-1}. The peak at 1739cm^{-1} is assigned for C=O stretch. The peak at 1319cm^{-1} is assigned for the aromatic amino group. The band 1054cm^{-1} is C-N stretching alcohols. The fingerprint region ranges from 1400-600cm^{-1}. In this region, the pattern of absorption is unique. Here, the FT-IR assignments for *D .regia* material have carboxylic, amine, and hydroxyl groups, which are responsible for high volatility [22]. The inherent chemical compositions of this species (*D. regia*) could be a clear definition of why it exhibits good bioenergy properties [23].

3.3. EDAX Analysis

EDAX analysis of *D. regia* shown in Fig. 2 has 1.20% for Al, 0.25% for Ca, and 0.03% for Si are minor elements. The minor elements present in the selected woody material are determinant factor for any thermochemical conversion process. The *D. regia* material has high carbon content (Table 3) that determines best for heat combustion and also better properties of biofuels [24].

Table 3: Elemental Analysis of *D.regia*

Element (K)	*D. regia* Mass (%)
C	66.03
O	32.49
Al	1.20
Ca	0.25
Si	0.03

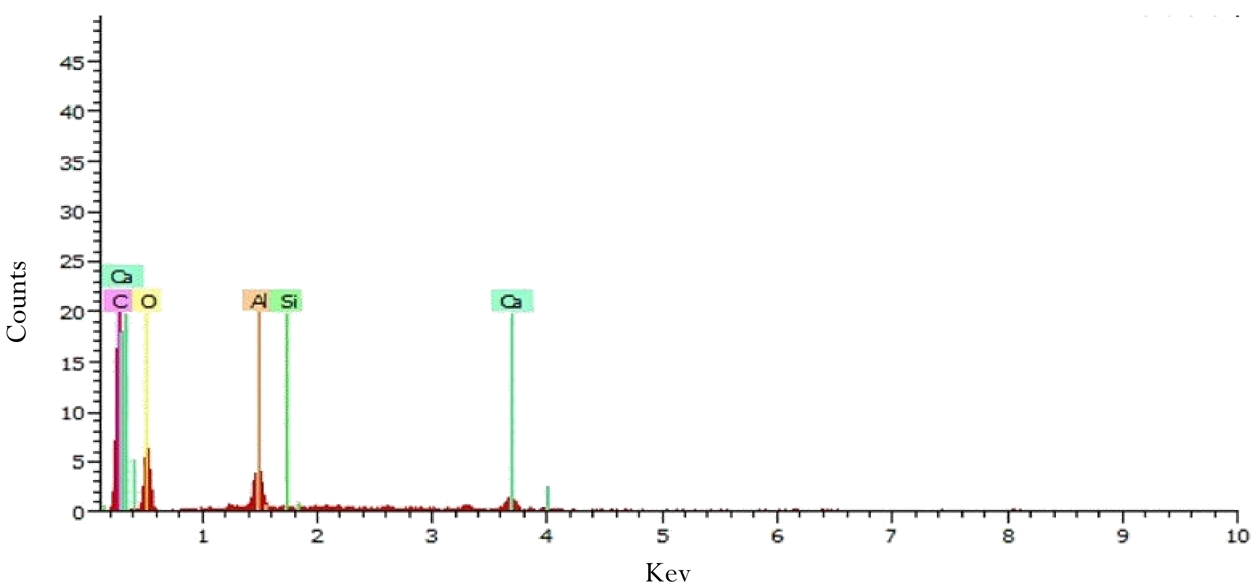

Fig . 2: Elemental analysis of *D.regia*

3.4. TGA Analysis

Thermo-gravimetric analysis (TGA) is employed in determining the thermal behavior of biomass fuels and as a premise for the design of pyrolysis reactor [25]. Generally, moisture content, lighter volatile, heavier volatile, lignin decomposition is the four stages involve in thermal behavior of biomass fuels. As depicted by the graphs, the first stage represents evaporation of moisture contents for the *Delonix regia*. At this point, moisture content is being absorbed from the sample as the heating temperature increases. Our result is in proximity to those reported by Nasser et al (2016) and Kumabe et al. (2007) [26, 27] for biomass fuels employed for the bio-energy production. Lighter volatile start to decompose first and maximum weight loss observed at 240°C-380°C. After lighter volatile, heavier volatile starts to decompose with a high temperature. The maximum weight loss observed at the range 380°C -510°C. Almost all heavier volatile is decomposed, at the end of the pyrolysis. Last one is lignin decomposition. It is most difficult to decompose; the temperature range or decomposition is 510°C-690°C. The four stages show different thermal behavior possibly result if variation in the inherent structures and chemical nature of these stages [28].

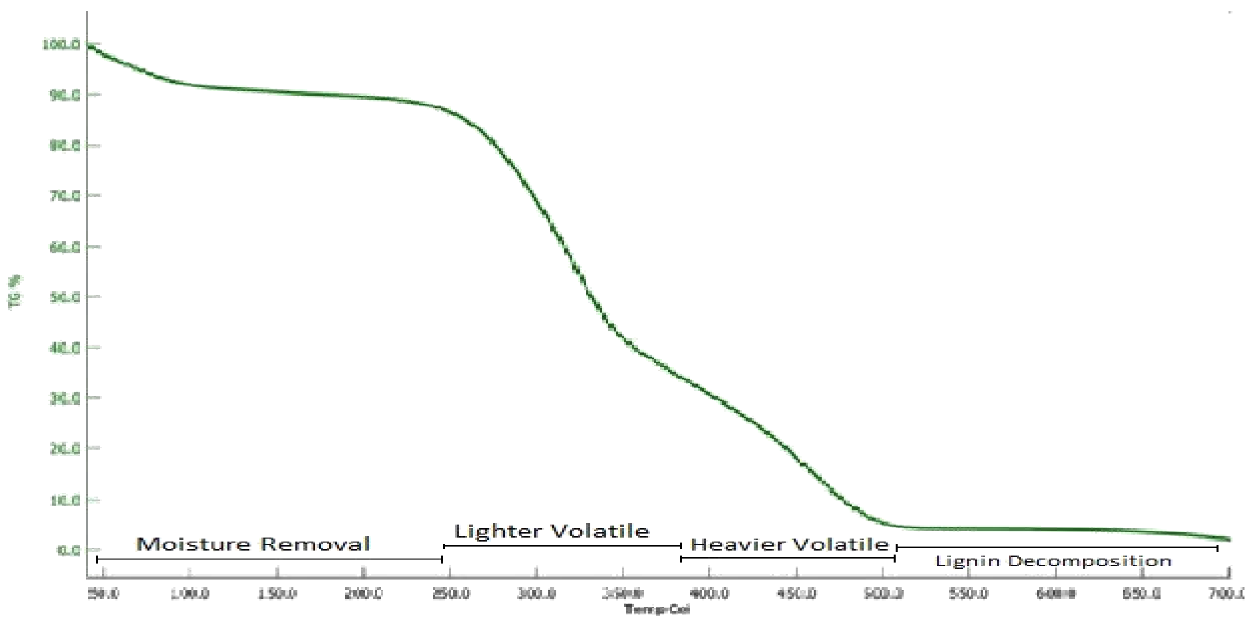

Fig. 3: Thermo Gravimetric of D.regia

4. CONCLUSION

Knowledge of physical and chemical properties of the *Delonix regia* woody material provides valuable information and comprehensively in this research to elucidate on its potential as a bioenergy feedstock. The proximate analysis revealed that the selected woody material is extremely rich in volatile matters, high calorific value, and low ash content, less moisture which is an indication that it is a good candidate for bio-energy production. FTIR analysis showed that functional groups are within the limit for biomass fuels attesting to its suitability for pyrolysis process. Elemental analyses determine the minor elements Al, Ca, Si, in *D. regia*, which are within the limit and also suitable for thermochemical conversion process. TGA curve implies that the observed weight loss due to the presence of volatile materials. However, on the basis of TGA analysis biomass material can be gasified effectively. It is concluded that the selected woody biomass material (*D. regia*) is recommended as a feedstock for power generation.

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