Samanea saman wood material for Power Generation: A green approach

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Abstract

Samanea saman wood material is explored for power generation is demonstrated. Particle size of the wood is measured as 22.6 nm by applying Debye Scherrer equation in PXRD analysis and shape of the particle is also determined as irregular by using SEM. Moisture content, volatile matter, fixed carbon and ash contents of the study material are well analyzed. From the proximate analysis calorific value is found to be 3665 kcal/kg. Lower value of ash content (4.6 %) enhance the higher efficiency of the gasifier, since very fewer pollutants would be produced. The elemental analysis (C, H, N, S and O composition) and thermal analysis (TGA, DTG, DSC) were fully studied for woody material. Using FT-IR, functional group present in the wood material is also discussed.

Keywords: Biomass, *Samanea saman*, Calorific Value, Ultimate analysis, Proximate analysis, Power generation

Introduction

The climate change and diminishing oil supplies are key issues for most countries in the world. The rapidly growing energy demand is becoming a challenge for human development because of fast depleting energy resources, effects on the environment and national energy security. The world energy related carbon dioxide emission will rise from 29.7 to 42.4 billion tons in the period of 2007–2035 while the global energy demand will rise by 49% in the same period, at an average rate of 1.4% per year [1]. Besides this, biomass is considered as an autonomous resource which partially avoids foreign energy dependence [2]. Because of the advantages when using biomass for energy production, it has experienced a huge development in recent years [3].

In the present study, we have disclosed our recent research on the wood material of *Samanea saman* as a raw material for power generation.

Samanea saman, also sometimes known as albizia saman, or the rain tree, is a species of flowering tree in the pea family, Fabaceae, that is native to the Central and South America. Saman is a wide-canopied tree with a large symmetrical umbrella-shaped crown. It usually reaches a height of 15–25 m

(49–82 ft) and a diameter of 30 m (98 ft) [4]. *S. saman* possesses some of the characters of other species known to have become invasive, e.g. prolific seeding, livestock as effective dispersers of seed, nitrogen fixation and adaptation to a variety of soil types. *S. saman* is a truly tropical species, intolerant of frost. It thrives in both the seasonally dry and wet tropics [5] [6] [7] [8] but is faster-growing where rainfall is >1000 mm. The wood of *S. saman* is strong, durable or very durable, with a light yellow sapwood and rich dark chocolate-brown heartwood. The wood also makes good quality fuel wood [9] and charcoal [10]. *S. saman* trees sprout vigorously and can be managed for fuel wood by pollarding in agricultural areas [6]. *S. saman* is a good quality fuel and charcoal, producing 5200-5600 kcal/kg [11]. *S. saman* tree pods had a very good potential as feedstock for bioethanol production [12]. The carbonized briquettes made from 50% rain tree (*Samanea saman*) residues and 50% coffee ground/tea waste (RT50:CT50) had the highest calorific value (20.17 ± 0.042 MJ/kg)—insignificant at the 95% confidence interval—and highest shatter index (99.16 ± 0.20%). Thus, making carbonized briquettes from rain tree residues and coffee ground/tea waste a viable alternative method of adding value to biomass residue for use as raw materials to produce fuel products for household cooking [13].

Materials and Methods

Biomass collection and sample preparation

The raw material *Samanea saman* wood was received from Siddha Medicinal Plants Garden, Mettur Dam, Tamil Nadu, located at Lattitude of N 11˚19' to 11˚ 58' and Longitude of E 77˚ 40' to 78˚ 50' and lies in south India. The raw material was dried over sunlight until fully dried (around 20-25 days). Dried wood materials were chopped in a household blender used without any pretreatment for proximate analysis. Powdered form of dried material was used for ultimate, PXRD, FT-IR, SEM, EDAX and thermal analysis.

Characterization

Samanea saman wood powder was subjected to X-ray Diffractometer (PANALYTICAL, NETHERLAND & X'PERT POWDER) with CuKα radiations. Scanning Electron Microscope (SEM) measurements were carried out using SEM (Vega 3 Tescan) equipped with Energy Dispersive X-Ray Analysis (EDAX, Bruker). The proximate analysis (moisture, volatile, fixed carbon and ash content) was done by Hot air oven and muffle furnace (GUNA model TC141P). Elemental analysis was carried out in a Thermo Finnigan Flash EA 1112 analyzer. IR spectrum was recorded on a JASCO FT/IR-5300 instrument. Thermal behavior of the wood material was studied using thermal analyzer (NETZSCH STA 449F3).

Result and discussion

Particle size of *Samanea saman* wood material is determined using PXRD analysis (Fig.1). The charcoal yield from a biomass feed stock is highly dependent on the rate of heating and size of the biomass particles [14]. The particle size of the material is calculated from the Debye Scherrer equation and found to be 22.6 nm. These small sized particles improve the energy efficiency [15]. The surface of the wood material is found as irregular in shape (Fig.2). The EDAX spectrum (Fig.3) of *Samanea saman*, clearly exhibit that the main elements present in the study material are Carbon and Oxygen while calcium, magnesium and potassium are in less quantity (Table 1). The amount of carbon atoms in the material clearly suggests that study material possesses more number of –C-C- bonds which would produce high energy while combustion [16]. CHN analysis shows the presence of carbon (67.62 %) and hydrogen content (13.08 %) (Table 2). Very little amount of nitrogen present in the study material (Figure 4) which clearly indicate that this material will not produce much environmentally hazardous gases like NO_x, SO_x etc., while combustion [17]. It is worthy to mention that the selected wood material has major constituent of hydrocarbons; hence it may be the potential material for power generation application [18]. The FT-IR spectrum (Fig.5) of *Samanea saman* wood material confirms the presence of –OH (hydrogen bonded), Carbonyl group and aromatic carbons. The presence of hydrogen bonded and carbonyl functional group exhibits the high volatility [19].

The volatile content (72.0 %) is directly proportional to gasification efficiency [20]. From proximate analysis (Table 4), the amount of volatile content represents that material is highly reactive while combustion process [21]. The calorific value of the woody material is 3665 kcal/kg, which strongly favours the gasification and this wood material can be supplied to the application of power generation [22]. The selected woody sample has very less amount of moisture (4.9 %). *Samanea saman* wood smoothly undergoes a thermal decomposition, while combustion. Since ash is very significant in thermo chemical conversion process [23] and the selected woody material has very less amount of ash (4.6 %), it is expected to produce very less pollutant when compared with other fuels.

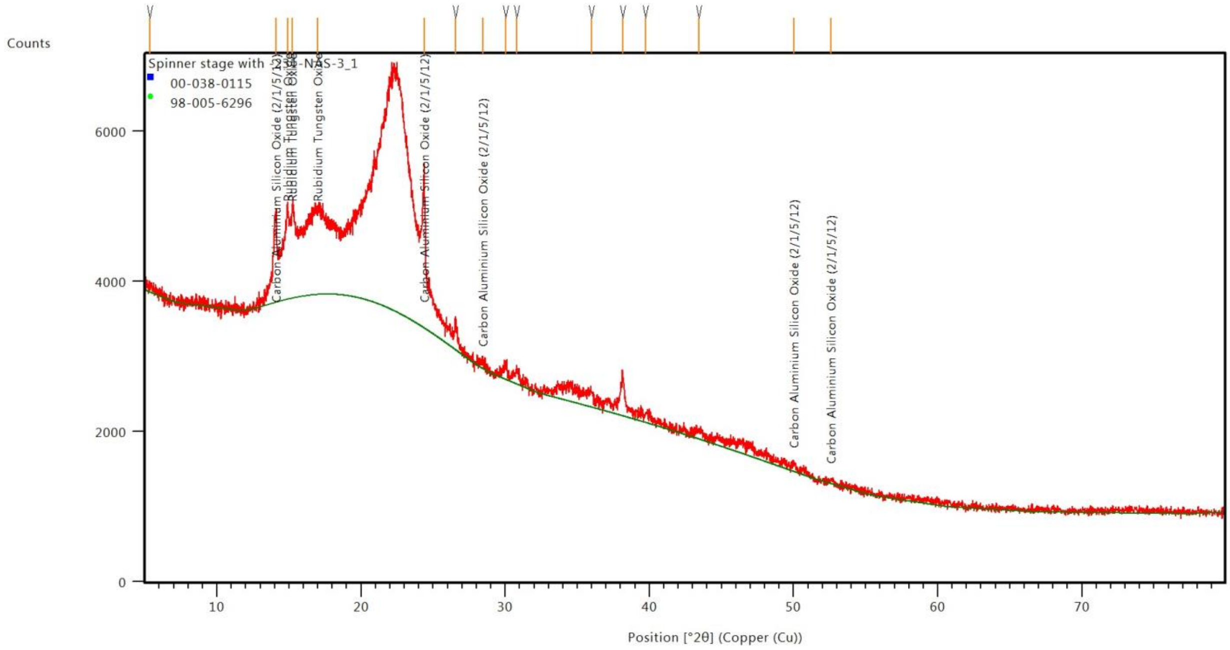

Fig.1: PXRD Analysis of *S.saman* woody biomass

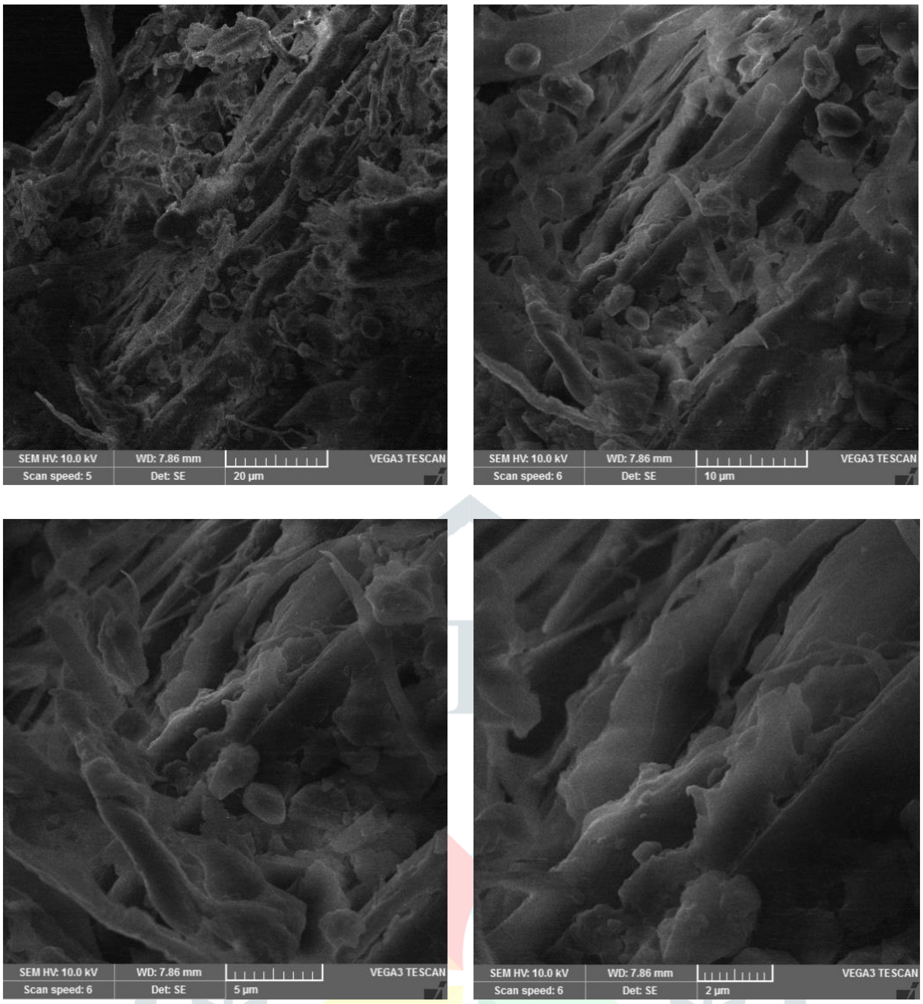

Fig.2: SEM Images of *S.saman* woody biomass

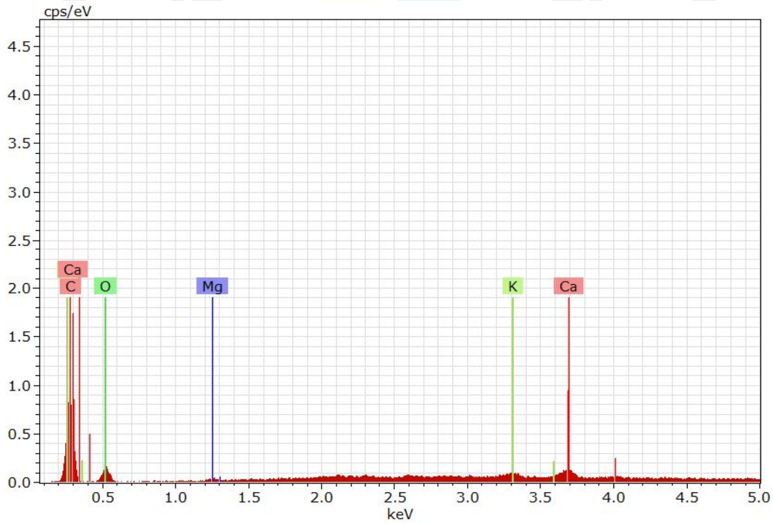

Fig.3: EDAX Spectrum of *S.saman* woody biomass

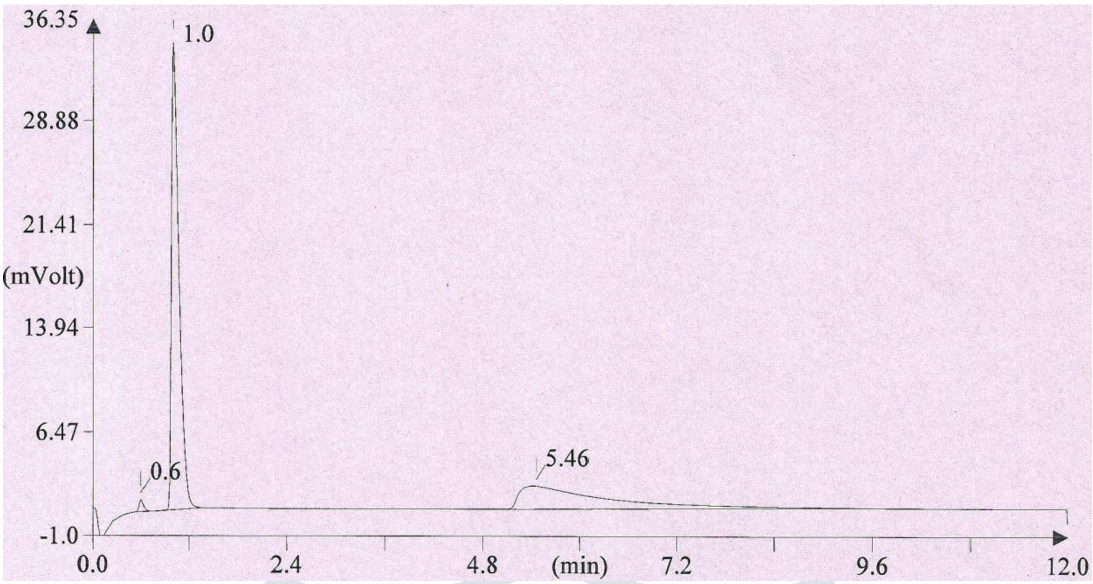

Fig.4: CHN Spectrum of *S.saman* woody biomass

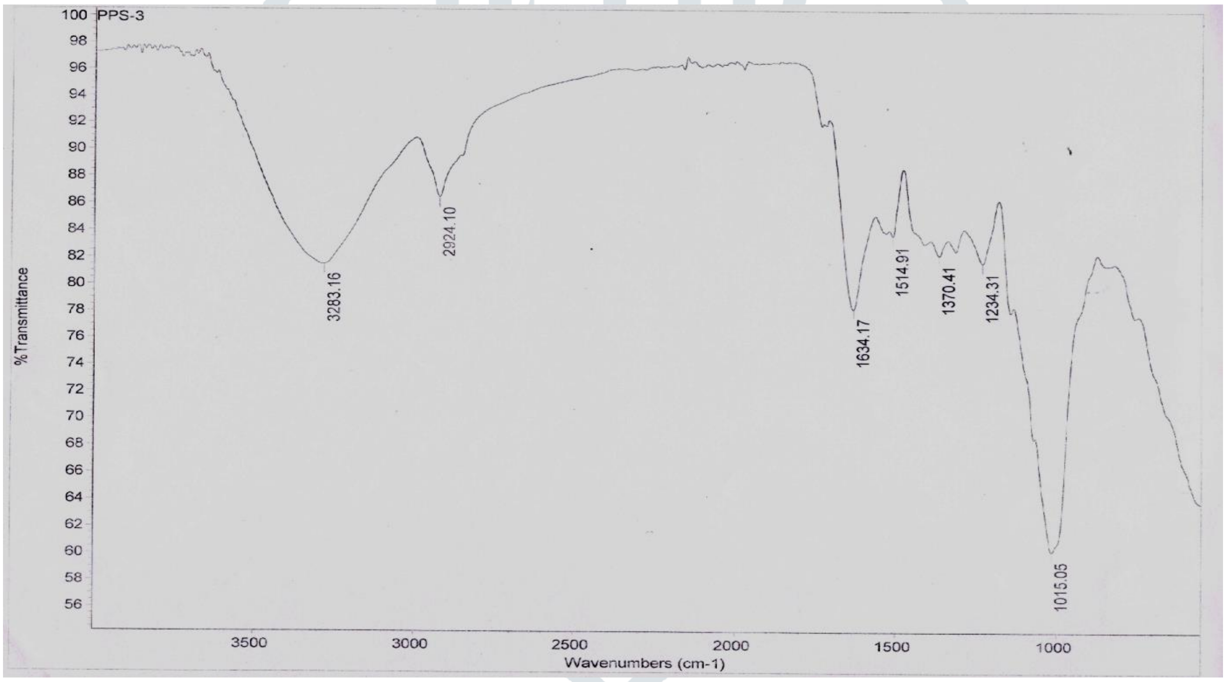

Fig.5: FTIR Spectrum of *S.saman* woody biomass

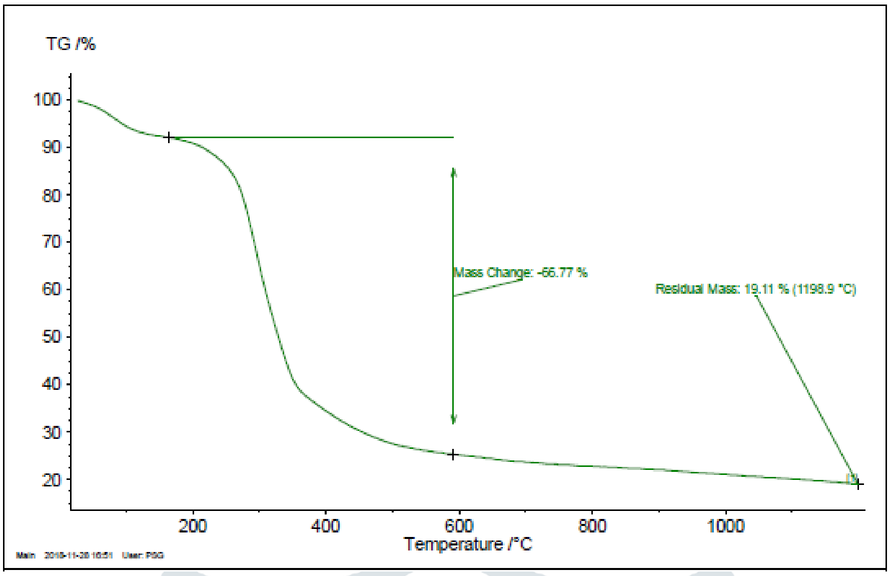

Fig.6: TGA Spectrum of *S.saman* woody biomass

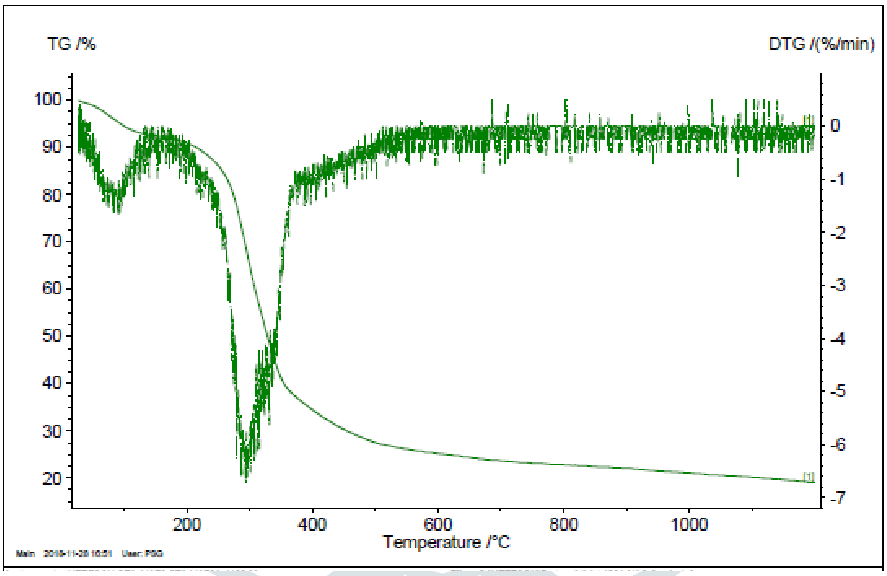

Fig.7: TGA- DTG Spectrum of *S.saman* woody biomass

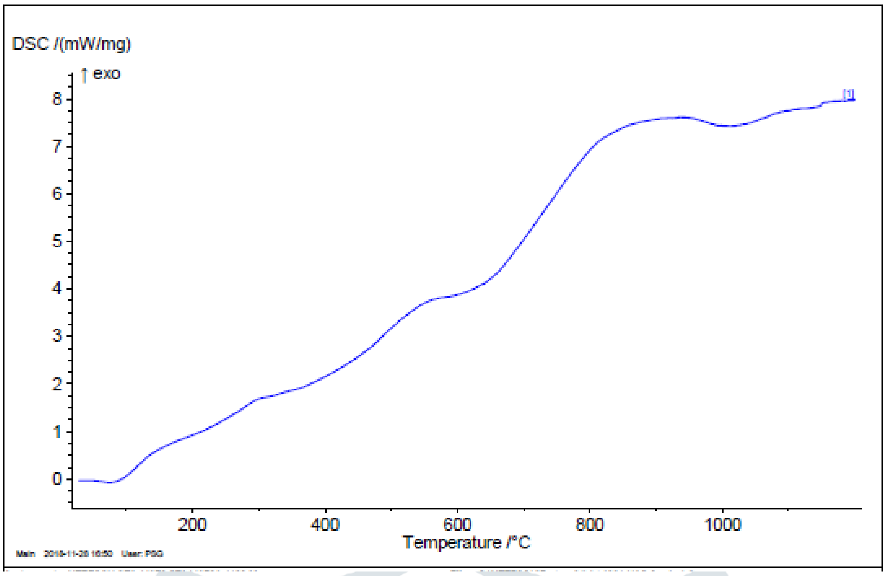

Fig.8: DSC Spectrum of *S.saman* woody biomass

Table.1: EDAX micro analysis of *D.sissoo* woody biomass

Sl.No	Elements	Weight %	Atom %
1	C	64.40	71.61
2	O	32.69	27.28
3	Ca	1.62	0.54
4	Mg	0.62	0.34
5	K	0.67	0.23

Table.2: CHN Data of *S.saman* woody biomass

Sl.No	Elements	Element %
1	N	0.06
2	C	67.62
3	H	13.08

Table.3: FT-IR Spectral data of *S.saman* woody biomass

Wave number cm^{-1}	Assignments
3283	-OH group with hydrogen bonding
2924	C-C stretching
1634	-C=C- (aromatic)
1514	-C=C- (aromatic)
1370	Methyl C-H asymmetry bend
1234	C-C stretch
1015	-C-H anti-symmetric stretch

Table.4 Proximate analysis of *D.sissoo* wood

Moisture (%)	Ash (%)	Volatile matter (%)	Fixed Carbon (%)	Calorific value kcal/Kg
4.9	4.6	72.0	18.5	3665

A more quantitative picture of pyrolysis is obtained through thermogravimetric analysis(TGA). In this technique, a small piece of biomass is suspended on a balance pan in a furnace, and the temperature is increased with time at a known rate. During pyrolysis, (sample is heated in an inert atmosphere) changes usually start for biomass around the temperature of 300 °C. Thermal analysis (TGA and DTA) of *Samanea saman* wood is depicted in the Fig.6 and 7. Initially, the changes in the curve (Fig.6) around the temperature of 40-105 °C, because of water content evaporation from the wood. After the temperature of 105-110 °C, moisture is completely removed from the wood material. The change in TGA around 155- 590 °C represents the large weight loss due to affect in the chemical bonds at this temperature as well and physical changes occurred in the wood sample. Volatile compounds present in the sample are being removed at this temperature range (around 350 °C). 66.77 % of mass loss while reaching the temperature 590 °C which is shown in TGA analysis (Fig.6 and 7). The analysis of DTA, clearly showed two peaks around 70 and 350 °C which strongly supports the aforesaid discussions. Differential scanning Calorimetry (DSC) measures the energy transferred to or from a sample undergoing a physical or chemical change. DSC spectrum (Fig.8) clearly indicate that the selected wood sample withstand upto 900°C.

Conclusion

The particle size of the *Samanea saman* material found to be 22.6 nm, which confirms the high energy efficiency. The selected wood material has lower ash content during combustion also has minimum amount of hazardous gas producing elements like nitrogen and sulphur, which suggests the *Samanea saman* is opt and good to environment. The presence of high content of carbon leads to high calorific value (3665 kcal/kg). The FT-IR spectrum confirms the presence of hydrogen bonded and carbonyl functional group which is responsible for high volatility. Thermal analysis of *Samanea saman* showed that the biomass is highly reactive while heating. Since biomaterials using green approach have more environmental benefits, it is concluded that the selected woody biomass material is recommended as a feedstock for power generation.

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