Physio-Chemical and Thermo-Gravimetric Analysis of Prosopis Juliflora and Fibre-Reinforced Plastic for Gasification Process

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Abstract: Significance of developing energy from waste biomass has grown extremely high in recent decades. Prosopis Juliflora (PJ - Organic) is a waste plant which was grown in agricultural landfills and Fibre-reinforced plastic (FRP - Inorganic) is procured from composite industry waste are collected for this work, which is abundant in quantity. Gasification are the adequate method for harvesting energy efficiently from organic and inorganic biomass. The objective of this research was to conclude the proximate and ultimate analysis of Prosopis Juliflora and Fibre-reinforced plastic to study the potential for thermo-chemical conversion process. Thermo-gravimetric analysis were observed at heating rates of 20, 30 and 40 ºC/min in inert (nitrogen) atmosphere with gas flow protection rate of 40 ml/min was analyzed for PJ, FRP and PJ+FRP (50:50).

Index Terms: Prosopis Juliflora, Fibre-reinforced plastic, Proximate analysis, Ultimate analysis, Thermo-gravimetric analysis, Gasification.

I. INTRODUCTION

The continuous growth of worldwide energy consumption raises imperative issues associated with energy opportunity, safe operation and its capability. Plants convert solar to useable form of energy and store it in the sort of structural parts of biomass adopting the CO_2 from the atmosphere. Biomass is environmental friendly for harvesting energy because it doesn't subsidize to associate degree rapid growth in CO_2 within the surroundings [1]. The common form of biomass was derived from forest, energy crops, crop residue and agro residual biomass. Agro-forestry may be promoted through contract farming whereby company bodies can organize teams of farmers to supply the specified biomass on contract through development of wastelands. India generates over 600 million loads of biomass from agricultural residues annually which may be regenerate into energy [2]. On the other side, using of fossil fuels causes various environmental issues, like air pollution and greenhouse gases emission. A potential path to accord these issues is that the development of

cleaner and renewable energy sources. Trendy use of biomass is a stimulating choice, as a result of biomass is worldwide on the market, it is used for power generation and biofuels production, and it should be created and consumed on a CO_2-neutral basis [3]. A practical examination has demonstrated that biomass power advances can possibly enter Indian market underneath a decent rivalry with the fossil innovations. Under optimum condition of green-house gas reduction system of biomass electricity penetration is predicted to succeed in 35000 MW in 2035, that is close to 9% of total power capability of India [4]. Biomass vitality is one of mankind's most punctual wellsprings of vitality especially in rural regions where it is regularly the main available and moderate wellspring of vitality. Overall biomass positions fourth as a vitality asset, giving roughly 14% of the world's vitality needs all human and industrial product waste, that is, typically unused and bothersome results of a particular procedure.

Another classification of biomass is lignocellulose feedstock, which can possibly meet an extensive piece of the present vitality request and is similarly less expensive than the stiffening based feedstock. Change of lignocellulose substances to form ethanol is confronting numerous difficulties; among the detachment of cellulose and hemicellulose from the lignocellulose material, and transformation of cellulose structure and hemicellulose structure to fermentable sugars and afterward to produce ethanol by means of maturation [5]. The process of ethanol preparation is economically static in study. Gasification is a thermo-chemical procedure by which any carbonized feed can be changed over to vaporous items within the heating quality [6]. Pyrolysis is a sub-classification of gasification, the distinction procedure happens in an inactive climate. Gasification and pyrolysis can change over lignocellulose materials to producer gas without the requirement for lignocellulose material. Producer gas can be additionally changed over to different synthetic gases (different improving procedures) or powers (by the Fischer–Tropsch strategy) or hydrogen can be isolated for energy unit application [7]. When compared with oxidation or combustion and gasification can use the feedstock proficiently creating an assortment of mixes for supplanting petro-chemical derived products. [8, 9] One more favorable position of gasification, contrasted and other form of bioenergy generation approach,

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is its capacity to use an extensive variety of feedstock running from any plant buildup, natural side-effect (with protein, lignin) of industry or municipal waste. In this way, gasification and pyrolysis are viewed as reasonable choices for handling biomass feedstock, which can't be aged to ethanol actually or financially.

Characterization of sample is the first step for efficient utilization of its energy potential therefore, present investigation was done with major objective of characterization of different organic and inorganic sample fuel. Thermo-gravimetric analysis is very important analysis to convert the solid fuels into gaseous fuel for gasification or pyrolysis. It was widely for the characterization of organic and inorganic feedstock. Researchers have used this process to determine the characterization of biomass before gasification and pyrolysis process for sugarcane bagasse in a nitrogen atmosphere as [10], rice husk in both inert nitrogen and oxygen atmosphere by [11] and maritime pine waste in both inert and oxygen atmosphere [12].

II. MATERIALS AND METHODS

A. Sample Preparation

The materials selected for the experiment was Prosopis juliflora, Fibre-reinforced plastic (FRP) and prosopis juliflora 50% + FRP 50%. Prosopis juliflora was obtained from waste agricultural landsides in Chidambaram and Fibre-reinforced plastic was procured from waste of "Composite industry" from Chennai. The size of both organic waste (Prosopis juliflora) and inorganic waste (Fibre-reinforced plastic) was maintained not more than 20 mm. Moisture content of organic waste and inorganic waste was measured by moisture meter, organic waste was maintained less than 15 percent and inorganic waste was retained up to 5 percent.

B. Characterization of fuel

The method of discovering the properties of organic and inorganic wastes are bulk density, calorific value, proximate analysis, ultimate analysis and Thermo-gravimetric analysis are discussed. The observed readings were documented in triplicate manner and average of triplicate values are used for observation.

i. Energy content - Bulk density

The mass thickness of the material is the proportion of the mass to the volume of a deliberate example. To measure the bulk density of any sample, a graduated standard cylinder was filled with a known mass of sample and weighted on weighing machine. Average of triplicate values was observed as the bulk density of organic and inorganic waste sample.

ii. Calorific value

The calorific value of the biomass sample was estimated by utilizing IKA/C5000 bomb calorimeter made by IKA Pvt. Ltd., India. The sample was filled in a gelatin container and after that, it was scorched in oxygen in a bomb calorimeter. The aggregate weight of the sample and the container was encouraged to the controller and the outcomes including the gross calorific value was printed. The calorific value of Prosopis juliflora, Fibre-reinforced plastic and Prosopis juliflora 50% + FRP 50% samples are measured in this work.

iii. Physical property measurement

Proximate analysis consists of characterization of moisture content, volatile matter, ash content and fixed carbon of organic and inorganic waste sample. The Proximate analysis of the sample was analyzed in the muffle furnace with a heating capacity of 1000 ℃. The photographic view of muffle furnace is shown in Fig. 1.

Fig. 1. Photographic view of muffle furnace for proximate analysis

Moisture content (M.C.)

Electrical heating oven was used to find the moisture content of Prosopis juliflora, Fibre-reinforced plastic (FRP) and Prosopis juliflora 50% + FRP 50% sample. A known weight of sample was dried in a crucible at the temperature in the range of 105 – 110 ℃ for one hour of operation and the moisture content was calculated by using the formula,

$$\% \text{ of moisture content (wet basis)} = \frac{(W_1 - W_2)}{(W - W_1)} \times 100$$

Where, W is the weight of the crucible,
W1 is the weight of the sample and
W2 is the constant weight of sample after drying.

Volatile matter (V.M.)

A known weight of sample was heated at a temperature of 600 ℃ for 6 to 7 minutes and then heating up to 900 - 925 ℃ for another 7 minutes of operation in a weighted silica crucible with lid in a muffle furnace. The measure of weight reduction in the sample gives the unstable matter or volatile matter of the biomass test evaluated utilizing the equation given underneath.

$$\% \text{ of volatile matter (dry basis)} = \frac{(W_1 - W_2)}{(W_1 - W)} \times 100$$

Where, W is the weight of the empty silica crucible with lid,
W1 is the weight of crucible, sample and lid, and
W2 is the constant weight of sample after drying.

Ash content (A.C.)

A known amount broiler dried sample was combusted in a pre-weighed and shut silica crucible at 700 - 750 ℃ for a half-an-hour for Prosopis juliflora, Fibre reinforced plastic (FRP) and prosopis juliflora 50% + FRP 50% test was combusted in a pre-weighed and shut silica crucible at 725 ℃ for at least for half-an-hour in a muffle furnace. The sum is assessed utilizing the formula given underneath:

$$\% \text{ of ash content (dry basis)} = \frac{(W_2 - W)}{(W_1 - W)} \times 100$$

Where, W is the weight of the empty silica crucible,
W1 is the weight of crucible and sample and
W2 is the constant weight of sample after combustion.

Fixed carbon (F.C.)

The measure of Fixed carbon (FC) show gives an unpleasant sign of the charcoal yield. Likewise, a higher fixed carbon material is more qualified for gasification than a lower fixed carbon material. The fixed carbon is assessed by utilizing the accompanying equation:

$$\% \text{ of Fixed carbon} = 100 - (\% \text{ of } M.C. + \% \text{ of } V.M. + \% \text{ of } A.C.)$$

iv. Ultimate analysis

The ultimate analysis was determined as the elemental analysis which includes Carbon (C), Hydrogen (H), Nitrogen (N), Sulfur (S) and Oxygen (O). The elemental analysis of the sample was done in CHNS and Oxygen analyzer. The known weight of sample was placed in the Perkin-Elmer 2400 series II analyzer in IIT Madras as shown in Fig. 2, the data's of Carbon (C), Hydrogen (H), Nitrogen (N), Sulfur (S) and Oxygen (O) was recorded.

Fig. 2. Photographic view of Perkin-Elmer 2400 series II analyzer for Ultimate analysis

B. Thermo-gravimetric analysis experiments

Thermogravimetric analysis was analyzed in "Centralised Instrumentation and Service Laboratory" at Annamalai University and the photographic view was shown in Fig. 3. Thermogravimetric analysis of three different biomass samples with three heating rate of 20, 30 and 40 ℃/min were analyzed. Thermogravimetric Analysis or TGA is a sort of testing that is performed on tests to decide changes in weight in connection to change in temperature. Such examination depends on a high level of accuracy in three estimations: weight, time and temperature run. Inert gas (nitrogen) stream is begun to flow not less than 15 minutes before heater warm up to keep up a without oxygen free atmosphere to confine the ignition of biomass. TGA is normally utilized in research and testing to decide the characterization of material such as polymers, to decide deterioration temperatures, ingested moisture content of the material, the level of organic and inorganic biomass mixes in material, disintegration purposes of explosives and dissolvable slag. The analyzer for the most part comprises of a high-precision balance with a skillet, stacked with the sample of Prosopis juliflora, Fibre-reinforced plastic and Prosopis juliflora 50% + FRP 50% weighted 0.31 g, each. The skillet is set in a little electrically warmed oven with a thermocouple to precisely quantify the temperature. The atmospheric air might be cleansed with an inactive gas to prevent oxidation or other undesired reaction. A computer is utilized to control the instrument.

Fig. 3. Photographic view of Thermo-Gravimetric Analysis

C. Kinetics Analysis

A thermo-gravimetric analysis represents changes in weight in connection to change in temperature. In this work, Kissinger equation is associated with choose the warm defilement, through procuring the activation energy (A), repeat factor and reaction demand of the warm corruption of every precedent. Generally, the reaction rate of corruption is in respect to the gathering of the reactant.

$$\frac{dx}{dt} = kf(x) \qquad (1)$$

Where (x=conversion of time (min), k=rate constant (min-1), and f(x) = the function of the conversion.

Equation (1) states the rate of change dx/dt at constant temperature T as a couple of components of the centralization of the reactant f(x) and the rate predictable K. In the event that there ought to be an event of polymer corruption, it is ordinarily acknowledged that the rate of progress is with respect to the centralization of the material which plans to react;

Condition (1) communicates the rate of transformation dx/dt at steady temperature T as a few elements of the centralization of the reactant f(x) and the rate consistent K. If there should be an occurrence of polymer debasement, it is typically accepted that the rate of change is relative to the centralization of the material which intends to respond;

$$f(x) = (1 - x^n) \qquad (2)$$

Where n=reaction arrangement. This capacity is utilized in polymer corruption energy where a strong material is deteriorating to give vaporous response items. The temperature reliance of the rate consistent is given by the Arrhenius equation;

$$K = Ae^{\frac{-E}{RT}} \qquad (3)$$

Where A=frequency factor (1/min), E=activation energy (kJ/mol), R=gas constant (8.3134 Jmol/K), T=Temperature (K). The combination of the above three equation gives the following relationship:

$$\frac{dx}{dt} = A(1-x)^n e^{\frac{-E}{RT}} \quad (4)$$

All together discover the actuation of vitality the waste drain front of 10 mg is warmed at various warming rate of 20,30 and 40°C/min, for temperature up to 600°C. This different warming rate is required for a dynamic examination dependent on the Kissinger strategy [13]. Temperature rises in the midst of the reaction, the response rate dx/dt will ascend to a greatest esteem, at that point come back to zero as the reactant is depleted [14]. The greatest rate happens when d2x/dt2 is zero. on the off chance that the temperature ascends at a steady warming rate B, in view of the separation of Equation (4).

The TGA strategy was utilized to discover the energy of warm deterioration response. The energy of waste polypropylene and high thickness of polyethylene utilizing TGA and determined the dynamic parameter utilizing an assortment of expository techniques. The enactment vitality of business elastic utilizing customary motor models to be specific Kissinger demonstrate, Friedman model and Ozawa show. The Kissinger display condition is

$$ln\frac{B}{T_m^2} = ln\left(\frac{AR}{E}\right) - \frac{R}{RT_m} \quad (5)$$

III. RESULT AND DISCUSSION

A. Proximate and Ultimate analysis

Prosopis Juliflora is the waste wood grown in agricultural area which was organic biomass but it is unwanted growth in cultivated lands. We collected samples from the agricultural landfills and it was squashed and pulverized to less than 300μm to avoid heat and mass transfer limitation. Fibre-reinforced plastic is the inorganic waste derived from glass fibre industry from Chennai and then the FRP material was squashed and pulverized in a crushing machine, the particle size was maintained less than 300μm to avoid heat transfer limitation. The proximate analysis (ASTM D5142), ultimate analysis (ASTM D3176), and calorific values (ASTM D3523) of Prosopis Juliflora (PJ), Fibre-reinforced plastic (FRP) and Prosopis juliflora + Fibre-reinforced plastic (PJ+FRP) (in the ratio of 50:50) are presented in Table 1.

TABLE I
DESCRIPTION OF CHARACTERIZATION

Properties	PJ	FRP	PJ+FRP (50:50)
Bulk Density (kg/m³)	412	910	670
Calorific value (kJ/kg)	20940	18860	19940
Proximate analysis			
Moisture content (%, d.b.)	9.1	3.78	4.55
Volatile matter (%, d.b.)	21	25	19
Ash content (%, d.b.)	1	25	14
Fixed carbon (%, d.b.)	68.9	46.22	62.45
Ultimate analysis			
Carbon (%)	46.18	46.12	48.11
Hydrogen (%)	5.73	3.71	4.13
Nitrogen (%)	0.31	0.14	0.20
Sulphur (%)	0.26	0.01	0.14
Oxygen (%)	47.52	50.02	47.42

The bulk density of PJ, FRP and PJ+FRP (50:50) was 412, 910 and 670 kg/m3 respectively. The bulk density of PJ and PJ+FRP was lower than FRP. FRP has high bulk density than organic biomass, it is very beneficial for combustion systems due to its higher energy value for smaller volumes and needs less storage area. Low bulk density results in improper flow of fuel as reported as [15] of Prosopis Juliflora has a bulk density as 407 kg/m3.

The calorific value of PJ, FRP and PJ+FRP (50:50) are 20940, 18680 and 19940 kJ/kg respectively. High calorific value shows the great qualities for gasification, on the grounds that higher warmth provoked during oxidation leads to high temperature in response zone. The calorific value of babul wood was 16820 kJ/kg as reported by [15] and the calorific values of 20 different biomass samples was investigated and reported that the calorific value of biomass was in the range of 16000 – 21000 kJ/kg was expressed by [16]. Lower calorific value biomass were also carried out by [17] and expressed the cashew nut shell calorific value was 4252 kcal/kg.

The moisture content of PJ, FRP and PJ+FRP (50:50) are 9.1, 3.78 and 4.55 (wt%, d.b.) respectively. The moisture content of PJ was higher when compared to FRP, because PJ was an organic biomass which was derived from nature but FRP is derived from industrial waste which was inorganic which naturally limits the moisture content. The moisture content of the wood pellets was in the range of 6.1 to 10.4 (wt%, w.b.), as mentioned in [18]. The volatile matter of PJ, FRP and PJ+FRP (50:50) are 21, 25 and 19 (wt%, d.b.) respectively. The ash content of PJ, FRP and PJ+FRP (50:50) are 1, 25 and 14 (wt%, d.b.) respectively. PJ and PJ+FRP has a low volatile matter when compared to FRP, due to the quality of resin present in the FRP material. The ash content of the FRP material is higher when correlated with PJ and PJ+FRP, whereas the ash content FRP material will be high due to fiber plastic content was present. PJ and PJ +FRP indicates the higher fixed carbon it shows the good biomass characterization for thermo-chemical process called gasification. The volatile matter, ash content, fixed carbon and calorific value of subabul wood was 82068, 1047, 15850 (wt%, w.b.) and 15187 kJ/kg respectively conferred by [19]. The volatile matter, ash content and fixed carbon of waste phenolic FRP was mentioned by [20] are 28.26, 57.32 and 14.42 respectively. [15] is reported that the moisture content, volatile matter, ash content and fixed carbon are 6.45, 79.54, 1.53 and 18.93 respectively for cashew nut shell.

The elemental analysis indicates the Ultimate analysis which belongs to Carbon, Hydrogen, Oxygen, Nitrogen and Sulphur. PJ and FRP has lower carbon content but higher in hydrogen and oxygen compare with PJ+FRP.

For the thermo-chemical conversion process, Carbon plays a major role in the elements as it has direct consequence on the calorific value according to same; higher the carbon content of PJ+FRP represents the higher calorific value of fuel. The ultimate analysis of phenolic FRP was performed by [20] and determined the carbon, hydrogen, oxygen and nitrogen content 37.52, 3.37, 10.76 and 0.05% respectively. [21] studied the ultimate analysis of peach stone and presented the carbon, hydrogen, oxygen, nitrogen and Sulphur content 51.59, 5.76, 40.7, 0.79 and 0.01 % respectively. The ultimate analysis of pine saw dust and rice straw analyzed and determined the carbon, hydrogen, oxygen, nitrogen and Sulphur content 45.39, 4.02, 38.10, 0.62 and 0.41%; 38.61, 4.28, 37.16, 1.08 and 0.65 respectively [22]. The ultimate analysis of coffee husk was performed by [23] and determined the carbon, hydrogen, oxygen and nitrogen content 46.8, 4.9, 47.1 and 0.6 % respectively.

B. Thermo-gravimetric Analysis
i. Effects of heating rate

A classical TGA plot of PJ, FRP and PJ+FRP (50:50) as a sample in a Nitrogen atmosphere with a gas flow protection range of 40 ml/min and purge2 gas flow as 100 ml/min with a heating rate of 20, 30 and 40 ℃/min simultaneously in a Al2O3 crucible. The TGA profile demonstrates the run of the mill corruption profile of the Prosopis Juliflora at a three diverse heating rate of 20, 30, 40 ℃/min all the while with a well arrival of dampness substance called moisture content, devolatilization and char degradation was shown in the Fig. 4.
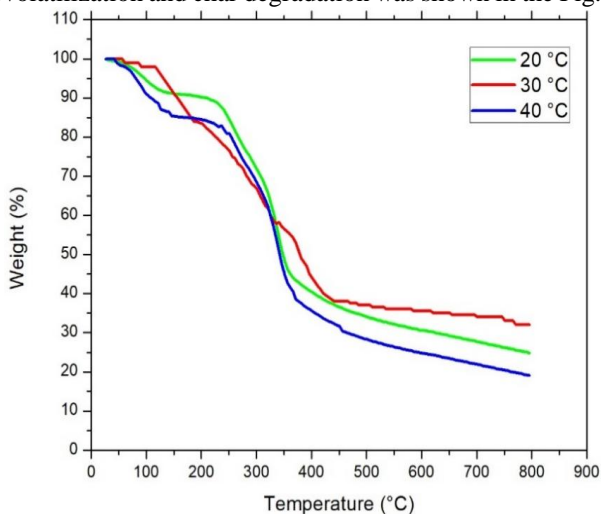

Fig. 4. Typical TGA diagram of Prosopis Juliflora at different heating rate

The consolidated TGA of various heating rate of 20, 30, 40 ℃/min as appeared in Fig. 5 demonstrating the thermal degradation attributes of Fiber-Reinforced Plastic. The lignocellulose biomass can be separated into three primary regions by pyrolysis process: dampness moisture content and light volatile segments removal (<170 ℃); debasement of hemicellulose (170– 313 ℃); lignin and cellulose disintegration (313 – 450 ℃) and lignin deterioration (>450 ℃). The absence of lignin occurs at a gradual rate over a wide range temperature of 180–800 ℃. Most of the de-volatilization occurred in the stage II (Active Pyrolysis) of weight loss, as a result of thermal decomposition of weak bonds in the polymeric structure of the constituent components of the FRP and the formation of stronger, stable bonds to take the lignocellulose components into degradation of sample.
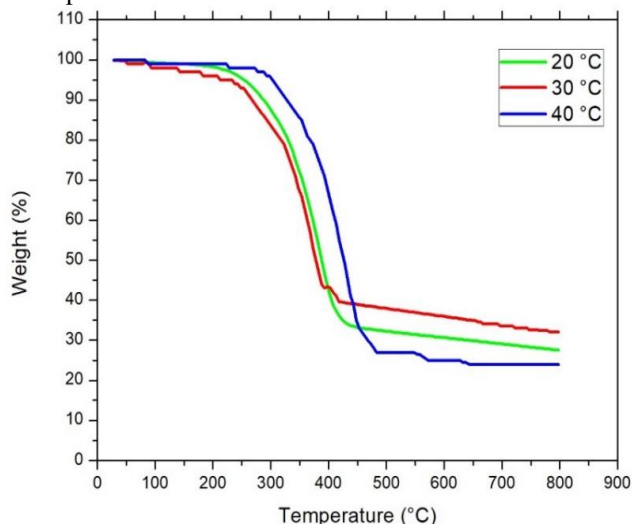

Fig. 5. Typical TGA diagram of Fibre-Reinforced plastic at different heating rate

The merged thermogravimetric anlysis of different heating rate of 20, 30, 40 ℃/min exhibiting the warm degradation properties of Prosopis Juliflora + Fiber-Reinforced Plastic (50:50). The pyrolysis procedure of the lignocellulosic biomass can be isolated into three essential areas: moisture content and light volatiles portions evacuation (<120 ℃); corruption of hemicellulose (120– 250 ℃); lignin and cellulose deterioration (250 – 400 ℃) and lignin debasement (>400 ℃). The loss of lignin normally happens at a slower rate over a much wide temperature scope of 130– 800 ℃ as shown in Fig. 6. The greater part of the Devolatilization happened in the stage II (Active Pyrolysis) of weight reduction, as the effects of warm decay of powerless bonds in the polymeric structure of the constituent segments of the PJ+FRP and the development of more grounded, stable bonds to take the lignocellulose segments into debasement of test.
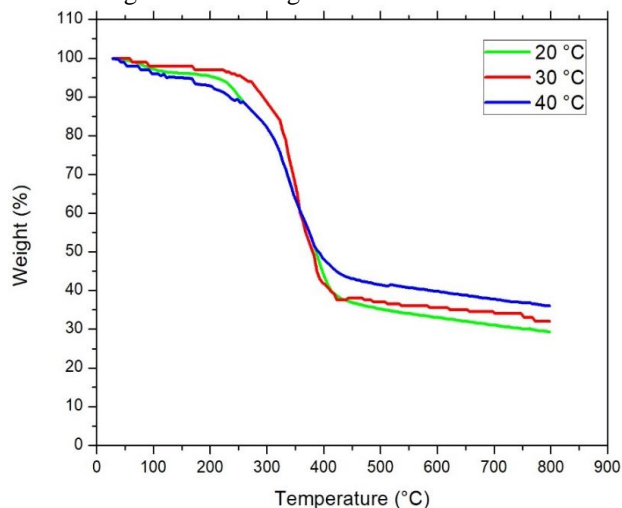

Fig. 6. Typical TGA diagram of PJ + FRP at different heating rate

ii. Effect of 20 ℃/min heating rate with different sample

Thermo-gravimetric analysis of the PJ, FRP and PJ+FRP (50:50) was measured and plotted in the Fig. 3.4 with a heating rate at 20 ℃/min.

The continuous and sustainable TGA curve has shown in the 20 ºC/min was given a successful curvature in a nitrogen atmosphere. Table 3.2 shows the first stage of PJ occurs a weight loss in the range from 26 ºC to around 241 ºC depends on the heating rate, it may correspond to the loss of water content present in the biomass. Light volatile matter dissipated is in the range of 303 ºC to 428 ºC and heavier volatile matter deplete in the bound of 428 ºC to 800 ºC. The derivative plot of the region between 303 ºC and 800 ºC showed only one observable peak. FRP matter reduces the moisture content in ambit of 26 - 208 ºC, light volatile matter scattered is in the scope of 253 ºC to 418 ºC and heavier volatile matter drains in the bound of 418 ºC to 800 ºC. And finally, Prosopis juliflora + Fibre-reinforced plastic (50:50) (PJ+FRP) was reduced the water vapour in the ambit of 26 - 103 ºC, devolatilization occur in the range of 233 – 418 ºC and passive pyrolysis occur in 418 ºC to 800 ºC.

TABLE II
TEMPERATURE RANGE AND WEIGHT LOSS AT 20(ºC/MIN)

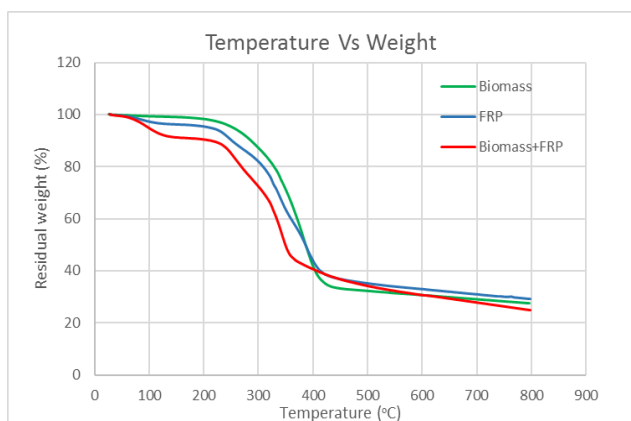|	PJ		FRP		PJ+FRP (50:50)	
	Temp. (°C)	Wt. (%)	Temp. (°C)	Wt. (%)	Temp. (°C)	Wt. (%)
Stage I	26	100	26	100	26	100
(Dehydration)	241	96	208	95	103	97
Stage II	303	86	253	89	233	89
(Active Pyrolysis)	428	34	418	39	418	39
Stage III	428	34	418	39	418	39
(Passive Pyrolysis)	800	27	800	29	800	24

Fig. 7. Effect of 20(ºC/min) heating rate on TGA plot of different samples

Stages of the reaction may change the temperature with effects of heating rate. Normally, increasing the heating rate will have led to increase the start and end temperatures of each stage due to its heat transfer limitations. Likewise, it ought to be noticed that temperatures specified in this might not have been the genuine sample temperature, but instead the temperatures of the purge gas streaming over the sample close to the holder. Higher heating rate and piece of stacking tends

to deliberate temperature from the real sample temperature [24]. Heating rate increases time might be compulsory for the cleanse gas to achieve harmony within the temperature of the heater because of its heat transfer restrictions.

However, not surprisingly, warming rate did not impact the total weight decrease in any stages of operation. At a moderate warming rate of 20 ºC/min, the weight reduction was like the weight reduction at the higher warming rates of 30 or 40 ºC/min up to the main phase of weight reduction. However, past that the weight reduction for the 20 ºC/min warming rate was out of the blue not quite the same as other warming rate for TGA. The weight loss of samples during the second stage was 63%, corresponding stages and residues are 23% respectively.

C. Kinetics Analysis

The values of ln B/T2m and 1/Tm were determined for different heating rates and Kissinger plot was drawn with ln B/Tm2 versus 1/Tm. From the Kissinger plot the slope was calculated and the activation energy was determined in table III.

TABLE III
ACTIVATION ENERGY BY KISSINGER EQUATION

S.No.	Sample	Activation energy, E (kJ/mol)
1.	Prosopis juliflora	995
2.	Fibre-reinforced plastic	15132
3.	Prosopis juliflora + Fibre-reinforced plastic	7173

IV. CONCLUSION

Prosopis Juliflora (PJ), Fibre-reinforced plastic (FRP) and PJ+FRP (50:50) was successfully analyzed. The variation and relationship between the organic and inorganic samples are found and discussed. The calorific values of PJ, FRP and PJ+FRP are 20940, 18860 and 19940 kJ/kg respectively. The volatile matter content of PJ, FRP and PJ+FRP and 21, 25 and 19 respectively and ash content of PJ, FRP and PJ+FRP 1, 25 and 14 respectively.

Thermo-gravimetric analysis of PJ, FRP and PJ+FRP are conducted in an inert atmosphere (Nitrogen) suggests that there were three distinct stages of weight loss. The weight loss for the 20 ºC/min heating rate was unexpectedly different from other heating rate for TGA. The stage I (Dehydration) ranges from 25 to 240 ºC, the stage II (Active pyrolysis) ranges between 250 to 420 ºC and the stage III (Passive pyrolysis) ranges from 420-450 to 800 ºC. It shows that the slower heating rate will gives the better combustion in the gasification process. The activation energy of PJ, FRP and PJ+FRP are 995, 15132 and 7173 kJ/mol respectively. From the kinetic study the activation energy of FRP is 15132 kJ/mol

which was high when compare to PJ and PJ+FRP, we conclude that about 10000 kJ/mol of activation energy may case higher explosion of toxic gases form FRP waste of gasification process. So, we came to the conclusion that the utilization of PJ and PJ+FRP for gasification process was suitable for generating producer gas.

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