# Thermal-physical properties of agricultural residues for syn gas production using thermo-gravimetric analysis

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**Abstract**

The thermal degradation behaviour and activation energy of biomass can be utilized to know the behaviour and constituent of biomass degradation rate prior to gasification. Suitability of biomass for gasification and power generation was prejudged by its thermo-physical properties. The present study was to explore the thermo-chemical behaviour of agricultural waste biomass for gasification were investigated by thermo-gravimetric analysis method. Two methods was adopted for evaluating the apparent activation energies of agriculture residue i.e. The Kissinger Akahira Sunose (KAS), The Flynn-wall-ozawa (FWO) methods. The results showed that corncob was sensitive to heat and it has the lowest lignin content and activation energy, therefore, it is best suited for feedstock in pallet form for gasifier engine system for producer gas generation in a remote area like village and hill station.

**Keywords:** Pearl millet cob, Corncob, TGA, Thermal degradation

## 1. Introduction

Biomasses is the largest natural resource of energy which is abundant in natures. The benefits of biomass are its abundance, renewability and its property of balancing carbon in nature (Mishra, 2004, Ragauskas et al. 2006).The third largest energy resource in the world is biomass (Vamvuka et al. 2003).The devolatilization parameter is effected the thermal history of biomass (Caballero et al. 1997; Wiktorsson and Wanzl, 2002; Biagini et al. 2004; Otero et al. 2007). Fuel produced from biomass as oil or gas can be used as substitutes for petroleum refinery. Thermal analysis technique, (TGA) which is now being extensively used for the study of thermal behaviour of coal, biomass, polymers (Zhaosheng et al. 2008; Mani et al. 2010) Generally, thermochemical methods are usually preferred over biochemical methods for energy production by lignocellulosic biomass. Gasification, liquefaction, pyrolysis, torrification and combustion are phases of Thermochemical methods (Raveendran et al. 1995). The kinetic study of corn cob, pearl millet cob and eucalyptus is important for the pyrolysis, combustion, gasification and liquefaction. DTG technique uses to measure the thermally weight loss of biomass as a function of temperature and used for evaluating the kinetic parameter of organic substances. The current work is focused on the investigation of thermal behaviour and kinetics of Pearl millet cob, corncob, and eucalyptus respectively.

**Table 1.** Characteristics of the biomass sample

| | Ultimate analysis (wt%, air-dried basis) | | | | Calorific value (kcal kg$^{-1}$ air-dried basis) | |
|---|---|---|---|---|---|---|
| | C | H | N | O | HHV | LHV |
| Pearlmillet cob | 45 | 6.4 | 0.8 | 47.8 | 17.0 | 15.6 |
| corncob | 42.7 | 6.3 | 1.3 | 49.7 | 15.5 | 14 |
| Eucalyptus | 46.6 | 6.3 | 0.03 | 47 | 20.4 | 19 |

## 2. Experimental Result and Discussion

### *2.1 Thermal Degradation of Components*

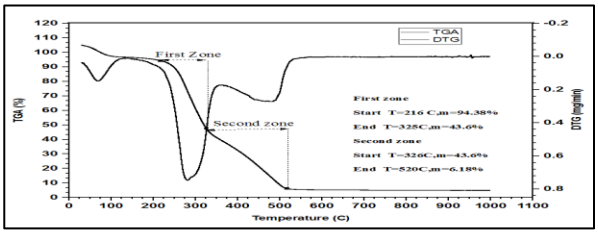
The thermal behaviour of pearl millet cob, corncob and eucalyptus at 10°C min$^{-1}$was shown in figures 1, 2 and 3 respectively. The first peak of differential thermogravimetry at 279 °C and 315 °C, 282°C for pearl millet cob, corncob and eucalyptus respectively.it is due to degradation of hemicelluloses and the second peak is due to the degradation of cellulose at 480 °C, 336°C and 474°C for pearl millet cob, corncob, and eucalyptus respectively which was shown in thermography.

### *2.2 Moisture discharge contours*

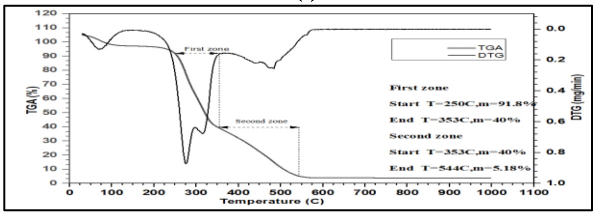
The moisture discharge contours showing the mass loss during the initial stage of thermograph. The pearl millet cob experienced the less mass loss of 2.52 % than corncob and eucalyptus which mass loss has 3.47% and 5.1 respectively. The DTG thermograph of the pearl millet cob one peak represents the moisture region. It has a value of 0.144 mg/min and noticed at 70°C which was more than corncob and eucalyptus whose moisture peak visualise at 66°C and 64°C respectively. The moisture in pearl millet cob is higher than other biomass and it is embedded inside the cell wall so it requires more energy compared to other biomass

### *2.3 Volatiles and char decomposition contours*

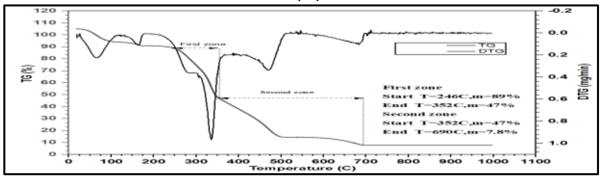
Volatiles and char decomposition stage is the most important region of the TG and DTG profile the volatile mass loss of pearl millet, corncob and eucalyptus were shown in the thermograph and table 2 i.e 85.63, 82.0% and 73.46%, respectively. Mass loss with respect to time is a sign of reactivity of biomass which is explained by DTG. With respect to this, the pearl millet cob and corncob are raidly reactive than eucalyptus. The main volatile matter in biomass start at around 190–215°C.



(i)



(ii)



(iii)

**Figure 1.** Combined TG and DTG contour of (i) Pearlmillet cob (ii) Corncob (iii) Eucalyptus

### *2.4 Burnout thermograph*

İt is that temperature at which mass loss rate continually reduced to less than 1%/min. the combustible nature of biomass is decided by burnout temperature. The low burnout temperature was exhibited by pearl millet cob (520°C). The corncob and eucalyptus showed relatively higher burnout temperature of 544°C and 690°C respectively. In this respect, the pearl millet cob is relatively more readily combustible than corncob and eucalyptus.

### *2.5 Kinetic parameters*

The activation energy of three biomass was determined by FWO, KAS.in this study, the heating rate, 10 °C min$^{-1}$ were used. Arrhenius plots were drawn at different mass conversion rate ranging from 0.1 to 0.9.the pre-exponential factor and activation energy was determined from the slope of the line of each conversion. The activation energies of corn cob, pearl millet cob and eucalyptus determined by kissinger method i.e., 91.29, 106.55 and 77.21 kJ mol$^{-1}$ respectively. The activation energy of three biomass was varied due to different chemical component present in the fibre. The activation energy obtained by KAS method was more suitable than the FWO method because activation energy obtained by KAS method greater than FWO method.

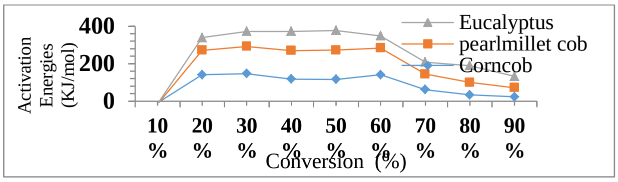



**Figure 2.** Activation energy by FWO method

**Table 2.** Mass loss of three biomass

| Material | Mass loss % | | | Burn out temperature °C |
|---|---|---|---|---|
| | Moisture | Volatile release | char | |
| pearlmillet | 2.5 | 85.6 | 5.5 | 520 |
| Corncob | 3.5 | 82.0 | 3.8 | 544 |
| Eualyptus | 5.1 | 73.5 | 6.6 | 690 |

## 3. Conclusion

1. The corncob and eucalyptus relatively more readily combustible compared to the pearl millet cob because the burnout temperature exhibited by the pearl millet cob is lower than that other two.
2. Generally, lower activation energy and pre-exponential factor has been observed in case of corncob compared with the values get from millet cob and eucalyptus
3. The activation energy obtained by FWO method was more suitable than KAS because activation energy obtained by FWO greater than KAS method.

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