BIOMASS CHARACTERIZATION FOR VARIOUS THERMO-CHEMICAL APPLICATIONS

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Abstract

More than 250 million tonnes of agro-residues under the category of biomass are available all over India. These agro-residues are underutilized. The residues are burnt directly in the field as a means of disposal. This process creates pollution and loss of energy. Agro-residues are considered new energy carriers all over the world.

In this research work ten agro-residues namely, rice husk , groundnut shell , corn cob , bagasse , rice straw , coconut coir , berry branches , wheat straw , cotton stalk , and babool have been characterized in terms of proximate analysis, bulk density, ultimate analysis, calorific value and thermo gravimetric analysis as per ASTM standards.

It has been confirmed from characterization results that almost all agro-residues can be considered good fuel and they can be considered for gasification process. As bulk density of all agro-residues are quite low so they all can be considered for briquetting.

Babool, bagasse, berry-branches, cotton stalk, and corn cob have very low percentage of ash. Hence these agro-residues should be very suitable for their use in the process of gasification and combustion as there will be less possibility of clinker formation and hence less obstruction for flow of gas through these reactors.

On the basis of higher fixed carbon percentage, agro-residues having high percentage of fixed carbon like babool, groundnut shell, rice-husk and cotton stalk can be preferred as raw material for making activated carbon and they seem to be suitable for charring operation through pyrolysis.

Thermo-gravimetric analysis on all selected agro-residues was done for further kinetic studies to design gasifiers, combustors and pyrolysers.

The conclusion of this paper is that all agro-residues need to be characterized before suggesting them for any thermo-chemical applications.

Index Terms- Agro–Residues, Bulk-density, Characterization, and Thermo-gravimetric Analysis.

1-INTRODUCTION

Indian dependence for energy from wood is leading to fast depletion of forest covers. The national reserves of fossil fuels, coal, oil and natural gas, are expected to last for 360 years, 20

years and 36 years respectively at current rate of consumption [1].

More than 250 million tonnes of Agro-Residues are available in our country. At present these residues are either grossly underutilized or completely unutilized by in situ burning in the field as mean of disposal. Development of technologies, to utilize this major resource and their management need to be emphasised to meet the demands of domestic as well as industrial sectors [2].

The performance of pyrolyser, combustor, gasifier etc. for thermo chemical conversion of agro-residues depends upon type of behaviour of individual agro-residues [1]. In general agro-residues normally have the following compositions on moisture and ash free basis: 50% carbon, 6% hydrogen and 44 % oxygen. The moisture content varies over wide range from oven dry to about 90% on wet basis and ash content varies from 0.5 to 22%. Agro-residues have to be characterized in terms of physical and chemical properties before it can be used for particular purpose. [3]

The objective of work presented in this paper is to characterize ten agro-residues: rice husk (RH) , groundnut shell(GNS) , corn cob (CC) , bagasse (Bag) , rice straw (RS), coconut coir (CC) , berry branches(BB) , wheat straw (WS) , cotton stalk (CS) , and babool(B) in terms of proximate analysis, bulk density, ultimate analysis, calorific value and thermo-gravimetric analysis and suggesting their utilization pattern as renewable source of energy through different thermo-chemical processes namely pyrolysis, gasification and combustion to generate energy and value added products in an optimal, economical and environment friendly way [1],[2],[4]. Themo gravimetric analysis of ten agro residues was done to find activation energies and kinetic parameters for activation.

2-MATERIALS AND METHODS

*BULK DENSITY***:** Bulk densities of various agro-residues are determined by standard procedure for storage and preparation of raw material for any reactor.

*PROXIMATE ANALYSIS***:** This involves the determination of moisture, volatile matter (V.M.), fixed carbon (F.C.) and ash content of agro-residues. ASTM standards, recommended for coal, sparking fuel, etc. have been used for the characterization purpose. Proximate analysis for agro-residues was done as per ASTM standards D3173-75 and is reported in **Table 1.**

Table 1: Proximate Analysis

Agro-Residues	V.M. (%)	F.C. (%)	Ash (%)	Bulk Density (kg/m^3)
Babool	72.03	24.97	3.00	207.30
Bagasse	80.27	14.72	5.01	63.50
Berry branches	78.60	19.10	2.30	179.30
Coconut coir	70.13	16.70	13.17	62.90
Corn cob	78.51	18.63	2.86	165.20
Cotton stalk	76.00	20.24	3.76	102.90
Groundnut shell	72.70	21.20	6.10	92.40
Rice husk	61.95	21.00	17.05	109.30
Rice straw	65.50	14.65	19.85	61.80
Wheat straw	72.50	17.60	9.90	55.10

*ULTIMATE ANALYSIS***:** Ultimate analysis as per ASTM standards D3174-76 for agro-residues was done and percentage of carbon, hydrogen and oxygen are reported in **Table2.** From ultimate analysis one can derive each component and overall material and energy balances during conversion process. These calculations are prerequisite in assessing the performance of any gasification/ combustion system.

Table 2: Ultimate Analysis

Agro-Residues	C (%)	H (%)	N (%)	O (%)	Ash (%)
Babool	47.42	5.792	0.87	42.92	3.00
Bagasse	45.76	5.911	0.10	43.23	5.01
Berry branches	45.81	5.942	0.61	45.34	2.30
Coconut coir	46.52	5.503	0.17	34.64	13.17
Corn cob	46.46	6.025	0.36	44.29	2.86
Cotton stalk	46.04	5.715	0.47	44.01	3.76
Groundnut shell	50.58	5.721	0.57	37.03	6.10
Rice husk	40.02	5.268	0.29	37.37	17.05
Rice straw	36.98	5.459	0.63	37.08	19.85
Wheat straw	40.36	5.281	1.44	43.02	9.90

CALORIFIC VALUE:

A high calorific value of the fuel is always advantageous. A very low heating value sometimes makes the agro-residues totally unsuitable and may require some pre-treatment for enriching the fuel. Heating values determined as per **ASTM D2075-77** are reported in **Table3**.

Agro-Residues	Gross Calorific Value (Cal/g)
Babool	4334
Bagasse	4172
Berry branches	4265
Coconut coir	4273
Corn cob	4057
Cotton stalk	4321
Groundnut shell	4694
Rice husk	3829
Rice straw	3494
Wheat straw	3923

Table 3: Calorific Value

THERMO-GRAVIMETRIC ANALYSIS:

For obtaining thermographs, thermo gravimetric analysis was used experimentally in presence of nitrogen gas. TGA is an important tool for obtaining weight loss of sample versus temperature/time. TGA analysis will help one to obtain kinetic parameters for various agro-residues which will further help one to know activation energy and kinetics of an any process (gasification, combustion and pyrolysis).

3-RESULTS AND DISCUSSION:

Table1 for characterization of agro-residues shows that except Babool all agro-residues have bulk density lower than 200 kg/m^3. Hence all except babool require briquetting [5] for their efficient and economical use in thermo-chemical operations like pyrolysis, gasification and combustion [6].

All agro-residues shown in **Table 1** have appreciable amount of volatile content. Hence all can be considered good for gasification process. Agro-residues having higher contents of volatiles are considered better for gasification operations.

As shown in **Table1, bagasse**, babool, cotton stalk, berry branches, and corn cob have reasonably very low percentage of ash. Hence these agro-residues should be all the more suitable for their use in the process of combustion and gasification as there will be less possibility of clinker formation and hence less obstruction for the flow of gases through the reactors.

Babool, cotton stalk, groundnut shell, and rice-husk have appreciably high percentage of fixed carbon (F.C.) as per **Table1**. High value of fixed carbon means high percentage of carbon in the solid char [5]. If ones objective is to get high percentage of carbon in the solid form, one

should go for pyrolysis of these agro-residues [3], [7], [8].

Table 2 shows Ultimate Analysis of considered agro-residues/biomass. These values will help one to know material balance for design of gasifiers, combustors and pyrolysers. Also these values will help one to know net calorific values from gross calorific value.

Further, **Table 3** shows that agro-residues have reasonable values of calorific values. They all may be considered good material for combustion as thermo-chemical process as energy carriers. However, if one wants to increase the calorific values of these agro-residues to a reasonably high value, they need to be briquetted.

.Pyrolysis was carried out in N_2 atmosphere at 40 ^oC/min for all ten biomass as reported in **Table 4.** As clearly seen weight percentage remaining is reducing with increase of temperature clearly indicating emission of volatiles. This data can be used to find rate of pyrolysis and hence kinetic parameters for the process of pyrolysis.similarly one can obtain data for process of combustion also.

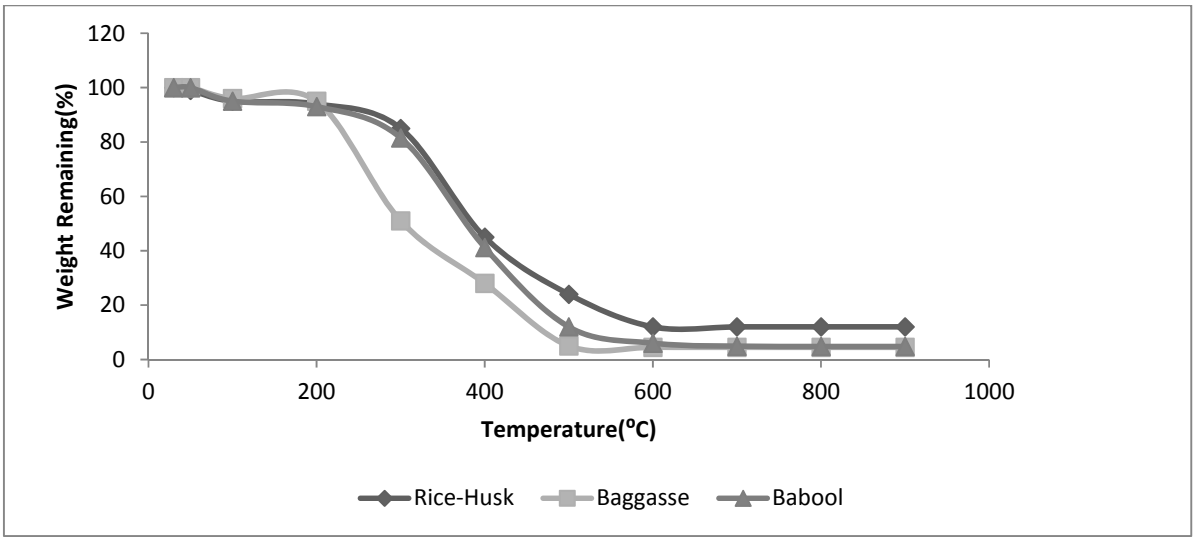
Thermographs of rice-husk, bagasse, and babool are also shown in **Fig1**

Table 4: TGA of Ten Agro- Residues samples (heating rate 40 per minute in N_2)

Temp.(^oC)	%Wt. Remains (B)	%Wt. Remains (Bag)	%Wt. Remains (BB)	%Wt. Remains (CNC)	%Wt. Remains (CC)	%Wt. Remains (CS)	%Wt. Remains (GNS)	%Wt. Remains (RH)	%Wt. Remains (RS)	%Wt. Remains (WS)
30	100	100	100	100	100	100	100	100	100	100
100	96	97	96	93	96	95	97	96	95	95
200	93	96	92	91	95	93	95	94	93	94
300	81	81	81	74	77	72	88	86	77	80
400	41	29	40	33	31	35	45	44	39	40
500	11	05	12	06	06	09	22	24	20	20
600	06	04	08	05	04	04	05	13	18	14
700	05	04	06	04	04	03	05	12	17	13
800	05	04	05	04	04	03	05	12	17	13
900	05	04	05	03	04	02	05	12	17	13

4-CONCLUSIONS

Agro-Residues need to be characterized before proposing to use them for energy carriers through the process of pyrolysis/gasification/combustion processes. Those agro-residues having high percentage of V.M., less percentage of ash are appreciably good for their use in gasifiers and combustors for energy generation. High percentage of fixed carbon (F.C.) is preferred for charring operation through pyrolysis



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