Bio oil Production from various Agro Residues through Pyrolysis

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Abstract

Biomass is considered as the renewable energy source with the highest potential to contribute to the energy needs of modern society. Various agro residues are found and they are selected for the bio oil production. Physical properties such as bulk density and moisture content of agro residues are studied. The bulk density ranges from 95 – 125 kg m^{-3} and moisture content ranges from 4 – 12 per cent for various feedstock. Chemical properties were also determined for the residues. The important properties such as volatile matter content (65 – 85 %) and fixed carbon (15 – 22 %), which were the main criterion for pyrolysis conversion, were found to be higher. Experiments were carried out in lab scale set up to study the temperature effect on the agricultural residues during pyrolysis.

Keywords: *Biomass, Agro residues, Pyrolysis*

1. Introduction

More than 300 million tonnes of agricultural residues are generated every year in the country. India is potentially rich in biomass resources. It is estimated that the quantity of biomass produced in the form of agricultural residues alone is about 395 million tonnes. Agro residues are available abundantly. The most efficient utilization of these residues can be achieved by converting them into a useful value added products by the process of pyrolysis.

Pyrolysis is the process that takes place when organic matter is first heated in the absence of oxygen. Pyrolysis by itself does not normally release excessive heat rather, it requires heat to sustain it. Pyrolysis of organic materials at high temperatures (greater than 220°C) decomposes the fuel source into charcoal and volatile matter. The latter comprises condensable vapors called pyrolysis oil at room temperatures and non-condensable (permanent) gases such as carbon monoxide, carbon dioxide, hydrogen and light molecular weight hydrocarbon gases such as methane, collectively called synthesis gas (syngas or producer gas).

Dai *et al.* (2000) developed an experimental setup of circulating fluidized bed (CFB) for pyrolyzing the wood powder. In this study they concluded that the lower heating rate favoured carbonization and also reduced the yield of liquid products.

Diebold (2003) stated that pyrolysis is the conversion of biomass to a liquid (termed bio oil), solid and gaseous fractions by rapidly heating biomass to about 500~600ºC in the absence of oxygen. Among the products, bio-oil is predominant with a yield between 60~70 per cent (wt.) for different biomass resources.

Pyrolysis produced energy fuels with high fuel-to-feed ratios, making it the most efficient process for biomass conversion, and the method most capable of competing and eventually replacing non-renewable fossil fuel resources (Ozcimen and Karaosmanoglu, 2004).

Islam *et al*., (2010) pyrolyzed the agricultural waste in the form of sugarcane bagasse in a fixed-bed fire-tube heating reactor under different pyrolysis conditions to determine the role of final temperature on the product yields. Final temperature range studied was between 375 and 575°C and the highest liquid product yield was obtained at 475°C.

Hence this study was carried out to assess the suitability and potential of various selected agricultural byproducts and wastes for liquid biofuel production.

2. Materials and methods

The study was carried out in the department of Bioenergy, Tamil Nadu Agricultural university (2010-11) on selected agricultural byproducts and wastes predominantly available in Tamil nadu.

The preliminary trials were conducted with laboratory scale pyrolysis set up fabricated for the production of bio oil from the agricultural residues. Two stainless steel pyrolysis cups were fabricated, maximum of 15 g of sample was filled in the cup and the setup was placed in the muffle furnace. The sample was heated up at five different temperatures of 450°C, 475°C, 500°C, 525°C and 550°C.

3. Results and Discussion

The physical and chemical properties were found out for all the agricultural residues that are considered for the bio oil production.

The bulk density ranges from 95 – 125 kg m^{-3} and moisture content ranges from 4 – 12 per cent for various feedstock. Chemical properties were also determined for the residues. The important properties such as volatile matter (65 – 85 %) and fixed carbon (15 – 22 %), which were the main criterion for pyrolysis conversion, are found to be higher.

Table 1: Bio oil Yield of Various Residues at Different Temperatures

Feedstock	450°C	475°C	500°C	525°C	550°C
FIELD LEVEL RESIDUES					
Paddy straw	37.00	37.00	38.00	38.00	38.00
Sugarcane bagasse	-	25.00	27.00	30.00	31.00
Maize cobs	37.00	37.00	38.00	38.00	38.00
Maize stalks	35.60	35.20	35.20	34.90	34.20
Cotton stalks	49.00	51.00	51.20	52.00	52.60
Soya stalks	57.80	60.10	60.30	56.40	55.40
Tapioca stalks	59.80	62.10	62.30	58.30	57.80
Sunflower head	-	-	16.00	16.40	17.00
Red gram stalks	65.10	68.50	69.00	69.50	69.80
PLANTATION CROP RESIDUES					
Casuarina wood	65.50	66.00	66.30	64.00	62.80
Cashew nut shell	52.00	55.80	58.10	59.20	59.80
Coconut oil cake	61.60	61.90	62.30	65.50	69.90
Coconut shell	62.60	62.90	63.30	66.50	70.85
Coconut husk	65.80	66.20	66.50	65.20	64.00
Arecanut husk	-	-	22.40	22.80	23.90
Jatropha seed husk	55.80	56.20	56.50	55.20	54.00
Jatropha oil cake	49.00	49.30	52.60	54.80	58.20
AGRO INDUSTRIAL RESIDUES					
Saw-dust (African wood)	67.10	67.90	68.90	69.50	69.55
Saw dust (Patak)	65.70	66.20	66.50	64.20	63.00
Rice husk	35.40	35.70	39.00	41.00	41.20
Ground nut shell	42.00	45.00	47.00	48.00	48.00
BIOMASS FROM NON-IRRIGATED WASTE LAND					
Prosopis Julifera	62.80	63.10	63.50	66.90	71.10
Tamarind peel	43.20	43.60	43.70	43.75	43.87
Millia dubia	60.10	61.00	61.22	62.10	62.40
Cotton shell	-	-	-	22.60	23.20

Bridgwater *et al*., (1991) denoted that high volatile matter content with low ash and sulphur content is the main criterion for pyrolysis conversion. It appears that the high volatile content of the feedstock favours the pyrolysis conversion.

3.1 Lab Scale Pyrolysis Study

The agricultural feedstocks were powdered and taken for estimating the bio oil production of each feedstock about 10 - 15 g. The experiment was carried out in a laboratory scale pyrolysis setup. The feedstocks were pyrolyzed at different temperatures of 450°C, 475°C, 500°C, 525°C and 550°C. The quantities of bio oil obtained at various temperatures are given in Table 1.

The bio oil and char yields were noted at these temperatures. It was found out that the bio oil production increased with steady increase in temperature upto 550°C and char production decreased with increase in temperatures.

3.1.1 Effect of Volatile Matter on Bio oil yield

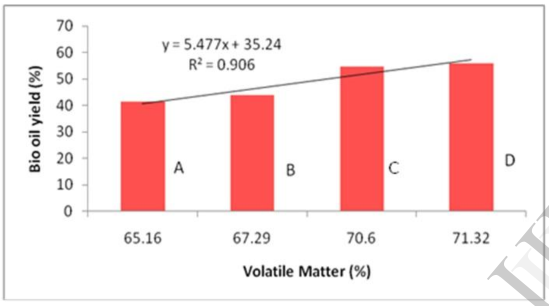

Fig 1. Effect of Volatile matter in Bio oil Production

A – Bio mass from non irrigated lands
B – Field level residues
C – Agro industrial residues
D – Plantation crop residues

Fig. 1 shows that, if the volatile matter present in the residue is higher, then the yield of bio oil was also increased. It is also observed that the increase in volatile matter by 2.5 % increases bio oil yield by 1 %. From the graph it is also depicted that plantation crop residues contains more volatile matter and it can be utilized for the production of bio oil in common.

3.1.2 Effect of Fixed Carbon on Bio oil yield

Fig. 2 shows that, if the fixed carbon present in the residue is higher, then the yield of bio oil was also increased. It also indicates that if 3 % of carbon content is increased in the feedstocks then the bio oil yield of 1 % will be automatically increasing.

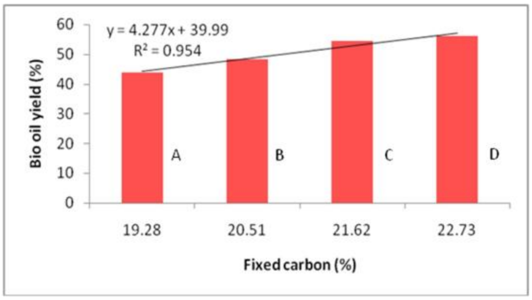

Fig 2. Effect of Fixed Carbon on Bio oil Production

A – Agro industrial residues
B – Bio mass from non irrigated lands
C – Field level residues
D – Plantation crop residues

But volatile matter and fixed carbon is not a constant factor for all the species. It varies for every feedstock. It is also confirmed that the plantation crop residues are much suitable for the production of bio oil.

4. Conclusion

Physical properties such as bulk density and moisture content of different agricultural byproducts were studied. The bulk density ranges from 95 – 125 kg m^{-3} and moisture content ranges from 4 – 12 per cent for various feedstock. Chemical properties were also determined for the residues. The important properties such as volatile matter content (65 – 85 %) and fixed carbon (15 – 22 %), which were the main criterion for pyrolysis conversion are found to be higher. To study the temperature effect on production of bio oil for agricultural residues, experiments were carried out in lab scale set up. 25 number of feedstocks were pyrolysed in lab scale pyrolytic reactor at different operating temperatures of 450°C, 475°C, 500°C, 525°C and 550°C. The bio oil and char yields were noted at these temperatures. It was found out that the bio oil production increased with steady increase in temperature upto 550°C and char production decreased with increase in temperatures.

4. References

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