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Research Article

PREPARATION OF FEED FOR COMBUSTION PURPOSE FROM WOODY MATERIAL BY TORREFACTION

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ABSTRACT

Stems, leaves, flowers, seeds, coconut shells were collected from NEERI, Nagpur campus in the month of April 2016. They were mixed together and pulverized into two particle sizes i. e. 1.4 mm and 3 mm. The pulverized matter of each particle sizes were subjected to low heat treatment with varying temperature and time as follows 230°C (30 min), 230°C (60 min) and 260°C (60 min). Ultimate analysis of raw as well as treated materials was performed by Vario EL III Elementar CHNS analyzer. Net calorific values (NCV) were calculated using modified Dulong formula from elementar analysis of raw and treated woody material.

Upon treatment, increase in calorific values of all the samples were found but the higher calorific value was obtained for 3 mm particle size at 230°C for 60 min.

Keywords: Woody matter, torrefaction, particle size.

1. INTRODUCTION

In India, demand of energy is increasing due to industrialization, transportation as a result of high population growth. The present energy resources are inadequate to meet the increasing energy demand. To solve this energy shortage problem, efforts are being done by the Indian government to tap an alternative non-conventional renewable energy sources and proposed that 17,000 MW shall be produced from biomass [1].

Biomass generated in our surroundings is used in hotels and restaurants for cooking. Economically weaker section use biomass for cooking and heating the water. In addition to this, people burn biomass outside the houses during the winter season. Biomass is also burnt by local residents and some time Nagpur municipality workers for cleaning surrounding areas. Raw biomass has high oxygen and moisture content, low calorific value and shows high hydrophilic nature. The use of raw biomass is harmful to the environment [2-4]. A study conducted by Pipalatkar et. al, (2014) in residential areas showed that nearly 9-15% mass is associated with $PM_{2.5}$ particulates due to biomass burning [5]. These particulates are associated with toxic metals and carcinogenic compounds such as polynuclear aromatic hydrocarbons and reaches up to alveolar region of respiratory tract [6,7].

Technologies such as thermo-chemical, biochemical and chemical processes are used to produce energy from biomass [2]. The thermal pre-treatment process in an inert atmosphere and the low temperature range of 220-300ºC can be used to produce charcoal type of material from raw biomass [8]. In this process, the fraction of hemicellulose decomposes, followed by a small degree of decrease in lignin and cellulosic material [3,9]. This process of torrefaction is useful in the treatment of biomass to make it hydrophobic [10-12]

This study aims to use the woody material which is available locally to prepare feed that can be used for combustion.

2. MATERIAL AND METHODS

2.1. Collection and torrefaction of raw biomass

Stems, leaves, flowers, seeds and coconut shell were collected from NEERI campus, Nagpur. Prior to treatment, moisture was removed from the samples at 105°C to obtained stable weight (ASTM standard

(D1762-84). The dried biomass was pulverized by Willey mill machine into two different particle sizes i. e. 1.4 and 3 mm.

The biomass samples were weighed ~15 gm placed in the centre of the oven in the ceramic crucibles. The samples were wrapped completely with aluminium foil to minimize contact with the atmosphere during the heat treatment. These materials were subjected to low heat treatment at different temperature (°C) and time (minutes) given in brackets 230°C (30 min), 230°C (60 min), 260°C (60 min). The samples were allowed to to cool and then kept in a desiccator. The experiment was repeated for four times. Raw as well as treated materials were subjected to ultimate (Vario EL III elementar CHNS analyser) analysis.

2.2. Elemental analysis

The elemental composition of all the samples were performed in a VarioEL Elementar Analysensystem GmbH. Vario EL III element CHNS analysis works on the principle of dynamic flash combustion, where the resulting gas species (CO_2, SO_2, H_2O and N_2) are separated by gas chromatography and detected by a thermoconductivity detector (TCD). Special Windows ® software WinVar software was used for automated analytical processes. To detect the CHNS elements, biomass samples were combusted in an oxygen atmosphere and the flow carrier gas helium (He) was used to carry the elements. The programming methods used in the analysis were: the flow (He) carrier gas 80 ml/min, pressure of carrier gas 80 kPa, at a temperature of 980°C for FF and 115°C for GC oven. Sample weights were taken for analysis up to 5mg.

2.3. Energy content

The net calorific values (NCV) of raw and treated woody material were calculated by modified Dulong formula using elemental results.

3. RESULTS

The following section presents the results of raw and treated woody material.

3.1. Visual observation

Biomass visual appearance before and after low heat treatment is shown in Fig. 1.

Colour of all the treated samples became black when compared with the raw biomass. The change in colour of the product became darker with the increase in temperature and residence time.

Fig. 1: Biomass visual appearance before and after low heat treatment

3.2. Mass and Energy yields

The mass yield, energy yield, and energy density ratio are the three key factors used in this study which are defined as:

$$My\ (\%) = \left(\frac{MTS}{MRB}\right) \times 100 \ldots\ldots\ldots (1)$$

Where; M_y - Mass yield, MTS-Mass of treated biomass, MRB – Mass of raw biomass

Results of ultimate analyses (C,H,N.S,O) and mass yield of raw and treated woody matter are summerized in Table 1. Results showed that, increase in temperature and residence time reduces the mass yield for both biomass particle sizes indicating degradation and vaporization of biomass constituents [3]. Thus, both temperature and time are significant variables in the low heat treatment of wood.

Reaction of woody matter of particle size 1.4 mm at 230°C for 30 min gave a mass yield of 94% decreasing to 84% for the exposure period of 60 min. Similarly, exposure of 3 mm particle size at 230°C for 30 min gave 94 % mass yield that decreased to 80% for the exposure time for 60 min. Slight variations in differences were observed in mass yield for the particle sizes 1.4 mm and 3 mm at 260°C for 60 minutes. This can be attributed to the oxidizing atmosphere under which the low heat treatment was performed. The partial combustion possibility of the biomass would explain the observed trends in mass yield. The mass yield data for biomass in this study is comparable with literature data for different biomass materials treated for 60 min in a N_2 atmosphere at 230°C. Pach et al. (2002) found a mass yield of 92.4% and energy yield of 96.5% for pine wood [13]. Zanzi et al. (2004) estimated values of 96.5% mass yield and 97.5% energy yield for wood pellets [14]. Among these studies, observed variations in mass yield may be attributed to the nature of biomass and the conditions (inert or oxidizing atmosphere) utilized. The NCV in Kcal/Kg of raw woody matter and treated biomass for two particle sizes are shown in Fig. 2. Higher NCV was found for 230°C for 60 min. for both the sizes but the higher NCV was observd for 3 mm particle size.

Table 1: Results of ultimate elementary analysis (%) and mass yield of raw and treated woody matter

Treatment conditions	Carbon	Nitrogen	Oxygen	Sulphur	Hydrogen	Mass Yield (%)
RAW	36(5)	2(9)	56(3)	0.4(27)	5(14)	-
1.4-230-30	36(6)	3.5(29)	55(7)	0.0(0)	5.4(11)	94
1.4-230-60	41(1)	1.6(8)	50(1)	2.5(34)	5.5(2)	91
1.4-260-60	38(17)	1.8(8)	55(14)	1.2(33)	4.2(26)	84
3-230-30	42(1)	3.4(38)	48(2)	0.0(0)	6.7(2)	94
3-230-60	45(6)	1.2(18)	45(4)	2.8(30)	6.1(1)	91
3-260-60	46(1)	1.4(17)	46(3)	1.2(29)	5.5(2)	80

Relative standard deviations in percentage are given brackets

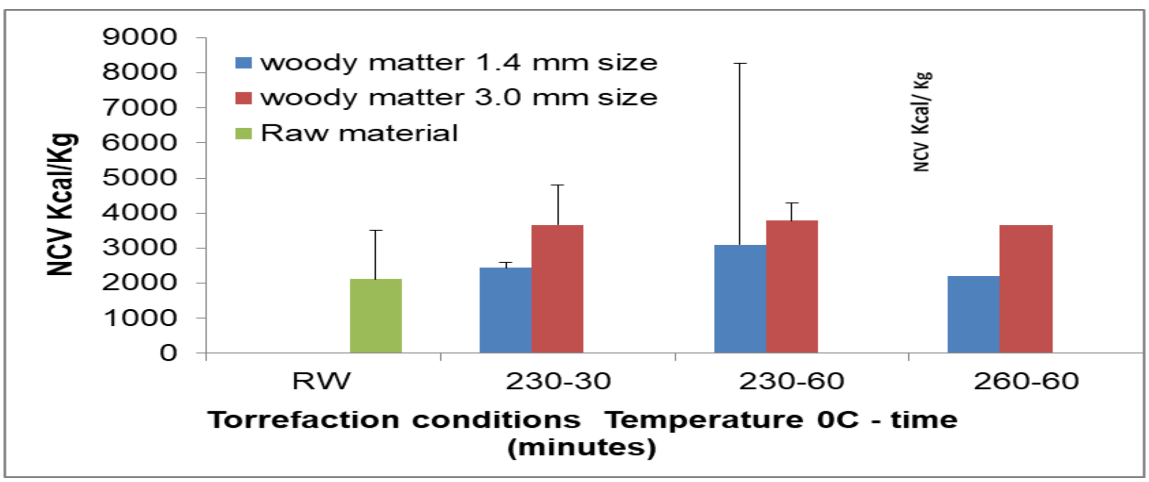

Fig. 2: NCV in Kcal/Kg of raw woody matter and treated biomass for two particle sizes

4. CONCLUSIONS

Burning of raw biomass generates a lot of air pollution. To minimize this kind of pollution, it is recommended to convert it into the product having high calorific value.

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