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Kinetics Analysis Of Coconut Shell By Using Thermogravemetric Analyzer

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Abstract

This study is highly focused to use the biomass waste for energy production, coconut shell is selected for this study, the tree of coconut found in South India, according to the hot climate condition's but coconut used everywhere in India and its waste coconut shell found mostly on coastal area and around holy temples. Coconut shell is a waste, it has good quality as a solid fuel.

In this study it is mentioned that physical and chemical characterization proximate analysis (moisture, volatile matter, fixed carbon and ash content and density) of coconut shell and thermal stability of coconut shell analyzed by calorific value and activation energy by using bomb calorie meter and TGA analyzer.

Keywords: Coconut shell, TGA analysis, kinetic rate, activation energy, frequency factor

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1.Introduction

Recently the Scientist of all over the world are giving their attention to utilizing the agricultural waste as a source of raw materials for the industry. The utilization of these wastes would lead to help in foreign exchange earnings, economical and reduction of pollution [1-2].

Coconut produced in 92 countries worldwide, Indonesia is the world's highest coconut producer country and along with India and Philippines they are producing around 75 % of world's coconut. Therefore, throughout various tropical countries of the world coconut shell can be utilized as an agricultural waste in a very large quantity. Coconut shell was major agricultural products for tropical countries as a new source of bio- fuel [3]. The coconut shell is constantly available and it is solid biomass fuel. Activated carbon produced from coconut shell is preferred as a powerful substance for the removal of impurities from water by treatment process. There are two methods for making of the activated carbon, these are chemical and physical activation. Chemical activation is mostly used in industries so it is preferable because it needed less temperature and less time. But chemical activation is more preferred than the physical activation

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because it generally takes place at lower temperature and lesser time and the development of porous structure is of good enough as compared to physical activation [4]. The coconut shell has potential to consist high heating value 20.8 MJ/Kg, therefore it can be used for the manufacture of energy- rich gases, steam biofuel (pyrolytic oil), charcoal etc. coconut shell is more acceptable for pyrolysis process because it has potential to generate clean energy because high calorific value, volatile matter and less inorganic contents .

Biomass contributes to about 14% of the total energy supply worldwide, India is a agricultural country therefore, it has a potential to generate energy through biomass. Generally biomass energy is produced from animal dung, agro based industries, firewood etc. India holds the fourth position in producing power from biomass in the world with this huge potential India is assured to become a world leader in the utilization of biomass. A large variety of fuel i.e. coconut shell, firewood (eucalyptus), rice husk, crop stalk etc., were used for the biomass- based power generation. In this article efforts were made to characterize the coconut shell by proximate analysis, calorific value and TGA analysis for the determination of the kinetic parameters.

2. Material and methods

2.1 Sample Prepration

Coconut has been collected from the nearest market. In my project I have used three coconuts. Then separate the shell from the whole coconut and dried in the presence of the Sun. After drying hand crushed the coconut shell in the small pieces with the help of hammer or any heavy metal. Then grind the pieces in the grinder to make the powder.

2.2 Proximate analysis

In this project proximate analysis has been analyzed by using ASTM method. Moisture content analyzed by D3173, Ash content analyzed by using D3174, Volatile matter analyzed by using D3175 and fixed carbon analyzed with the help of weight difference [5-6] .

2.3 TGA

Thermal analysis of the coconut shell measured by using Thermogravemetric analyzer (TGA) it is working automatic and made by Perkin Elmer, model number E1200 Series. It is working on the basis of ASTM method, the apparatus used for creating TG curves is named as thermo balance. It contains furnace, temperature, programmer, recording balance and a recorder. There are two types of balances:- a) deflection type b) null balance. Sample can be heated in inert environment or in O_2 environment, according to the application (pyrolysis or gasification).

Kinetics parameters can be determined by Coats and Redfern method it is discussed below [ ].

3.Results and discussion

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3.1 Proximate analysis

Table 1 : Proximate analysis of coconut shell

Proximate analysis	Moisture	9.5
	Volatile matter	71
	Fixed carbon	18.2
	Ash content	1.3
Density	(kg/m^3)	0.21
Calorific value	(Kcal/kg)	3650

Above, Table indicates that, after the calculation analyzed less moisture content 9.5 wt.%, high volatile matter (71 wt.%), fixed carbon (18.2 wt.%) and less ash content (1.3 wt.%). Volatile matter found higher, it represents the high holocellulose content (hemicelluloses+cellulose) in the Eucalyptus wood. Its density is higher 0.21 Kg/m^3 but the good calorific value so it used to for burning purpose in cook stoves. The stiffness of the coconut shell are high, so it can use for the decoration purposes by using various kinds of painting and it's also used for the burning purposes in the domestic cook stoves for cooking purpose due to the highly volatile matter (71 wt.%) and good calorific value (3650 Kcal/kg).

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3.2 FTIR analysis

Table 2: FTIR analysis of coconut shell

S.No.	Peak	Intensity	Chemical bonds and Identification of functional group	References
1	422.42	56.474	C-C Stretching observed in finger print region	[7]
2	515.98	58.205	C-C Stretching observed in finger print region	[7]
3	766.73	74.849	C-H (def) , mono substituted	[8]
4	848.71	74.95	C-H (def)	[7]
5	896.93	71.785	C-H (def)	[8]
6	1041.6	48.005	C-O stretching chemical bond	[7]
7	1247.02	58.776	C-O stretching (acetyl group)	[8]
8	1328.03	65.962	NO_2 chemical bond found	[7]
9	1374.33	65.794	NO_2 chemical bond found	[7]
10	1426.41	68.951	C-H stretching	[9]
11	1462.09	67.317	C-H (def) (alkane bonds)	[7]
12	1511.28	65.947	C=C stretching, found aromatic compounds	[7]
13	1603.86	70.425	C–C stretching chemical bonds	[7]
14	1653.05	73.409	C–C stretching chemical bonds	[7]
15	1727.31	71.422	C=O stretching chemical bonds	[10]
16	2885.6	85.407	C-H stretching (alkane bonds)	[11]
17	3411.22	63.712	O-H chemical bond found	[11]

Close look of Table 2, indicates that coconut shell represent C-C bonds, C-H, O-H, NO2 chemical bond C=C stretching chemical bond, C=O bonds , all of these bonds represented that coconut shell is a good source of the chemical bonds and functional groups. It represented that coconut shell can be used for the higher energy production for pyrolysis or gasification for clean energy production.

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3.3 Kinetic analysis

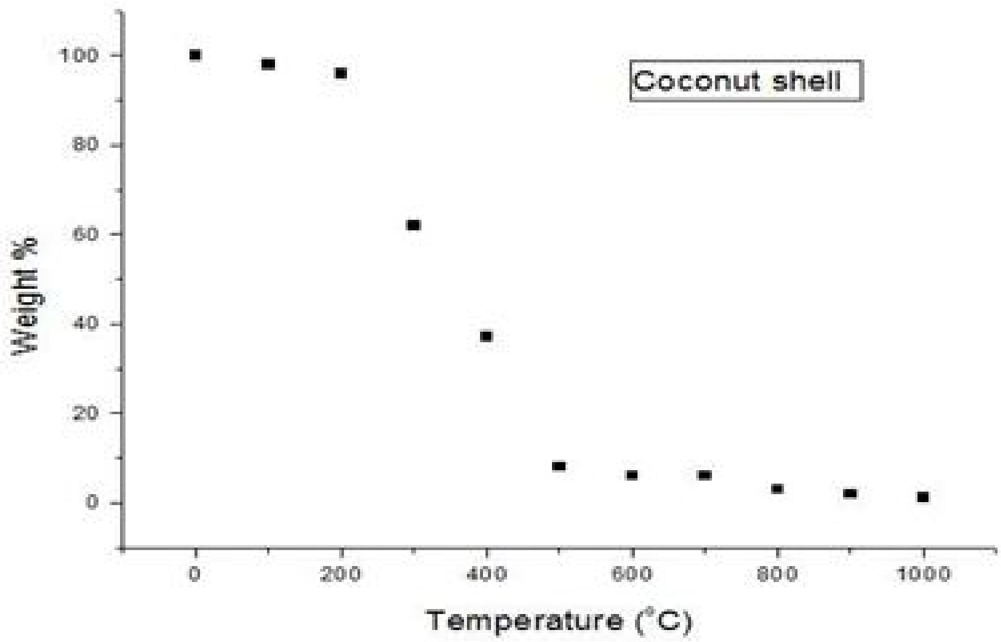

Fig.1 TGA thermogram of coconut shell

TGA thermogramis illustred in Fig. 1, it reports the weight degradation of coconut shell sample, by using this thermogram kinetics parameters, these were calculated by using Coats and Redefern equation.

Fig.1, represents the thermogram between temperature and weight degradation of the coconut shell, in this curve at 100 ^oC weight is maximum and at 200 ^oC temperature, moisture removed from the sample and measure changes occurred between 300 ^oC- 600 ^oC temperatures after 600 ^oC temperature weight is being constant. Coconut shell consists cellulose, hemicelluloses and lignin, cellulose and hemi-cellulose content degradation starts at 200-350 ^oC temperature and lignin is degraded after 350-600 ^oC temperature. The volatile emitted due to the holocellulose content and char remains due to the lignin content [12].

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$$\ln[1-\frac{(1-m)^{1-n}}{(1-n)}] = \ln\left(\frac{AR}{\beta E}\right)\left[1-\frac{2RTa}{Ea}\right]-\frac{Ea}{RTa} \quad \text{(for } n \neq 1) \quad ....(1)$$

for n=1

$$\ln[\frac{\ln((1-m))}{T^2}] = \ln\left(\frac{AR}{\beta E}\right)\left[1-\frac{2RTa}{Ea}\right]-\frac{Ea}{RTa} \quad ....(2)$$

Where m = fractional weight loss of the wood sample

$$m = \frac{(Mi - Mt)}{(Mi - Mf)}$$

M_i = initial weight of the sample

M_t = weight at any time t

M_f = final weight of the sample

Activation energy (Ea) , Ta is the temperature in Kelvin and n is the number and R is the gas constant (8.31 J/mol.K).

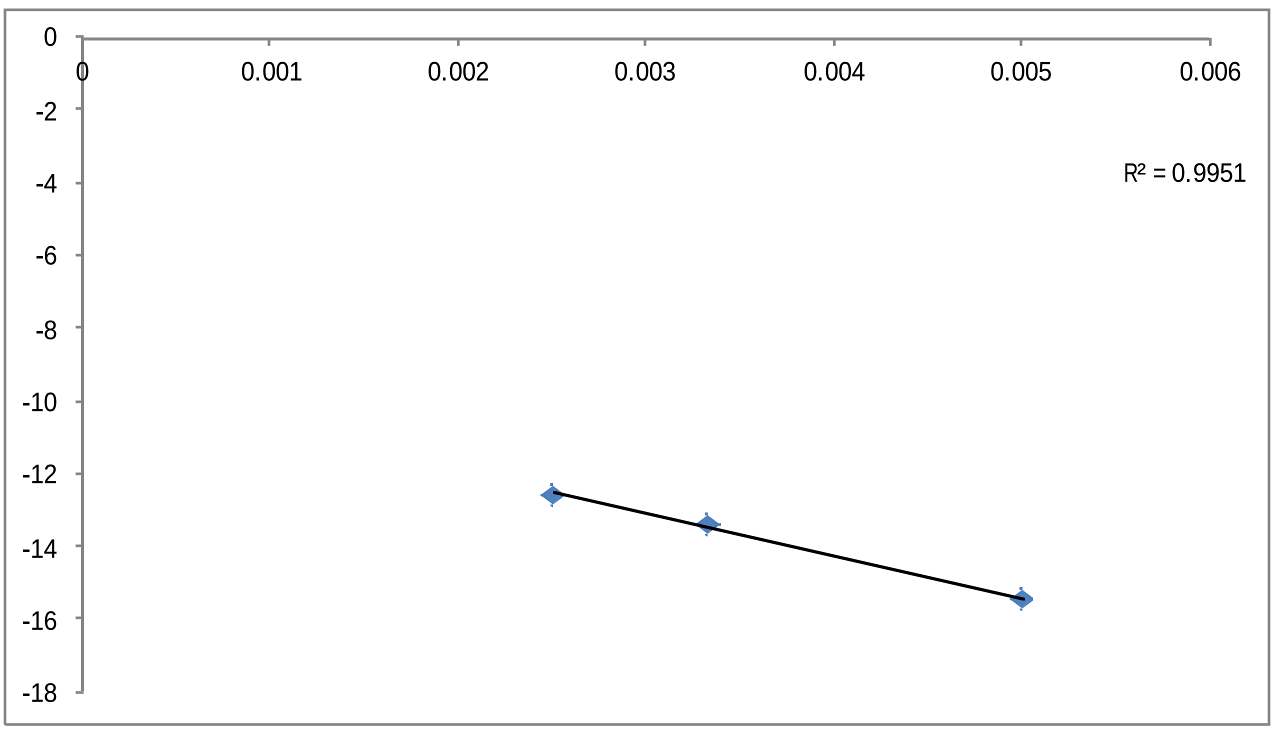

Fig.2 Activation energy graph

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Fig.2 represents the activation energy plot of coconut shell, this plot between 1/T Vs $F(x) = \ln[-\ln(1-x)/T^2]$ by using the Coats and Redfern equation.

Table 3: Test result of TGA thermo-gram of coconut shell

T (k)	β (heating rate)	A(second^{-1})	K (kinetic rate constant)	E(KJ/Kmole)
823	10	0.0086	0.0353	147.24

Above Table 3, indicates the test results of TGA thermogram of coconut shell, Kinetics calculation performed by using Eucalyptus wood thermogram in temperature range 0-1000 ^oC with 10 ^oC/min. heating rate and calculated activation energy 147.24 KJ/Kmole and frequency factor 0.0086 second^{-1} and kinetic rate calculated 0.0353. After the Physico-chemical and thermal analysis, it is found that coconut shell has good thermal stability because its activation energy is high 147.24 KJ/Kmole and good calorific value (3650 Kcal/kg) and high volatile matter (71 wt. %) but less ash content (1.3 wt.%). So, it can be used for the solid fuel in boiler operation, cook stove operation and the gasifiere operation without briquetting.

4.0 CONCLUSION

This study is highly focused to use the biomass waste for energy production, coconut shell is selected for this study, the tree of coconut found in the South India, according to the hot climatic conditions, but coconut used everywhere in India and its waste coconut shell found mostly on coastal area and around holy temples.

This study concluded that the thermal stability of coconut shell is high because it has good thermal stability activation energy 147.24 KJ/Kmole and good calorific value (3650 Kcal/kg) and high volatile matter (71 %) but less ash content (1.3 wt.%) so it is a best solid fuel for the thermal applications for boiler operation, cook stove operation and the gasifiere operation for energy production and electricity generation as well as its charcoal can be converted into activated charcoal.

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