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Activation Energy Analysis of Thermal Degradation of Bamboo Fiber as a Reinforcing Material in Bio-Composites

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Abstract: To study the behavior of thermal degradation of bamboo fiber at single heating rate Broido's method is used. Bamboo is easily available & cheapest material in world wide. It is ecofriendly in nature, renewable & biodegradable. It require low investment cost & high growth rate. It is used as reinforcement material for preparation o composites material. It is suitable for construction industry. TGA analysis is done for thermal degradation behavior. Activation energy is calculated with the help of Broido's method at single heating rate.

Keywords: Bamboo fiber, Thermal degradation, Activation energy, Broido's method

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1. Introduction

From last many decades natural fiber has many advantages over synthetic one. Bamboo fiber is best known natural material & amply available in china. Bamboo fiber is bast fiber [1]. Bamboo is available at approx. 1000 variety. Bamboo is also known by its scientific name Bambusoideae. The Demand of bamboo is increasing as population is increasing. These fibers are Biodegradable, anti-bacterial, bio degradable, environment Friendly, & Shiny appearance [2].

There are many application of bamboo fiber like in manufactures of bridges & poles & in residential complexes such as in building & flooring material [3]. Bamboo is cellulosic fiber Extraction of bamboo fiber is done by bamboo plant. Bamboo fiber is prepared by different steps like cutting of stem, separation, boiling & fermentation. Bamboo fibers are durable & cheap [4]. Application of bamboo fiber is in construction industry, biofuel production, paper industry, musical industry etc. it is alternate source for pulp & paper industry. Thermograivnoemtric analysis (TGA) is done for thermal degradation of fiber. Bamboo fiber is best suited material or reinforcement material for preparation of composites [5]. TGA analysis is used to calculate the activation energy of fiber & it is different for different fibers like for hemp fiber its value is 170 KJ/mol & for wood pine its value is 150 KJ/mol [6]. Thermal degradation of fibers naturally occurs between 210-320˚C. Thermal degradation kinetics can be analyze by different method at different heating rate. There are three different method for calculation of activation energy at different heating rate like KAS, FWO & Friedman method [7]. These methods are suitable at different heating rate but if we want to calculate activation energy at single heating rate Coats & Redfern & Broido's method is used [8].

2. Materials & Methods

The Bamboo fiber purchased from Vruksha composites and service Chennai. Firstly fibers were washed with distilled water and dried in ambient condition & cut to 60-70 mm before use. TGA-4000 thermogravimetric Analyzer is used for TGA Analysis & the flow rate of nitrogen was kept constant at 200 ml/min. 8-10 mg samples were used for the analysis at a single heating rate of 10°C/min [9]. Thermal stability analysis of the fibers was tested by heating it from room temperature to 650° C. to understand the decomposition behavior of Bamboo fiber. The outcome of decomposition activation energy helps to understand the thermal stability and decomposition behavior of natural cellulosic fibers concerning composite processing [9]. The thermal decomposition activation energy of the Bamboo fibers was calculated using the Broido's relation given in equation below:

$$\ln [\ln (1/Y)] = - (E/R) [(1/T) + K] \quad (1)$$

Where:

Y: normalized weight (Wt /Wo)

E: kinetic activation energy

R: universal gas constant

T: temperature

K: reaction rate constant.

3. Results and discussion

From the Broido's method, graph is plotted as indicate in Fig. 1 & activation energy is calculated [10]. Thermal degradation occurs at three steps, & initially degradation starts at approx. 99.5˚C [11]. Initially weight loss occurs due to water vaporization. The next stage of vaporization starts at approx. 205˚C to 315˚C. At this stage mass loss occur due to elimination of amorphic fractions and glycosidic linkages of cellulose [12]. The third & last stage of degradation occurs at around 315 to 525˚C & this occurs due to decomposition of lignin and α-cellulose [13]. Activation energy is calculated with the help of equation (1) & data is shown in Table 1. Activation energy of natural fiber is different for different fiber [14] & It is concluded that activation energy is 90 KJ/mol [15,16].

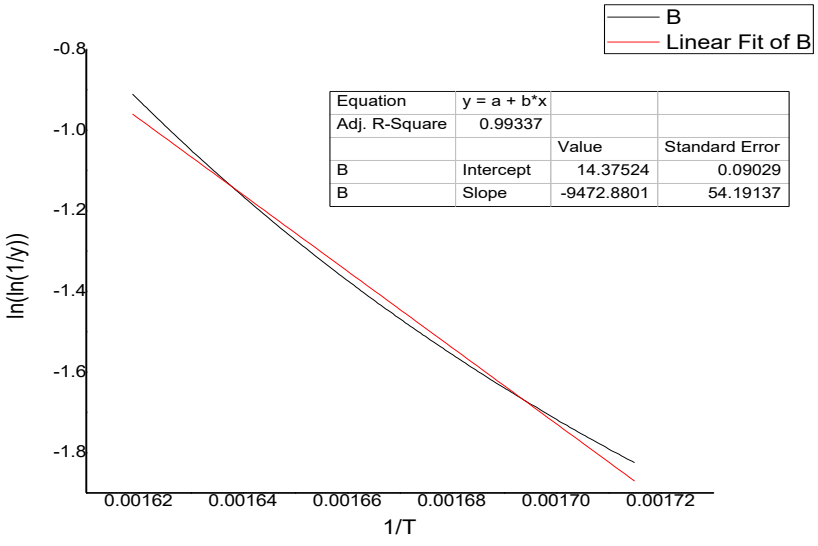

Figure 1. Plot of Broido's method at single heating rate

Table 1. Data for calculation of activation energy

Equation	y = a + b*x	
Adj. R-Square	0.99337	
	Value	Standard Error
Intercept	14.37524	0.09029
Slope	-9472.8801	54.19137

4. Conclusion

This work mainly focusses on thermal degradation behavior with the help of TGA data. Thermal degradation behavior of bamboo fiber is investigated. It is used as reinforcement material in bio composites. Broido's method is used to find activation energy at single heating rate i.e. 10˚C/min. Calculated activation energy with the help of Broido's equation is 90 KJ/mol.

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