Progress in Engineering Application and Technology Vol. 3 No. 1 (2022) 037-043
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PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Bleaching Bamboo Fibre Using Eco Enzyme from Food Waste

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DOI: https://doi.org/10.30880/peat.2022.03.01.005
Received 13 January 2022; Accepted 11 April 2022; Available online 25 June 2022

Abstract: The use of synthetic fibres has caused various environmental problems because carbon and glass fibres are not readily biodegradable and act as pollutant to the environment. Natural plant such as bamboo was introduced to replace synthetic fibres hence the need for bleaching. This research is aimed to study the effect of natural bleaching agent known as eco enzyme on bamboo fibres and compare the results with conventional bleaching agent. The most suitable condition for eco enzyme was analysed and discussed thoroughly. Bamboo fibres were bleached with eco enzyme in different temperature (35 °C, 50 °C, 70 °C) and bleached time (60, 90, 120 minutes) accordingly and further oven dried at 40 °C - 48 °C. Tensile strength and whiteness of the resulting bleached fibres are analysed. Both parameter on the bleach fibre significantly improved compared to untreated fibre with tensile strength increase 64.59 % at temperature of 35 °C – 50 °C and 60 - 90 minutes bleaching, whereas for whiteness it increases 21.70 % at temperature of 50 °C and 60 minutes bleaching. In conclusion, eco enzyme provides better result compared to hydrogen peroxide in term of bleaching duration at considerably low temperature.

Keywords: Bamboo Fibre, Bleaching, Eco Enzyme, Tensile Strength

1. Introduction

Over the past few years, the use of synthetic fibres has caused various environmental problems, because carbon and glass fibres are not readily biodegradable and therefore pollutant to the environment [1]. Because of environmental concerns, fossil fuel depletion and climate change there was a growing concern that natural plant fibre such as jute, coir, flax, hemp, bamboo, and sisal should replace synthetic fibres in polymer composites. The low density, thermal insulation and mechanical properties, low price, durability, sustainability, and biodegradability of natural plant fibres are the main factor that attracts its usage. For thousands of years, bamboo has been utilised in agriculture, crafts, papermaking, furniture, and architecture. However, attempts to make textile fabric from bamboo have been made [2].

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Bamboo is a plentiful natural resource. Bamboos are evergreen perennial blooming plants that belong to the grass family's *Bambusoideae* subfamily. Some of bamboo species can grow 910 mm (36 inches) in a day, at a rate of about 40 mm (12 inches) every hour (a growth around 1 milimeter every 90 seconds, or 1 inch every 40 minutes) (Liese, 2015). The grass family's largest members are giant bamboos. Bamboo is a natural cellulose regenerated biodegradable textile material that is also environmentally friendly. It is not only a green fibre, but it also possesses antibacterial and UV protection properties, making it a unique eco-friendly textile material in the twenty-first century.

The creation of bamboo fibre for textiles has some advantages. Bamboo fibres are an environmentally beneficial fabric derived from bamboo, which is renewable, fast-growing, degradable, and does not take up any cultivated land. In hilly places, exploitation of plentiful bamboo resources can provide a major economic benefit. Furthermore, in China, bamboo fibres are used to compensate the shortage of natural textile fibre and may partially replace the demand for synthetic fibres in clothing and furniture fabric. Bamboo and bamboo fibres are relatively cheap [2]. Because of its good mechanical qualities and high specific strength, bamboo fibre has been employed as reinforcement with various thermoplastic and thermoset polymers in many studies. When fibres are utilised as reinforcement, the mechanical properties of composites are heavily influenced by the fibre-matrix interfacial bonding, which is influenced by the fibre and matrix's physical and chemical properties [3].

Yellow impurities can be found in all natural and regenerated cellulose fibres. As a result, bleaching is frequently used to prepare fibres for dyeing and finishing in order to remove coloured impurities. Natural and regenerated cellulose fibres, as well as their blends with various synthetic fibres, are bleached with hydrogen peroxide (H_2O_2). H_2O_2 bleaching is done in an alkaline bath with a pH of 10-12 and temperatures of up to 120 °C [4]. H_2O_2 has a strong oxidising impact and produces a variety of additional whitening agents, including perhydroxyl anions (HO_2^-) and hydroxyl radicals (OH^-). The type of reaction generated is affected by the pH of the product, temperature, the activation process utilised, and the presence of certain transition metal elements [5]. Using H_2O_2 as a bleaching agent will release a significant amount of poisonous and dangerous chemicals into the environment, which will eventually end up in the soil and water bodies as effluent. The wastewater of these activities acts as a significant source of point contamination because the conventional process cannot remove the inorganic materials.

Therefore, this study is conducted to substitute H_2O_2 with eco enzyme or garbage enzyme that is multipurpose liquid where it is produced from the fermentation of organic waste for bleaching bamboo fibre. The organic solution of the simple fermentation of fresh vegetable waste, fruit waste with brown sugar and water constitutes Eco Enzymes [6]. This fermentation produces a vinegar-like liquid rich in natural proteins, minerals, and enzymes, making it incredibly practical in and out of the kitchen. This enzyme is a composite organic molecule made up of organic acids, protein chains (enzyme), and mineral salts that is created by fermenting waste vegetables, fruits, or peels, sugars, and water [7].

Schizostachyum grande (semeliang bamboo) is adopted to produce bamboo fibre via fibre extraction machine (decorticator). The effect of temperature and bleaching time of eco enzyme on bamboo fibre observed in order to find the suitable condition for bamboo bleaching. The bleached fibre is analysed in term of its tensile strength and brightness.

2. Materials and Methods

Illustration of the details experimental is shown in Figure 1. The flow chart acts as a guide for conducting the research. Three key processes were included in this research project. The initial step was to produce bamboo fibre as the main substance of this research. The bamboo fibre is bleached in the second phase. The final step involves analyzing the treated bamboo fibre.

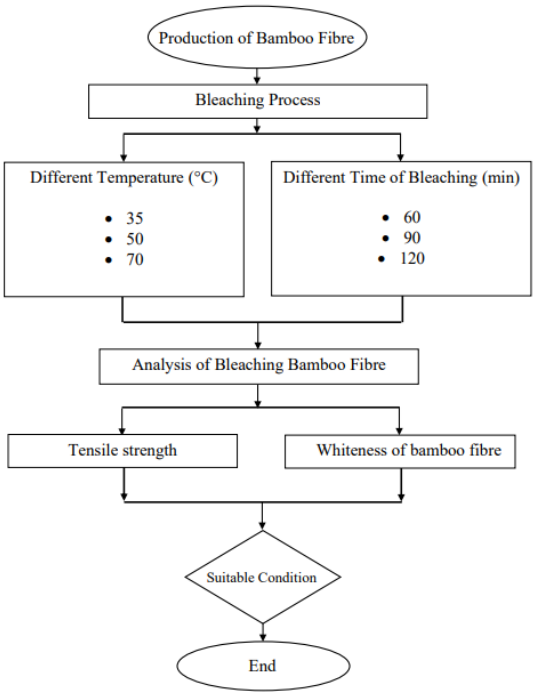

Figure 1: Process Flow of the Experiment

2.1 Materials

The core material for this study are semeliang bamboo strips and eco enzyme in liquid state purchased via online platform, while the main equipment used as listed below:

- Bamboo biber extraction machine (Decorticator, Ameoweld, UTHM JTKM Laboratory)
- Water bath (Memmert, Malaysia)
- Drying Oven (Memmert UN 55, Universal Oven, Germany)
- Universal Testing Machine (INSTRON 50 kN Blue Hill 3369, Malaysia)
- Colorimeter (Hunterlab MiniScan EZ Colorimeter, United Stated)

2.2 Methods

To produce bamboo fiber, semeliang bamboo was selected as the sample due to its thin outer layer and easier to extract. The bamboos were purchased in the form of strips to further facilitate the insertion of the bamboo into the bamboo fibre extraction machine (decorticator). Prior the process of fibre production, the purchased bamboo strips are soaked in water for approximately 3 to 7 days to soften it. Bamboo strips were prewash prior fibre extraction process to remove all the dirt. The washed bamboo strips were divided based on the thickness of the strips to thinning it using machete to avoid the bamboo strips stuck in the machine. The thinned bamboo strips are subjected into decorticator one by one to produce bamboo fibre.

2.3 Bleaching of Bamboo Fibre Using Eco Enzyme

The process of bleaching bamboo fibre had been conducted in two different condition to study the effect on bamboo fibre and gain suitable condition of bleaching bamboo fibre using eco enzyme that was purchased from EnzymeSOS from Malaysia. The condition was included temperature and the bleaching time. 40 mL of eco enzyme is diluted with 1000 mL of distilled water and stirred it using magnetic stirrer for complete mixing. Upon completing bleaching process, all bamboo fibres were oven dried at 40 ℃ - 48 ℃ until fully dried prior subjected to tensile strength and whiteness analysis.

The experiment of eco enzyme on bamboo fibre in different temperature and bleached time were conducted with the condition as shown in Table 1. The temperature and bleaching time for this research was selected according to previous study that using hydrogen peroxide as bleaching agent.

Table 1: Bleaching process condition

Temperature, ℃	Bleaching time, min
35	60, 90, 120
50	60, 90, 120
70	60, 90, 120

2.4 Fibre Analysis

Tensile strength was conducted via INSTRON 50 kN Blue Hill 3369 Universal Testing Machine while for the brightness analysis, Hunterlab MiniScan EZ Colorimeter was used.

Manila card was used to stick the bamboo fibre for tensile strength testing. The manila card was cut according to the predefined size. The sample was tightly clip on the machine to ensure the fibre not sliding from the clipper. The tensile test was performed with speed of 0.48 mm/min.

The whiteness of the fibre is obtained thru colorimeter that compares the amount of light getting through a sample with the amount that can get through a sample of pure solvent. Before the colorimeter read the sample, it was calibrated by taking two measurements. The reading obtained from the colorimeter was lightness (L), redness (a), and yellowness (b) of the sample. The bamboo fibre was ensured that there were no space and gap between the fibre to avoid error and negative reading.

3. Results and Discussion

3.1 Tensile Strength of Bamboo Fibre

The results of tensile strength for control and bleached bamboo fibres with different bleached time and bleached temperature were shown in Figure 2. Tensile strength is defined as stress which is measured as force per unit area. Eco enzyme helped in increasing the tensile strength of bamboo fibre. It can be seen that the tensile strength firstly increased and then decreased with the extension of bleached time and temperature.

Based on Figure 2, sample 1 at temperature of 35 °C with bleached time of 60 minutes showed a huge increment of 194.04 compared to untreated bamboo fibres. However, the tensile strength started to drop significantly when the bleached time increased for each temperature. The deterioration of tensile strength is caused by extension bleached temperature and time to some extent, which results weak interactions between molecules [8]. Hence, the tensile strengths decreased when the treated fibres were over 50 °C. The longer the bleached time and the higher the temperature, the lower the tensile strength. Sample 9 was test at the highest temperature, 70 °C and the longest bleached time at 120 minutes resulted the lowest tensile strength of 79.36 MPa. High tensile strength of treated bamboo fibres with eco enzyme were due to the high load imposed to the fibres. Therefore, the suitable condition for better result in tensile strength is using temperature between 35 °C – 50 °C and bleach in range of 60 – 90 minutes.

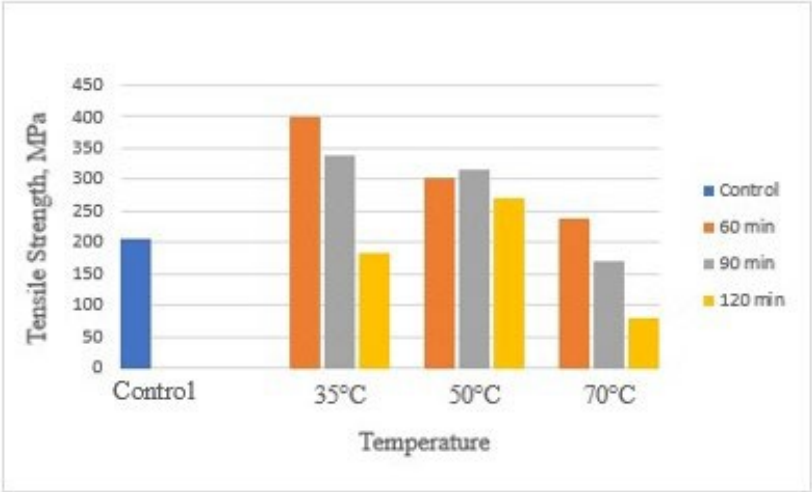

Figure 2: Tensile Strength Using INSTRON 50 kN Blue Hill 3369 Universal Testing Machine

3.2 Brightness of Bamboo Fibre

Table 2 shows the data of the brightness test for each bleached bamboo fibre. The data have three readings which are lightness, redness, and yellowness of the sample. The method started with the controlled sample where it acted as a referenced to compare bleached fibre with the controlled sample. The lower in lightness value indicate that the sample is darker. The controlled sample was the darkest at the lightness of 61.15.

Table 2: The brightness of bamboo fibre for each sample

No. of Sample	Temperature, °C	Time, min	Lightness, L*	Redness, R*	Yellowness, Y*
Control			61.16	6.22	20.33
Sample 1		60	70.29	5.39	21.06
Sample 2	35	90	71.68	4.28	20.36
Sample 3		120	71.95	4.64	19.71
Sample 4		60	74.46	3.68	18.74
Sample 5	50	90	72.69	4.59	19.82
Sample 6		120	70.30	5.29	22.13
Sample 7		60	69.91	4.87	21.23
Sample 8	70	90	68.44	4.59	18.83
Sample 9		120	66.17	6.02	21.20

Bleaching process increase the bamboo fibre lightness by 14.92 % for sample 1 with the lightness value of 70.29. When using different samples and varied bleached duration with constant temperature of 35 °C, the lightness shows increasing value. Sample 4 shows the highest value in lightness with bleaching condition of temperature 50 °C and bleached duration of 60 minutes. It shows that the eco enzyme helps in increasing the brightness of the bamboo fibre with usage of moderate temperature. But the value of lightness started to drop from sample 5 to sample 9 when the temperature and time keep

increasing. Most enzymes prefer a temperature of around 98.6 degrees Fahrenheit (37 degrees Celsius) though enzymes that perform effectively at both low and high temperatures existed. Yet, enzymes are mostly built-up of proteins, and at temperatures exceeding 104 degrees Fahrenheit, they, like other proteins, begin to degrade [9].

As a result, the range temperature for eco enzyme to activate is between 35 °C to 50 °C as shown in Figure 3. The lower in lightness value indicate that the sample is darker. The brightness of bamboo fibre using eco enzyme was higher than bleached using hydrogen peroxide at temperature 50 °C where the value of brightness for fibre bleached with eco enzyme was 74.46 compared to hydrogen peroxide, 20 [10]. Hydrogen peroxide is not very active in short bleaching time and at temperature below 95 °C, the effect of hydrogen peroxide concentration on the whiteness was relatively weak [11]. Therefore, the suitable condition is using temperature 50 °C with bleaching time 60 minutes.

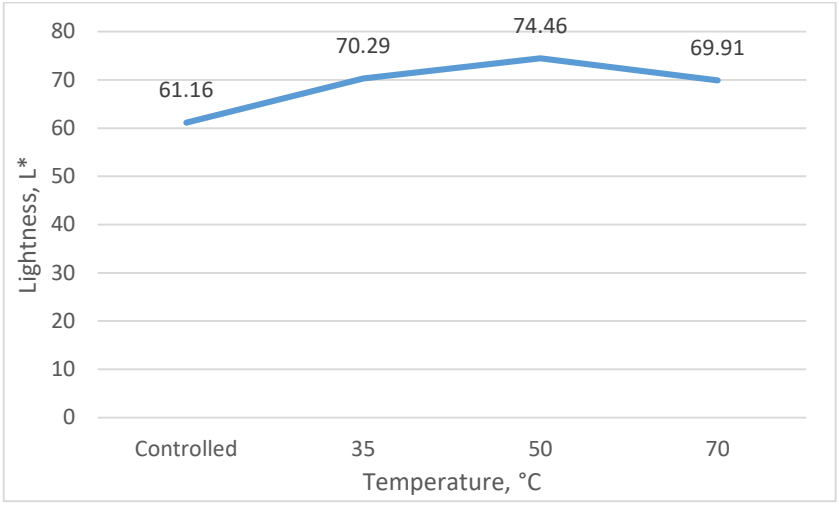

Figure 3: Effect of Different Temperature in 60 Minutes on Lightness Using Hunterlab MiniScan EZ Colorimeter

4. Conclusion

There are many existing methods used in bleaching bamboo fibre either using mechanical or chemical method. Hydrogen peroxide, H_2O_2 is the most widely used as bleaching agent for bamboo fibre as it is cheap and simultaneously act as a bleacher. But the uses of H_2O_2 can affect the environment where it will release effluent that can be toxic and hazardous. This study is focus on the usage of eco enzyme as another alternative or substitute to H_2O_2 as natural bleaching agent where eco enzyme is the mixture of enzyme namely amylase, protease, cellulase and lipase. All of this enzyme has the properties as bleaching enzyme.

This study had been conducted with different parameter in bleaching bamboo fibres to find the suitable condition to use eco enzyme as natural bleaching agent. The treated bamboo fibres have been tested on its tensile strength and brightness to observe the effectiveness of eco enzyme on bamboo fibres. Based on the result, it is concluded that the best condition of bleaching bamboo fibres using eco enzyme is by using the temperature range between 35 °C ~ 50 °C and bleaching duration of 60 minutes.

5. Recommendations

It is recommended that bamboo fire is to be subjected to test with different concentration of eco enzyme to analyze the effectiveness of eco enzyme on bamboo fibre. Besides that, future study can explore more about addition and reaction of other natural enzymes with eco enzyme in bleaching process. It can compare either using one enzyme or more natural enzyme have more effectiveness in bleaching bamboo fibres.

Acknowledgement

The authors would like to thank Universiti Tun Hussein Onn Malaysia (UTHM) for the use of laboratory.

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