Journal of Fibers and Polymer Composites 3 (1): 33-40 (2024)

Journal of Fibers and Polymer Composites

https://journals.gesociety.org/index.php/jfpc/index

BACTERIAL CELLULOSE POWDER AS A FILLER IN A MATRIX COMPOSITE FROM OIL PALM TRUNK

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Abstract. *The paper is to reveal the bacterial cellulose powder as a filler for a composite matrix with an oil palm trunk. The use of oil palm trunks is excellent because of their abundant availability and because they can reduce waste. It is low-density, environmentally friendly, inexpensive, non-toxic, and easily degraded as a matrix that produces hydrogels obtained from cross-linking. This research is a laboratory experiment that makes films by masks using the bacterial cellulose powder obtained through enzyme hydrolysis fillers with the addition of 1%, 2%, 3%, 4%, and 5%. Bio-composite films are readily biodegradable, so the films made from extracting oil palm trunks with stem starch are environmentally friendly. The pH value of the five preparations for film gel masks was the shelf life of bio-composite, which could last for 21 days. Characterization of film masks includes physical properties and analysis of chemical composition, where the amount of water in the film will decrease as the size of the polymer that makes up the film matrix increases. The treatment that produced bio-composite films with the best mechanical properties under the addition of bacterial cellulose powder was 3% filler. The cellulose bacterium can be applied as a filler for making composites by modifying the oil palm trunk as a matrix composite.*
Keywords: *bacterial cellulose; composite matrix; oil palm trunk*

1. Introduction

The current cellulose is the most abundant biopolymer in nature, known as a constituent of the cell walls of eukaryotic plants, algae, fungi, and extracellular polymers from microbes. Bacterial cellulose (bio-cellulose) is a specific product of primary bacterial metabolism and acts as a protective layer, while plant cellulose acts more as a structure in plants. The bacteria salmonella, acetobacter, rhizobium, aerobacter, Achromobacter, and Sarcina can generate bio-cellulose [1], [2], [3].

Bacterial cellulose are extracellular polymers produced from monosaccharide or glucose [4]. Glucose acts as a substrate or carbon source. Compared to plant cellulose fibers, the time needed to obtain bacterial cellulose is shorter, easily degraded, recyclable, non-toxic, non-allergenic, and

Received February 23, 2024; Accepted March 19, 2024; Published March 29, 2024
https://doi.org/10.55043/jfpc.v3i1.157

directly economical. Cellular production is more economical than plant cellulose fiber production. Bacterial celluloses are very expensive when using the Hestrin-Schramm media [5].

Typically, the waste from coconut water contains trace levels of glucose, which is utilized as a substrate. Not only can trash be used as a substrate to minimize production-related waste, but it can also lower the cost of producing bacterial cellulose. A cellulose-producing bacteria known as "nata de coco" ferments waste coconut water. Nata de coco serves as one substitute source of biocellulose. This material can be produced at a reduced cost because it is simple to make, process, and obtain. To enhance the added value of nata de coco products beyond their use as food items, extensive research on nata de coco is required for a variety of fields of application. Bio cellulose has the same chemical structure as cellulose from plants and is a straight-chain polysaccharide composed of D-glucose molecules via β-1,4 bonds [6]

Over the last ten years, cellulose fiber has increased in quantity as a polymer matrix. These benefits include low density, good mechanical qualities, environmental friendliness, abundance, affordability, non-toxicity, easy degradation, and inclusion in renewable natural resources. Marine life, plants, and microbes can all create cellulose fibers. The size and quantity of Indonesia's forest resources have been drastically decreased by the ongoing usage of forest plants to produce cellulose fiber. The outcomes are destroying forests and causing soil erosion, flooding, landslides, and global warming. It is essential to locate substitute cellulose fiber producers to reduce the detrimental effects of these plants' cellulose production [7], [8], [9].

The research aims to reveal the use of bacterial cellulose powder as a filler for a composite matrix with an oil palm trunk. The use of oil palm trunks is excellent because of their abundant availability and because they can reduce waste. It is low-density, environmentally friendly, inexpensive, non-toxic, and easily degraded as a matrix that produces hydrogels obtained from cross-linking. The characteristics of film masks include their physical properties and chemical composition.

2. Materials and Methods

2.1. Materials

The materials used in this study are coconut water waste, sugar, distilled water, Acetobacter xylinum, oil palm trunk (OPT), stem starch, aspergillus nigger, universal indicators, filter paper Whatman, 70% alcohol, carboxymethyl cellulose (CMC), ammonium sulfate (NH_2SO_4), 1% sodium hydroxide (NaOH), acetic acid (CH_3COOH), 98% sulfuric acid (H_2SO_4), hydrochloric acid (HCl), 96% ethanol (C_2H_5OH), and glycerol. All chemicals used in this study were pro analysis grade and purchased from Merck Germany.

2.2. Methods

This work mainly comprises the processes of manufacturing and characterization. To conclude, the characterization data were evaluated. Each phase is explained in detail in the corresponding section below.

2.2.1 Making biocomposites from Oil Palm Trunk (OPT)

Once the OPT stem starch was collected, it underwent two milling treatments: a first treatment in which water was added and a second treatment in which a 0.5% sodium bisulfite solution was added. It was then squeezed and filtered through a filter cloth. Wet starch is created after the garbage is disposed of, and starch-containing water is left for 12 hours. After being cleaned with distilled water, the wet starch is left for 12 hours. After that, the wet starch is dried in an oven set to 50ºCelsius for roughly 30 hours to produce dry starch flour. It is next ground and sieved using a 100-mesh sieve.

2.2.2 Making bacterial cellulose powder

So that the resulting bacterial cellulose is in suspension form, the manufacturing process is carried out dynamically using a shaker during the incubation process. The media used is Hestrin-Schramm (HS) synthetic media with xylan additives with variations of 0%, 0.25%, 0.5%, 0.75%, 1%. As a starter for making bacterial cellulose, acetobacter xylinum was used, with an incubation period of 7 days.

2.2.3 Production of a film matrix

A temperature of 65°C is applied to 1000mL tubes containing 50 grams of extracted stem starch until the starch dilates. Add 1% CMC and stir for 10 minutes. Next, add glycerol (1% according to the treatment), stir, and cool the mixture for thirty minutes at 65ºC. Finally, add vitamin C and nano-crystalline cellulose. Furthermore, add stem starch in various quantities (0%, 1%, 2%, 3%, 4%, and 5% by weight) and mix with a stirrer for an hour. The film solution is applied to a 20 x 20 cm glass plate or a 120 mm Teflon sheet and is dried in an oven at 50°C for 24 hours.

2.2.4 Characterization of bacterial cellulose

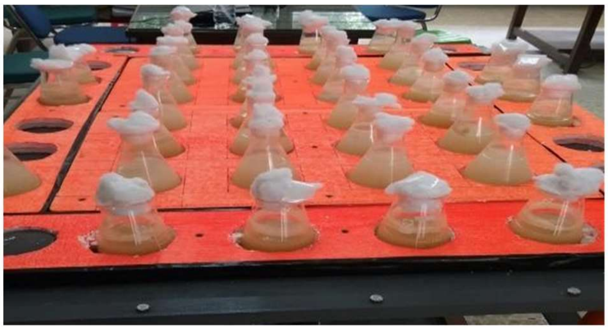
FTIR (FTIR-Shimadzu 4800) was used to analyze bacterial cellulose powder's structure and functional groups.

3. Results and Discussion

The observations showed that the slurry produced from making bacterial cellulose dynamically is very small. The dynamic process causes the formation of bonds between bacterial cellulose to be broken. The incubation of bacterial cellulose in 7-day images on the shaker and slurry devices can be seen in Figures 1a and 1b below. Preparation of biocomposite begins with the OPT as a stem starch material. The wood powder obtained was milled with two treatments by adding a sodium bisulfite concentration of 0.5%, then squeezed and filtered with a filter cloth. The waste is disposed of while the water containing starch is deposited for 12 hours, then wet starch is produced.

The bacterial starter used in this study to manufacture bacterial cellulose suspension was pure culture from acetobacter xylinum. Acetobacter xylinum needed to be inoculated to multiply the amount and adapted or acclimatized to the growing media used for the bacterial cellulose formation fermentation. In this case, the media used is the media Hestrin and Schramm. Treating this type of bacteria is quite complicated; it requires the maintenance of the technique and sterility of materials and the environment. So, all equipment must be sterilized before use to avoid being contaminated by fungi and other microorganisms. The bacterial starter doses that must be added to the media grow bacterial cellulose formation. The dose added as much as 10% is added to the media up to a volume of 100ml in the Erlenmeyer, which is then incubated for seven days on top of the shaker. Then, the resulting bacterial cellulose yield was calculated at 20.45%.

(a) Bacterial cellulose



(b) Incubation bacterial cellulose

Figure 1. The results 7 days on a shaker.

The bacterial cellulose obtained was then purified, and microbial cellulose purification was done by soaking it in 1% NaOH solution. Soaking with NaOH aims to eliminate non-cellulose components and remaining bacteria, where non-cellulose components will block the hydrogen bonds between the cellulose molecule chains and neutralize pH bacterial cellulose. Then, it was centrifuged to reduce bacterial cellulose water content.

Characterization of bacterial cellulose powder is needed to see whether the product produced from the abacterial xylinum fermentation process produces bacterial cellulose, so the characterization in this study uses FTIR to determine the functional group structure [10], [11], [12]. Test of the structure: a functional group is used to find information on the functional group of an organic compound. Structural testing was carried out through the FTIR test in the form of red-light spectroscopy; the working principle of this method is the absorption of inflammatory radiation by the sample to experience the level of the first excited vibration to the last. The results of FTIR spectrum analysis are shown in Table 1.

Table 1. Bacterial cellulose powder function group

No	Wavenumber	Function	Compounds
1	3000 – 3600	O – H	Carboxylic Acid
2	2850 – 2960	C – H	Alkenes

Table 1 shows the functional groups found in bacterial cellulose powder. The wavenumber vibration peaks are shown in the 3000 – 3600 cm^{-1} area. This vibration shows a stretch of hydrogen with O-H bonds. The widespread peak shape shows that the number of groups of functions –OH contained in the sample is huge. Regional vibrational peak of 1636.78 cm^{-1}. This vibration shows the bond vibration C = C. Forms of stretching C = C alkene occur in 1640-1680 cm^{-1}. This band is evident if only one alkene group attaches to a double bond. The more alkene groups are attached, the lower the absorption intensity because vibrations occur with changes in smaller dipole moments. For substituted alkene, substituting C = C often has a low or unobserved intensity.

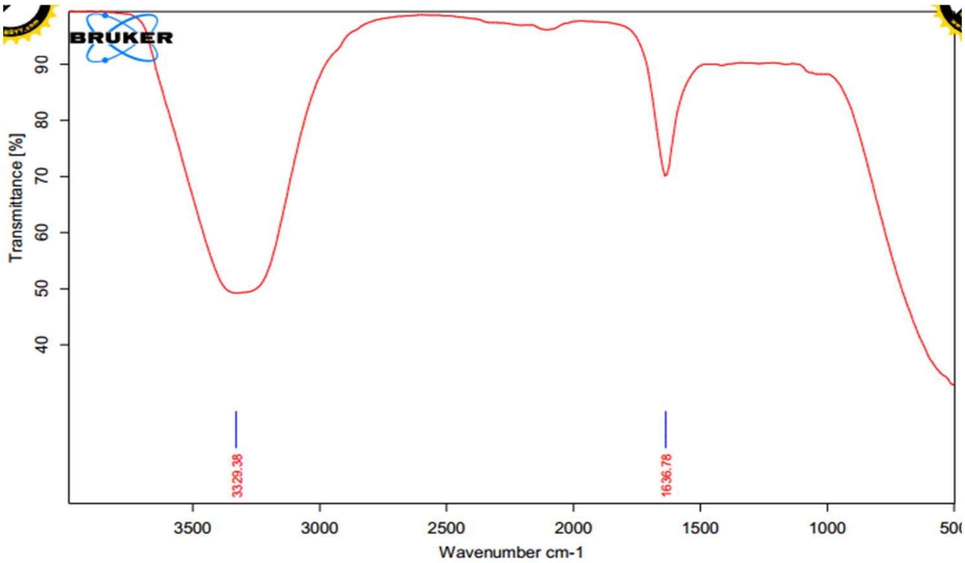


Figure 2. FTIR bacterial cellulose spectrum.

The results of FTIR spectroscopic analysis (see Figure 2) showed that bacterial cellulose slurry provides a spectrum that describes cellulose structure. The oil palm trunk with a stem starch obtained in the above process is dissolved in aquades and then heated at 65ºC until gelatination occurs, heating using a hot plate and magnetic stirrer to prevent crystallization at the top. Then added 1% CMC, which was first dissolved in water so that it was quickly dispersed into the starch matrix, and then glycerol and bacterial nano-crystalline cellulose filler with a concentration of 0%, 1%, 2%, 3%, 4%, and 5%. For 1 hour to maximize the dispersion of bacterial nano-crystalline cellulose. Then, the film's solution is poured into the mold and dried in an oven at 50ºC for 24 hours [13].

Structural testing, in this case, is a functional group that finds information about the functional groups of an organic compound. FTIR tests were used to do structural testing. This method's operation is based on the sample absorbing inflammatory radiation and experiencing vibrations ranging from the first to the last. For the value of tensile strength film in various combinations of bacterial cellulose filler concentration, treatment is shown in Figure 3.

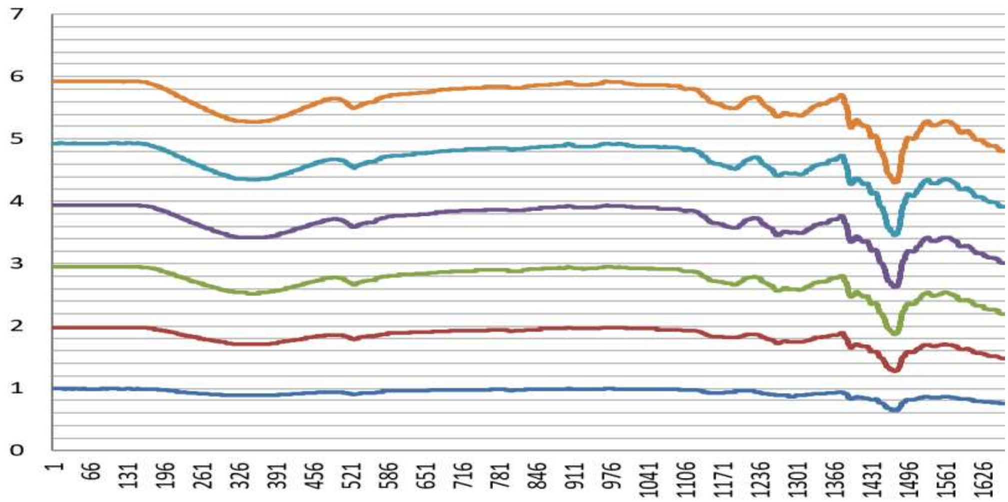


Figure 3. FTIR films masks

The graph above shows that the nano-crystalline bacterial cellulose filler concentration affects the film's tensile strength. The higher the concentration of nano-crystalline bacterial cellulose, the more the tensile strength of the films increases. Material with a small size has the property of expanding the surface area of the matrix containing nano-filler. With a broader surface area, the force of the displacement efficiency increases. The water content of films tends to decrease with an increasing suspension of nano-crystalline bacterial cellulose concentration [14], [15].

Increasing the concentration of bacterial nanocrystalline cellulose will increase the number of polymeric and viscosity bonds that make up the film matrix because nanocrystalline bacterial cellulose will enter the starch matrix pores. The amount of water in the film will decrease as the size of the polymer that makes up the film matrix increases because there will be more solids in the film. That is corroborated by the claims that the amount of water remaining in the film network decreases with the size of the polymers that comprise the film matrix and that the thickness of edible films decreases with increasing viscosity.

In general, it can be said that water content and water activity are very influential in determining the shelf life of food products because these factors will affect physical properties its hardness, drought, physicochemical properties, chemical changes with non-enzymatic browning, microbiological damage, and enzymatic changes, especially unprocessed food [16]. Testing for film biodegradation is done on media developed by degrading fungus under specific temporal variations, with significant losses dependent on those fluctuations [17], [18], [19].

4. Conclusions

The treatment produced a biocomposite film with the best mechanical properties by adding bacterial cellulose filler. The film's gel masks are all the same, still within the normal pH of the skin. Adding bacterial cellulose nano-crystalline decreases the film's water content, influencing the physical and storage properties of biocomposite films. Biocomposite films are readily biodegradable, so films are made from the extraction of the oil palm trunks.

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