Chitosan Modified Bio-Fibre Based Board as Antimicrobial and Anti-Crack Board

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Abstract. Bio-based products represent a key component of global bio-economic growth. In the process of forming a bamboo fibre-based bio board in this study begins with the preparation of bamboo fibres to make it compatible as a filling material in polyester polymers. The mixing of bamboo fibre is done by considering the composition of the fibre material with the polymer used, namely polyester at a ratio of 90%:10%, 80%:20% and 70%:30% of the total weight of the mixture. This mixture is added with a natural substance that has been investigated to have resistance to microbial contamination (anti-microbial), chitosan at a ratio of 1%, 3% and 5% by weight of the total mixture of all components. Bio board printing is carried out using a hot press (moulding) tool. The functionality of bio-based and conventional natural fibre-based materials was investigated for a series of bio boards. The tests include tensile, antimicrobial activity and morphological testing using Scanning Electron Microscopy (SEM). The overall test results put bio board with a ratio of 70%:30% with the addition of chitosan as much as 5% wt as the best sample with a tensile strength value of 147 Mpa, the flexural value of 0.09 kN. The sample shows a good interface appearance of the bond that occurs between the polymer and the filler under the electron microscope.

1. Introduction

In recent years, the joint is more environmentally friendly while synthetic fibers can be a source of environmental pollution. Composite is currently considered the most promising material in society because of its unique mechanical properties, biodegradable and abundant raw material availability. Many researchers have proven increasing interest in developing composite biodegradable polymer (BFRP) reinforced fibers as conventional fuels, especially in the automotive, marine, packaging, furniture and building construction industries. The production of natural fibers has become very attractive and beneficial, due to global problems and reduced petroleum. Natural fibers play an important role in developing biodegradable composites to solve environmental problems and current problems [1].

Natural fibers such as bamboo have been studied as reinforcement and fillers in composites. Bamboo is a plant that can grow quickly, high mechanical properties and specific gravity he low one. so it has the potential to be an abundant source of fiber, including the Bambusae family, under the genus Gramineae [2]. There is increasing public demand for a self-binding bio-board that is produced to have antimicrobial functions such as antibacterial and without high formaldehyde emissions with the emergence of bamboo-based panels [3]. The antimicrobial bio-board can be improved by chitosan.
modified bamboo fibers before hot pressing. Chitosan \((\beta-1,4-D\text{-glucosamine})\) is a natural polymer obtained from chitin which originates mostly in skeletons of insects and crustaceans [4]. Chitosan has antimicrobial activity due to positive amino acid groups. Chitosan has antimicrobial activity due to positive amino acid groups the leakage of protein and intracellular components of the microorganism that causes these amine groups to react with the cell membrane of negative microorganisms [5].

The present study prepared a antimicrobial and anticrack board by hotpressing, and examined its properties by tensile, microbial activity and morphological testing using Scanning Electron Microscopy (SEM).

2. Material and Method

2.1. Preparation of chitosan modified bamboo fiber.
Cut bamboo and crusher using a crusher machine to obtain bamboo powder. Wash bamboo powder using water then immersed in sodium hydroxide \((\text{NaOH})\) at a concentration of 6% of the volume of water for 3 hours at room temperature. The fiber is then washed twice with water, then mixed with chitosan with a variation of concentration of 1%, 3%, and 6% and dried at room temperature for 8 hours then dried at 50 °C for 2 days. Dry fibers are stored in sealed plastic bags to avoid atmospheric moisture contamination before the bio-board is formed.

2.2. Stage of Making Bio-board Materials
The mixing of bamboo fibre is done by considering the composition of the fibre material with the polymer used, namely polyester at a ratio of 90%:10%, 80%:20% and 70%:30% of the total weight of the mixture. The appropriate amount of fiber and matrices are mixed into the glass and then stirred slowly with a spoon until evenly distributed. Add catalyst in the ratio according to the resin volume fraction. Stir gently until it is mixed for about 2 minutes. Pour the mixture into the mold that has been formed according to STM D 638 Type I standard for tensile test and ASTM D 695 for flexural test. Flatten the surface of the mixture on the mold, wait for it to dry for about 24 hours. The dried specimen is removed from the mold and then the surface parts are smoothed with a miser. Bio-board specimens that have been smoothed and measured in geometry were initially said to be specimens ready for testing.

2.3. Characterization of Bio-Board

2.3.1. Tensile Strength Test \((\text{ASTM. D 638-02 type 4})\)
This mechanical property test is carried out by tensile strength testing of composite specimens using ASTM D 638 Type I. Tensile testing equipment is conditioned at a load of 200 kgf with a with drawal speed of 20 mm / min, the specimen is observed to break, recorded maximum stress \((F_{\text{max}})\) and its strain.

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\sigma = \frac{\text{Load}}{A}
\]

2.3.2. Antimicrobial Activity
The antimicrobial effect of chitosan modified bio-fiber (bamboo) samples was measured according to the inhibition zone [6].

2.3.3. SEM analysis
To analyze the effect of treatment on the surface structure of the fiber is done with a SEM microscope. The surface structure of the fiber was observed using a JEOL-T20 microscope. Scanning electron analysis is carried out at 5-20 KV [7].
3. Result and Discussion

3.1. Tensile strength analysis on chitosan modified bio-board.
Tensile testing of bio-board material was strengthened by natural fibers and chitosan was analyzed using Universal Testing Machine (UTM) Model E43 with the sample specimen used, namely ASTM D-638. The influence of fiber volume fraction, chitosan, and bamboo polyester bio-board matrix on the tensile test characteristics as shown in table 1, where the mixture of filler: matrix and chitosan fibers at a ratio of 70%:30% with chitosan concentration 5% yields a maximum value of 147 Mpa, while at a ratio of 90%:10% with a chitosan concentration of 1% produces a minimum value of 73 MPa. Composite stiffness increases significantly with increasing matrix content.

Table 1. Wave Number with Alleged Compounds

| Fraksi Volume Filler:Matrix | Tensile Strength (Mpa) |
|----------------------------|------------------------|
|                            | Chitosan 1% | Chitosan 3% | Chitosan 5% |
| 90%:10%                    | 73          | 83          | 107         |
| 80%:20%                    | 89          | 90          | 108         |
| 70%:30%                    | 96          | 114         | 147         |

Theoretically, bamboo fiber reinforced polyester (bio-board) composites have good tensile properties due to their high cellulose content in bamboo fibers. Help the alkali process by immersing the bamboo fiber in a 6% NaOH concentration as reported by Abdul Chalil [8], that the optimum value was found and produced the best mechanical properties for composite bamboo. This increase is also caused by the removal of hemicellulose, wax, lignin and other impurities resulting in a rough topographic surface on bamboo fibers and offers better interface adhesion properties to the fiber / matrix. Alkaline treatment also causes an increase in the surface area of the fibril fiber so that it is more effective when moistened with resin.

3.2. Antimicrobial activity of Bio-board
In applications, bio-board is easily destroyed by insects and bacteria, and greatly reduced. To enhance the antimicrobial effect of bio-board, bamboo was treated with chitosan and then hot pressed to make chitosan modified bio-fibre (bamboo). The characteristics of the inhibition zone of chitosan modified bio-fiber (bamboo) for microbial growth were observed and are listed in Figure 1.

In figure 1, that chitosan used for the modified bio-fiber treatment was shown to enhance its antimicrobial properties. Different concentrations of chitosan used on the fiber had different effects. The results demonstrated that the treatment with chitosan can significantly enhance the antimicrobial activity such as antibacterial of a bio-fiber against Escherichia coli and Staphylococcus aureus [9].

In the case of bacterial pathogens, bio-fiber modified with 5% chitosan showed the highest antibacterial activity against gram-negative pathogens of E. coli with a 17 mm inhibition zone. Meanwhile, antibacterial activity against S.aerus sp. the diameter of the inhibition zone is 15 mm. Gram negative bacteria have a relatively simpler structure with thick cell walls (15-80 nm) so that antibacterial compounds more easily enter the cell and find targets to work [10].
Figure 1. Antimicrobial activity of chitosan modified bio-fiber

3.3. Results of SEM Analysis
The scanning electron microscope (SEM) analysis is used to study the surface structure of a material. In this study, SEM analysis was carried out on composites that had the best and lowest mechanical properties in order to see the failures that occurred in the composite.

![SEM images of composites](image)

**Figure 2.** (a) Filler:matrix at a ratio of 90:10% with chitosan concentration 1% at 100x Zoom, (b) Filler:matrix at a ratio of 70:30% with chitosan concentration 5% at 100x Zoom,

From the results of the analysis published in Figure 2. (a) it is clear what is in the polyester in the modified fibers with chitosan 1% which is calculated between the fibers and above to effectively compile the voltage transfer from matrix to fiber, where the maximum The use of fiber strength in the composition is approved and affects the mechanical properties of the composite which have been caused by the results of the tensile test in the previous discussion. The morphology of polyester composites in the modified fibers with 5% chitosan is shown in Figure 2. (b) observed at 100x magnification shows an increase in fiber and matrix adhesion that is distributed evenly throughout the composite so that it shows the optimal attachment of the interface between the fiber and the matrix. Interlocking is one of the bonding mechanisms that occurs between fibers and fiber-reinforced polymer matrices. The interlocking properties exhibited by polyester composites in the modified fibers with 5% chitosan...
involve diffusion of the polymer matrix into the porous fiber surface. The polymer matrix will flow to the surface of the porous fiber and the polymer is embedded and compacted so as to form a strong bond between the fiber and the matrix so that it shows the optimum value as has been reported in the flexural test results previously.

4. Conclusion
From the result of this study some conclusion can be drawn: (1) Optimal tensile strength values obtained on the bio board with a ratio of 70%:30% with the addition of Chitosan 5%, which is equal to 1.47 MPa. (2) Bioboard modified with Chitosan is able to control the activity of microbes such as bacteria (E.coli and S. Aerus sp). (3) The morphological structure of the bio-board shows the presence of voids and interlocking the filler interface with the matrix thereby affecting the mechanical properties of the bio board.

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