

Antimicrobial Properties of Bamboo Fibres

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ABSTRACT

The article reviews some significant recent research in development antimicrobial textiles using bamboo fibres. Study was conducted with 12 commercial bamboo viscose, conventional rayon, cotton fibers, 4 bamboo species and 12 Natural Bamboo Fiber (NBF) samples to test antibacterial activity against Staphylococcus aureus and Klebsiella pneumoniae. The accuracy and efficacy of test methods were investigated and modified for antibacterial assessment. While the spectrophotometric method was found to be less effective due to low bacterial reduction, the revised viable plate counting technique was consistent and effective for samples in fabric, fiber or powder form. The antibacterial activity of moso bamboo shoot skin (*Phyllostachys pubescens*). The nature of antibacterial property of natural bamboo fiber was determined with the method of dynamic test and compared with other fibers for textile, such as jute fiber, flax fiber, ramie fiber and regenerated bamboo fiber. The bacteria used in the test were Escherichia coli, Staphylococcus aureus and Candida albican.

Introduction

With the advancement of textile technology, the uses of textiles are not limited to apparel, clothing, coverings, or protection against the weather. Technical textiles such as medical textiles, geotextiles, and smart textiles are being developed for specialized uses. Textiles because of their nature are ideal substrates for providing antibacterial properties. Currently, textiles and apparel with antibacterial/antimicrobial, antifungal and anti-mildew properties are very important for use in medical clothing, therapeutic clothing, wound healing, and protective clothing as well as regular daily use. The necessity and demand for such products has led to novation and development of antibacterial textiles [1-17]. Accordingly, the research and the production of antibacterial textiles has grown to help meet the demand [18]. Properties can be developed in the products by special treatment during dyeing, wet processing, finishing or other process stages [19-24]. A challenge has been to develop chemical compounds that can provide antibacterial activity in industrial processing, as currently, they can be toxic and harmful to the human body and health [25]. In contrast, natural compounds that provide antibacterial properties are considered more human-friendly. Consequently, there are numerous efforts to develop antibacterial properties from natural materials and processes, such as natural antibacterial activity from plants or microorganisms

in fibers, pigments or dyes. Moreover, if a material has natural antibacterial activity it could prove more durable as part of the material that would not wash away as opposed to artificially added antibacterial compounds.

As an abundant resource in China and an eco-friendly and multifunctional plant, bamboo has been used in architecture, agriculture, furniture and paper-making for thousands of years. Recently, research on producing textile fiber from bamboo has been conducted. According to different preparation techniques, the bamboo fiber for textile has been divided into two kinds, natural bamboo fiber and regenerated bamboo fiber [26]. The natural bamboo is usually in the form of fiber bundle which is produced by unique chemical and physical technique [27,28]. The regenerated bamboo fiber is made from bamboo pulp, which has a similar processing method to the ordinary viscose fiber [29].

Comparative Studies on Bamboo Plants, Bamboo Fibres and Commercial Bamboo Viscose Textiles

Interestingly, bamboo has been reported as naturally antibacterial and this property is expected to be retained if the fibers are extracted in their natural form along with some non-fibrous trace elements. Since most of the existing natural and

synthetic fibers do not have antibacterial activity, but rather some promote bacteria growth, extraction of NBFs with such activity is of great interest. Studies have concluded that extracts from bamboo leaves have shown antibacterial activity against some bacteria [30]. The inhibition of extract from Moso bamboo shoot skins against *Staphylococcus aureus* has been studied and reported that it exhibited antibacterial activity [15]. Moreover, different parts of bamboo plants (roots, leaves, skins) have already been used for manufacturing preservatives and medicinal products [31-35]. These studies on multiple bamboo species confirmed that the plants possess antibacterial activity. It was also shown that bamboo culms exhibited very high antibacterial property and fibers are mainly extracted from the culms. Therefore, it can be proposed that natural fibers from bamboo have the potential to retain antibacterial compounds, for example, phenolic compounds and lipids, and thus antibacterial properties [36]. Some studies have indicated that NBFs extracted from bamboo will have antibacterial properties [37-41].

To test the antibacterial property of natural fibers or plants, it is important to have suitable methods that can be conducted appropriately to assess even when the activity is very low. Since the zone of inhibition technique is not suitable and not highly precise for non-fabric specimens, this study was conducted on spectrophotometric and viable plate counting techniques to assess the antibacterial property of different types of specimens. Since the natural bacterial inhibition/reduction of the fibers is generally not very high and thus the change in Optical Density (OD) is very low, the spectrophotometric technique was found to be unsuitable for such tests [42]. The viable plate counting was revealed to be very suitable for almost all types of samples such as fabrics, fibers, and crushed raw bamboo samples. Results were found to be consistent and repeatable if conducted properly. Sterilization of the samples before the experiment is recommended as any contaminating bacteria is eliminated. A longer period can be allowed to provide more time for growth for slow-growing bacteria for better counting precision. The percentage reduction of bacteria by bamboo viscose textiles was tested where antibacterial activity was found in only one out of 12 products. This provides an understanding that antibacterial properties by bamboo viscose may not be a property from the bamboo, rather it comes from special treatments or through processing chemicals. Without these additional treatments, products from bamboo viscose would not offer bacterial protection. On the other hand, microscopic images revealed that there were some non-fibrous elements with Natural Bamboo Fibers (NBFs) of four bamboo species. All four bamboo species and their NBFs exhibited antibacterial activity to a certain degree. The activity was stronger against *K. Pneumoniae* than against *S. Aureus*. Results also suggested that though raw bamboo has antibacterial compounds, it may have bacteria-promoting substances at the same time that caused higher growth of bacteria if non-sterilized samples were tested. The bacterial inhibition was higher for sterilized bamboo

and NBF samples. Thus, due to the presence of bacteria from the environment, some NBF specimens showed a greater number of colonies and a negative reduction of bacteria when sterilization of the fiber specimens was not performed prior to the experiment protocol. Further investigations are needed to establish this technique in textile materials and to confirm if bamboo species and its NBFs have antibacterial activity and such activity is not contributed by processing chemicals. Moreover, the antibacterial property of such materials needs to be tested against other bacteria species.

Factors Influencing Antibacterial Properties of Bamboo Fibres

Clothing manufactured by regenerated bamboo fiber has entered the textile market with a claim for its antimicrobial property, but without scientific evidence [43]. With the success of the separation techniques of natural bamboo fiber, people start to pay attention to the antibacterial property of natural bamboo fiber. However, there are different opinions on this issue. High bactericidal rate of natural bamboo fiber against some kinds of bacteria has been reported and the antibacterial agent in bamboo fiber has been identified as anthraquinone compounds that contain four α -hydroxylation functional groups [44,45]. However, results released from other studies have indicated that natural bamboo fiber has no significant antibacterial effect (Zhou Hengshu and Deng Libin. 2005) and even if it does, it is just because of certain natural micro-structure, not the antibacterial constituents [46,47]. The aim of this paper was to investigate the natural antibacterial property of natural bamboo fiber and its influencing factors. As cotton, jute, flax and ramie are also plant fiber being used in textiles, they were selected to be compared with natural bamboo fiber. Meanwhile, the antibacterial property of regenerated bamboo fiber was also evaluated and compared with natural bamboo fiber. In this study, the antibacterial property of natural bamboo fiber and its influencing factors were investigated. The antibacterial test results show that natural bamboo fiber has no natural antibacterial property compared with other textile fiber [48]. The fact that the growth of bacteria on different shapes of bamboo was nearly equal may indicate that the shape could not impact the antibacterial activity of natural bamboo fiber. The linear relationship between the moisture regain and the bacteriostatic rate suggests that the hygroscopicity may be a influencing factor in antibacterial performance of fiber. Some extraction method could improve the antibacterial property of natural bamboo fiber against bacteria, therefore, extractives have influence on that.

Conclusion

Results revealed that only one viscose product showed antibacterial activity but the majority of the specimens from bamboo plant species and NBFs showed a quantifiable percentage reduction of bacteria against *K. Pneumoniae* (8-95%) but had

more modest results against *S. Aureus* (3–50%). As the quantity of bacteria promoting compounds is lower than bacteria-killing compounds due to processing; NBFs showed higher reductions of bacteria than raw bamboo specimens. The relationships between the antibacterial property of natural bamboo fiber and its shape, hygroscopicity and extractives were tested to analyze the influencing factors. In the results, compared with natural cotton the bacteriostatic rates of natural bamboo fiber against the bacteria were all zero; that of jute fiber and flax fiber against ATCC10231 were 48% and 8.7%; that of ramie fiber against ATCC 6538 was as high as 90.2%; that of regenerated bamboo fiber against ATCC6538 was higher than 70%. The bacteriostatic rates of the bamboo with different shape were all zero, that of plant fibers was inversely proportional to their moisture regain and the bacteriostatic action against ATCC 10231 of natural bamboo fiber extracted was lower; however, that against 8099, and ATCC 6538 was stronger except extracted with benzene. The results show that natural bamboo fiber has no natural antibacterial property. The shape could not impact the natural antibacterial property of natural bamboo fiber but the hygroscopicity and extractives have influence on that.

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