Preparation of Antibacterial and Deodorizing composite regenerated cellulose fibers based on natural functional agents

Cundong Lv1, Chunli Qiu1 and Husheng Yu1,*

1 College of Textiles and Garment, Qingdao University, Qingdao, China

*Corresponding author e-mail: qdyhshmm@163.com

Abstract. The regenerated cellulose fibers with antimicrobial and deodorizing functions were prepared by wet spinning process by blending the extract of Artemisia argyi and activated clay powder into the spinning solution. The mechanical properties and antimicrobial and deodorizing functions were tested. The results show that the breaking strength and breaking elongation rate of the composite fibers are slightly lower than those of ordinary cellulose fibers. The inhibition rate of Staphylococcus aureus, Escherichia coli and Candida albicans were 95%, 81% and 83% respectively, and the reduction rates of ammonia, acetic acid and isovaleric acid were 80%, 95% and 78%, respectively. It has excellent antimicrobial and deodorizing performance.

1. Introduction

With the healthy lifestyle is widely accepted by people, textiles with antibacterial, deodorant and other functions are loved by people [1, 2]. At the same time, compared with chemical synthetic antimicrobial and deodorizing agents, natural functional agents have attracted widespread attention because of their advantages of green, environmental protection and pollution-free[3, 4, 5, 6]. China is rich in plant resources, and as the birthplace of Chinese medicine, China has been using herbs for thousands of years and is well received by consumers. With the gradual recognition of Chinese medicine in the world, the use of herbal will be paid more and more attention. Activated clay is a mineral material contains more micropores and has a high specific surface area, so it has strong adsorption ability and can be used to absorb odor gas.

2. Experimental

2.1. Test the antimicrobial properties of extracts

In order to meet the functional requirements of composite regenerated cellulose fibers, the antimicrobial properties of extracts from Artemisia argyi at different concentrations were tested.
Specific steps are as follows: take a certain quality of extract of Artemisia argyi in beaker, then add appropriate amount of distilled water, fully stir, and configure into different concentration of functional agent solution. The pure cotton fabric was soaked in solution for 6 hours and dried. According to GB/T 20944.3-2008 Textiles-Evaluation for antibacterial activity-Part 1: Agar diffusion plate Method, the antibacterial activity of functional agents of different concentrations were tested by comparing the size of the antibacterial circle.

2.2. Preparation of Blended Spinning Solution

Take a certain quality of extract of Artemisia argyi into beaker, add a proper amount of distilled water, stir with glass rod to dissolve it continuously, and then filter with 400 mesh filter. The activated clay powder and extract aqueous solution were added into the spinning solution and stirred fully with an electronic stirrer until the components in the spinning solution were evenly dispersed. Because there will be a lot of bubbles when stirring, the prepared blend spinning liquid will be kept for a period of time to remove bubbles.

2.3. Preparation of blend membranes

The prepared spinning solution was evenly coated on the glass sheet with glass rod, and then put into the pre-prepared coagulation bath. After curing, the blend film fell off naturally from the glass sheet. It is desulphurized in sodium hydroxide solution and then washed to neutrality with distilled water.

The surface morphology of the blend film was observed by biomicroscopy. The blend film was sheared into strip specimens of 2 cm *1 cm, and its mechanical properties were tested by electronic single fiber strength tester. The best spinning scheme is the blending scheme with uniform dispersing of functional agents and excellent mechanical properties.

2.4. Spinning

According to the selected spinning plan, spinning solution was prepared, and the blended spinning liquid was sprayed out of the spinneret by wet spinning method. The fiber bundles were reacted with the coagulation bath in the reaction tank, and the formed fiber bundles were stretched through the drafting roller for post-processing to test their properties.
2.5. Properties testing

2.5.1. Mechanical properties testing:
A suitable amount of composite fibers and ordinary regenerated cellulose fibers were put at 20°C and 65% humidity for 24 hours. Then the mechanical properties were tested by fiber strength tester. The test conditions are as follows: the distance is 10 mm, and the drawing speed is 10 mm/min. Each group of samples was tested 20 times and the average value was obtained.

2.5.2. Antibacterial property testing
According to GB/T 20944.3-2008 Textiles-Evaluation for antibacterial activity-Part 3: Shake flask method, the inhibitory rates of composite fibers against Staphylococcus aureus, Escherichia coli and Candida albicans were tested with pure cellulose fibers as control samples.

2.5.3. Deodorant property testing
According to GB/T 33610.2-2017 Textiles-Determination of Deodorant property of Textiles-Part 2: Detector tube method, the reduction rates of samples to ammonia and acetic acid gases were tested. According to ISO 17299-3:2014 Textiles-Determination of Deodorant property of Textiles-Part 3: Gas chromatography method, the reduction rate of samples to isovaleric acid gases was tested.

3. Results and discussion

3.1. Antibacterial properties of extracts
The bacteriostatic effects of extracts with different concentrations are shown in Figure 2.

Figure 2 shows that a certain bacteriostatic circle was formed when the extract concentration ranged from 1% to 7.5%. When the concentration is more than 2.5%, the bacteriostatic effect is more obvious. With the increase of the concentration of the extract, the width of the bacteriostatic circle increases, which shows the extract of Artemisia argyi has excellent antimicrobial function.

3.2. Mechanical properties
The breaking strength and breaking elongation rate of ordinary regenerated cellulose fibers and composite fibers are shown in Table 1.
Table 1 shows that the breaking strength and breaking elongation rate of composite fibers are lower than those of ordinary regenerated cellulose fibers under dry and wet conditions. This may be due to the fact that the compactness of the macromolecular chain of the fibers is reduced, the intermolecular force is weakened, and the aggregation structure of the composite fibers has changed to some extent, resulting in the change of the mechanical properties of the fibers when the extracts of herbal medicine and the activated clay powder are added into the spinning solution.

3.3. Testing of Antibacterial and Deodorizing Properties

Antibacterial and deodorizing property of composite functional fibers are shown in Figure 3.

Figure 3 shows that the inhibition rate of composite fibers to Staphylococcus aureus, Escherichia coli and Candida albicans were 95%, 81% and 83% respectively, while ordinary cellulose fibers did not have the antimicrobial function. This shows that the addition of herbal medicine extracts makes the composite fibers have the function of antimicrobial, and the effect is excellent.

Figure 4 shows that the reduction rates of ammonia, acetic acid and isovaleric acid were 80%, 95% and 78% respectively, while the main components of sweat odor were ammonia, acetic acid and isovaleric acid, which indicated that the sample had strong sweat odor elimination performance. This is due to the successful addition of activated clay powder in the composite fibers, which contains a
large number of microporous, good adsorption performance, and effective absorption of odorous
gases.

4. Conclusion

In summary, the antibacterial and deodorization rates of the composite regenerated cellulose fiber
prepared in this paper were over 80% and 70% respectively, so it has excellent antimicrobial and
deodorizing property. Through pure spinning or blending with other fibers, it can be widely used in the
production and manufacture of knitted underwear, coat, curtain carpet and other clothing, life and
decorative articles, so as to give full play to the green, environmental protection and multi-functional
characteristics of anti-bacterial and deodorizing composite regenerated cellulose fibers.

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