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Short Communication

Antimicrobial evaluation and paper protection of cellulose-traditional Chinese medicine A

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ABSTRACT

As the main carrier of cultural inheritance, paper cultural relics are easily affected by the microorganism and external environment. In order to protect paper cultural relics, in this paper, traditional Chinese medicine A and sodium carboxymethyl cellulose (CMC) were prepared into a multi-functional mixture solution to use for antibacterial and reinforcement of paper relics. The antibacterial effects of the A on *Escherichia coli* and *Staphylococcus aureus* were studied through the single factor experiment. The minimum inhibitory concentration (MIC) of A and the concentration range of A-CMC for paper reformulation were determined. The results showed that the MIC values of A to *Escherichia coli* and *Staphylococcus aureus* were 0.2 mg/ml. The optimal ratio of the composite liquid is 0.8% CMC concentration and 0.2 mg/ml A. Under this condition, the paper has a good bacteriostatic effect. This showed that the traditional Chinese medicine A can be used as an antibacterial agent for paper.

Keywords: Traditional Chinese Medicine A, bacteriostasis, CMC, paper properties.

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INTRODUCTION

Paper is one of the four great inventions of the Chinese nation. As the witness and recorder of human civilization, paper cultural relics carry the wisdom of people in the past and play a role in spreading human civilization (He et al., 2019; Camargos et al., 2017). With time, paper cultural relics are easily affected by their internal structure, microorganisms, the external environment (temperature humidity, light, air pollution) and other factors, their mechanical strength gradually decreased, become yellow, blurred writing, aging, and so on, causing great losses (Li et al., 2014; Huang et al., 2018). In order to protect paper cultural relics, it is very important to explore a new antibacterial reinforcement agent for paper (Castillo et al., 2019; Potthast and Ahn, 2016). The enduring threat of microbial contamination to paper products in archives and museums is still one of the main issues in cultural heritage protection(Li, et al., 2014). Chinese herbal medicine A as a natural antibiotic has the advantages of abundant natural reserves and no secondary pollution after use (Thangamani et al., 2016; Li et al., 2019). Therefore, it has potential value in paper protection. CMC is a water-soluble cellulose ether, which has the advantages of renewable and low price. Studies have found that adding CMC to the pulp is beneficial to enhance the tensile strength and folding resistance of the paper (Chen et al., 2016).

In this paper, Chinese herbal medicine A and CMC were mixed into a multifunctional compound solution, in which Chinese herbal medicine A was used as a bacteriostatic agent and CMC was used as a reinforcement agent to study the bacteriostatic and reinforcement effect of the compound solution on paper to apply in the protection of paper cultural relics fields, to provide a reference for the research on the protection of rice paper.

MATERIALS AND METHODS

Materials

Staphylococcus aureus and Escherichia coli came from the laboratory of the School of Chemical Engineering, Zhengzhou

University (Henan, China). The traditional Chinese medicine A is Berberine, which was purchased from Sinopharm Chemical Reagent Co., Ltd.. (Shanghai, China). CMC was purchased from Shanghai Jingchun Biochemical Technology Co., Ltd. (Shanghai, China). Agar, peptone, beef extract were purchased from Beijing Aoboxing Biotechnology Co., Ltd. (Beijing, China). NaCl was purchased from Tianjin Zhiyuan Chemical Reagent Co., Ltd (Tianjin, China).

Determination of MICs of Chinese herbal medicine A

Escherichia coli and *Staphylococcus aureus* were used as experimental strains. *S. aureus* and *E. coli* were activated first, and then the activated bacteria were prepared into 10^5 CFU bacterial suspension with normal saline. Minimum inhibitory concentration was measured by the AGAR disk diffusion method. Seven kinds of Chinese herbal medicine A solutions with a concentration of 0.1~0.7 mg/ml were prepared, and circular paper with a diameter of 6 mm was soaked. Normal saline was used as the control group. The minimum inhibitory concentration was measured by the AGAR disk diffusion method at 37°C for 24 h (Parvin et al., 2021).

Determination of bacteriostasis of CMC-Traditional Chinese Medicine A

Taking the concentration of CMC mass and the A concentration of Chinese herbal medicine as the influencing factors, the orthogonal experimental arranges are shown in Table 1.

According to Table 1, 9 kinds of mixed solutions were prepared and tested for their antibacterial activity.

Table 1. Orthogonal experiment.

Experiment number	CMC/ (%) mass concentration	Chinese herbal A /(mg/ml)
1	0.6	0.2
2	0.6	0.4
3	0.6	0.6
4	0.8	0.2
5	0.8	0.4
6	0.8	0.6
7	1.0	0.2
8	1.0	0.4
9	1.0	0.6

RESULTS AND DISCUSSION

MIC value of Chinese herbal medicine A

The MIC results of Chinese herbal medicine A on *Escherichia coli* and *Staphylococcus aureus* can be judged by observing whether there are bacteriostasis circles in different concentrations of culture medium after 24 h of culture. The MICs are shown in Table 2.

It is shown from Table 2 that for *E. coli* and *S. aureus*, the MIC value of Chinese herbal A is 0.2 mg/ml. When the A solution concentration of Chinese herbal medicine is 0.2 mg/ml, the bacteriostasis circle begins to appear around the paper. This indicates that Chinese herbal A has an obvious antibacterial effect on *E. coli* and *S. aureus.*

Bacteriostasis circle of CMC -Traditional Chinese medicine A

The results of an orthogonal experiment are shown in Table 3. When the mass percentage of CMC was 0.8% and the concentration of Chinese herbal medicine A was 0.2 mg/ml, the antibacterial effects of the compound solution on *E. coli* and *S. aureus* were shown in Figure 1.

Table 2. Determination of *E. coli* and *Staphylococcus aureus* MIC Chinese herbal A.

Bacteria	MIC (mg/ml)
Escherichia coli	0.2
Staphylococcus aureus	0.2

Table 3 shows that for *E. coli* and *S. aureus*, 9 different concentrations of CMC-Chinese herbal medicine A experiments have appeared bacteriostatic circle. When the A of Chinese herbal medicine is controlled at a concentration, the size of the bacteriostasis circle does not change obviously with the increase of CMC concentration. The results show that Chinese herbal medicine A plays a major bacteriostatic role after mixing CMC with Chinese herbal medicine. Figure 1 shows that when the mass fraction of CMC is 0.8% and the concentration of Chinese herbal medicine A is 0.2 mg/ml, the composite solution has an obvious antibacterial effect on *E. coli* and *S. aureus*. According to the economic benefit, this concentration is selected as the best concentration ratio of a composite liquid.

Table 3. Bacteriostatic results of orthogonal experimental.

Number	CMC (%)	BBR (mg/ml)	Bacteriostasis circle size (mm)	
			Escherichia coli	*Staphylococcus aureus*
1	0.6	0.2	9.0	8.0
2	0.6	0.4	9.4	9.1
3	0.6	0.6	10.0	10.0
4	0.8	0.2	9.0	8.4
5	0.8	0.4	9.5	9.0
6	0.8	0.6	10.0	10.3
7	1.0	0.2	9.0	8.4
8	1.0	0.4	9.4	9.0
9	1.0	0.6	10.4	10.2

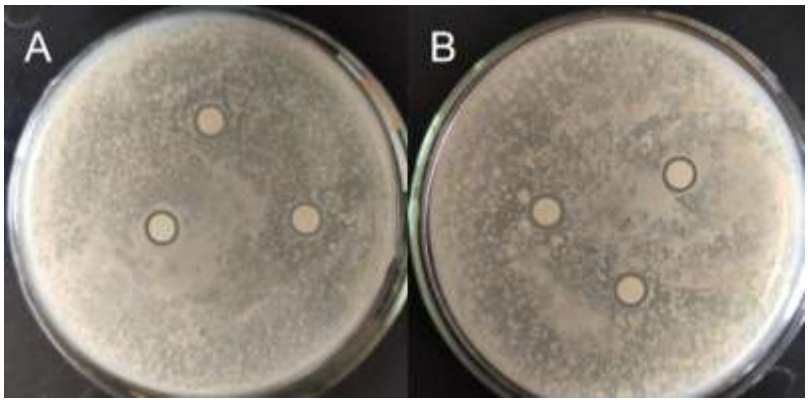

Figure 1. Bacteriostatic result. A. The Antibacterial Circle of *Staphylococcus aureus*, B. Bacteriostasis circle of *E. coli.*

CONCLUSION

Our synthesized mixture solutions (A-CMC) show a significant inhibitory effect against different strains of bacteria proved by a laboratory such as *Escherichia coli* and *Staphylococcus aureus*. The minimum inhibitory concentration (MIC) for paper protection was determined through the single factor experiment and orthogonal experiment. When the mass fraction of CMC is 0.8% and the concentration of Chinese herbal medicine A is 0.2 mg/ml, the composite solution has an obvious antibacterial effect on *E. coli* and *S. aureus*. The results provide basic data for the bacteriostatic application of drugs.

Conflict of interest

The author declares no conflict of interest regarding the publication of this paper.

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