

# Preparation and Research of Environment-friendly Degradable Paper Mulching Film of Cotton Stalk Fiber

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**Abstract.** In order to eliminate the white pollution caused by film mulching and reduce the consumption of non renewable resources, scientists both at home and abroad are studying the completely degradable plant fiber film. In this study, a kind of environment-friendly degradable paper mulching film of cotton stalk fiber was prepared by mixing cotton stalk fiber and a part of waste cotton fiber as raw materials. The tensile strength index of cotton stalk fiber paper mulching film is  $29.43\text{N}\cdot\text{m}^2\cdot\text{g}^{-1}$ , tearing index is  $77.26\text{mN}\cdot\text{m}^2\cdot\text{g}^{-1}$ , and the wet strength is 32%. After 75 days of soil landfill, the degradability of the test was 64%, and the degradation in the soil was dispersed into small pieces. Through experimental study, the paper mulching film of cotton stalk fiber prepared is a completely biodegradable environment-friendly paper mulching film.

## 1. Introduction

At present, the PVC and PE agricultural paper mulching film used in agricultural production in China is difficult to degrade in the soil, seriously destroying the soil structure, causing great harm to the growth and development of crops [1-2]. If this phenomenon continues, 15 years from now, agricultural land will become wasteland because of environmental pollution and no crops will grow in the cultivated land. [3]. Therefore, the preparation of degradable agricultural film is an important way to solve the problem of white pollution and promote sustainable development. Because of its excellent biodegradability, plant fibers have attracted wide attention in the field of preparing degradable paper base films. The paper based paper mulching film has a wide range of raw materials, including wood fiber, crop straw fiber, waste cotton short wool [4], grass fiber, and hemp fiber [5]. Cotton fiber and waste cotton fiber are natural fibers, in the soil can be completely degraded into carbon dioxide and water [6], does not cause any damage to the soil, and does not affect the growth of crops. In this article, we have made a new paper based film material, using cotton rod fiber and waste cotton fiber as the main raw materials and additives or auxiliary materials, and studied its degradation performance.

## 2. Experiment

### 2.1. Material

Cotton stalk fiber, laboratory self-made; waste cotton fiber (long about 6mm), factory provided; cationic chitosan (CCTS), hydroxypropyl guar gum (HPG), self-made; cationic starch (CS), cationic polyacrylamide (CPAM), polyamide epoxy resin (PAE), all come from the day Suzhou Co., Ltd.



## 2.2. Instrument

The paper sample reader (ZQJ1-B - II), the beating machine (ZQS2-23), the computer TT & C test machine (DC-KZ300C), the computer test paper tearing meter (DCP-SLY1000), and the Fourier transform infrared spectrometer (FTIR-850).

## 2.3. Preparation of paper mulching film

First, the cotton stalk was broken and screened, and the chemical cotton stalk pulp was prepared according to the chemical mechanical pulp preparation process 4% NaOH solution was added to the dry cotton stalk at a liquid ratio of 3:1 and treated for 1 hours in a closed container at 90 degrees Celsius. The treated cotton rod was washed with a disc mill at 5% solid content after washing. The distance between the grinding disc was 0.4mm, 0.15mm and 0.1mm respectively. After three grinding, the fiber size of the cotton rod was obtained. Because the cotton stalk fiber is short and the heterozygous cells are more, the cotton stalk pulp is treated with 200 mesh sieve, which removes a number of heterozygous cells and fines. The cotton fiber with better performance is obtained.

The waste cotton fiber is pulping with the tile pulping machine. Because the length of the waste cotton fiber is long, the cotton fiber should be taken as much as possible when the waste cotton fiber is used to prevent the winding. Cotton stalk fiber with different beating degree were grinded by PFI grinding. After the two kinds of fiber beating, the paper was mixed with 70% cotton fiber and 30% waste cotton fiber, and the reinforcing agent CS, CPAM and PAE were added to form the paper base membrane 40 g/m<sup>2</sup>. The paper base film samples were placed in the constant temperature and humidity chamber 24h at 23 and 50% humidity.

## 2.4. Determination method

Tear index test: refer to the determination method of tear strength of paper and board (GB / T455 - 2002).

Tensile index and wet strength test: refer to the determination method of tensile strength of paper and paperboard (GB / T453 - 002).

The test of paper mulching film degradability tests

The paper mulching film and plastic film were cut into 10 cm 5 kinds of two kinds of membranes were embedded in the soil and buried 5 to 10cm, and the degradation was observed after a period of time. With the degradation of the paper based degradation process, it appears in the late stage of degradation, when the membrane degrades in the soil, the 5 mesh screen screen is used to screen the fragments of the paper covering film that does not pass through the screen, and then sieves after the two kinds of membrane SA. The membrane was completely cleaned, the weight of the remaining film was recorded, and the weight of the original sample was compared, and the degradation residue was measured. Number. In order to study the degradation trend of the membrane, a group of cotton rod fiber membrane and a group of ordinary paper cover films are taken every 15 days until the screen screen cannot be screened. On this basis, degradation curves of 15 days, 30 days, 45 days, 60 days and 75 days were degraded respectively.

## 3. Results and discussion

### 3.1. Influence of beating degree on strength properties of paper mulching film

The purpose of beating is to change the degree of fiber broom through physical means, so as to improve the performance of paper and improve the strength of paper. The PFI pulping machine is used for grinding 70% cotton rod fibers in different degrees, and the physical properties of the paper page under different beating degrees are tested, as shown in figure 1.

With the increase of beating degree of cotton stalk fiber, the tensile index of paper mulching film increased. This is because with the increase of the beating degree, the degree of fibrous broom becomes larger, the hydrogen bond begins to be exposed, and the force between the fibers becomes larger. At the same time, the content of the fibers is increased to a certain extent, and the hydrogen

bonding between the fibers is promoted, and the tensile index of the film becomes larger, reaching  $22.19\text{N}\cdot\text{m}^2\cdot\text{g}^{-1}$  at  $40^\circ\text{SR}$ . The main factor affecting the tear index of the film is the fiber length. With the increase of the beating degree, the tear index of the film increases first, and when the cotton fiber beating degree is  $62.32\text{mN}\cdot\text{m}^2\cdot\text{g}^{-1}$  at  $40^\circ\text{SR}$ , as the fiber of the cotton rod is short, the fiber is further higher with the beating degree. The average length of the paper mulching film decreased and the tear index of the paper mulching film began to decrease. Considering the comprehensive consideration, the beating degree of cotton stalk fiber is determined to be  $40^\circ\text{SR}$ .

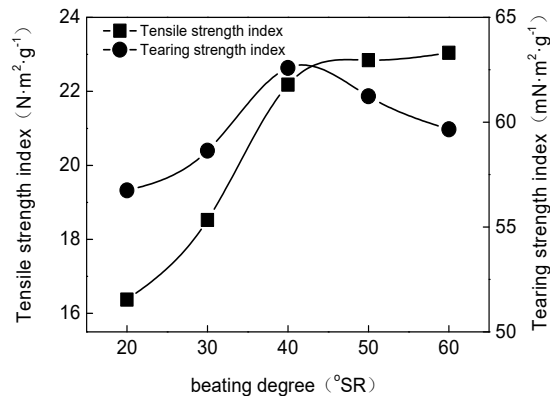


Figure 1. The effect of beating degree on the tensile strength of paper mulching film

### 3.2. Effect of cationic dry strength agent on strength properties of paper mulching film

Although the tensile strength of the paper mulching film can be improved by beating, the shape stability of the film can be affected to a certain extent. Adding cationic dry strength agent can change the binding force among the fibers, improve the tensile strength of the film dry, and do not affect the other properties. The effect of CS dosage on the film properties is shown in figure 2 under the condition that the beating degree of cotton fiber is  $40^\circ\text{SR}$  and CCTS is 0.1%. With the increase of CS, the tensile index and tearing index of the paper mulching film all increased. When the amount of CS was 1.5%, the film tensile index reached the maximum of  $26.34\text{N}\cdot\text{m}^2\cdot\text{g}^{-1}$ , the tear index reached  $73.25\text{mN}\cdot\text{m}^2\cdot\text{g}^{-1}$ , and the amount of CS was increased and the tensile index decreased. The amount of CS is 1.5%.

In order to further enhance the strength of paper mulching film, we studied the effect of different doses of CPAM on the strength of paper mulching film. As shown in figure 3. The effect of the dosage CPAM on the strength of the film shows that the tensile index and tearing index of the film increase gradually with the increase of CPAM dosage. When the amount of CPAM is 0.6%, the tensile index reaches  $29.43\text{N}\cdot\text{m}^2\cdot\text{g}^{-1}$ , and the tear index reaches the maximum  $77.26\text{mN}\cdot\text{m}^2\cdot\text{g}^{-1}$ . Continue to increase the amount of CPAM, although the tensile index of paper mulching film is on the rise, but the upward trend begins to slow down, and the tear index decreases. Considering the total dosage of CPAM is 0.6%, the effect is better.

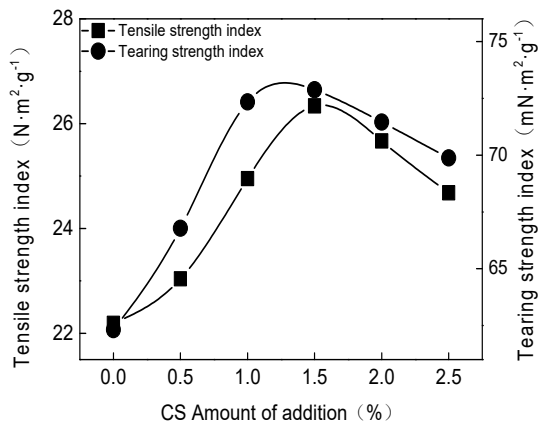


Figure 2. The effect of CS on the tensile strength of paper mulching film

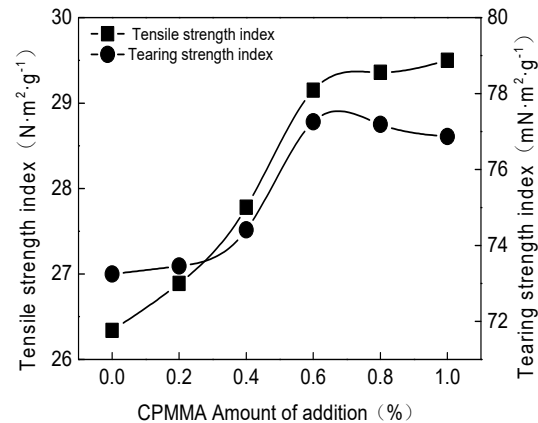


Figure 3. The effect of CPMMA on the tensile strength of paper mulching film

### 3.3. Effect of PAE dosage on wet strength of paper mulching film

During the field use of agricultural film, the influence of water vapor is inevitably encountered, especially in the rain gas, which requires a good wet strength of the paper based film. The effect of PAE dosage on the wetting and strengthening properties of paper mulching film of cotton stalk fiber is shown in figure 4. The effect of the amount of PAE on the wet strength of the film shows that the wet strength of the film gradually increases with the increase of the amount of PAE. When the amount of PAE is 2%, the wet strength index is  $9.44\text{N}\cdot\text{m}^2\cdot\text{g}^{-1}$ , and the wet strength is 32%. After increasing the amount of PAE, the effect of its humidification and strength increases unidentified. Obvious. In the process of paper copying, it is easy to cause the phenomenon of sticking of paper. Considering the comprehensive consideration, it is determined that the suitable amount of PAE is 2%.

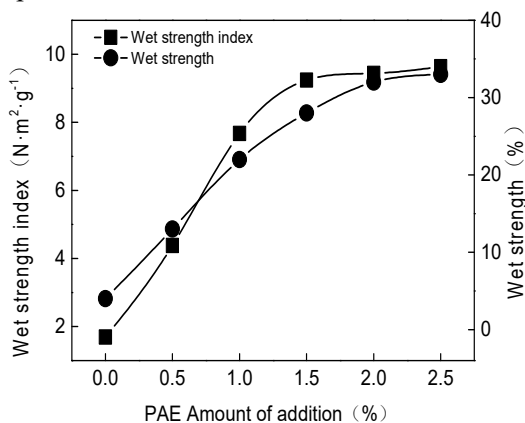


Figure 4. The effect of PAE on the wet strength of paper mulching film

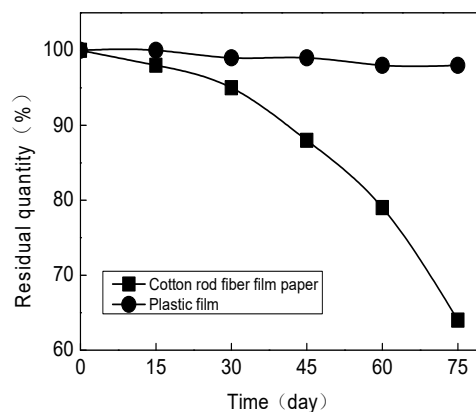


Figure 5. Degradation curves of paper mulching film and plastic film

### 3.4. Study on degradation performance

The reason why mulched paper is widely concerned is that it has complete biodegradability. In this study, the main material of the paper mulching film is cotton fiber and waste cotton fiber, which ensures that the tested film can be completely degraded by microorganisms in the soil without pollution, and the degraded products can become plant fertilizer. figure 5 is degradation curves of paper mulching film of cotton stalk fiber and plastic film.

It can be seen from figure 5 that with the increase of degradation days, the residual quality of paper mulching film of cotton stalk fiber decreases. The degradation of the residual amount to 64% at

the end of the 75 day, especially in the 30 day drop of the burial time, may be due to the time that the microorganisms in the soil are attached to the surface of the film, and as the time of degradation continues to grow, the microbes continue to reproduce, and when the cotton rod fiber paper mulching film is broken into small pieces, it is more beneficial to the microorganism. Degradation of the substance. Because of the serious fragmentation of the paper mulching film of cotton stalk fiber, we cannot continue to obtain the film fragments, but the change curve analysis shows that the paper mulching film of cotton stalk fiber can be completely degraded within 150 days. However, after 75 days, the quality of ordinary plastic film changed slightly and did not degrade. This is because ordinary plastic film is mainly based on non-degradable polyethylene resin as raw material, microorganisms cannot degrade it.

After 75 days of degradation, analyzed the structural changes in the degradation process of the paper mulching film of cotton stalk fiber. figure 6 is the infrared spectrum analysis of two kinds of paper mulching film of cotton stalk fiber before and after degradation.

It can be seen from figure 6 that the absorption peak of OH is near  $3500\text{cm}^{-1}$ , and the absorption peak of C-H is near  $3000\text{cm}^{-1}$ . After degradation, their strength decreased, indicating that the secondary bond of hydrogen bond was destroyed after the degradation of soil, and the interaction force between molecules decreased. Near the  $1750\text{cm}^{-1}$  is the absorption peak of the telescopic vibration of C=O, and the H-O-H deformation vibration and C=O stretching vibration peak near the  $1600\text{cm}^{-1}$ , and the telescopic vibration absorption peak of C-O-C near  $1180\text{cm}^{-1}$ . After analysis, the composite film was affected by factors such as humidity and microorganism in soil, and the interaction force between molecular chains weakened, and the strength decreased.

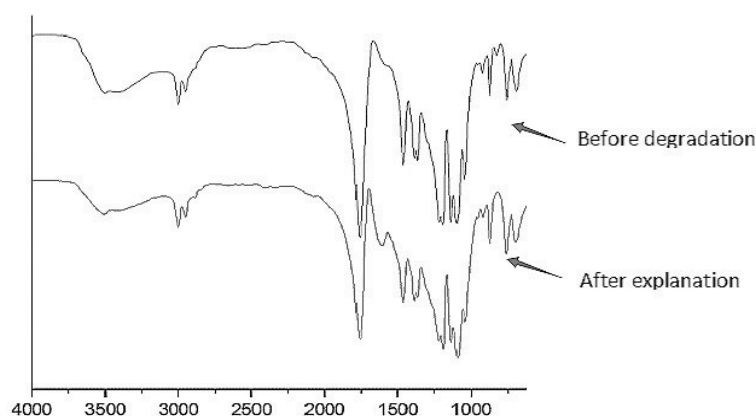


Figure 6. The infrared spectrum analysis of two kinds of paper mulching film

#### 4. Conclusion

In this paper, an environmentally friendly degradable paper mulching film of cotton stalk fiber is studied. This paper mulching film can replace traditional plastic film and reduce environmental pollution. The paper mulching film has high tensile strength and wet strength, and its physical properties fully meet the application in agricultural production. The paper mulching film can completely degrade in 150 days compared with plastic film, and can be converted into nutrients for crop growth. This research is of great significance for protecting the environment and promoting sustainable development.

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