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# The effect of guar gum and chitosan on fiber and fiber fine micromorphology in paper-process reconstituted tobacco pulp

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ABSTRACT

To study the effect of guar gum and chitosan on the micromorphology of tobacco pulp and the retention mechanism of different retention aids by the MorFi Compact fiber analyzer, changes in the micromorphology of the tobacco pulp fibers and the fiber fines were studied by adding different dosages of guar gum and chitosan. The results indicated that the retention mechanisms of guar gum and chitosan on fibers and fiber fines were different. Addition chitosan, components of pulp intertwined to form a spatial reticular through the neutralization effect that consists of tobacco fiber bundles, fiber fines and fillers. The reticular size increased, fiber fines (especially those below the detection limit) and fillers bonded with chitosan to combined with fiber and fiber fines. Guar gum wrapped the fiber through "nucleation and growth" to achieve the retention effect. Microstructures of the handsheets were observed using SEM, and the change in the fiber curl rate was analyzed to verify the effects of mechanisms of two different retention aids.

## 1. Introduction

The retention aid for papermaking is generally a water-soluble polymer of relatively high molecular weight and is typically added to the pulp before paper is formed to improve the retention of fine components in the paper (Howard, Hudson, & West, 2010; Whipple & Maltesh, 2002). Because of its applicability to cigarettes, security of smoking and characteristics of tobacco raw material, making tobacco pulp has unique properties compared with traditional papermaking pulp, such as the higher amount of fiber fines and dissolved polymer and colloidal substances (DCS). In addition, because of the processing resistance of cigarettes, the physical properties (bulk and tensile strengths) of paper produced by papermaking had to be higher (Wang, Qiu, & Liu, 2012). Polyethyleneimine, carboxymethylcellulose, guar gum, and chitosan as commonly used retention aids in reconstituted tobacco pulp, the tensile index of sheet showed a distinct increase in chitosan retention system (Zhao, Liao, He, Yao, & Wang, 2012).

Chitosan and guar gum are polysaccharide consisting of straight chain, they are common retention aids in paper-process reconstituted tobacco industrial, which have both retention effect and food safety (Abdallah, 2004; Chi, Li, Liu, & Zhan, 2007; Dodi, Hritcu, & Popa, 2011; Nicu, 2011; Renault, Sancey, Badot, & Crini, 2009; Rojas & Neuman, 1999; Thombare, Jha, Mishra, & Siddiqui, 2016). A lot of research on the application of modified guar gum in papermaking, it has a certain improvement of papermaking's retention and drainage, increasing mechanical strength at the same time (Wan & Song, 2006; Zhao et al., 2016). Guar gum modified PCC by using OT as crosslinking agent can be used to manufacture high filler content paper products (Wei, Song, Liu, & Qian, 2016). Li et al. through the analysis of and research on the reaction of different degree of deacetylation (D.D%) of chitosan with cellulose through wet end chemistry, analyzed different mechanisms of different types of bonding in the reaction and provided some thoughts for our study (Li, Du, Xu, Zhan, & Kennedy, 2004). Many studies have chosen the Zeta potential measurement to study the change of charge density in the pulp and the effect of additives on the fiber (Lai et al., 2016; Li et al., 2004). LV-SEM has also been used in fiber analysis in recent years to better demonstrate the connectivity and surface morphology of fiber−fiber (Fischer et al., 2014). The fiber analyzer has been widely used in the microanalysis of fiber, and the physical indexes have their own meanings, such as the length as well as coarseness, and are the main influences on the quality of paper-process reconstituted tobacco (Turunen, Leny, Tienvieri, & Niinimaki, 2003). The micromorphology of the fiber determines the microstructure of the paper-process reconstituted tobacco sheet, and it is also one of the most important factors affecting the physical properties of the paper-process reconstituted tobacco. A lot of research has focused on the effect of

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adding retention aids on the mechanical properties of paper, until now few studies have been reported on the effects of retention aids on the micromorphology of tobacco pulp and its effect on the retention mechanism.

In this study, the effects of mechanisms of different retention aids were determined through detection of the microcosmic indexes of tobacco fiber and fiber fines through the fiber analyzer and analysis of the effect of changing these indexes by a data process. Finally, analyzing paper microstructures of the handsheet surface by scanning electron microscope (SEM) verified whether the retention mechanism was correct. By studying the mechanism of chitosan and guar gum retention effect on fiber, it is a great significance to guide the use and dosage of retention aids in industrial.

## 2. Materials and methods

### 2.1. Materials

Water (500 g) was mixed with 2.5 g of acetic acid (AR, Shanghai, China), and 2.5 g of chitosan (D.D% = 89.5%, Food Grade, Jiaxin, Zhejiang, China) was dissolved in the aqueous solution, with 0.5% (w/w) acetic acid; finally, 500 g of water was added, and the solution was stirred for 30 min by the C-MAG HS10 magnetic stirrer (IKA, Germany), thus resulting in a solution with a 0.25% (w/w) concentration of chitosan.

Guar gum (Food Grade, Jiaxin, Zhejiang, China) was dissolved in water to prepare a solution with a concentration of 0.25% (w/w), which was stirred for 30 min before being used. All the water in experiment was deionized water.

Bleaching needle wood pulp (Kamloops, Canada) as additional fiber and $CaCO_3$ (Food Grade, China), and the tobacco pulp was taken from the outlet of a low-consistency Refiner provided by China Tobacco Yunnan Reconstituted Tobacco Co., Ltd.

### 2.2. Methods

#### 2.2.1. Preparation of tobacco pulp by adding different retention aids

Twenty-five grams of tobacco pulp was diluted with 900 mL of water, stirred evenly, and then mixed with 0.04 g of $CaCO_3$, Chitosan or guar gum solution was then added according to Table 1; finally, the solution was diluted with water to 1000 mL.

#### 2.2.2. Detection of fiber microscopic of the tobacco pulp

The microscopic indexes of fibers and fiber fines of tobacco pulp were measured by the MorFi Compact Fiber Analyzer (Techpap, France) according to Table 1; these indexes included content (pulp concentration), the length (fiber arithmetic length), width, coarseness, curl rate of fibers and the length or width of fiber fines. The Origin Pro 8.0 software was used to process the data.

#### 2.2.3. Papermaking

According to Section 2.1, handsheets with basis weight of 20 g/m$^2$, 16%wt $CaCO_3$, 22%wt additional fiber (based on the total mass of oven-dry tobacco pulp) and the tobacco pulp were put into the ZBJ-1 pulp standard dissociation machine (Paper Testing Machine Factory of Changchun, China) and mixed completely (10,000 r/min). 2.5%wt chitosan or guar gum solution and 0.3% of the solution dosage (based

**Table 1**
Different dosages of the chitosan and guar gum solution in tobacco pulp.

| Group | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Dosage of the chitosan solution/g $L^{-1}$ | 0 | 0.125 | 0.250 | 0.375 | 0.500 | 0.625 |
| Dosage of the guar gum solution/ g $L^{-1}$ | 0 | 0.125 | 0.250 | 0.375 | 0.500 | 0.625 |

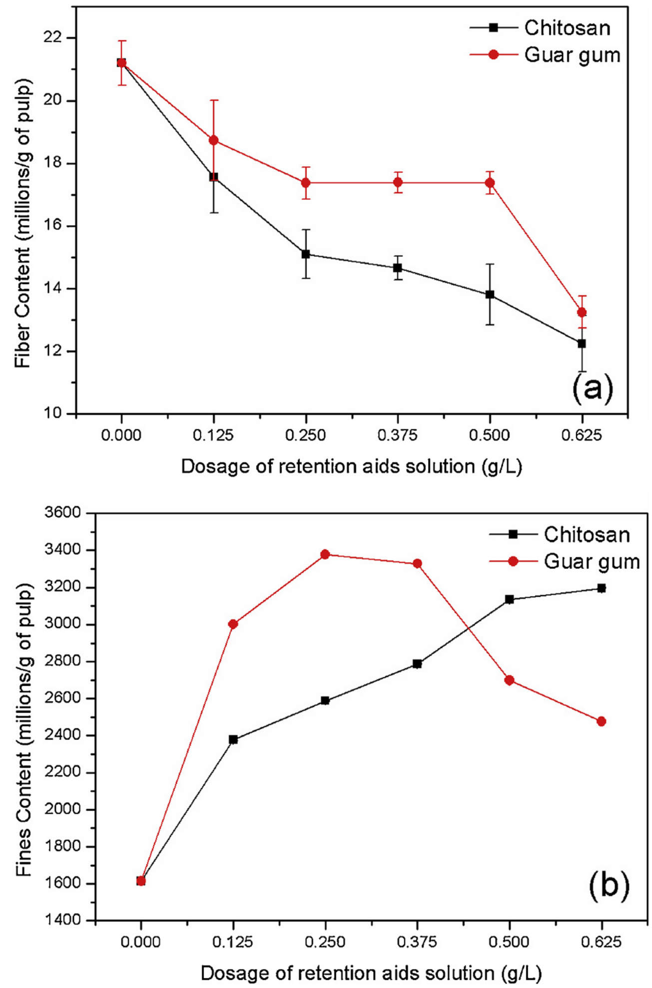


**Fig. 1.** The effect of chitosan and guar gum dosages on contents of (a) fiber and (b) fiber fines.

on the total mass of oven-dry tobacco pulp) was added to pulp respectively and ones of pulp without any retention aid for papermaking by BBS "Rapid-Koethen" system sheet former (ESTANIT, Germany).

#### 2.2.4. Scanning electron microscope

Handsheet surface microstructures were analyzed by JSM-7610FPLUS Thermal Type Field Emission Scanning Electron Microscope (JEOL, Japan). Images from SEM and EDS indicated the morphology of the handsheet as well as the distribution of the fiber and the filler (Joy & Joy, 1996; Reimer, 1993). The beam energy of 15 kV was used in this study.

## 3. Results and discussion

### 3.1. The effect of the dosage of retention aids on contents of fibers and fiber fines

From Fig. 1(a), it can be seen that the dosage of retention aids increased from 0 to 0.250 g/L, the fiber content decreased from 21.20 to 15.10 million/g of pulp after the addition of chitosan, and the decrease scale was 28.87%; meanwhile, the fiber content decreased from 21.20 to 17.37 million/g of the pulp after the addition of guar gum, and descending rate was 18.07%. The reason for this is that unit masses of the particle differ by kind of retention aids, thus resulting in different effect models and combinations of binding sites with fibers in pulp. The fiber content due to the addition of guar gum was higher than that due to the addition of chitosan, and retention aid effects on the fiber were

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