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Natural Cellulose Fibers from Eulaliopsis Binata

Mingwei Tian [a,b,c], Lijun Qu [a,b,c,*], Shifeng Zhu [a,b,c], Xiaoqing Guo [a,b,c]
Guangting Han [b,c], Yaning Sun [a], Zhiyou Ma [a]
Kaikai Sun [a,b], Xiaoning Tang [a,b]

[a] *College of Textiles, Qingdao University, Qingdao 266071, China*

[b] *Laboratory of New Fiber Materials and Modern Textile, the Growing Base for State Key Laboratory Qingdao University, Qingdao 266071, China*

[c] *Collaborative Innovation Center for Marine Biomass Fibers, Materials and Textiles of Shandong Province, Qingdao University, Qingdao 266071, China*

Abstract

Natural cellulose fibers extracted from Eulaliopsis Binata (EB) were systematically investigated in this paper. Fourier-transform infrared (FTIR), Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD) were used to investigate the chemical composition, morphological structure and crystalline structure of the resulting fibers. Furthermore, some basic physical properties of the EB fiber, i.e., mechanical properties, water absorption, antimicrobial performance were also evaluated and discussed. It was found that the non-cellulose substances were sufficiently removed or reduced after the degumming process, but the cellulose I structure was not changed based on the XRD and FTIR results. Meanwhile, the EB fibers exhibited high breaking strength (3.5∼6.9 cN/dtex) and remarkable moisture region (6.3∼7.7%). It also exhibited moderate antimicrobial effects against *Escherichia coli*. All these results indicated that the BP fibers had properties resembling those of traditional natural cellulose fibers (e.g. cotton and flax); therefore, they could be viewed as a promising alternative source for natural cellulose bundle fibers.

Keywords: Eulaliopsis Binata; Chemical Degumming; Structure; Antibacterial Property

1 Introduction

According to the report of the National Bureau of Statistics of China [1], with the price of wheat and corn increasing, more and more farmers have shifted to cultivate income-generating crops instead of cotton, leading to a dramatic decline of cotton yield in China, i.e., alone to 6.4 million tons in 2009 from 7.6 million tons in 2007. Unfortunately, this decline is expected to continue and even accelerate in the next years and will directly impact the raw materials support chain for the textile industry. Therefore, finding alternative sources of natural cellulose fibers is a crucial and urgent issue.

*Corresponding author.
Email address: lijunqu@126.com (Lijun Qu).

In fact, as supplementary sources for natural cellulose fibers, some common bast plants have been investigated historically, including jute [2], hemp [3, 4] and flax [5]. Recently, a few other novel natural cellulose fibers were extracted with acceptable textile properties, from e.g. hop stems [6], corn stalk [7], velvet leaf [8], wheat and rice straw [9], switchgrass [10], soybean straw [11], and also some regenerated fibers (pineapple leaf, banana) [12].

Eulaliopsis Binata is a perennial grass belonging to the subtribe Apocopidinae in Gramineae, which is widely distributed in Southern and central China. This plant is noted as an excellent natural cellulose material for its good strength and toughness [13]. It is annually renewable, available in abundance and now plays a key role in soil and water conservation [14] and pulping and papermaking [15]. In our earlier works, Eulaliopsis Binata fibers were obtained using chemical degumming process and the optimum technology parameters were determined [16, 17], but the properties and applications of these fibers were not further investigated. Therefore, in recent and present works, some properties of Eulaliopsis Binata fiber were investigated and their potential applications as antimicrobial textile were explored.

2 Experimental

2.1 Materials

Eulaliopsis Binatas (EB) used in our study were planted in the upland area of Shandong Province, China. The alkali-H_2O_2 one bath degumming approach [18] was utilized to extract EB fibers and the parameters in each process step were finally determined as:

Acid pretreatment: H_2SO_4 solution (1 mL/L), temperature 50 °C, liquor ratio 1:15, water bath heating for 60 min.

Alkali-H_2O_2 one bath degumming: NaOH solution (5 g/L), $MgSO_4{\cdot}7H_2O$ solution (0.1 g/L), H_2O_2 solution (4 g/L), ATMP (Amino Trimethylene Phosphonic Acid) and magnesium chloride ($MgCl_2$) as H_2O_2 stabilizer (1.2 g/L), temperature 99 °C, liquor ratio 1:15, water bath heating for 150 min.

2.2 Characterization and Measurement

Fourier transform infrared spectrometer (NEXUS-670, Nicolet Company, USA) with the wave number range of 500-4000 cm^{-1} was used to analyze the sample. The samples were all milled to powder and mixed with an analytical grade KBr and then pressed into a disk for the FTIR measurements. The morphological structures of EB and its EB fibers were studied with scanning electron microscopy (SEM, JSM-5600LV, operating at 15 kV), and a small amount of gold was painted onto the surface of all samples to get a clear photograph. The crystal structure of Eulaliopsis Binata and its fibers were measured by the powder X-ray diffraction (D/Max-2550PC, RIGAKU, Japan).

2.3 Physical and Antimicrobial Performance

Tensile properties: the tensile tests were performed using YG001 single fiber strength tester (Shanghai, China) at standard conditions and the average result of fifty measurements was