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Preliminary Study on the Exploitation of Chinese Fevervine Fibre

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Abstract

In this paper, the Rubiaceae Chinese Fevervine stem as raw material was used, with pool dipping, sodium hydroxide scouring and acid dipping as degumming methods, to produce Chinese Fevervine fibre (CF fibre). The components and structure of the fibre were tested and indicated with the relative component test method, infrared spectroscopy and a scanning electron microscope. The CF fibre produced possesses good spinnability: cellulose content 82.82%, specific gravity 1.323 g/cm³, length 41 mm, diameter 40.29 μm, linear density 2.93 tex, single fibre strength 55.4 cN, tenacity 18.9 cN/dtex, and break elongation 2.87%. The results show that CF fibre is natural cellulose fibre, whose components is similar to those of flax.

Key words: Chinese Fevervine fibre, degumming, scouring, spinnability, testing.

In this work, the Rubiaceae Chinese Fevervine stem as raw material was used, with pool dipping, alkali scouring and acid dipping as degumming methods, to produce CF fibre, and the components and structure of the fibre were tested and indicated with some advanced methods, aiming at establishing a foundation for the exploitation and usage of CF fibre.

CF fibre production technology

We adopted pool dipping, twice alkali scouring and the twice acid dipping process to degum and produce CF fibre. The production technological process is as follows:

Stem preparing and dipping → Alkali scouring → Washing → Decorticating → Acid dipping → Washing → Second alkali scouring → Washing → Second Acid dipping → Washing → Dewatering → Drying and opening → CF fibre.

The Chinese Fevervine stem is cut one meter long, tied up with 30 to 50 in a bundle, and then dipped in a natural pool for 30 days at a temperature of about 20 °C.

The stem bundles are fished out from the pool and then go through alkali scouring with a sodium hydroxide mass fraction of 1% for 1 hour as the first degumming process.

By washing the alkali scoured stem with room temperature water and decorticating the stem by hand or the mechanical method, the removal of xylem and phloem is obtained. In the acid dipping process, phloem contained in the CF fibre is dealt with using sulphuric acid with a mass fraction of 0.3% at room temperature for 30 minutes. The purpose of acid dipping is to neutralise the alkali and remove some impurities such as stiff bark and pectin.

Introduction

There are many kinds of fibres in nature, but fibres as textile material used in the production of yarn and fabric are after all limited. Textile fibres must have certain properties so as to meet the requirement of textile processing. At present, many new plant fibres, such as mulberry fibre, banana fibre, bamboo fibre, bromelia fibre, hemp fibre, apocynum fibre and so on, have been exploited and put into use^[1-6]. However, there is no report on the exploitation of Chinese Fevervine fibre (CF fibre).

Chinese Fevervine belongs to Rubiaceae plant, it is a perennial liana. The stem length is about 3~5 meters. The place of origin for the plant is in Asia tropical zone and its vitality is strong, it can grow on harsh ground such as country roadside, rock aperture, brushwood, moat, field edges, etc. The distribution in China is in the Yangtze river basin and the south region of the river.

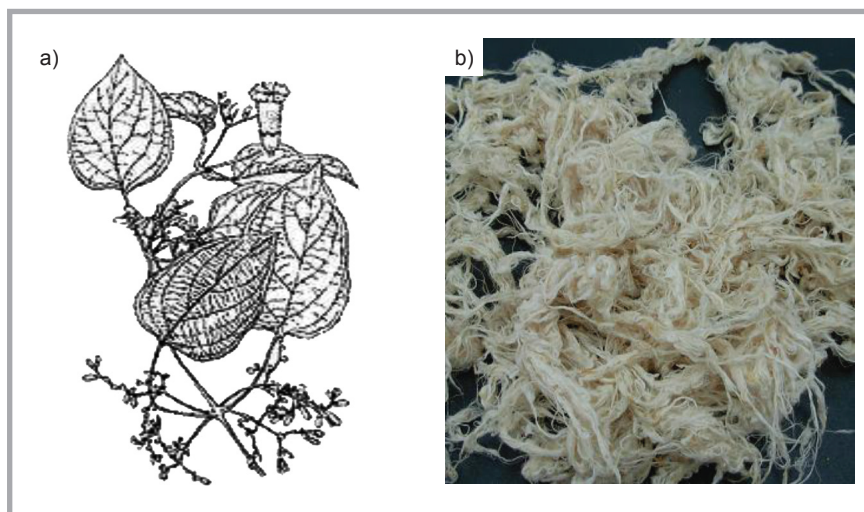


Figure 1. Original Chinese Fevervine plant and CF fibre: a) Original Chinese Fevervine plant, b) CF fibre.

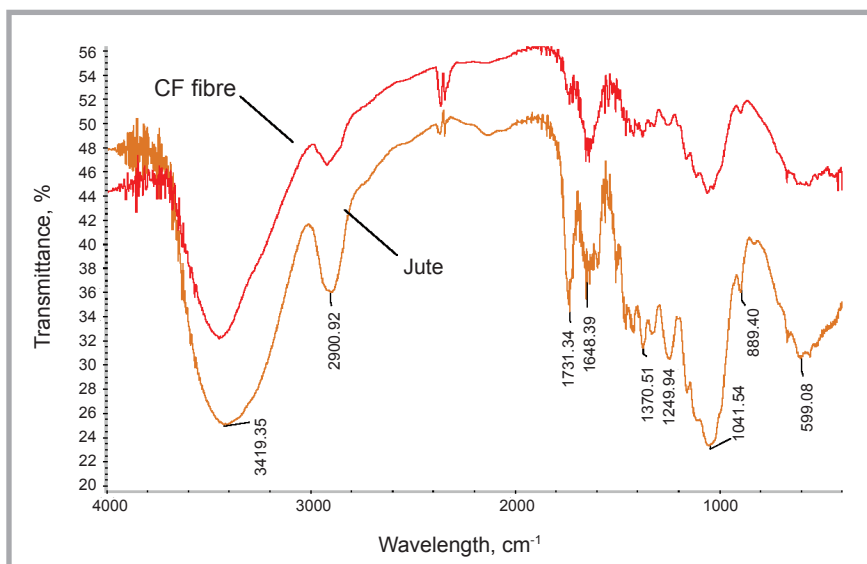


Figure 2. Spectrograms of CF fibre and jute specific gravity testing.

The **technology** of the second alkali scouring is a sodium hydroxide mass fraction of 1% and scouring for 1 hour, meanwhile sodium silicate and sodium tripolyphosphate as accessory ingredients are employed. The mass fraction of both is 1.5%, and the bath ratio is 5:1.

After twice alkali scouring and acid dipping, the CF fibre undergoes mechanical dewatering, drying at 110 °C, opening by hand, and the CF fibre is finally obtained. The original Chinese Fevervine plant and CF fibre are illustrated in **Figure 1**.

Test and analyses of components of CF fibre

The chemical components of CF fibre were tested with the Chinese standard testing method: GB5889-86 “Quantitative analysis of ramie chemical components” as CF fibre is a kind of natural cellulose fibre. The chemicals, instruments and steps for the testing experiment are omitted here. **Table 1** gives the testing results. The corresponding components of hemp, flax and jute [7] are also supplied in **Table 1** for comparison.

Generally speaking, for natural cellulose fibre, the higher the cellulose content, the lower the hemi-cellulose and lignose content, and the better the fibre spinnability and clothing performance. **Table 1** reveals that the cellulose content of CF fibre is a little lower than that of hemp and much higher than that of flax and jute, while the hemi-cellulose contents of CF fibre are much lower than those of flax and jute, and the lignose content is much lower than that of hemp and jute, all of which proves that CF fibre belongs to the group of cellulose fibres and possesses good spinnability and clothing performance.

In order to confirm the cellulose content of CF fibre, the components of CF fibre and jute were analysed with infrared spectroscopy, the spectrograms of which are illustrated in **Figure 2**. The two infrared light transmittance spectrum curves are very similar to each other, indicating that the components of CF fibre and jute are similar, both being cellulose fibres. This result is in conformity with the results listed in **Table 1**.

Table 1. Chemical components of CF fibre and flax fibre, %.

Sample	Cellulose	Hemi-cellulose	Lignose	Pectin	Water soluble matters	Lipid and waxiness	Ash
CF fibre	82.82	4.19	3.15	1.14	5.18	0.19	3.33
Ramie	70~77	12~15	0.2~1.0	3.5~4.5	6.5~9.0	1.0~1.4	0.6~1.1
Hemp	85.4	–	10.4	–	3.8	1.3	0.9
Flax	70~80	12~15	2.5~5	1.4~5.7	1.00~2.00	1.2~1.8	0.8~1.3
Jute	64~67	16~19	11~15	1.1~1.3	–	0.3~0.7	0.6~1.7

Specific gravity testing

Generally the fibre specific gravity is tested by the specific gravity flask method. The testing principle is dipping the fibre in a liquid thoroughly, making sure that no chemical reaction between the fibre and liquid can take place. The fibre specific gravity is calculated with the volume of liquid discharged by the fibre and fibre mass.

According to the fibre specific gravity test standard: “GB/T15223–2008, Specific Gravity Flask Method”, the specific gravity of the CF fibre was tested with anhydrous ethanol as testing liquid. The mean value is 1.323 g/cm³, which is similar to that of wool and polyester.

Analyses of the shape of CF fibre

A Japanese JEOL company Type JSM-6360LA scanning electron microscope (SEM) was employed. **Figure 3** illustrates 300 times to 3000 times magnification SEM photos of the longitudinal and cross section shape of CF fibre.

From the longitudinal shape, we can see that there are some cross striations on the CF fibre surface. It is the cross striations that make the fibre surface somewhat coarser, being not too smooth but with good cohesiveness, which is conducive to be spun into yarn. The fibre cross section is an irregular polygon, with no hollow section in the fibre center.

From the longitudinal and cross section SEM photos, we can see that the fibre cannot be divided into more fine ones, and the twice alkali scouring experiment also confirmed it. Therefore, we get a conclusion that the CF fibre is elementary fibre, rather than technical fibre.

Spinnability property testing

CF fibre spinnability properties such as length, diameter, linear density, strength, tenacity, breaking elongation, etc. were tested according to the methods in the text book [8]. For each item, the results are the average value of 30 samples and test results are listed in **Table 2**. The corresponding properties of cotton and ramie [9] are also provided in **Table 2** for comparison.

In **Table 2**, we can see that the length of CF fibre is longer than that of cotton, the linear density higher than that of cotton

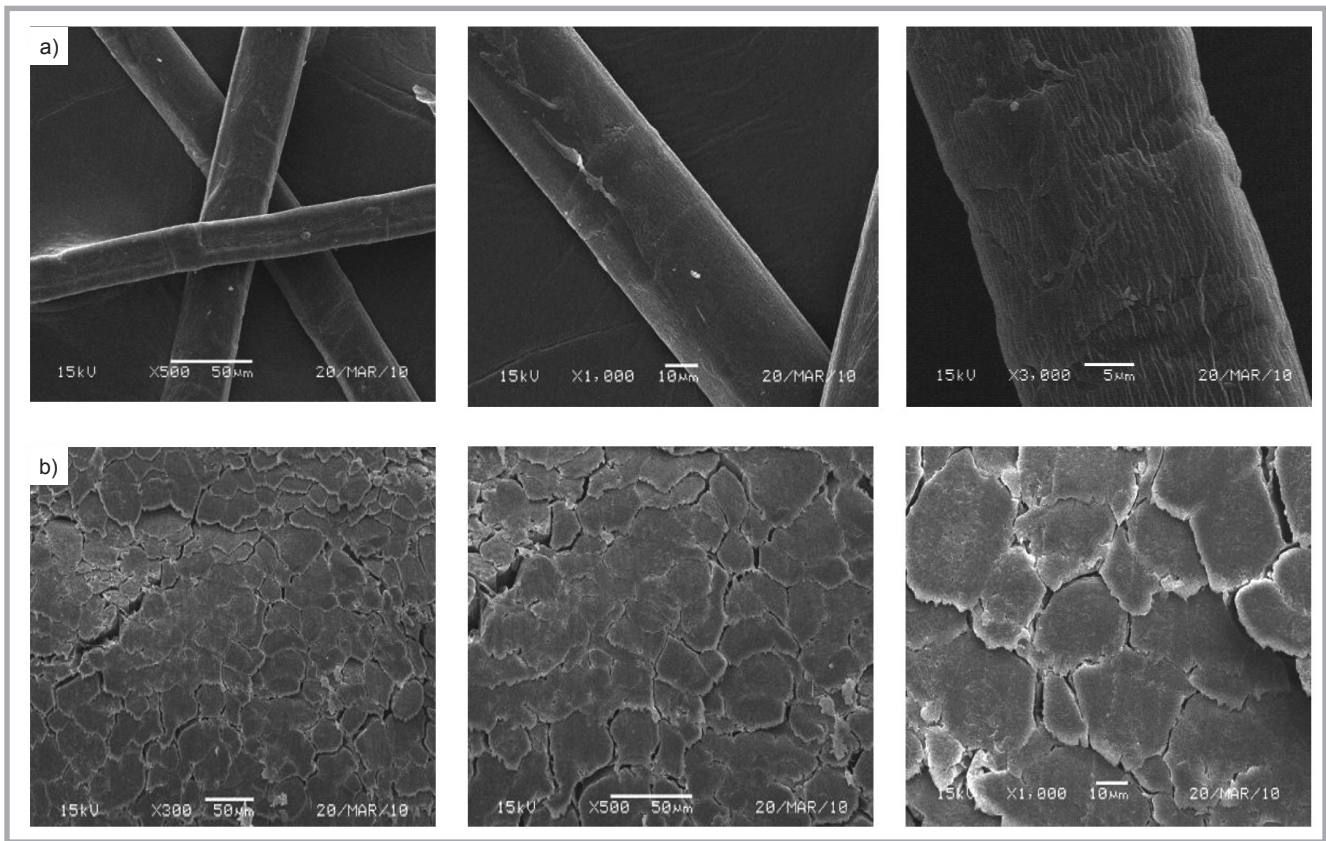


Figure 3. SEM Photograph of CF fibre: a) longitudinal shape, b) cross section shape.

but lower than for ramie, the tenacity much higher than for cotton and ramie, and the breaking elongation is a little bit lower than for the others. The CF fibre length is somewhat longer than for cotton, and the other properties, especially tenacity, are higher than those of cotton; thus CF fibre may be spun into yarn with the cotton spinning system.

Economical benefit expectation

Table 3 shows the dry stem production per square hectometer (kg/hm^2), the fibre output ratio (%), fibre turnout per square hectometer (kg/hm^2), the fibre unit price ($\text{¥}/\text{kg}$), the fibre total value per square hectometer ($\text{¥}/\text{hm}^2$) of flax and hemp [10-12], and the expected CF fibre value.

From Table 3, we can see that the dry stem production per square hectometer of CF fibre is much larger than that of flax and hemp, but the fibre output ratio is much lower than the latter as the xylem of Chinese Fevervine is the main section of the plant and its mass is large. The expectation of the CF fibre total value per square hectometer is lower than that of flax and hemp, and as it is a new kind of

fibre, its spinnability and application performance are to be studied further.

Chinese Fevervine can be cultivated on a disused area of a hillside or ravine, and once cultivated, it can be harvested many times. We can even harvest the mature stem in autumn or winter. The planting of Chinese Fevervine is easier than that of flax and hemp and a disused area can be utilised, thus saving on farmland. Hence the CF fibre planting cost will be much

lower than that of flax and hemp. In addition, CF fibre may have medical or health protection factors as Chinese Fevervine is a kind of Traditional Chinese Medicine. Therefore a high economic and social effect may be expected in the exploitation of CF fibre.

Conclusions

The components of CF fibre are similar to those of flax and is a kind of cellulose

Table 2. CF fibre spinnability properties.

Sample		Length, mm	Diameter, μm	Linear density, tex	Strength, cN	Tenacity, cN/dtex	Breaking elongation, %
CF fibre	Average value	41	40.29	2.93	55.4	18.91	2.87
	Coefficient of variation, %	30.71	36.56	—	16.25	—	10.79
Cotton		25~33	15~20	0.118~0.222	3~5	1.96~3.92	6~11
Ramie		20~250	30~40	0.45~0.91	37~63	6.7	3.8

Table 3. Economical benefit analyses of CF fibre.

Fibre	Dry stem, kg/hm^2	Fibre output ratio, %	Fibre turnout, kg/hm^2	Fibre unit price, $\text{¥}/\text{kg}^1$	Fibre total value, $\text{¥}/\text{hm}^2$
Flax	3000~5000	10.0~16.7	300~835	23~34	6900~28390
Hemp	10060~11188	13.2~18.5	1328~2070	17~20	22576~41400
CF fibre	13000~14000	2.25~3.01	292.5~421.4	10~20	2925~8428

fibre. There are also some cross striations on the CF fibre surface which makes it conducive to be spun into yarn. The spinning property of CF fibre is similar to that of cotton, and it may be spun into yarn with the cotton spinning system.

How to optimise scouring technology so as to achieve a better spinnability property is to be researched further. Whether CF fibre possesses some other medical or health protection functions is also to be further verified.



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