Study on Application the Collagenous Fiber in Paper-making

Wang Jian, Zhang Meiyun

ABSTRACT

The collagenous fiber made from the solid waste of leather and plant fiber are both natural linear macromolecules. Some combination can be produced from these two different fibers. Treating the solid waste of leather by physical and chemical ways, blending these two different fibers to make paper can decrease the pollution of leather waste, also reduce the consumption of raw material for papermaking and improve the characteristics of paper. In this paper, the pulping capability of the solid waste of leather treated by multi-methods was investigated. The properties of the paper made from the fiber mixture were also analyzed. The result showed that by proper treatment, the solid waste of leather could be made into collagen fiber that can be used for papermaking. The collagenous fiber made from the solid waste of leather should get rid of collagen bundles which are negative factor for tensile strength of paper. When mixing 8% collagenous fiber, treated with 8%H_2SO_4, the tensile index of paper can be enhanced by 46.7%.

KEYWORDS: collagenous fiber, plant fiber, acid- hydrolysis, sheet property

Introduction

The quantity of the solid waste of leather is very large. Every year, there is more than 500,000-ton solid waste of leather to be handled in the world. The main components of those are collagen that may be 80%, and Cr^{3+}, that may be 4%. In recent years, there are many researches to explore the processing technique of these solid wastes at home and abroad. But the handling of waste and the development of product are still limited, because most methods are expensive or low additional value product. Now a days, resource shortage and the pressure of environmental protection force people to seek the better way to use these wastes[1].

The collagenous fiber and plant fiber are both natural linear macromolecules. The collagenous fiber is a kind of polypeptide chain which consists of α-amino acid linked with peptide bond, while the plant fiber is a macromolecule cellulose chain which consists of glucose linked with 1,4-β glycosidic bond. There are many COOH、NH_2、OH in collagen, while plenty of OH are in cellulose[2].Both of them contain a lot of active radical groups and active positions. Therefore certain combination can be produced between these two kinds of fibers. Treating the solid waste of leather by physical and chemical ways and blending these two kinds of fibers to make paper can decrease the pollution of leather waste. It can also reduce the consumption of raw material for papermaking and improve the characteristics of paper. To develop this program, a series of experiments are carried out in order to analyze the solid waste of leather's pulping and the mixture's property of paper-making.

College of Papermaking Engineering, Shaanxi university of Science & technology, Xian'an, 710021, China

Experiment

Material

Chromium leather scurf, H_2SO_4(98%), unbleached soft wood pulp(37.2°SR)

Methods

The waste is treated with H_2SO_4 of certain consistency, and refined to form fiber by beater. Then the fibers are blended with plant fibers to make paper by using ISO handsheet former. Wet sheet of the paper is pressed for 4 min under the pressure of 4kg/cm^2 and dried for 5 min at 90°C. The measurements of the paper sheets are performed according to Chinese Standard. The properties of pulp from collagenous fiber are analyzed by multi-media microscope.

Result and Discussion

The Acid-hydrolysis of the Solid Waste of Leather

The solid waste can be decomposed by many ways, such as acid-hydrolysis,

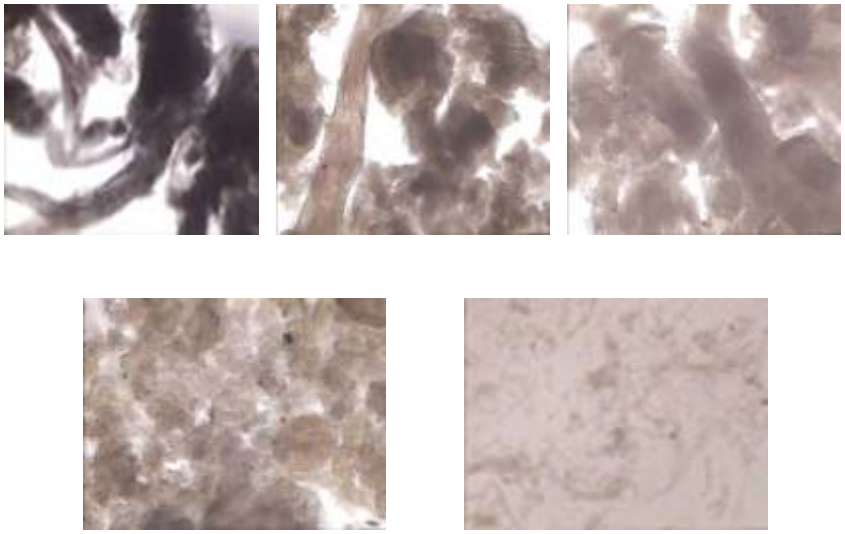

Fig.1 The configuration of collagenous fiber with different consistency of H_2SO_4

alkali-hydrolysis, enzyme-hydrolysis and refining by machine. Enzyme-hydrolysis is difficult to control. Alki-hydrolysis puts out unsolved solid. Because of the restriction of time and condition, we chose to treat the solid waste through acid-hydrolysis with H_2SO_4 and refining by machine. The waste doesn't hydrolyze at normal temperature and hydrolyze quickly when temperature is above 80˚C, so 90˚C is chosen to be the hydrolysis temperature. Because the degree of hydrolysis is determined by the time of hydrolysis, we choose 2 hours as the time of hydrolysis[2]. Under these conditions, a series of H_2SO_4 with different consistency is used to treat the waste. The collagenous fibers that were obtained by acid-hydrolysis with H_2SO_4 are analyzed by multi-media microscope by enlarging 125 times. The results are shown in Fig.1.

The pulping of collagenous fiber is one of the critical effects to blending in papermaking. If the collagenous fiber is not treated well, its reactive radical of side chain can't be exposed well. It will not improve the property of the sheet, on the contrary, will be the obstruction that limits the integration of the plant fibers, and affect the strength of the paper sheet. Even if the strength of collagenous fiber is high, the integration of the two kinds of fibers isn't strong enough and the strength of paper sheet will be affected. As shown in the Fig. 1, under the condition of acid-hydrolysis, the length of the collagenous fiber becomes short. When the consistency of H_2SO_4 is less than 4%, decomposition isn't obvious and the collagen is still mainly of fiber bundle and some collagen pellets. When the consistency of H_2SO_4 is increased to 8%, the level of hydrolysis is very deep. The waste were decomposed into fine fibers, which is equivalent to the small fibers in papermaking. So they can be used in papermaking directly.

Treating of the Combination

Now, the neutral papermaking has become popular. When blending the two kinds of fibers to make sheet, the decrease of pH is not hoped. In order to avoid the lower pH, low consistency of H_2SO_4 must be used to decompose the solid waste. But, as indicated above, when the consistency of H_2SO_4 is low, the waste can't decompose well, and there are still some collagenous fiber bundles left. In order to treat these fiber bundles, the waste is refined with beater after acid-hydrolysis. The condition of refining is as following: refine for 6 min when the pressure is 0 kgf, then raise the pressure to 2 kgf and refine for 6 min, raise the pressure to 3 kgf and refine for 8 min. The collagenous fiber is analyzed by multi-media microscope under enlarging 125 times. The results are shown in Fig.2.

From Fig.2, after refining, the pulping of the collagenous fiber, which hydrolyzes with low consistency of H_2SO_4, is better. When treated by acid-hydrolysis with 4% H_2SO_4 and refined, the waste has been pulped mostly. But there are still some fiber bundles left. Treated with 6% H_2SO_4 and refining, the pulp is fit for papermaking. Research the suspension of collagenous fiber, there are also a few fiber bundles. Refining more, the collagenous fiber will become too fine to fit for papermaking.

Fig.2 The configuration of collagenous fiber with refining after acid-hydrolysis

The Properties of the Blending Paper Sheet

In order to analyze the property of the paper making from collagenous fibers, the sheet is made of collagenous fibers and plant fiber. The strengths of the sheet are shown as Table 1 and 2.

From Table 1 and 2, as the increasing of the ratio of collagenous fiber, obtained with 6% H_2SO_4 treated and refining, the tear index and tensile index decrease, but the folding endurance increases. As the increasing of the ratio of the collagenous fiber, obtained with 8% acid treated, the tear index decreases gradually, but the tensile index and fold endurance increase. The toughness of the collagenous fiber is better. So it can improve the toughness of sheet when blending with the plant fiber. Because the folding endurance mainly relies on the strength of fiber and the toughness of sheet, so when the toughness is increasing, the folding endurance is improved. But the length of the collagenous fiber is shorter than plant fiber, so the average length of the blending fiber will be reduced. The tear resistance of the sheet, that relies on the average length of the fiber mainly, is decreased. The tensile strength of the sheet is determined by the link strength and the length of fiber. When using the collagenous fiber, obtained with 6% acid and refining treated, the collagen bundle is avoidable appended to sheet. The collagen bundles limit the link of

Table 1 The effect with different addition of collagenous fiber obtained with 6% H_2SO_4 and refining treated

Collagenous fiber additive %	Basis weigh g/m^2	Density g /m^3	Tear index (mN·m^2/g)	Tensile index (N·m/g)	Folding endurance
0	63.2	0.55	13.90	75.05	308
2	64.4	0.55	13.85	72.40	339
6	63.1	0.56	13.94	68.15	512
10	63.5	0.58	13.11	62.83	490
15	62.6	0.55	12.36	61.44	480
30	62.7	0.51	11.52	60.24	395
50	61.9	0.50	10.48	60.83	304

Table 2 The effect with different addition for collagenous fiber obtained with 8% H_2SO_4 treated

Collagenous fiber additive %	Basis weigh g/m^2	Density g/m^3	Tear index (mN·m^2/g)	Tensile index (N·m/g)	Folding endurance
0	61.5	0.55	13.90	75.05	308
2	63.4	0.55	12.15	79.67	356
4	65.6	0.56	12.23	82.80	411
6	61.8	0.56	11.73	87.19	460
8	63.1	0.58	11.45	90.09	535
10	63.4	0.56	11.98	89.57	526
12	61.5	0.55	11.40	83.50	499
20	57.8	0.53	10.82	79.74	457

the fibers. Although the collagenous fiber increases the link of the fiber, the tensile strength of the sheets decreases at last. So the collagen bundles should be get rid of to ensure the tensile strength. There is little collagen bundle to the collagenous fiber, obtained with 8% H_2SO_4 treated, the fine collagenous fiber increase the link of the fiber obviously. As shown in Table 2, the tensile index of paper can be enhanced 20.0% when blending 8% collagenous fiber. Noteworthy , when the collagenous fiber is added, the fold endurance marked increase. Especially, as shown in Table 2, the fold endurance of paper can be enhanced 73.7% when blending 8% collagenous fiber.

As showed in Table 1 and 2, when the collagenous fiber additive is lower than 10%, it is good to the sheet's mechanical properties. So the collagenous fiber additive should be lower than 10% in plant fiber to make blending sheet. Because the output per year of papermaking is very large, it will solve the question of the solid waste of leather. So for the environment protection, the work has profound meaning.

Conclusion

1. The solid waste of leather could be made into collagen fiber for papermaking.
2. The pulp made from the solid waste of leather should first get rid of collagen bundles; otherwise it will bring negative effect to the tensile strength of paper.
3. The collagenous fiber can blend with plant fiber to make paper. It is feasible for the strength of paper when the addition ration of the collagenous fiber is lower than 10%.

References

1 Fu Lihong, Zhang Mingrang, The prospect of composite material from regenerate cellulose and collagen, China Leather, 2001(7): 16~17

2 Jiang Tingda, Zhang Chunping, Collagen protein, Beijing: Chemistry Industry Press, 1992

3 Chen Peirong, Qu Weijun, Experiment of pulp and paper, Beijing: Chinese Light Industry Press, 1990

4 Fu Lihong, Qi Yongqin, The study of the compound structure of the collagenous fiber and plant fiber, Leather Science and Engineering, 1999(12): 13~17

5 Long Yanquan, The theory and engineering of papermaking, Beijing: Chinese Light Industry Press, 1994