PREPARATION AND NEEDLEPUNCHING OF KENAF FIBERS FOR AUTOMOTIVE NONWOVENS

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Abstract

Kenaf bast fibers are derived from bark of the Hibiscus Cannabinus L plant. The fibers are biodegradable, renewable and environmentally benign. Demand for moldable nonwoven fabrics containing kenaf for automobile interiors is rising.

Raw kenaf fibers consist of coarse bundles of single fiber cells glued together by lignin and pectin in a meshwork of interconnected single fibers. These fibers have to be chemically retted and refined. To be efficiently carded on a cotton card some of the binding glue (lignin and pectin) has to be removed so that the resulting fiber will have bundle fragments that are fine enough. Continuing research efforts at SRRC have resulted in a simplified chemical retting of mechanically harvested fibers. Chemical retting procedures have been developed for two distinctly different varieties of kenaf, namely, Forage harvested Tainug-2, 1.5"-3" short fibers supplied by Mississippi State University, and naturally retted Cultivar Everglades-41, 40"-50" long ribbons supplied by University of Arkansas. The development of chemical retting procedures is expected to provide guidelines for retting of any kenaf variety.

In addition to chemical retting and the application of a card-finish to the fibers, certain properties of needlepunched thermoformable composites made with kenaf and other vegetable fibers for auto interiors are also described. Chemically retted and finished kenaf fibers were processed in combination with other fibers such as greige cotton, recycled polyester and polypropylene.

Introduction

The bast fibers are constructed of thick-and-thin walled single-fiber cells (length: 2 to 7 mm, and diameter: 10 to 30 m m) that are overlapped andglued together by noncellulosic materials (lignin, pectins, and hemicellulose) to form continuous ribbons, Figure 1 and 2. The ribbons may run the entire length of 10 to 14 ft of the plant stem.

Kenaf plants can grow to a height of 10 to 14 ft in 5 to 6 months, which make them an abundant, renewable resource. Their bast fibers offer the advantage of being biodegradable and environmentally benign. The harvested stems are decorticated to yield kenaf fiber. Because of the coarseness and stiffness of the bast fiber bundles, they can be carded only through a coarse wool system or through a modified cotton card. For the fibers to be carded on a cotton card, it is necessary to remove controlled amounts of the binding glue and make the fibers sufficiently fine and pliable. By controlling the lignin and glue that are removed, it should be possible to obtain fibers that are suited to the cotton carding system. The present research is a continuation and fine tuning of the earlier work of SRRC to develop and demonstrate an economical route of making kenaf fibers suitable for carding on a cotton system.

Moldable nonwoven automotive fabrics are currently made of synthetic fibers that are not easily biodegraded. Incorporating kenaf fibers in nonwoven fabrics may enhance biodegradabilty besides imparting greater acoustical insulation and light weighting the car. The nonwovens with kenaf fibers are 20% lighter than those from glass fibers; the fiber density of kenaf is 1.4 g/cm3 vs. 2.55 g/cm3 for glass.

The market for moldable automotionwovens is large. With some 15 square meters of nonwovens used in interior and trunk of an average automobile, and 15 million vehicles in a year, over 225 million square meters are used.

Materials, Equipment and Method

Tainug-2 (T-2)-

Kenaf fiber stocks were obtained in 400 pound bales from Mississippi State University. The mature fiber plants were commercially harvested using machinery and methods adapted from other crops, namely, forage, cotton and sugarcane. This technique did not allow complete decortication and resulted in 1.5" to 3.0" short fiber stocks. "Fiber stock" may be defined as the bast fiber that had undergone mechanical separation from most of the core material. The T-2 supply, however, contained bark, core and vegetable debris of nearly 35%. Fiber stocks have generally been sent to paper mills as a source of pulp. Adhering bark in any form results in downgrading the fiber and is not acceptable in fibers for carding. At SRRC, T-2 fibers were made free from bark and core by a passage through a Rando cleaner. On mechanical cleaning, the brittle fibers became even shorter, 1.0" to 1.5". Chemical retting was studied at this stage of fiber. Incidentally, the T-2 bast fibers visually bear resemblance to peat moss fibers.

Everglades 41 (E-41)-

Fifteen pounds of long ribbons, 40"-50" in length, of kenaf E-41 were obtained from the University of Arkansas. The kenaf stalks were harvested while they were green, decorticated, and naturally (bacterial) retted. Stalks were tied together in

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bundles of ten, weighted and submerged in water in large containers. Bacterial retting took place for 6 to 8 weeks, after which time the bark became soft and could easily be separated from the core by hand. The bundles were removed from the water and washed in high pressure water. The high pressure of water cleaned the bark of any slime and allowed to be separated from the core. The fibers were dried in the open environment with air circulating around the fibers. The E-41 supply, however, contained nearly 13% of the bark or core fibers. Unlike T-2, these E-41 ribbons were pliable with high moisture content (20%), and did not require any mechanical cleaning. The resulting fibers after chemical retting were gold in color with a pleasing luster. The fibers, after chemical retting and finishing, were chopped to 2.0" to 3.0" length for processing into nonwoven fabrics.

Nonwoven Composites

Needlepunched carded nonwoven fabrics were produced using refined (water boiled, and caustic extracted) kenaf fibers T-2, and E-41 along with (a) greige cotton, in weight percent ratio of 80:20, and (b) recycled polyester and PP in weight percent ratio of 35:35:30. Other vegetable fibers such as cotton fines (cotton waste from swab manufacturing), jute, and flax were used as received. Cotton-, jute-, and flax composites produced in the ratio of 35:35:30 were also studied for comparative evaluations. Composites of kenaf and other vegetable fibers were also made with PP in the weight ratio of 50:50.

Analysis

Two 25 g specimens were randomly removed from the fiber supply. Each specimen was manually separated into fibers, core, bark, and dust and the average percentage of each constituent was determined, Table I.

Groen Reactor

It had a 42-L capacity with a positively driven motor agitator to move the fiber mass and was heated indirectly with steam, Figure 3. The outer jacket of the reactor could be either heated by steam or cooled by circulating cold water. After loading/packing the T-2 fibers, the lid was locked using locking screws to withstand the pressure. The reactor is almost like a conventional kier for cotton scouring that can be operated under pressure, however, with the following difference. In a cotton kier, the fiber mass is stationary and the liquid is circulated through the fiber mass (does not need an agitator), whereas in the Groen reactor, the fiber mass is rotated with an agitator in a stationary liquid. The agitator occupies considerable space of the reactor thereby permits less fiber mass for chemical retting. T-2 fibers (2400 g) were prewetted in water (24 L) containing 1% (owf, 24 g) surfactant and squeezed to remove air from the fibers. Air removal and wetting of the fibers were essential to compacting and packing a large quantity of fiber in the reactor. A maximum of 2400 g of compacted prewetted fibers can be loaded in the reactor. (Maximum fiber that can be packed in the reactor was determined experimentally). A 40-L solution was used with the liquor-to-fiber ratio of 16:1. The fibers were subjected to a two-step cycle of water- and caustic- extraction. Caustic retting formulation was similar to that was used in polymat trials and is given in Table V. Water solubles were extracted in water containing 1% surfactant at boil (100 C), and lignin and the binding glue were extracted in caustic extraction with 20% (480 g) caustic along with 1% surfactant at boil under pressure (105 C), Figure 6. Total cycle time was 305 minutes.

The chemically retted fibers were given a special card finish. 36.0 g (1.5% owf) of soap was dissolved in hot water (50 C) and applied to fibers for 10 minutes followed by acid treating with weak acetic acid (2-4 g/L) for 10 minutes.

Results And Discussion

T-2: Shorter Retting Cycle

We further developed a cycle with reduced time of water extraction at 75 C, followed by caustic extraction at 105 C with a total retting time of 263 minutes, Figure 7. Finish was applied on the retted fibers.

E-41 Retting and Finishing

E-41 ribbon fibers were prewetted in 1% surfactant solution (without any mechanical cleaning). The fibers were extracted in hot water at 75C retted in the formulation developed for T-2. 20% caustic + 1% surfactant + 0.2% anthraquinone followed by only one hot water wash at 90 C before finishing with 1.5% soap, Figure 8. Preparation cycle was shorter than that of T-2. Fibers were a lustrous gold color, and were easy to handle on card and needlepunching.

T-2: Chemical Retting and Finishing

Essential features of good chemical retting and finishing of kenaf, as revealed by the various experiments conducted, are enumerated in Table VIII. Compared to the earlier work [10], we significantly improved the preparation of kenaf by using a powerful alkali-stable surfactant in the prewetting and in the caustic retting formulation. Only through the prewetting and the removal of air from the fibers was the compacting of fibers possible. This in turn helped in lowering the liquor-to-fiber ratio in the reactor to 16:1 vs 75:1 in the earlier work [10]. With the inclusion of the surfactant and a catalyst in the caustic retting formulation, we were able to use 0.12N (480 g) caustic for retting 2400 g fibers, compared to 2N to 3N solution in the earlier work. The use of a card finish certainly aided the carding.

Because of the limitation in the supply of steam, the heat ramping was slow and took longer to reach 105C. This cycle time would be considerably shorter in an industrial environment where hot water at 90C and the required steam supply are plentiful. The weight loss in one hour caustic retting of water-boiled T-2 was 21%. Thus refined fibers were found acceptable for carding through cotton carding system. The T-2 fibers refined by a shorter cycle, Figure 7 (where water extraction was reduced), were equally good for processing on the cotton card.

E-41: Chemical Retting and Finishing

Compared to T-2 fibers, the refining cycles forE-41 fibers were far simpler. The E-41 fibers neither needed mechanical cleaning nor needed a long caustic wash off. The fiber waste losses were low, Table IX. The retting produced a lustrous fiber. However, the loss of fiber in carding, was in the same range as that of the T-2. For example, the 50:50 blend of chopped E-41with PP (to produce 600 g nonwoven fabric) showed a fiber loss in carding in the range of 21%- 24%. Incidentally, it is worth noting that we have found carding loss in the same range (20-25%) for carding jute, flax and other vegetable fibers.

Conclusions

Modified chemical retting procedures have been developed for two distinctly different varieties of kenaf, namely, Forage harvested short T-2 fibers and naturally retted long E-41 fibers. The procedures deliver fibers of acceptable and reproducible quality. For kenaf to become a value-added crop for use in nonwovens, considerations must be given on harvesting the plants while they are green and producing decorticated fiber ribbons for chemical retting. The chemical retting cycle of E-41 kenaf ribbons can be much shorter than that of the T-2 fibers. Also, the quality of E-41 fibers thus produced is suitable for processing through a cotton card. Not only the fiber-waste loss in chemical retting is decreased, but also the fiber quality is superior in luster, brittleness and flexibility. However, for fibers to be suitable for processing on a card, they need to be refined via caustic retting. For processing on an air-laid system, the fibers may not be refined to that extent. Hot water extraction (without any caustic retting) and finishing with a card finish produces fibers that are suitable for air-laid and needlepunching. In general, long fibers are found suitable for use in nonwovens. Mechanically harvested short fibers should be best utilized in pulp and paper industry.

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