Manufacturing Technique and Mechanical Properties of Environment-Protective Composite Nonwoven Fabrics

Jia-Horng Lin[1,2,b]*, An-Pang Chen[1,c]*, Jan-Yi Lin[1], Ting-An Lin[1] and Ching-Wen Lou[3,a]*

[1]Laboratory of Fiber Application and Manufacturing, Department of Fiber and Composite Materials, Feng Chia University, Taichung City 407, Taiwan, R.O.C.

[2]School of Chinese Medicine, China Medical University, Taichung 40402, Taiwan, R.O.C.

[3]Institute of Biomedical Engineering and Material Science, Central Taiwan University of Science and Technology, Taichung 406, Taiwan, R.O.C.

*corresponding email: [a]cwlou@ctust.edu.tw, [b]jhlin@fcu.edu.tw, [c]tim_duncan_tim21@hotmail.com

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Abstract. Ecological environment deteriorates drastically and rapidly, which can be ascribed to the fast advancement of international economy and technique. Hence, people become green consumers, using green products. The series of lyocell fiber, called as recycled fiber, has been pervasively used. This study used Tencel® fiber, Polylactic Acid (PLA) fiber and high absorbent fiber as well as nonwoven manufacturing, creating Tencel®/PLA/HAF composite nonwoven fabrics. Among the manufacturing parameters, an increase in Tencel® fiber ratio, needle-punching density and basis weight all contributed to heighten the mechanical properties of nonwoven fabrics. In particular, the Tencel®/PLA/HAF composite nonwoven fabric exhibited an optimum tensile strength of 68.8 N and bursting strength of 193.7 N when Tencel® fiber ratio was over 80 wt%, basis weight was 200 g/m^2 and needle-punching density was 300 needle/cm^2.

Introduction

Green fibers are also called environment-protective fibers or environment-friendly fibers, not generating detrimental substance to environment or people's health during the production process. Their fiber components are derived from Nature, and could be recycled. The lyocell fiber spun from cellulose solution in an amine oxide solvent (N-methylmorpholine – N-oxide, NMMO), has fibrillar morphology and high crystallinity and provide omnigenous characteristics contrast with cotton [1-2]. This manufacture is environmentally benign since the nontoxic NMMO solvent is used and the solvent of 99% can totally recycled. As a result of these advantages, lyocell fiber has been research in nonwoven process [3-4].

Bleeding is the most commonly seen complication with the trauma incurred on the battlefields and in the daily life; in particular, if bleeding and oozing from large-area injury of soft tissue was not taken care in time, they could further cause severe bleeding instead. The method for effective hemostatic is important to advance the remedy level for the injured in wartime, highlighting the significance of absorption of the blood exuded from wounds by high absorbent materials. This study planned to create the Tencel® /PLA/HAF composite nonwoven fabric by using high-absorbent Loycell fiber, high absorbent fiber, and PLA and nonwoven process, after which the prepared samples were measured with tensile strength and bursting strength.

Experiment

Materials

There were three kinds of fibers. Tencel® staple fibers (fiber length: 51 mm; fineness: 1.7 denier) were offered by Taiwan Web-Pro Co., Ltd, Taiwan. Polylactic acid (PLA) fibers (fineness: 2 denier; length: 50mm, strength of mono fiber: 3.5g/D, elongation: 45%) were supplied by Far Eastern New Century Corporation, Taiwan. High absorbent fibers (HAF), made of high-absorbent polymers by polymerization, were purchased from Asiatic fiber corporation, Taiwan.

Processing

Tencel® fiber, PLA fibers and HAF with a variety of weight ratio (8:0:2, 7:1:2, 6:2:2, 5:3:2, 4:4:2) underwent the nonwoven manufacturing process consisting of various stages: opening, mixing, carding, laying, and needle-punching, forming the Tencel® /PLA/HAF composite nonwoven fabric. Meanwhile, basis weight was varied ranging 100, 150, and 200 g/m^2 while needle-punching density was also changed from 150, 225, to 300 needle/cm^2.

Testing

The resulting samples were measured with tensile strength by employing Instron 5566 (USA) in accordance with ASTM D5035-06 (Standard Test Method for Breaking Force and Elongation of Textile Fabrics). And the Bursting strength is according to the constant-rate-of-extension type as specified in CNS 12915.

Results and Discussion

Tensile strength of composite nonwoven fabrics

Figure 1 reveals the influence of the Tencel® fiber content on the tensile strength of the Tencel® /PLA/HAF composite nonwoven fabrics. Mixing ratio of Tencel® fiber, PLA fibers and HAF varied from 8:0:2, 7:1:2, 6:2:2, 5:3:2, and 4:4:2; needle-punching density was 300 needle/ cm^2; and basis weight was 100 g/m^2. The tensile strength of the composite nonwoven fabric increased with an increase in Tencel® fiber, as exemplified in Figure 1. This phenomenon could be ascribed to Tencel® fiber, which offered a larger amount of fiber distribution within a unit volume than PLA fiber did, increasing the tensile strength of the resulting composite nonwoven fabric. Additionally, regardless of the Tencel® fiber content, the sample also exhibited a higher tensile in CD than in MD.

In the nonwoven processing, the net carding direction was perpendicular to the net discharging direction, so the fibers were arranged in a tendency toward CD, resulting in a higher tensile strength in CD accordingly.

Figure 2 presents the influence of the needle-punching density on the tensile strength of composite nonwoven fabric. The tensile strength of the sample increases with an increase in needle-punching density of the composite nonwoven fabric, as can be seen in Figure 2. In nonwoven processing, the barbed needle plate pushed the fibers down and caught the fibers through the nets repeatedly; in this way, the fibers between webs intertwined and entangled, giving a rise in the tensile strength.

Figure 3 displays the influence of the basis weight on the tensile strength of composite nonwoven fabric. The greater the basis weight, the higher the tensile strength. Basis weight referred to the content of the fiber within a unit volume of the resulting sample. When the basis weight ascended, there was a greater amount of fiber within unit area, which was able to disperse more stress, heightening the tensile strength.

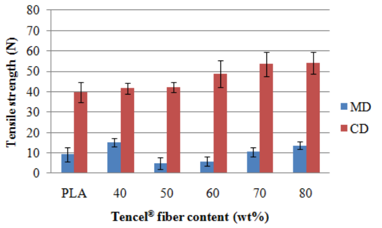

Figure 1 Tensile strength of composite nonwoven fabrics with various content of Tencel® fiber.

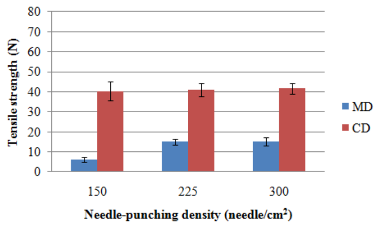

Figure 2 Tensile strength of composite nonwoven fabrics with various needle-punching density.

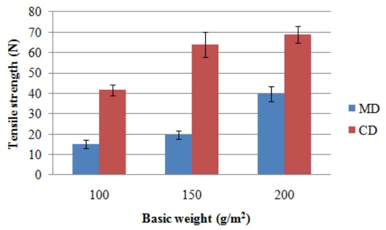

Figure 3 Tensile strength of composite nonwoven fabrics with various basis weight.Bursting strength of composite nonwoven fabrics

Figure 4 reveals the influence of the Tencel® fiber content on bursting strength of composite nonwoven fabrics. When Tencel® fiber content was increased, the bursting strength increased. This can be ascribed to the molecular chain in Tencel® fiber, which contained many benzene rings as well as had high crystallinity and orientation, resulting in an increase in bursting strength.

Figure 5 illustrates the influence of the needle-punching density on the bursting strength of composite nonwoven fabric. The bursting strength ascended with an increase in needle-punching density, due to the nonwoven processing. In nonwoven processing, the barbed needle plate pushed the fibers down and caught the fibers through the nets repeatedly; in this way, the fibers between webs intertwined and entangled, giving a rise in the bursting strength.

Figure 6 shows the influence of basis weight on the bursting strength of composite nonwoven fabric. When the basis weight was increased, the bursting strength ascended. Basis weight referred to the content of the fiber within a unit volume of the resulting sample. When the basis weight ascended, there was a greater amount of fiber within unit area, which was able to disperse more stress, heightening the tensile strength.

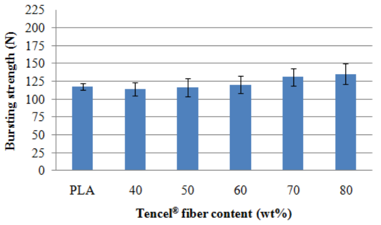

Figure 4 Bursting strength of composite nonwoven fabrics with various content of Tencel® fiber.

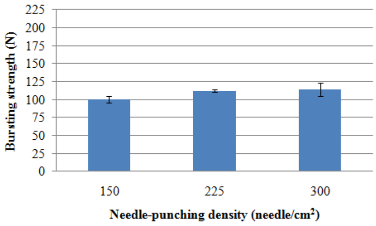

Figure 5 Bursting strength of composite nonwoven fabrics with various needle-punching density.

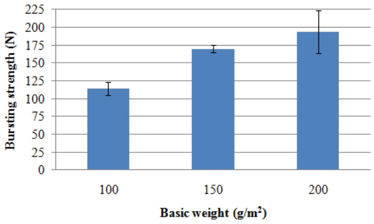

Figure 6 Bursting strength of composite nonwoven fabrics with various basis weight.

Conclusion

This study successfully created Tencel® /PLA/HAF composite nonwoven fabric, using Tencel® fiber, PLA fiber and HAF by nonwoven processing. Tencel® fiber content, needle-punching density, and basis weight were all able to reinforce the mechanical property of nonwoven fabric. Tencel® /PLA/HAF composite nonwoven fabric exhibited a tensile strength of 54.0N and a bursting strength of 135.1N when Tencel® fiber ratio was over 80 wt%, basis weight was 100 g/m^2 and needle-punching density was 300needle/cm^2. In addition, regardless of the three parameters, the composite showed a greater tensile strength in CD than in MD. Tensile strength in MD and CD of composite nonwoven fabric with a basis weight of 200 g/m^2 were greater than those of composite nonwoven fabric with a basis weight of 100 g/m^2; the former was 663.1% greater in MD and 70.6% greater in CD.

Acknowledgement

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