BIODEGRADABLE NONWOVENS FROM COTTON-BASED COMPOSITIONS

Rong Haoming, Gajanan S. Bhat and Kermit E. Duckett
University of Tennessee
Knoxville, TN
Mac Mclean
Cotton Incorporated
Cary, NC

Abstract

With the expansion of nonwovens into several novel applications, there is growing interest in the development of biodegradable/compostable nonwovens. Over the past few years, research has been done at the University of Tennessee, Knoxville to produce and evaluate nonwoven products containing cotton, especially those with cellulose acetate as binder fibers. Recent studies have shown that, by modifying the fibers or process conditions, nonwoven fabrics with good performance properties can be produced. Other combinations of cotton and biodegradable thermoplastic fibers also result in good quality nonwoven fabrics. These nonwoven products may have additional advantages in molding type applications, due to the nature of the binder fiber used, opening door to new opportunities, such as in automotive products. The production of nonwovens by the thermal bonding process from such compositions, and the structure and properties of the resulting products are discussed.

Introduction

In recent years, there has been increased attention to biodegradable and compostable nonwoven products. Biodegradability becomes more important for products that can not be recovered or recycled. Properties of cotton/cellulose acetate biodegradable nonwovens have been studied at the University of Tennessee, Knoxville [1]. However, one disadvantage in using cellulose acetate as a binder fiber is its relatively high softening temperature (T_s: 180°C~205°C), even with the use of some kind of plasticizer to decrease its melting temperature [2]. A bicomponent fiber (with the sheath T_m: 125~135°C) and a biodegradable copolyester fiber (T_m: ~120°C) were selected as binder fibers in this research. Apparently, the biodegradable copolyester (Eastar) fiber can be totally degraded into CO_2, H_2O and biomass [3]. Production and properties of nonwoven fabrics made by these two binder fibers under different processing conditions of were characterized for their structure and properties.

Experimental Methods

Eastar Bio copolyester fiber used in this study was produced by Eastman Chemical Co. from conventional diacids and glycols. It has excellent tensile strength, is dart and tear resistant, moisture resistant, has soft feel and hand, and easy to process. The bicomponent fiber, supplied by KoSa Inc., was selected as a control fiber in this research for comparing the physical properties. This sheath-core fiber was made by polyethylene and polyester. First a sandwich mixture of cotton/binder/cotton was made by hand mixing. Then the blend fibers were carded to form a web using a Hollingsworth carding machine. The carded webs were thermally bonded by point bonding on a Ramisch Kleinewefers 23.6 inches wide five-roll calender. The tensile properties were determined according to ASTM D 3822-91 standard under standard atmosphere for testing of textiles. Basis weight was tested according to INDA standard Test 130.1-92. Scanning Electron Microscopy (SEM) pictures were taken for bond points under a Hitachi S-3500N Scanning Electron Microscope.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:673-674 (2001)
National Cotton Council, Memphis TN

Results and Discussion

The properties of the nonwoven fabrics are highly dependent on the composition of cotton and the binder fibers, calendering temperature, speed and pressure. Effects of binder fibers component and bonding temperature are shown in Tables 1 and 2. With increase in binder fiber composition, tensile strength increased. And with increase in calendering temperature, the strength increases, reaching a peak value, before dropping off with overbonding. The nonwoven fabrics bonded by bicomponent fibers show very high tensile strength (Table 3) due to good bonding between cotton fibers and the binder fibers (Figure 1). Also the nonwoven fabrics made by biodegradable polyester fibers have good bond structure (Figure 2) with a relatively high tensile strength (Table 3). The tensile properties of cotton/Eastar blends are almost same as cotton and cellulose acetate (CA) nonwovens (Table 3). But the calendaring temperature of CA bonded nonwovens was much higher than those of the other two binder fibers (Table 3).

Because of its good processability with the biodegradable binder fibers, further research will concentrate on exploring the applications of these nonwovens, in automotive, civil engineering, and medical use.

Summary

High performance nonwoven fabrics, which are cotton-based can be made by carding and thermal point bonding under low calendering temperature. The properties of the fabrics obtained can be engineered by the proper selection of binder fiber, its composition and the processing conditions.

Acknowledgments

The authors would like to thank Cotton Inc. for financial support, and Eastman Chemical Company, Kingsport, TN and Kosa, Charlotte, NC for providing the fibers used in this study.

References

1. Suh, H., Duckett, K. E. and Bhat, G.S., Biodegradable and Tensile Properties of Cotton/Cellulose Acetate Nonwovens, Textile Res. J., 66, 1996, 230-237.
2. Xiao Gao, Effects of Water Treatment on Processing and Properties of Cotton/Cellulose Acetate Nonwovens, Master Thesis, The University of Tennessee, Knoxville, August 2000.
3. http://www.eastman.com/flex/biodeg/index.htm

Table 1. Effect of binder fiber (E) component and bonding temperature on peak load.

	Calendering Temperature (ºC)			
Cotton/E	**105**	**110**	**115**	**120**
85/15	0.60kg	0.91kg	1.01kg	0.91kg
70/30	1.14kg	1.60kg	1.73kg	1.77kg

Basis weight: ~80g/m^2
Calendering pressure: 25Mpa; calendering speed: 10 m/min

Table 2. Effect of binder fiber (B) component and bonding temperature on peak load.

	Calendering Temperature (ºC)	
Cotton/B	**125**	**135**
85/15	0.45kg	1.90kg
70/30	5.07kg	5.32kg
50/50	1.36kg	6.12kg

Basis weight: ~80g/m^2
Calendering pressure: 25Mpa; calendering speed: 10 m/min

Table 3. Tensile properties of nonwoven fabrics.

Sample name	Calendering Temperature (ºC)	Peak load (kg)	Peak elongation (%)
Cotton/B	135	5.32	38.85
Cotton/E	115	1.73	15.80
Cotton/CA	190	1.73	8.0

Basis weight: ~0g/m^2; Component: Cotton/B or Cotton/E is 70/30
Calendering pressure: 25Mpa; calendering speed: 10 m/min

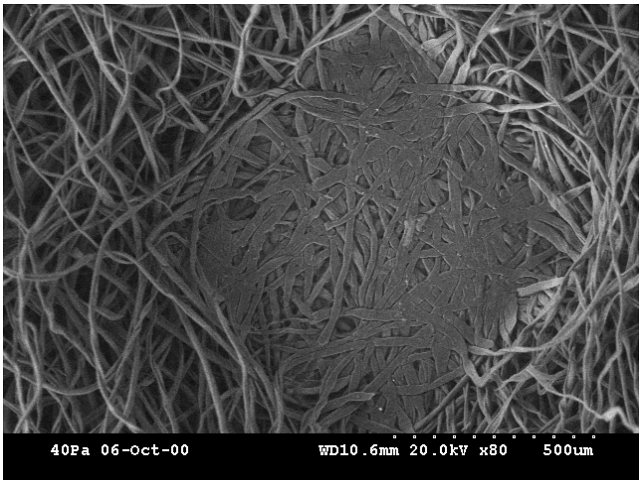

Figure 1. SEM Photograph of a Bond Point of Cotton/B Nonwoven.

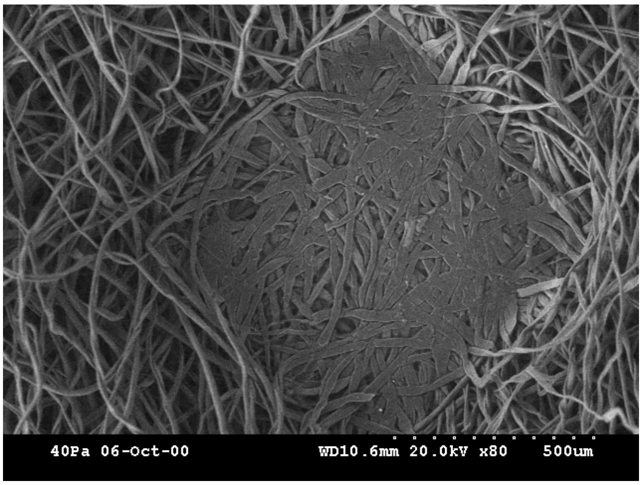

Figure 2. SEM Photograph of a Bond Point of Cotton/E Nonwoven.