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ADVANTAGES OF USING NATURAL FIBERS IN NONWOVEN COMPOSITES

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Although the size of the nonwoven cotton market is small, this industry is one of the few that has managed to hold its own in a climate which has seen most conventional cotton markets shrinking, as well as most textile markets, in general. This may be due, in part, to the very favorable price cotton merchants have seen recently, (November 2001 spot market price of $0.31/lb versus November 2000 spot market price of $0.62/lb), and, in part, to new and potentially significant markets for cotton nonwovens. The market for cotton composites made from griege cotton fibers and synthetics is quite promising in the insulation market, in general, and in automobile insulation market, in particular. The potential for bleached cotton nonwovens is also bright in the children's diaper and the adult incontinence markets, in the feminine hygiene market, and in the area of cotton wipes for home and commercial use. We at the Southern Regional Research Center (SRRC) have tried to select those areas of nonwoven cotton research which will have an impact on the nonwoven cotton market, and which we are capable of studying with the equipment at hand, and which do not require a large staff. Of the many potentially important areas of nonwoven cotton research, we have chosen to study enhanced cotton absorbency, improved nonwoven insulation for sound and heat applications, nonwovens with enhanced resiliency and resistance to burning, and automobile nonwoven insulation with significant weight reduction and environmental friendliness.

Increased Absorption

Our research on improved water absorption of cotton nonwovens goes back a number of years. It has long been known that the removal of natural waxes and pectins from cotton fibers greatly improves their moisture holding capacity. When one studies the rather complex problem of increased absorbency of cotton fibers and textiles, it is quickly realized that for a number of applications these non cellulosic materials must be removed and removed in the most economical way possible. It was this fact that induced Cotton Incorporated to perfect their so-called Greenville line, in which medium to low grade greige cotton could be scoured and bleached continuously in an efficient, low-cost process. The Edward Hall Corporation of High Peak, United Kingdom, licensed their process and produced scoured and bleached nonwoven cotton fibers for a number of years. They had bleached comber noil and other less expensive cotton wastes for surgical applications such as bandages. They also sold much of their production to wipe producers for industrial and household use. To the surprise of many, Edward Hall closed its operations recently and sold its equipment and licenses to Barnhardt Manufacturing of Charlotte, NC. With Hall's closing, the principal producers of scoured and bleached cotton fiber in the world are Bardhardt Manufacturing and BBA Nonwovens (formerly Veratec) of Walpole, MA.

Considering the fairly ready domestic availability of scoured and bleached cotton, we at SRRC have looked at mercerization and chemical modification of this purified cotton to further enhance cotton's wicking and moisture holding ability. This would certainly allow such cotton to compete more effectively in the diaper, bandage, and wipe market. Mercerization was first studied. Both griege and scoured and bleached cotton sliver was mercerized in the laboratory, neutralized and dried. These mercerized fibers were then recarded and then needlepunched several times. The rate of water absorption of the nonwoven arrays, as well as the total amount of water absorbed was measured by means of a gravimetry absorption testing system (GATS). When the GATS values were compared with nonmercerized fibers arrays, very little increase in the values for the mercerized samples was observed. Since only marginal increases in both wicking and water retention values (WRV's) were produced by mercerization, research emphasis was then shifted to chemical modification. Although some limited mercerization research continues at SRRC, however, the bulk of the research on increasing water retention values and wicking is concentrated on various types of chemical modification such as carboxymethylation. Research carried out on the carboxymethylation of spunlaced (hydroentangled) cotton gauze underline the importance of carefully adjusting the degree of substitution so as to achieve near maximum increases in moisture holding capacity, yet at the same time, maintain the integrity of the spunlaced gauze. A degree of substitution of about 0.15 could be accomplished in a simple one step treatment. This appeared to be optimum if both ends mentioned above are to be achieved. A book chapter was recently published by Dr. Parikh in which he describes this carboxymethylation work in detail. The potential new uses for cotton having enhanced wicking and water retention is limitless. No doubt there is significant added costs associated with chemical modification. We feel that the benefits will more than offset the increased costs.

Thermal and Sound Insulation Properties of
Moldable Nonwoven, Cellulosic Composites
for Automotive Applications

The market for automotive nonwovens in the USA is very large. Typically, about twenty square meters of nonwovens are used in the interior and trunk of the average car. More than three hundred million square meters of nonwoven fabrics are used in the approximately 16 million new cars produced each year. Currently, there is a major upsurge in research on the use of recyclable and biodegrable materials in manufactured products. This has triggered a need for biodegradable nonwovens for a number of automotive interior components. These components currently contain traditional materials such as fiber glass, other manufactured fibers, and organic foams that are difficult or impossible to recycle. By incorporating cotton or various inexpensive agricultural lignocellulosic (bast) fibers such as kenaf, or jute in the manufacture of automotive nonwovens, their biodegradability can be enhanced. Because of the difference in densities of cellulosic and glass fibers, cotton and kenaf-based nonwoven composites are lighter than those containing glass. This will also lead to a more efficient, lightweight, "green" automotive interior with enhanced ecological friendliness. Preliminary research studies have shown that several cellulosic-based (kenaf, jute, cotton, and other less-expensive vegetable/bast fibers) nonwovens are efficient sound absorbers and greatly reduce the noise level in a car. These nonwovens meet or exceed industry specifications of flammability, odor, mildew, bond strength, drapeability, tensile strength, elongation, and compression properties. We have also developed improved chemical retting and finishing techniques for refining and carding of several varieties of kenaf. We have fabricated and subsequently measured the physical, mechanical and acoustical properties of needlepunched thermoformable nonwoven fabrics for certain automotive interior applications. Needlepunched nonwoven fabrics were produced using cotton and refined kenaf fibers in intimate blend with recycled polyester, and polypropylene (PP) in various weight percent ratios in thermoformable composites. Most of these composites made from natural cellulosics proved to be superior sound absorbers when compared to conventional composites containing glass fiber.

The thermal conductivity of the nonwoven composites were determined by a steady-state heat flow method, in accordance with ASTM C518, which involves the use of a thermal conductivity meter. Average thickness and air permeability of the samples were measured in accordance with Standard ASTM methods. The test results show that the thermal insulation properties of the composites vary significantly, depending on the type of cellulosic fiber, the pretreatment of fibers, the ratio of cellulosic to synthetic fibers, and the overall densities of the composite. However, these low cost nonwoven cellulosic composite materials had excellent thermal insulation properties and good tensile and flexural strength, excellent shape stability and enhanced biodegradability. Data also show that addition of cellulosic fibers significantly improved the thermal insulation properties of needlepunched composites compared to those made from synthetic fibers alone.

The best nonwoven fabrics developed used optimally retted kenaf and jute fibers in various blends with greige cotton, recycled polyester, and off-quality polypropylene. Use of cellulosic fibers in automotive nonwovens would be more environmentally benign and will lead to a considerable expansion of the use of cotton as well as other cellulosic nonwoven composites in the automotive industry.

FR/Resilient Perpendicular-Laid Nonwovens Containing Cotton

Highloft nonwoven fabrics are usually made with synthetic fibers. The concept of incorporating cotton into highloft fabrics is the focus of one of our present research efforts. The major problem with the use of cotton is its non-resilient/flammable character. Compressional resistance and elastic recovery of highlofts containing untreated cotton tend to be inferior to those of synthetic fibers. The purpose of this research was to carry out simultaneous chemical finishing of perpendicular laid highloft fabrics (containing cotton) to impart improvements in fiber resiliency and flame resistance. Dr. Parikh will report later in this session on the success he has had in imparting both fiber resilienc and flame resistance to cotton containing highlofts.

Compressional Behavior of Perpendicular-Laid Fabrics Containing Cotton

Highloft perpendicular-laid fabrics are usually made with synthetic fibers. We have studied the preparation of perpendicular-laid nonwovens with short staple and mill waste cotton (such as comber noil). These fibers have been blended with recycled synthetic staple fibers and low-melt bonder fibers, to produce value-added highloft products containing waste cotton. Currently, low quality, short, waste cotton fibers find only limited use in nonwovens. Much of these materials are used in the paper industry in combination with wood pulp for the production of high quality paper. During the past ten years, new technology has been developed at SRRC in cooperation with the Technical University of Liberec (TUL), Czech Republic, in which low quality synthetic fibers are combined with short cotton fibers, then processed into highloft nonwoven structures with excellent compressibility characteristics.

We have studied such high-loft perpendicular-laid nonwoven structures made from cotton, polyester, and bicomponent bonding fibers, and compared their compressional resistance and subsequent recovery properties (when the deforming forces are removed) with those made by conventional cross-laid technology. Low cotton-content highlofts containing up to 20% cotton have good compressional behavior and dimensional stability similar to those of 100% synthetic-fiber fabrics. These low cotton-content highlofts are economical to produce and have improved biodegradability.

In conclusion, considering the combined research effort of SRRC, Cotton Incorporated, universities and the nonwovens industry as well as the myriad new uses developing rapidly for improved nonwoven products, in which cotton or other cellulosics can play an important part, it is reasonable to expect a rather significant increase in cotton's share of the nonwovens market in the near future. Furthermore, it is expected that the present price of cotton on the spot market will be a further inducement to the producers of nonwovens to consider cotton a little more carefully.