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Nonwoven Structure Statistics: Simulation Of Effects
Of Fiber Crimp, Flocculation, Density and Orientation

Role of Fiber Finish In The Conversion of Fiber To Nonwovens — Part 2:
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A Comparison Of Antimicrobials For The Nonwovens Industry

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Many companies invent more technology than they can use. One way of putting such technology to good use is to donate it to a university for further development and commercialization.

Donations of intellectual property can potentially open new research opportunities for faculty and students, generate a revenue stream for the university, and improve the lives of people who use products stemming from the technology.

In 2000, The Clemson University Research Foundation received, as a donation from Eastman Chemical Company, 23 U.S. patents, a group of U.S. patent applications, and 97 foreign patents and applications relating to capillary-surface fibers. Additionally, Procter & Gamble recently donated its proprietary capillary channel film and fiber technology to the Clemson University Research Foundation.The Procter & Gamble donation consists of 10 U.S. patents and 84 foreign patents and patent applications. The combined intellectual property portfolios cover channeled fibers and films, manufacturing processes, and several end-use applications of capillary-surface materials.

Channeled fibers have a much larger surface area than round fibers of comparable cross section and can spontaneously move fluids through the process of capillary action. Applications for channeled fibers include fluid transport and storage, thermal and acoustical insulation, and filtration. End-use applications include disposable diapers, training pants, feminine napkins, tampons, adult incontinence products, activewear, filters, and insulation materials.

Understanding The Process

Prior to accepting a donation of intellectual property, Clemson conducts a thorough study of the potential impact of the technology. Clemson assesses the potential for the technology to enhance its teaching, research and public service goals and ensures that adequate resources are available for supporting the commercialization process.

The donations have created new opportunities for teaching and research at Clemson University. Students in Clemson School of Material Science and Engineering are experimenting with a unique class of fibers that will potentially find use in a wide range of consumer products. Additionally, Clemson scientists are collaborating with researchers at Procter & Gamble to explore applications of capillary-surface materials in new product designs.

At Clemson, interest in the donated technology extends beyond the School of Material Science and Engineering. The donated technology has attracted researchers in chemistry, horticulture, and biomedical engineering who are investigating novel applications of capillary-surface materials. In addition, faculty and students in Clemson’s business college are actively engaged in planning and executing strategies aimed at commercializing the donated technologies.

Fiber Innovation Technology, Inc., of Johnson City, TN is currently supplying a variety of Clemson’s capillary surface fibers in the form of staple fibers and continuous filament yarns made from several polymers.
RESEARCHER’S TOOLBOX

**Banning of Mercury Thermometers**

Being “banned in Boston” may be good (or bad) for a book or a play. However, the most recent banning in Bean Town has been the banning of mercury thermometers, the fever type as well as others containing mercury. Several other cities, as well as some state and local governments, have taken steps to discourage the sale and use of these thermometers.

The reason for this action, of course, is the concern with mercury contamination of the environment. The mercury in just one thermometer can contaminate an 11-acre lake, and broken thermometers could add some 17 tons of mercury to the U.S. waste stream annually.

There is no problem if the mercury stays inside the glass capillary of a thermometer. When the thermometer is broken and the mercury is allowed to escape into the environment, problems can result. If the escape is inside a structure, the small globule of mercury can volatilize slowly, raise and maintain the level of mercury vapor at a dangerous level.

If released outdoors, the mercury generally finds its way into streams, rivers and lakes. In this aqueous environment, metallic mercury is converted into methylmercury, which is particularly troublesome, as this compound can easily enter into the fish population and thence into the food cycle of human beings.

This was the cause of “Minimata Disease” that struck a small fishing town on Minimata Bay in Japan several years ago. Discharge of mercury from a nearby chemical plant that used a mercury compound as a catalyst resulted in contamination of the bay, which surprisingly resulted in the formation of highly toxic methylmercury and a subsequently dangerous mercury level in the fish. Because fish from the bay was a major part of the diet of the population, many people were afflicted with what was eventually recognized as mercury poisoning. Numerous deaths and disabilities resulted.

Mercury poisoning was also the cause of “Mad Hatter’s” disease, which in years past plagued felt hat manufacturers and those that used mercury chloride to de-hair animals.

One of the major concerns with mercury contamination is the effect on small children and on a growing fetus. This stems from the fact that the developing nervous system is especially vulnerable to mercury toxicity. This has resulted in advisories about the potential dangers to pregnant women and children of consuming fish from some areas and at some times.

In the metallic form, mercury is not inherently dangerous. However, the liquid vaporizes at room temperature, giving rise to mercury vapor which can enter the human body very easily. If the mercury is exposed to heat, of course, vaporization is greatly accelerated and absorption is increased. Thus, mercury vapor and in aquatic environments are of prime concern to humans.

There are several alternatives to mercury thermometers, and these are becoming much more common. The digital electronic thermometer is probably the best known alternative, and is an excellent substitute for the mercury version. The alcohol thermometer (usually shows as a red liquid) and the galinstan (gallium-indium-tin liquid) thermometers are also good alternatives. In Boston and elsewhere, area stores are offering digital and other safe thermometers in exchange for mercury models.

The primary environmental concern arising from use of alternative thermometers relates to the disposal of button cell batteries used in digital electronic thermometers. Button cell batteries used in such thermometers contain significantly less mercury than in a mercury thermometer — about 3.5 to 11 milligrams of mercury per battery (depending on type) versus approximately 700 milligrams in a small thermometer. Such button cell bat-

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**Computer Disposal**

Along with being concerned with mercury from thermometers, researchers and others must become more concerned with the disposal of computers and similar electronics equipment.

What do you do with an old computer? The usual practice is to give it to someone who doesn’t need the latest high-speed unit with a monstrous memory. However, a computer is eventually discarded. With millions of them being sold each year, the number ready for discard is rapidly as well.

In years past, there were enterprising individuals that would disassemble an old computer to salvage parts and other items. Older units used to have gold in the connectors, a fair amount of copper and other salvageable materials. Some computer companies are setting up facilities to take in their own outdated units, by way of showing some environmental responsibility.

Another feature that must be considered is the high levels of potentially toxic flame retardants that can be released into the air when old computers, TVs, microwave ovens the like are dismantled. Researchers at Sweden’s Stockholm University found airborne levels of flame retardants at two to three orders of magnitude higher than in other work environments, including a circuit board assembly plant. Very likely the flame retardant agents arise from the use of these materials in the cabinet especially, but in other components as well.
Nonwoven fabrics can have a problem because of the irregularity of the fibrous surface. This can be overcome in many cases by using heat and pressure to convert the web into a flat film. This treatment generally does not change the surface characteristics, but this point has to be established in each individual case. In some situations, measurement of single fiber contact angle by a receding or advancing liquid can give very useful information. Automation of this type of measurement can also be accomplished by melding computer power with surface instrumentation.

As is well known, low energy surfaces will cause of drop of water to “bead up,” making the contact angle greater than 90 degrees. On high energy surfaces, such as clean glass, the contact angle goes almost to zero and spreading occurs. Using fluids of known surface tension, only the contact angle needs to be measured to obtain the surface energy.

With video-based measurement equipment, the contact angle can be obtained directly or via a shadow image; use of a computer provides very accurate measurement and extensive data processing and storage. Also, a time record can be obtained, showing changes in contact angle due to a variety of conditions. As a result, surface measurements can provide substantial information, both static and dynamic. For these reasons, use of automated contact angle data is finding many applications in such areas as medical plastics, printing, plating, semiconductor processing, coating, bonding, painting, and so forth.

The principal suppliers of this type of instrumentation consist of eight companies, most of which provide equipment and services on a world-wide basis. These systems involve a drop dispenser, drop stage, video camera, frame grabber and computer, with various software programs and additional features.

- First Ten Angstrons (www.firsttenangstroms.com) is an American company with expertise in custom vide-based electronic measurement systems. Some of their equipment is geared for QA, while other units are especially designed for research.
- KSV (www.ksvltd.fi) is based in Helsinki, Finland. Their equipment allows surface measurements by a variety of methods and equations. The software uses an internal database system where all the recorded data is stored for convenience for future analysis.
- Ramé-Hart (www.ramehart.com) is an American company that is a leader in surface treatment of materials. Consequently, it specializes in instruments for treatment measurements. For contact angle measurement, the drop shape is determined by software that uses a contour-following algorithm.
- Tantec (www.tantecusa.com) is an Illinois firm that specializes in corona treatment of materials and static control. Their contact-angle system uses a fiberoptic light source to increase the light intensity for sharper image definition and easier measurement in brightly lit rooms. Image projection is also available.
- AST Products (www.astp.com) is an American firm that provides a large range of plasma treatment equipment along with surface measurement equipment. Besides contact-angle measurement for sessile drops, the software includes pendant drop analysis and calibration for fluid surface tension measurement.
- Krüss (www.kruss.de) is a German firm that is probably the largest specialist in surface instrumentation. They offer a variety of models for static and dynamic measurements of a range of surface properties. They have accessories for high temperature work and modifications for handling large samples.
- DataPhysics (www.dataphysics.de) is another German company that offers a wide range of variations on the basic video contact-angle meter, including surface and interfacial tension based on the analysis of the drop shape.
- Fibro (www.fibro.se) is a Swedish firm that has specialized in printing and surface matter relating to that area. Its Dynamic Contact Angle and Absorption Tester measures the interactive wetting (contact angle) and sorption (volume between a liquid droplet and a specimen surface as a function of time, with a timing accuracy of a single millisecond. This information relates to printing, gluing, and coating behavior.
DIRECTOR’S CORNER

Role Playing in Forecasting

While there still seems to be a lot of black magic in forecasting, the application of experimentation and scientific principles to the practice of forecasting has resulted in more understanding of the process and some improvements in the results.

A recent study by a marketing professor in the Wharton School at the University of Pennsylvania has suggested a useful tool to improve forecasting efforts. With a colleague from Victoria University in New Zealand, Professor J. Scott Armstrong has been studying how to make more accurate predictions, specifically in conflict situations. Professor Armstrong explains that such situations include the crucial decisions arising from such diverse activities as military clashes, marketing challenges; labor-management conflicts and others. Such circumstances would even include the conflict situations involved in the competing research and development groups of competitive industrial companies striving for the best technologies, superior products, and enhanced positions in the marketplace.

Professor Armstrong explains that “research tells us that experts are not good at forecasting decisions in conflict situations. The reason is that conflicts are complex and often involve several rounds of action and reaction. Fortunately, there is an effective alternative: role-playing. For conflict situations, research shows that role-playing yields the most accurate predictions.”

The research involved a large number of students who were presented with descriptions of six actual conflicts and were then instructed to select the most likely decisions. Without any further assistance, the results were only slightly better than chance; the participants were correct on only 27% of the decisions. The researchers then asked 21 game theorists from around the world to make predictions, reasoning that their greater understanding of conflicts, along with their expertise and knowledge of game theory would produce better forecasts. Surprisingly, they were correct on only 28% of their decisions.

A large group of students (352) were then given the same assignment, but were instructed to use role-playing in their efforts. On average, there were 61% correct predictions versus the 27% when similar participants made unaided predictions. Professor Armstrong concluded: “I have been involved in forecasting since 1960 and have never before encountered a forecasting method that produces such large improvement over other procedures.”

Over a wide range of studies, the researchers found that instructing the decision makers to think like their opponent or giving them information about the roles of the parties involved did not improve accuracy of their decisions.

Authorship and Inventorship

In granting a U.S. patent, the Patent Office requires that everyone that contributed to the invention be listed as one of the inventors; also, it is a requirement that no one be listed as an inventor, unless they made an actual contribution to the patent.

Obviously, such is not the case when considering the authors of a paper or publication. A recent study of scientific papers whose publication corresponded timewise to the granting of a US patent was made. Of the 40 papers studied, 38 had more authors than inventors, only two had the same number, and none had more inventors than authors.

In both the academic and industrial research worlds, the gift of authorship is somewhat common. In the granting of a patent, no such gift is possible, as such action would be the basis for invalidating a patent.

In an effort to stem such practices, the International Committee of Medical Journal Editors has established guidelines for authorship; these guidelines require that each and every author contribute to all of the following elements:

- Conception and design or analysis and interpretation of data.
- Drafting the article or revising it critically for important intellectual content.
- Final approval of the version to be published.

With such guidelines in place, some observers have expressed the opinion that the specifications for co-inventorship are less stringent than co-authorship. This stems from the fact that inventorship requires that each of the inventors work on the same subject matter and make some contribution to the inventive thought and to the final result.

A somewhat similar situation exists in the order of listing authors and inventors. Seniority in position or tenure often rules the order, not the proportion of contribution. This situation is often a little more difficult to sort out.

The scholar who carried out the study suggested that designating an “author” be done only for those “who made a significant contribution to the conception of the work.” Clearly, all authors should also merit co-inventorship if the technology proves patentable. (P. Ducor, Science 2000, 289, 873-875).

Life is a little simpler when there is only one author or one inventor.
Consequently, the researchers emphasize that role-playing must simulate the complex interactions.

Along with numerous examples, the use of role-playing in a specific military conflict was described. During the Vietnam War, role-playing was employed in assessing potential strategies. Armstrong points out that unfortunately, top government officials did not believe the conclusion from the role-playing that moderate bombing was the worst strategy the U.S. could follow.

Stress-Relieving Strategies

In the previous issue of *International Nonwovens Journal* (Winter 2001), the problems associated with job stress and stress management for the research administrator were discussed.

Information and data continue to accumulate to verify the growing character of job stress, along with the many manifestations of the problems arising from such stress. Long workweeks, crazy hours, and concerns with downsizing, outsourcing and outright unemployment continue to foster apprehension and emotional pressure and tension.

Like all of life’s problems, there are steps that can be taken to reduce the level of anxiety and temper the results of the pressure. While no one approach is guaranteed to alleviate all of the problems, different techniques can be explored to find the one or combination that seems to fit, as this whole area is very subjective.

Here are some suggestions that may help to minimize stress and to provide some much-needed breathing time in an otherwise difficult schedule:

- Arrange to telecommute regularly or on occasion: Many companies have become more comfortable with having their employees work at home regularly or on occasion. For R&D people, this is more difficult, but still can be employed at times. Literature research, computer work, writing and other tasks common to research activities can be arranged at times, providing a change of scenery and a sense of control. Such an action can often result in increased productivity.

- Utilize lunch breaks for recreation: “Recreation” in this case does not necessarily mean hard physical exercise, although that is certainly one good method of relieving stress. Others that can be done in a short, timeout, can be a brisk walk, a musical interlude, or even easy stretches that can be done at the desk, lab bench or out in the hall, if no designated facilities are available. The important elements are “a break” and “recreating.”

- Exploit floating holidays or minor holidays: A day away from work can really make a difference in the stress level experienced. If the day away is planned, and arranged specifically to help reduce stress, it can be particularly refreshing and beneficial. One expert suggests that such a time should involve some exercise, since that increases the endorphin level and makes a person feel good all over.

- Put a relaxaton break into every hour: Taking a few minutes to simply get up and move about can be quite relaxing and often helps to break the tension that accompanies stress and routine. Lack of movement can actually create fatigue, according to one expert. Both mind and body can often benefit from such a brief change of activity.

- Use Flex Time and Flexible Scheduling wisely: As one expert put it: “Taking ownership of your time cuts down stress by allowing you to have a more flexible timetable for taking care of life’s obligations.” Everyone has a life outside of work, and some flexibility in scheduling both lives can often reduce those unforeseen problems that add to on-the-job stress.

Along with these possibilities, every wise administrator knows that the annual vacation, with its possibilities of refreshment and renewing, is provided not because it is simply a tradition, but because thoughtful experience has proved it has a real value when used wisely.

Another interesting facet of stress reduction comes from the fact that growing plants have been shown to be effective in stress reduction. Results of studies conducted by Texas A&M and Washington State University confirm that visual exposure to settings involving growing plants can produce significant recovery from stress within five minutes; this same study revealed that this type of surrounding can improve productivity by 12%.

Apparently being surrounded by plants can lead to more positive emotions — such as happiness, friendliness and assertiveness — and fewer negative emotions such as sadness and fear, compared to feelings prior to exposure. The researchers concluded that interior plants can play a critical role in the workplace by reducing stress while stimulating a more productive environment.

Hey, where would you like these African Violets? — INJ
TECHNOLOGY WATCH

PLA — The Newest Generic Fiber

To be designated as a generic fiber by the U.S. Federal Trade Commission means that the fiber has been given an official name and classification that recognizes it as a unique and identifiable fiber in commerce, distinct from other fibers. In announcing the official designation, Cargill Dow LLC indicated that the designation as “PLA” is to be used for the fiber and that their name “NatureWorks” will be used by them to identify their specific trade name product.

As a part of receiving the new generic classification, Cargill Dow had to show: properties and chemical composition that is radically different from other fibers; what commercial use is foreseen; and that the new generic is of importance to the public. PLA now joins other fiber classifications including cotton, wool, silk, rayon, nylon, polyester, and others.

For a fiber to be classified as PLA, it must be a synthetic fiber manufactured from polylactic acid or poly lactate derived from naturally occurring sugars, such as those in corn or sugar beets. The process used to create NatureWorks PLA fibers involves converting plant starches into natural plant sugar building blocks. Such monomers are then used to make a series of polymers called polylactide (PLA). The development and manufacture of PLA relies on basic fermentation and distillation as its core chemical process, followed by direct polymerization.

NatureWorks PLA fiber will compete head-to-head with traditional fibers on a cost and performance basis and is generating worldwide interest among leaders in the textile and film packaging industries. NatureWorks PLA is the first commercially viable polymer produced from annually renewable resources that performs as good or better than traditional polymers and is fully compostable in industrial and municipal composting facilities.

Founded in 1997, Cargill Dow LLC is based in Minnetonka, MN. It is a joint venture of Dow Chemical Company and Cargill, the largest privately owned corporation in the U.S. Cargill is based in Minneapolis, and is an international marketer, processor and distributor of agricultural, food, financial and industrial products.

In November of 2001, Cargill Dow began commercial operation in their world-scale polymer production facility to produce polylactide (PLA) polymers in commercial quantities. This PLA was the first to produce commercially viable polymer produced from annually renewable resources. Located in Blair, Neb., USA, the plant has a capacity of more than 300 million pounds (140,000 metric tons) of PLA annually. The plant supplies resin for use in global markets, including Europe and Asia Pacific.

Within the past few weeks, Cargill and Purac have agreed to a joint venture to supply lactic acid to Cargill Dow for use in the manufacture of polylactide (PLA) polymers in the U.S.

Meltblown Web As An Insect Barrier

An interesting new application for meltblown and resin technology is emerging from the research work of the New York State Integrated Pest Management (IPM) program at Cornell University (Dr. Michael P. Hoffman, Professor of Entomology and Director). This group is investigating the use of meltblown fiber webs as barriers to invading insects.

Describing their webs as “cotton candy” polymer, the scientists form a fibrous meltblown web around the stem of young plants that are susceptible to the attack by relatively large insect pests. The polymer that has been employed thus far is an ethylene vinyl acetate (EVA) resin, typical of a commercial hotmelt material. The web is formed by means of a hand-held nozzle (Dynatec System, ITW Dynatec, Hendersonville, TN) aimed at the base of the plant. A multi-dimensional barrier is formed at the strategic location on the plant where it can interfere with insect behavior.

Without protection of chemical insecticides, onion and cabbage fields can be attacked by maggots, which will destroy 40-90% of the crops. In experiments with the mechanical meltblown barrier, webs of 5-50 micron fibers were applied directly to the soil around the plant’s base. The EVA barriers kept onion maggots with their hook-shaped mouth parts from feeding on young plants, resulting in significantly lower crop destruction, and fewer eggs laid. For cabbage maggots which attack roots, the EVA fiber was applied to broccoli plants with the same success.

The researches are working to produce fibers with optimum characteristics (fiber density, diameter, color, etc.) for pest-repellence. Research is also underway on the incorporation of other beneficial materials in the polymer web. For environmental protection, timed-degradation of biodegradable formulations is being investigated.
in making PLA resin. Under the agreement, the joint venture will supply lactic acid until Cargill Dow has developed its own capacity, expected to occur by mid-2003. This agreement will allow Purac, a unit of Dutch food Group CSM, nv (Amsterdam), and Cargill to accelerate expansion of plants in Brazil and the U.S. by about 40,000 metric tons per year. This move will thus insure the availability of sufficient lactic acid to Cargill Dow to ratchet up their new polymer plant to full capacity as soon as possible.

**Super-Functional Clothing**

Over the past few months the popular press has described a variety of "Gee Whiz" items of wearing apparel and other specialty functional articles that depend on fibers and textiles for their outstanding functionality. Nonwoven materials are involved in some of these developments; with a little ingenuity and innovation, nonwovens could certainly be involved in many more ways, and actually be the key element in some of these advanced developments.

One such development involves the storage of body heat to provide a garment that keeps an individual warm. Most thermal insulation works by creating voids which are filled with entrapped air, which provides the insulation. Air has a limited heat capacity, however, so the ability to store heat in an air mass is quite limited.

A material that melts and solidifies at a temperature close to body temperature can be used as a much larger heat reservoir.

This development uses waxes that have melting points that range from 0 degrees C to about 60 degrees C, broadly spanning normal body temperature. The waxes are microencapsulated, to make them easy to manage and contain. In microcapsule structures, the wax particles are coated with gelatin or a similar substance as the capsule forming element. When the temperature is above the melting point, the molten wax is contained within the microcapsule shell. When the temperature is lowered, the wax solidifies, again contained with the microcapsule. During the process of melting, a definite amount of heat must be absorbed (Heat of Fusion).

When the temperature is lowered, the same amount of heat is given off as the particle freezes.

In contact with a warm body, the microencapsulated material picks up heat and undergoes melting and warming of the wax. When placed in a colder environment, the capsules give up their heat in cooling to the melting point and then further give up the Heat of Fusion as they solidify. Thus, the capsules are an active heat source.

In use, the microencapsulated waxes are added to a coating solution that includes a polymer dispersion, thickener, and surfactants. The coating is applied to a fabric using a knife-over-roll coater and then dried. Waxes of C-18 and C-20 carbon atoms are particularly suited for use in garments, as they have melting temperatures of 28 and 38 degrees C. respectively — below and at body temperature. Higher melting waxes may be useful in heat protective garments.

A somewhat different approach to the same problem has been used by researchers at Malden Mills in Massachusetts, working with textile experts at the U.S. Army’s Natick Laboratory. This approach centers on situations where the amount of heat generated by the body is inadequate for extreme environments that soldiers and outdoor enthusiasts must endure for extended periods. The solution is this project has been to develop high-tech jackets that create their own warmth by means of lightweight lithium batteries.

Instead of heat being developed from an electric current running through embedded wires, a more subtle approach has been taken. This involves developing heat within stainless steel microfibers that are an integral part of the fabric. The microfibers are thinner than a human hair, and when blended with conventional fibers, give a fabric that is as washable, soft and conformable as a normal fabric.

The electrical power for heating is provided by small lithium battery that is affixed to a holder on the exterior of the jacket. This battery is about the size of a pocket watch. The current jacket has two settings; the “normal” setting heats the fabric around the chest area to 108 degrees F. for five hours, or on a “high setting, goes to 114 degrees F. for 2.5 hours. The heating occurs in the chest area to heat up the body core where the heart and lungs are located; if the core, where all of the blood circulates through, is warm, then the extremities are satisfactory.

The use of “nanotechnology” — the science of making electronic and other devices on the tiniest of atomic scales— is being explored for application to textile and fibers, to make “smart clothing.” Motorola, for instance, is working on developing clothing that can “talk” to washing machines to give instructions on how the garments should be washed, by relaying the appropriate wash machine settings.

Burlington is working with Nano-Tex Inc. to develop fibers that comprise molecular-scaled sponges that absorb the rancid hydrocarbons that are responsible for body odors. The sponges are designed to release such odors only when they encounter a detergent in the washing machine.

DuPont is working with fibers having unique cross-sections which enable microscopic “wings” of different materials to be added to the core fiber, like wings of a bird; the fabric can then be made to contract or expand, loosening and tightening clothing, or changing color as the wearer desires. This area of “textronics,” as DuPont likes to call it, will combine textile and fiber properties with electronics in some unusual ways. This is an area where the company hopes it can leverage its extensive knowledge in chemistry, textiles and electronics.

Other advanced programs involving fibers, fabrics and apparel are aimed at monitoring ill patients, fitness enthusiasts, sporting participants and military personnel. Consider installing a GPS system in a child’s clothing or the clothing of an Alzheimer patient to assist in determining location. The potential extension of such capabilities seems almost limitless, and nonwoven structures are likely the ideal for many of these advanced concepts.

— INJ
Effect of Synthetic Fibers on the Absorption Properties of Pads

By Dr. Cecilia Rosinskaya, Doctor of Technical Sciences; Prof. Amotz. Weinberg, President; and Sebastian Fishman, Graduate Student of Industrial Chemistry Department, Shenkar College, Ramat-Gan, Israel

Abstract
Absorption and retention capacity of a mixture of wood pulp, superabsorbent and synthetic fibers (polypropylene, polyamide and polyester), designed for production of the core for disposable pads, were studied. The measurement of absorbency was carried out in the broad range of component weight ratios in a solution NaCl at different lengths of time both with and without pressure. The insertion of the synthetic fibers into the mixture of wood pulp and superabsorbent influences on the physical structure of this assembly which in turn causes the initial rate of absorption to rise. Absorptive and retention capacity of the structures is influenced by the type of synthetic fiber: in the presence of polypropylene no change was detected; the presence of polyester and polyamide fibers caused an increase in absorption ability of the composite structure.

The behavior of the components for the absorbing layer: cellulose, synthetic fibers and superabsorbent was found to be independent, i.e. they do not influence the absorption of liquid of one another in these tests. The content of the mixture with definite properties may be predicted according to the properties of its components.

Key words
Incontinence pad, wood pulp, superabsorbent, synthetic fiber, absorption capacity

Introduction
A variety of pads for adult incontinence is produced today. Most of them have as the main part – an absorbing layer, or core, that contains cellulose fibers from wood pulp and superabsorbent – synthetic polymer from the group of polyacrylates. Absorptive properties of these two components determine the behavior of the pad in the process of absorption of urine, i.e. absorption capacity, liquid holding ability, and transport of liquid through the core [1-5]. Besides the mentioned parameters, physical properties of cellulose fibers: stiffness, resilience, deformation in the wet state without and under pressure influence the absorptive behavior of the pad, because the absorption involves not only swelling of hydrophilic fiber, but imbibition of liquid in interstitial voids and capillaries and spreading of liquid in the core. Survey of the articles in the literature has shown that notwithstanding all the improvements of the incontinence pads, one problem remains in their use – leakage of the liquid if time of application is relatively long (the whole night, 6-8 hours). The principal cause of leakage is inability of the core to absorb and retain all the volume of urine evolved during this long time and to distribute it to all the volume of the core, because the swelled cellulosic fibers from wood pulp are prone to partial entanglement and clotting especially under pressure, and this circumstance restricts the possibility of this structure to absorb liquid. The superabsorbent is able only to absorb and to retain liquid, but it does not promote its spreading in the core [6-11]. The comparison of the total absorption capacity of a middle size (weight of the core 100g) incontinence pad equal to 1000g and the volume of liquid (urine), evolved during night – 500 ml, points out that the potential of the absorbing layer is not utilized, because almost all the volume of liquid is stored in the place of insult, i.e. in the crotch but not in the side, front and back parts of the pad. The diminution of the volume of voids in the structure of the core owing to the deformation of the assembly of fibers in the wet state represents hindrance to the spreading of liquid.

For enhancement of physical properties of the assembly from short cellulosic fibers it would be expedient to insert into the mentioned structure the synthetic fibers that are hydrophobic i.e. do not swell in water, are stiffer and more resilient than cellulosic fibers and are not prone to clotting in the wet state. Due to these properties of the synthetic fibers it may be supposed that they should keep the physical structure of the core after wet deformation and consequently improve the distribution of liquid in the core.

The purpose of this study was to evaluate the influence of the synthetic fibers on the absorption capacity of the assembly of cellulose fibers from wood pulp and superabsorbent by different ratio between them and to find optimal composition for the core.
Materials and Methods

The materials used for the experiment were: bleached soft wood fibers from Southern Pine, Sanwet Superabsorbent (Clariant), commercial synthetic fibers: polypropylene (PP) (5.8d), polyester (PES) (5.6d), polyamide (PA) regular (5.0d) and texturized (5.0d) (length ~ 3-4 mm). Characterization of the absorption capacity (AC) was carried out by the modified test of EDANA [12-15]. Specimens for the test were prepared by mixing all the components in the blender, weighing, keeping under pressure, wrapping in the wipe and placing in the wire basket, soaking the basket with the specimen in the solution 0.9% NaCl for some periods of time: 15, 30, 60, 360 and 720s, removing the sample, draining for 30s and then weighing. When the weight of the wet sample was constant, it was taken out from the solution, kept under pressure 5 kPa for 360s and weighed.

The absorption capacity (AC) was calculated as total mass of liquid (g) that 1g of the sample absorbs after soaking. The retention liquid ability (AC rm) was calculated as total mass of liquid that 1g of the sample contains after the 5KPa pressure for 360s. Coefficient variation for the determination of AC was ~ 10%.

The experiment was carried out in several stages:
1. Influence of synthetic fibers (SF) on AC of their mixture with wood pulp.
2. Influence of wood pulp and SF on AC of their mixture with superabsorbent (SAP).
3. Influence of SF on AC of ternary mixtures: wood pulp, SAP and SF.

Results:

Influence of synthetic fibers on absorption capacity of their mixtures with wood pulp

The results of the experiment are presented in Table 1. The data show that the values AC and ACrm for the mixture wood pulp with PP (ratio from 90/10 till 70/30) are equal to the value AC for wood pulp alone. By ratio 50/50 AC of the mixture is lower than AC of wood pulp alone owing to the lower value AC for PP alone. The values AC for the mixtures wood pulp with PES (ratio 70/30-50/50) are higher than for the wood pulp alone, because AC of PES is significantly higher than AC of the wood pulp. The values of AC of the mixture wood pulp with PES correspondingly are noticeably above the values for the mixtures with PP. This points out that the importance of the physical structure and its behavior in the wet state is on a level with swelling of the cellulosic fibers. It is known that the resilience and elasticity of PES fibers are higher than of PP fibers, and these properties of PES stipulate the lesser deformation of the structure in the wet state and the higher absorption and retention of liquid by the absorbing layer.

For the verification of this statement the analogous experiment was performed with two types of PA fiber: regular and texturized. According to physical properties of these types of PA, i.e. particularly its generation of high volume, the texturized PA would produce the more porous structure and the higher value of AC. The data in Table 2 confirm this statement.

For the evaluation of any type of the interaction between cellulosic and synthetic fibers during absorption of liquid in the wet state the value of AC for the mixture was calculated according to AC of individual fibers and their quantity (share) in the mixture. The comparison of the calculated and experimentally found values of AC for the mixtures of wood pulp and synthetic fiber (Tables 1 and 2) after being in the wet state for 360s shows that the difference between them does not exceed the value of coefficient variation. The value of the coefficient of correlation between the calculated and experimental data confirm this statement.

Table 1

<table>
<thead>
<tr>
<th>Content</th>
<th>Absorption Capacity, AC</th>
<th>Retention, AC rm, g/g</th>
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</thead>
<tbody>
<tr>
<td>% Pulp</td>
<td>PP</td>
<td>PES</td>
</tr>
<tr>
<td>100</td>
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</tbody>
</table>

*Exp-experimental
**Acc-accounted – calculated based on the sum of the AC of each component multiplied by its percentage in the mixture.
The concordance of the calculated and experimental values of AC for initial period of time (15s) is significantly lower because of the presence in the structure of the core any volume of voids still unfilled with liquid and uncompleted process of swelling of the components of the mixture.

Thus, the behavior of the mentioned fibers in the double mixture is additive, i.e. both components behave independently and do not disturb one another. This fact points out that the advantages of both components may be utilized by their application in the mixture.

Using of the pads sometimes is often combined with the necessity to absorb liquid under pressure according to posture of an adult. Table 3 represents the values of AC for the individual fibers and their mixtures after soaking in the solution NaCl under pressure 5 kPa and then draining the sample while maintaining this same pressure. Data of Table 3 show that the values AC for the individual fibers and their mixtures are lower than in the free state because the pressure partially deteriorates the physical structure of the assembly and reduces the volume of voids in it. The structure of the assemblies, containing PES fibers, is more stable to the deformation in the wet state and is able to retain and discharge after wringing more liquid than wood pulp alone. This fact may be premise for the next enhancing the absorptive and spreading properties of the core. The behavior of the each component of the mixture by the soaking under pressure is also independent what is confirmed by the values of the coefficient correlation (Table 3).

All the experimental data of this part permit to appraise the influence of the synthetic fibers on the absorptive behavior of their mixtures with wood pulp as positive because AC in the presence of PP does not change and enhances in the presence of polyester by use under or without pressure.

Absorptive behavior of superabsorbent in mixture with wood pulp and synthetic fibers

The AC of SAP alone and in the presence of the cellulosic and synthetic fibers are presented in Tables 4 and 5. Data from Table 4 describe the absorptive properties of the mixture SAP with wood pulp in the broad range of ratio. AC of the

<table>
<thead>
<tr>
<th>Content, %</th>
<th>Absorption Capacity, AC, g/g</th>
<th>Retention AC rm, g/g</th>
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</thead>
<tbody>
<tr>
<td>Pulp</td>
<td>time, s</td>
<td></td>
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<tr>
<td>Pulp</td>
<td>15</td>
<td>360</td>
</tr>
<tr>
<td>PP</td>
<td>Exp*</td>
<td>Acc**</td>
</tr>
<tr>
<td>PP</td>
<td>12.7</td>
<td>11.2</td>
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<tr>
<td>PES</td>
<td>1.9</td>
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<td>10.6</td>
<td>17.4</td>
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<tr>
<td>PES</td>
<td>10.8</td>
<td>9.5</td>
</tr>
<tr>
<td>PES</td>
<td>10.1</td>
<td>7.3</td>
</tr>
<tr>
<td>PES</td>
<td>16.0</td>
<td>12.1</td>
</tr>
<tr>
<td>PES</td>
<td>19.6</td>
<td>11.7</td>
</tr>
<tr>
<td>Coefficient correlation (r)</td>
<td>0.85</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Exp-experimental **Acc-accounted

Table 2
INFLUENCE OF POLYAMIDE FIBERS ON AC OF THEIR MIXTURE WITH WOOD PULP

<table>
<thead>
<tr>
<th>Content, %</th>
<th>AC, g/g</th>
<th>Retention, AC rm, g/g</th>
</tr>
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<tbody>
<tr>
<td>Pulp</td>
<td>time, s</td>
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<td>Pulp</td>
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<td>360</td>
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<tr>
<td>Polyamide</td>
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<td>Acc**</td>
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<tr>
<td>Regular</td>
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<td>18.3</td>
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<tr>
<td>Texturized</td>
<td>14.2</td>
<td>12.2</td>
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<tr>
<td>85</td>
<td>20.4</td>
<td>19.9</td>
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<td>19.4</td>
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<tr>
<td>85</td>
<td>20.1</td>
<td>17.6</td>
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<tr>
<td>70</td>
<td>22.8</td>
<td>18.3</td>
</tr>
<tr>
<td>Coefficient correlation (r)</td>
<td>0.78</td>
<td>0.97</td>
</tr>
</tbody>
</table>

*Exp-experimental **Acc-accounted

Table 3
INFLUENCE OF SF ON ABSORPTIVE PROPERTIES OF THEIR MIXTURE WITH WOOD PULP UNDER PRESSURE

<table>
<thead>
<tr>
<th>Content, %</th>
<th>Absorption Capacity, AC, g/g</th>
<th>Retention AC rm, g/g</th>
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<tbody>
<tr>
<td>Pulp</td>
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<tr>
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<td>PP</td>
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<td>PES</td>
<td>16.0</td>
<td>12.1</td>
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<tr>
<td>PES</td>
<td>19.6</td>
<td>11.7</td>
</tr>
<tr>
<td>Coefficient correlation (r)</td>
<td>0.85</td>
<td>1.00</td>
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</table>

*Exp-experimental **Acc-accounted
mixture after soaking during 360s depends upon quantity of SAP, but this dependence is not proportional; for instance, the increase of the quantity of SAP from 5 till 50%, i.e. at 10 times, is accompanied by the growth of AC only at 50%, i.e. 0.5 time. This fact proves the unsuitability of using this mixture with content of SAP more than 30% because it is not expedient.

The second cause of the application of the restricted quantity of SAP is ability of the swelled particles of SAP to migrate in the wet core under pressure and by change of the adult’s posture.

The reduction of AC of the mixture of wood pulp and SAP can be explained by the result of the comparison of the accounted and experimental values AC and ACrm for the double mixtures (Table 4) by soaking during 360s. The correlation coefficient between these two groups of the values is very high (r = 0.98 and 0.94), this fact points out the absence of interaction between SAP and cellulosic fibers, that may be the cause of the obviation of mechanical hindrance to the swelling of SAP. At the initial period of time (60s) the coefficient correlation between the accounted and experimental values is low, what is stipulated by the difference in the rate of swelling of cellulosic fiber and superabsorbent due to their properties.

In order to determine the role of the synthetic fibers in the absorption of liquid by superabsorbent in their mixtures was determined AC and ACrm in the range of ratio: 70/30; 50/50; 30/70. The data are presented in Table 5. The values of AC show that the initial absorption of saline (time 15s) grows as a consequence of the use of the synthetic fibers in the mixture with SAP. It may be supposed that SF reduce contacts between the swelling particles of SAP and obviate the hindrance to flowing liquid to the outer surface of the SAP particles. The influence of SF on the absorption capacity of SAP at the long period of time is analogous to the influence of the cellulosic fibers: the increase of AC is not proportional to the

<table>
<thead>
<tr>
<th>Table 4</th>
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<tbody>
<tr>
<td>ABSORPTIVE PROPERTIES OF THE MIXTURE WOOD PULP AND SAP</td>
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<tr>
<td>Content, % Pulp</td>
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<td>%</td>
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<tr>
<td>95</td>
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<tr>
<td>Coefficient correlation (r)</td>
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*Exp-experimental **Acc-accounted

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<th>Table 5</th>
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<tr>
<td>INFLUENCE OF SF ON THE ABSORPTION CAPACITY OF THEIR MIXTURE WITH SAP</td>
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<tr>
<td>Content, % SAP</td>
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<tr>
<td>Coefficient correlation (r)</td>
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</table>
increase of the quantity of SAP in the mixture. The coefficient correlation of the accounted and experimental values AC is high \((r=0.91)\) at the long period of time, at the initial period of time it is low \((r=0.21)\). PP and PES fibers influence equally on the AC of the mixtures with SAP in the free state, but after wringing the assembly with PES fiber retains more liquid than with PP due to its physico-mechanical properties.

Thus, it may be concluded that the independent behavior of the components of the mixture in the state of completed absorption of liquid permits to use the synthetic fibers in the mixture with SAP for production of the core for the incontinence pads.

**Absorptive properties of the ternary mixture: wood pulp, SAP and synthetic fibers**

The values of AC and ACrm for the ternary mixtures of wood pulp, SAP and PP or PES fibers are presented in the Table 6. The data in Table 6 show that AC of the ternary mixtures, containing 80% wood pulp, varies insignificantly by the variation of the content SAP from 5 till 15% and ratio SAP/SF from 3:1 till 1:3. The ternary mixtures, containing as base 70% wood pulp, behave in the same manner: the change of the content SAP from 10 till 20% by ratio SAP /SF 2:1 – 1:2 is not accompanied by the significant change of AC as in the presence of PP so of PES fibers. Nevertheless PES fibers cause the increase of AC and ACrm as compared to PP due to the ability of PES to form the physical structure more resilient and stable in the wet state. The influence of the quantity of SAP on AC of the ternary mixtures, containing 60% wood pulp, is more significant than for the preliminary ones: the reduction of the content of SAP from 30 till 10% is accompanied by the decrease of AC to 20%.

It should be noted that the absorptive behavior of the mixture, containing 70% wood pulp, at least depends on the variation of the quantity of SAP and ratio SAP/SF, what may be the basis for the appraisement of this ratio as optimal.

The comparison of the accounted and experimental values of AC, determined for the period of time 360s, that are presented in the Table 6, show that there is concordance with the results shown in the previous divisions of the article for the double mixtures of wood pulp, SAP and synthetic fibers. All the components of the mixture behave independently in the process of absorption, swelling and retaining of liquid and do not disturb in the absorption of liquid to one another.

In the commercial incontinence pads the absorbing layer may contain diminutive quantity of binder and may be treated by pressure or high temperature during the process production for enhancing of transporting ability of the core. This treatment influences on the absorption capacity of the core. Therefore the absorptive properties of the absorbing layer (wood pulp and SAP) from the area of the crotch in the commercial pad were evaluated in the free state and under pressure without and with addition of the synthetic fibers. The results, presented in Table 7, show that the addition of 30% PP fibers to the core does not change its AC, simultaneously PES and PA fibers provoke the growth of the absorption and retention capacity of the absorbing layer without and under pressure. Besides the addition of SF is accompanied by the

<table>
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<th>Table 6</th>
<th>ABSORPTIVE PROPERTIES OF TERNARY MIXTURES: WOOD PULP, SAP AND SF</th>
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<tbody>
<tr>
<td>Content, %</td>
<td>Absorption Capacity, AC, g/g</td>
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<tr>
<td></td>
<td>AC, g/g</td>
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<td>80</td>
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<td></td>
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<tr>
<td>Coefficient correlation (r)</td>
<td>0.94</td>
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</table>
change of the content of the mixture, i.e. the decrease of the quantity of wood pulp and SAP. This fact points out the possibility to reduce the quantity of SAP in the core.

These results are in the concordance with aforementioned for the ternary mixtures of wood pulp, SAP and SF and confirm the positive effect of the insertion of the optimal quantity of the synthetic fibers into the absorbing layer of the pad. It should be noted that especially the use of polyester fibers in the mixture with wood pulp and SAP enables to decrease the quantity of the expensive SAP in the mixture keeping the equal results of the absorption.

Conclusion

Today the healthcare disposable pads are in widespread use for adults suffering from the incontinence and other diseases at home as well as in hospitals. The principal quality of these products is the high absorption capacity and ability to distribute liquid in the whole space of the absorbing layer (core) of the pad. These parameters of the core are stipulated by the absorptive behavior and the physical structure of the assembly of cellulosic fibers from wood pulp and superabsorbent that are used for the production of the disposable pads by the most firms – producers.

The short cellulosic fibers from wood pulp are able to absorb liquid instantly and partially to retain it in intra- and interfiber space but in the wet state and under pressure the assembly of the cellulosic fibers is prone to the deformation and clotting that leads to the change of the capillary volume and hinders the flow of liquid. The particles of superabsorbent have the absorptive capacity in the NaCl solution, that is 2-3 times higher than the same for wood pulp, and are able to retain the fluid absorbed during the long period of time. However, rate of the swelling of SAP at the initial period of time is slow, furthermore sometimes there is an effect of “gel-blocking” and migration of the swelled particles of the superabsorbent when the core is in the wet state and especially under pressure. These shortcomings of both components of the core cause the basic problem that has been encountered for the incontinence pads – leakage of liquid (urine) sidelong and backside of the pad as a result of the deformation of the physical structure of the absorbing layer in the wet state i.e. the decrease of the volume of voids and capillaries in the interstitial space and insufficient possibility of the core to absorb, retain, and distribute liquid in all the space of pad.

The main objective of this research was to enhance absorptive and retention behavior of the fiber assembly, intended for production of the pad, by including the synthetic fibers, that distinguished from the natural ones by their hydrophobity, stiffness, resilience. The mentioned properties of the synthetic fibers should lower the deformation of the core in the wet state and keep partly unchanged voids in the inner space of the core.

The results of the investigation have shown that the synthetic fibers according to their physico-mechanical properties are able to form the structure that imbibes and retains liquid without and under pressure. The presence of the synthetic fibers in the dual mixture with wood pulp has positive effect on the absorption and the retention capacity: polypropylene fiber does not change its value, polyester, and polyamide fibers enhance the absorptive behavior of the assembly owing to “strengthening” of its physical structure. The synthetic fibers in the dual mixtures with superabsorbent do not influence on its absorption capacity but promote the rapidity of the swelling SAP at the initial period of time due to the facilitation of the contacts and obviation of the hindrance to flowing liquid. The absorptive properties of the ternary mixtures of wood pulp, SAP, and synthetic fibers are dependent on the swelling ability of the components as well as on the physical structure of their assembly, and by variation of ratio between the components the role of the mentioned mechanisms changes. The most counterbalanced structure of this assembly is reached by content of wood pulp ~ 70%, when the variation of the quantities and accordingly of the ratio between superabsorbent and synthetic fibers has not significant effect on the absorptive characteristics of the assembly.

The application of PES fibers enhances the absorptive behavior of the absorbing layer and probably would improve the quality of the pad. The addition of the synthetic fibers to mixture wood pulp/SAP, isolated from the area of crotch of
commercial pad, leads to the enhancing its absorptive, and retention ability what may be explained by the increasing stability of the physical structure in the wet state under pressure owing to the resilience especially of PES fibers. The positive effect obtained by use of the synthetic fibers is also stipulated by independent behavior of the components of the assembly, which is confirmed by the high values of the correlation coefficient between the experimental and accounted values of AC and ACrm for the dual and ternary mixtures of the cellulosic and synthetic fibers and SAP. This fact permits to predict the content of the assembly with necessary properties according to the properties of the individual components.

The application of synthetic fibers for the production of the core of the incontinence pads has yet some advantages: reduction of the weight and price of the pad, improving its absorptive properties and minimizing the escape of liquid.

References:
Automatic Characterization Of The Refractive Index Profile Of Fibers By Interferometry

By Han Seong Kim, Department of Textile Engineering, Pusan National University, Korea; and Behnam Pourdeyhimi, Nonwovens Cooperative Research Center, College of Textiles, North Carolina State University

Abstract

Interferometry provides a non-destructive method for examining the refractive index profile or the radial birefringence distribution within fibers. The key step in the interference data reduction involves the extraction of the refractive index profile along the axial direction of the fiber. The profile is due to the path difference between the fiber and the immersion liquid when a fiber is oriented perpendicular to the fringe field in an interference microscope.

The refractive index provides a measure of the degree of optical anisotropy and is indicative of the degree of orientation of the structure. This is of particular interest to nonwovens because in thermally bonded nonwovens, the orientation plays a major role in how well the fibers are bonded and the ultimate properties of the fabric.

Despite its long history, however, the interpretation of the interference fringe shift is not precisely defined. Consequently, the data are not reproducible from one laboratory to the next. We outline below an objective and quantitative method for precisely measuring a fiber’s refractive index profile from a digitized image of the interference fringe. This new algorithm uses the Fast Fourier Transform (FFT) to remove the inherent noise present in the fiber interferogram and to aid in extracting the profile.

Introduction

Typically, fiber interferograms are used for qualitative comparison of different fibers. Quantitative measures, at best, extract the mean refractive indices along and perpendicular to the fiber axis. Refractive indices are important since they are measures of how well the fiber structure is oriented. The degree of orientation, of course, controls the fiber properties and performance. In thermally bonded nonwovens, the degree of orientation can affect bonding and therefore, the ultimate properties of the fabric. Wei et al. [1] used commercial polypropylene fibers with varying draw ratios to produce overall-bonded (using a smooth calender) nonwoven fabrics. It was found that fibers with lower orientation yielded fabrics with higher tensile strength and flexural rigidity as compared with those made with fibers having higher orientation and a microfibrillar structure. It was stipulated that the less-oriented amorphous regions and the lamellar crystal structure would promote better fusion between fibers. In other words, this implies that an oriented microfibrillar structure inhibits fiber-to-fiber fusion in the thermal bonding process and will result in a lower degree of bonding [2]. The same would be true for the through air bonding process [3].

Interference microscopy continues to be the method of choice for assessing the microstructure variation within the fiber particularly variations from the fiber core to the fiber surface (sheath). Because of the inherent noise in fiber interferograms, it would be impossible to manually extract the refractive index profile. Therefore, it is not possible to reliably measure the mean refractive index and refractive index distribution of the fiber. There is clearly a need for objective and efficient measurement of the reflective index profiles. Below, we propose a possible method for the extraction of the index profile from digitized images.

A first step in analyzing the digitized interference image is to extract the exact contour of the fringe patterns. Because of the high level of noise present in the image, this is not possible by using simple thresholding methods that use one or two threshold levels to convert the image to black and white. Even under the best of conditions, the result will be unacceptable (Figure 1). In cases where noise is prevalent, Mastin and Ghiglia suggest the use of the Fast Fourier Transform (FFT) as a fast precise alternative for extracting contours [4]. Theoretically, the Fourier Transform of the fringe pattern should yield one fixed frequency (one amplitude and one phase) for a fringe pattern that has one dominant spatial frequency. In practice, however, even the sophisticated FFT approach cannot be effective because

1. It assumes that the input data represent exactly an inte-
In the fundamental frequency and phase information derived by the FFT approach will not represent the true single spatial frequency associated with a fringe pattern. The problems associated with edge discontinuities have been discussed before [5].

2. The distortion of a signal by noise may cause the FFT to yield several frequencies.

The deviation of the fundamental frequency depends on the noise pattern, and thus is unpredictable and random [6]. Below, we propose a new scheme for automatic contour extracting, by

1. extracting interference fringes by eliminating noise components that cause the distortion of a signal and lead to errors in computing the dominant frequency and phase of the fringe patterns, and
2. removing the edge discontinuities by means of redefining the data size (hereafter referred to as backward resizing method) so as to represent exactly an integral period of the total waveform.

Noise Filtering

Among the great many varieties of instrumental configurations, the Mach-Zender interferometer occupies an important position for applications in light microscopy. This configuration is depicted in Figure 2. Mach-Zender interference system consists of two semi-silvered plates ($S_1$ and $S_2$) and two fully-silvered mirrors ($T_1$ and $T_2$) arranged symmetrically at $45^\circ$ at the corners of rectangle. A parallel light beam is split into a transmitted component and a reflected component.

The extent of deformation depends on the optical path difference ($\Delta l$) introduced by varying the angle ($\beta$) at mirror $T_2$. The optical path difference interferes to produce visible interference patterns. The optical path difference is expressed as follows:

$$\Delta l = OP - OP' = b \frac{1 - \cos(2\beta)}{\sin(2\beta)} = b \tan \beta \cdot \beta$$

The total number of fringe ($N$) at $OP$ is

$$N = \frac{\Delta l}{\lambda} = \frac{b \beta}{\lambda}$$

In this system, the measured intensity of any scan line along the fiber axis perpendicular to the fringe field is theoretically a periodic function with the width of fringe $B$ and the dominant frequency does not change with position.

The same optical path difference ($\Delta l$) is chosen at the fringe interval of the width of the fringe ($B$) by fixing angle ($\beta$) at mirror $T_2$ and fixing the wave length (551 nm). Therefore this leads to the one dominant spatial frequency. The fringe image represents the spatial details in the form of brightness transitions. Consequently, we can apply the Fast Fourier Transform to decompose the signal and extract the dominant frequency.

When a fiber is inserted into the fringe field, because of the refractive index different between the fiber and liquid, fringes inside the fiber image are shifted. FFT has been used to extract fringe contours as the phase differences introduced by re-combining the light beam that runs along the reference beam-path and along the object beam-path. In one dimension, the corresponding direct Fourier Transform is given as

$$F(u) = \int_{-\infty}^{\infty} f(x) \exp(-i2\pi ux)dx$$

Where $f(x)$ is the image and $F(u)$ is its transform, $u$ refers to the frequency along $x$ direction.

For a full description of the Fourier Transform of a continuous function see reference 7. In discrete form, a continuous function, such as $f(x)$, is discretized into a sequence

$$\{f(x_0), f(x_0 + \Delta x), f(x_0 + 2\Delta x)......f(x_0 + (N-1)\Delta x)\}$$

by taking $N$ samples $\Delta x$ units apart. Thus

$$f(x) = f(x_0 + k\Delta x)$$

Where $k$ assumes the discrete values 0, 1, 2, ..., $N-1$.

$$F(u) = \frac{1}{N} \sum_{x=0}^{N-1} f(x) \exp\left(-i2\pi ux\right)$$

For $u = 0, 1, 2, ..., N-1$, and
If the fiber axis is not perfectly perpendicular to the fringe field or is not perfectly focused, discontinuities will occur at the edges of the fiber. This is demonstrated in Figure 3. In this case, the frequency image will contain erroneous spatial frequency components because the Fourier Transform will attempt to model the discontinuities as part of the signal. This problem can be somewhat reduced by using windowing functions (Figure 4). Windowing functions attempt to reduce the edge discontinuities thereby minimizing spatial distortion artifacts [5]. Note however, that while windowing functions may reduce the spatial frequency errors, they cannot eliminate the problem entirely. When digitizing images, it is therefore, critical to ensure that
1. the image is in focus
2. the fringe field is perpendicular to the direction of scan.

Wu and Davis discussed the difficulties associated with applying FFT to remove noise and edge distortions and developed a minimization technique to extract the fundamental frequency of the fringe pattern [6]. Instead, we choose to introduce a Dirac delta function (or the unit impulse function) given by:

\[ F(u) = \frac{1}{N} \sum_{k=0}^{N-1} f(x) \exp\left(-\frac{i2\pi k u}{N}\right) \delta(u - p_r) \]  

(7)

Where \( p_r \) is a dominant spatial frequency of fringe pattern taken between 1 and \( N \).

Usually, a Dirac delta function is introduced to solve problems involving short impulses. To handle our case, we consider the single dominant spatial frequency of the fringe as a short impulse term. In our setup, the measured intensity of the scan line along the fiber axis perpendicular to the fringe field has a dominant frequency along the fiber axis. We first apply a forward FFT, and use this property (equation 7) during the inverse FFT process. In this process, all the unnecessary frequencies except the dominant frequency (considered as a short impulse term) are eliminated. The transform is implemented by processing all rows. The result is a one-dimensional set of values with each having one dominant magnitude and one dominant phase.

**Backward Resizing Method**

Of interest are the phase values. The phase values of the result of the inverse FFT transform do not match those of the original waveform exactly as shown in Figure 5 because an integral period of the total wave does not represent exactly the input data. In other words, in the discrete form of FFT the dominant frequency \( p_r \) should be an integer value because the independent variables are discrete as integer orders from 1 to \( N \). However the actual frequency can be a real number between 1 and \( N \). Therefore, we apply the backward resizing method by computing \( y \) using the equation given below:

\[ \Psi = \max \left\{ \frac{1}{m} \sum_{n=0}^{m-1} (F(w) \cdot f(w)) \right\} \]  

(8)

For \( m = N-1, N-2, \ldots, N(1-1/p_r) \)

\( y \) is calculated for each scan line after the FFT procedure. This process is implemented from the scan line size \( N \) until the scan line size becomes \( N-1.1N/p_r \), which approximately corresponds to the length of one period or slightly larger. The optimum image size is chosen at the maximum value \( y \) reached when the phase of the inverse transform matches that
of the original waveform exactly. The results shown in Figure 6 clearly demonstrate the excellent agreements between the phases of the two waveforms. After implementing the whole process, the digital coordinates of the refractive index profile can be obtained by simply extracting the boundaries as shown in Figure 7.

Materials
To examine the applicability of the method for examining the refractive index of different fibers, two fibers were melt spun. The polymer used was high molecular weight PET. A spin pack designed for spinning monofilaments was used. The orifice of the spinneret plate measured 0.6 mm in diameter and 1.38 mm in length. The threadline was cooled at room temperature through a 4-meter cooling path. The take-up velocities were 2 km/min and 7 km/min. To keep the fiber denier constant (4.5 denier), the mass throughput rate was appropriately adjusted.

Application of the Reflective Index Profiles
One of the important applications of the reflective index profiles is the determination of radial distribution of refractive index. Many authors have attempted to obtain a complete picture of radial distribution of refractive index [7-9]. Below, we demonstrate the applicability of our automatic contour extraction method to determining the radial distribution of refractive index. We adopt the shell model and assume that the refraction at the liquid-fiber interface is negligible and that index variation inside the fiber are sufficiently small to be also negligible [8, 9]. While the Shell model analysis provides an intuitive and convenient way to deduce the fiber fringe shift pattern, it is also true that the assumption of straight line ray path means limited accuracy.

We can calculate the refractive index at point \( y \), measured from the fiber center. Figure 8 shows schematically the ray and the interferogram for the calculation of the radial distribution of refractive index. The cross-section is divided into \( m \) concentric circles. The \( y \) coordinate can be expressed as:

\[
y_k' = R \sqrt{\left(1 - \frac{k}{m}\right)^2 - \left(1 - \frac{j}{m}\right)^2}
\]

Where \( j \) = section number corresponding \( x \) coordinate
\( k \) = section number belonged into
The fundamental equation is used for any shifted fringe (d)

\[
\frac{d}{D} \lambda = (n - N) \cdot t
\]  \hspace{1cm} (10)

Where \( \lambda \) = wavelength of light
\( N \) = refractive index of the immersion liquid,
\( n \) = refractive index of the fiber and
\( T \) = fiber diameter

By substituting \( y \) for fiber diameter \((t)\) and expanding equation 10 to any ray passing through the fiber, the fringe shift term is given by:

\[
\frac{d}{D} \lambda = \sum_{k=1}^{j} (n_k - N) \cdot 2(y_k' - y_k')
\]  \hspace{1cm} (11)

Then, this equation lead to

\[
n_j = N + \frac{D \cdot \lambda}{2} \sum_{k=1}^{j-1} (n_k - N) \cdot 2(y_{k-1}' - y_k')
\]  \hspace{1cm} (12)

The profiles obtained by equation 12 are shown in Figure 9 for our two fibers. The radial distribution of refractive index is shown for directions parallel and perpendicular to the fiber axis for both. The data in Figure 9 demonstrate that the refractive index in the parallel direction is higher than that in the perpendicular direction, and a higher refractive index is shown in comparison with the center portions for both fibers. Additionally, as expected, the fiber spun at the higher speed shows a higher refractive index. The radial distribution of isotropic refractive index is shown in Figure 10. The higher isotropic refractive index that can make possible inference of higher orientation and density in a same fiber is shown at the outer portions of the fiber in comparison with the center portions for both fibers.

**Concluding Remarks**

We have demonstrated a new methodology for automatic extraction of refractive index profile from fiber interferograms obtained by interference microscopy. We have demonstrated that the noise can be eliminated and that the exact frequency of the fringe pattern can be determined from which the refractive index, its profile and its radial distribution can be determined. We have demonstrated the applicability of this procedure for two fibers with varying degrees of draw ratio expected to result in different refractive indices.

**References**

Nonwoven Structure Statistics: Simulation of Effects of Fiber Crimp, Flocculation, Density and Orientation

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Abstract

New simulations suggest a universal relationship between the mean number of fibers per zone in a complete sampling scheme and the mean void size, independent of whether the structure is isotropic or anisotropic, contains crimped or straight fibers, randomly laid or flocculated.

The mean and standard deviation turn out to be positively correlated for some network parameters, such as mean void size, density, and mean number of fiber contacts. Also, our simulations suggest that fiber crimp has a higher impact on isotropic nonwovens. As crimp is increased, isotropic structures tend to present smaller mean voids, higher mean number of fibers per zone, and higher total number of bonds per fiber, than anisotropic structures.

Introduction

It is known that for a given fabric density and structure, smaller pores, better barrier properties and higher flexibility can be obtained utilizing smaller fibers (Kim et al., 2000). However, fiber crimp and fiber orientation also can affect the fabric pore size distribution, and at the same time it influences the number of fiber-to-fiber contacts and hence mechanical properties. Certainly, fiber-to-fiber contacts and fiber orientation play a crucial role in determining the physical behavior of nonwoven fabrics. These properties affect the fluid transportation pattern within the fabric, its mechanical properties, surface appearance and hand (Gong et al., 1996) and fiber crimp may affect local network density, as we see later. Such phenomena are usually difficult to measure experimentally, or it might be costly to acquire sufficient experimental data. Under these circumstances, computer simulation may help clarify such intricate behavior.

Recently, Kim and Pourdeyhimi (Kim et al., 2000) discovered a relationship that exists in random fiber networks between the properties of fiber crimp and orientation. However, real fiber networks are flocculated (i.e. clumped) and not random (Deng et al., 1994) (Dodson et al., 1997), and their results need to be extended to this case. Also, it is consensus that network properties such as the density of fiber-to-fiber contacts are intrinsic to fiber networks (Deng et al., 1994), however this property is difficult to measure experimentally and it has been neglected in previous works reported in the literature. In this article, we approach these relevant issues.

Both meltblown and spunbonded fabrics are stratified stochastic (i.e. multiplanar) fibrous materials, with little or no order or orientation through the thickness. Published work on modeling and simulation of stratified stochastic porous media tends to use a one-dimensional structure representation (Scharcanski et al., 1998), or a random aggregation process involving extended geometric objects (e.g. disks) (Deng et al., 1994) to limit computation costs. Recently, some analytical models of pore size distributions in multiplanar stochastic porous media have been proposed (Dodson et al., 1997). We consider pores as two-dimensional entities (Kim et al., 2000). We adapt a stochastic model, the Neyman-Scott (NS) process (Neyman and Scott, 1958), to the problem of modeling the statistical properties of stratified materials composed of fibers. The method involves using a Poisson process of Poisson clusters. Although widely studied (Cox and Isham, 1980), we are not aware that the NS has been used in this context. We use NS as a device for simulating the distribution of fibers in a single or multi-planar network forming a network of inter-connecting pores, thereby deducing properties of the interconnecting pore network from the simulated structures; but as explained above it can also be adapted to the modeling of pores directly if their distributions of size and shape are given. This approach is dealt with in a separate paper.
Spatial Fiber Distribution In Stratified Stochastic Fiber Networks

Several attempts have been made to model different aspects of the spatial fiber distribution and the void structure in stratified fiber networks. Most models have focussed on specific issues such as the void size distribution (Dodson et al., 2000; Dodson et al., 1997), adjacent inter-fiber distances (Deng et al., 1994), or the spatial distribution of density (Deng et al., 1994). Usually, such models are used to predict particular structural properties (e.g. void size distribution), given the information known a priori about other, related properties (e.g. deviation from randomness of the spatial distribution of density).

Fiber networks result from the stochastic spatial deposition of fibers, and the fiber deposition process is well described by a homogeneous Poisson process (Deng et al., 1994) when fibers are positioned completely at random. However, incomplete randomness is the ideal, and in practice fiber networks deviate significantly from a Poisson process (Dodson et al., 1997); in industrial fibrous materials, mean density often varies spatially and fibers form clusters. The NS process used in our work is a spatial clustering process describing the spatial occurrences of fiber groupings (i.e. fiber clusters) (Cressie, 1993). Such clusters are generated by a spatial point process having parameters that control the deposition of fibers within each cluster, as described below.

As mentioned above, some aspects of the fiber and void structure have already been reported elsewhere. Consequently, it is our concern that our simulation model generate structures that are compatible with those found in practice, while any new model that is proposed must retain those features of earlier models that are known to be consistent with reality, while improving, where possible, on those aspects where existing models are less satisfactory.

Statistical properties of the NS process, originally proposed as a model of galaxy clusters in cosmology, have been described by Cox and Isham (1980) and Cressie (1993), among others. It can be used either (a) to model voids of given shape and size distributions occurring in different layers of a multi-layer structure, so as to allow for correlation between void position and size in different layers, or (b) as in the application described below, to model fiber position and orientation. For this second application, the structure of the NS process is as follows.

1. A set of N parent events (i.e. cluster centroids) is realized from a Poisson process (in its most general form, not necessarily homogeneous) with mean (i.e. density) fiber_density.

2. Each parent produces a random number of offspring, according to a discrete probability distribution \( p(K=k) \). Each offspring corresponds to a fiber. A simple form for \( p(K=k) \) is the Poisson distribution, either truncated \( K \geq 0 \) or untruncated \( K \geq 0 \); other discrete distributions are also possible.

3. The locations of the \( K \) offspring, relative to their parent, are the points \((x, y)\), where the coordinates \( x, y \) are realizations of random variables having a bivariate, continuous probability distribution \( f(x, y) \). Relative to the parent event, each pair of coordinates defines the midpoint of a fiber. A particularly simple model is obtained by taking \( f(x, y) \) to be bivariate Normal with zero correlation, with deviations along the axes \( x \) and \( y \) given by \( \sigma_x \) and \( \sigma_y \), respectively; a further simplification takes \( \sigma_x = \sigma_y \), giving circular symmetry of fiber mid-points about the parent event. With \( \sigma_x \) and \( \sigma_y \) unequal, fiber mid-points are distributed anisotropically.

4. Each offspring is a fiber of length \( L \), where \( L \) is a random variable with continuous distribution defined on the interval \([0, \infty)\). In our simulations, the distribution of \( L \) was taken as the lognormal probability distribution with parameters \( \mu_L, \sigma_L \).

5. The orientation \( \theta \) of each fiber is a realization of a random variable with distribution defined over the interval \([0, \pi]\). In its simplest form, the distribution of \( \theta \) is uniform, \( p(\theta)d\theta = d\theta/\pi \), for which fiber distribution is isotropic; the uniform distribution is a special case \((a=1, b=1)\) of the beta distribution

\[
f(\theta|a,b) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} \left( \frac{\theta}{\pi} \right)^{a-1} \left( 1 - \frac{\theta}{\pi} \right)^{b-1}
\]

with mean \( a/[\pi(a+b)] \) and variance \( ab/[\pi(a+b)^2(a+b+1)] \).

6. The final realization is composed of the superposition of offspring only.

In our model, at each layer, the incidence of parent events within a zone is considered to be a Poisson process such that its probability density is \((\text{Stoyan et al. 1995})(\text{Dodson et al., 2000})\):

\[
p(N=n) = (\lambda S)^n \exp(-\lambda S)/n!
\]

where \( n \) is the number of parent events in a zone of area \( S \) and \( \lambda \) is the mean number of parent events per unit area.

We use a multi-planar model with layers of fibers. In this work, we assume that layers are independent (although as noted above, the NS process can be used to model the correlation between pore positions in different layers). Given a simulated multi-layer void structure, structural properties can be evaluated, such as the spatial density distribution of matter and voids, and properties of the network of communicating pores.

One of the simulation parameters is the degree of fiber crimp*, \( k=P/L \), which is defined as the ratio between the fiber perimeter \( P \), and the end-to-end distance, or length \( L \) of each fiber. Therefore, fiber crimp \( k > L \) implies that fiber perimeter \( P \) is larger than the fiber end-to-end length \( L \), and that the fiber is not straight (i.e. the fiber perimeter is constant regardless of the degree of fiber crimp, however the end-to-end fiber length tends to decrease as fiber folding increases). Given a step \( p \), fiber crimp is then simulated as if the fiber was folded in \( n = L/p \) pieces, and each piece is an isosceles triangle with height \( a = kp/2 \), and angle \( \psi = \cos^{-1}(p/(2a)) \) to the base.

Some criteria have been proposed for the simulation of the parent events and their offspring elsewhere, considering they are events drawn out of statistical distributions (Ripley, 1983) (Cressie, 1993) (Lewis et al., 1979).

* In this work, we use the term “degree of fiber crimp” \( k=P/L \) to denote the effect of fiber folding in our simulation, which corresponds to the concept of “curl ratio” in nonwovens.
Simulation Results And Discussion

A range of simulated nonwovens were generated with different conditions of anisotropy, fiber crimp, fiber clumping, and fiber spatial density. Figures 1 (a), (b), (c) and (d) show some simulated crimp fiber networks. Usually, in papermaking mean fiber length (i.e. L) ranges from 1.5–6 mm (Smook, 1994). In our experiments we utilize short fibers, i.e. mean fiber length of 2 mm, and standard deviation of 0.5 mm. The density of the simulated samples in Figure 1 vary from 15 – 70 fibers per mm$^2$. The area represented in those images corresponds approximately to 100 mm$^2$ (i.e. approximately 10 mm x 10 mm). Notice that Figures 1(a) and (b) show random isotropic and anisotropic simulated samples with 20 fibers per mm$^2$, and $k=1.35$.

Figures 1(c) and (d) show the polar plots obtained for those samples, using the technique proposed in (Scharcanski et. al., 1996), indicating that the sample shown in Figure 1(a) is in fact nearly isotropic (i.e. $e=1.30$), while the sample shown in Figure 1(b) is anisotropic (i.e. $e=2.33$).

Both samples were simulated with the same density and fiber length distributions. Nevertheless, we used $s_x=4$ mm and $s_y=4$ mm to generate the nearly random sample. For image analysis purposes, the simulated images were sub-divided into approximately 200 x 200 square blocks, namely, pixels (i.e. each pixel is $25 \times 10^{-4}$ mm$^2$), and after that, the density (i.e. pixels occupied by fibers) as well as void areas (i.e. pixels not occupied by fibers) were computed. Therefore, the side of the square zones utilized for fiber density calculations correspond approximately to 50 microns (i.e. nearly one fiber width).

Our simulation procedure can generate a wide range of structures, such as those displayed in Figures 2(a), (b), (c) and (d). Two examples of isotropic fiber networks constituted by straight fibers (i.e. $k=1.0$), with different fiber densities and degrees of flocculation (i.e. fiber clumping), are shown in Figures 2(a) and (b). Also, two examples of isotropic fiber networks constituted by crimped fibers (i.e. $k=1.3$), with the same fiber densities, but different degrees of flocculation, are displayed in Figures 2(c) and (d).

All statistics displayed in Figures 3–11 were obtained by simple image analysis techniques applied to the synthesized images of the simulated structures (e.g. detecting voids based on zones not occupied by fibers, or counting fiber crossings at zones/pixels as the pixel intensities generated by the simulation).

Figures 3 and 4 show logarithmic scale plots of the mean versus the standard deviation of all voids occurring in each
simulated structure, as well as density distributions, for a wide range of structures (i.e. random and floculated, isotropic and anisotropic). The observation of those plots indicates that, in general, mean and standard deviation of voids, as well as of density, have a positive correlation. Also, a similar conclusion may be derived about the number of contacts per fiber from Figure 5. In other words, within a wide range of structures (random and flocculated, isotropic and anisotropic), the mean and the standard deviation of the number of contacts per fiber are not independent, but are in fact correlated variables. In order to model these underlying distributions, the dependence between mean and standard deviation is a relevant information, and should be taken into account.

The analysis of Figures 6 and 7 provides some insight into the effect of increasing the number of fibers per zone, on the number of fiber contacts (i.e. number of fiber crossings). It is shown that the number of fibers per zone may be increased by varying different parameters independently, such as: increasing density, increasing fiber clumping, or even by decreasing anisotropy. Figure 6 shows that the mean number of fibers at bonds increases when the number of fibers per zone is increased* . However, Figure 7 shows that the total number of

* The mean number of fibers per zone may in fact present real values (as shown in Figure 6), because the mean calculation takes into account all zones, but some zones may not contain fibers.
bonds per fiber (i.e. fiber contacts), follows a different trend and is not substantially affected by the increase in the number of fibers per zone. Actually, a better response in terms of increasing the total number of bonds per fiber can be obtained by increasing fiber crimp, as we discuss next.

The effect of fiber crimp on several fiber network properties is shown in Figures 8, 9 and 10. In general, increasing fiber crimp (keeping fiber density, flocculation and anisotropy constant), also increases the mean number of fibers per zone, and more interestingly, it increases substantially the total number of bonds per fiber (if compared to the effect of increasing density with fiber crimp constant). On the other hand, mean void size tends to decrease when fiber crimp is increased. Fiber crimp has a higher impact on isotropic structures than on anisotropic structures. As crimp is increased, isotropic structures tend to present smaller mean voids, higher mean number of fibers per zone, and higher total number of bonds per fiber, than anisotropic structures.

It is also relevant to observe the existing relationship between mean number of fibers per zone and mean void size in Figure 11. For a wide range of structures (random and flocculated, isotropic and anisotropic, with various degrees of crimp), the shape of the curve shown in Figure 11(a) is similar to that found experimentally by Bliesner, shown in Figure 11(b) (Bliesner, 1964). Therefore, we may conclude that such a relationship is independent of the nature of the stochastic fibrous structure, i.e. the shape of the curve is the same if the structure contains crimp fibers or not, if it is random or flocculated, isotropic or anisotropic.

It was verified analytically that in our simulation, distances between adjacent fibers may be modeled by a Gamma process, fiber density may be modeled by a Poisson process, and the obtained relationship between mean number of fibers per zone and mean void size per sample follows the predicted mathematical model. This behavior was confirmed by measurements in our simulated structures, and agree with known analytical results obtained for stochastic fiber networks (Deng and Dodson, 1994), as will be discussed in more detail elsewhere.

**Concluding Remarks**

Our simulation procedure provides computer experimentation to study the effects of altering process variables in the manufacture of nonwovens. It extends previous work reported in the literature by including the effects of anisotropy, fiber crimp, fiber clumping, and some porous media structural elements. Our simulation procedure provides sufficient flexibility to model several conditions occurring in practice. Results suggest that some models reported in the literature do not adequately predict void size distributions, fiber contacts, network density and their relationship with fiber crimp, neither in isotropic nor anisotropic structures. Moreover, new
process control instruments could be devised to exploit our methods and results.

We find that mean and standard deviation are positively correlated for some fiber network parameters, such as mean void size, network density, and mean density of fiber contacts. Therefore, increasing (or decreasing) their mean also increases (or decreases) their variability. Fiber crimp seems to have a higher impact on isotropic structures; they tend to generate smaller mean voids, higher mean number of fibers per zone, and higher total number of bonds per fiber, than do anisotropic structures. It seems significant also that our simulations also suggest a relationship between mean number of fibers per zone and mean void size, independent of the nature of the stochastic fibrous structure. In other words, the shape of the transfer function curve will be the same, even if the structure contains crimped fibers or not, if it is random or flocculated, isotropic or anisotropic; this could be an important universal effect. These information provide valuable insight, that could help modeling the underlying distributions of these parameters in fiber networks.

Future work, will probe the transport properties through the voids in nonwovens (isotropic or anisotropic), model structural elements such as constrictions (i.e. throats) and pore connectivity (i.e. tortuosity and coordination numbers), as well as comparing the results of our simulations to experimental data.

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References


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Figure 11
Relationship between the means of local mass (i.e. density) and mean void size in (a) For constant crimp k=1.35 statistics of random samples as density is increased are displayed as crosses; statistics of flocculated samples as fiber clumping is increasing are displayed as circles; statistics of anisotropic samples as anisotropy is increasing are displayed as triangles. For crimp increasing from k=1.0 to k=4.0: statistics for isotropic samples: random data are displayed as squares and flocculated data are displayed as x-marks; statistics for anisotropic samples: random data are displayed as hexagram, and flocculated data are displayed as points; and (b) experimental data (Bliesner, 1964).
Role of Fiber Finish In The Conversion Of Fiber To Nonwovens — Part II: Finish Performance As A Mechanical Processing Aid In Carding

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Abstract
This part of the study aims to investigate the role of fiber finish in the carding process. Two different fibers, namely, polyester and polypropylene with different levels of finish and finish uniformity, are processed on carding machine. Certain key response parameters such as fiber breakage, fiberweb cohesion, fiberweb uniformity, nep generation and static charge generation, are chosen and the effect of finish level and its uniformity on these parameters are observed. The finish performance is also studied for possible interaction effects between other carding process parameters. The results indicate a significant effect of finish add-on percentage on most of the response parameters. On the other hand, finish uniformity was found to have less influence on the response parameters. It has also been found that the response parameters behave differently for each of the two fibers and hence results based on one type of fiber may not be applicable for another.

Introduction
Carding is a very crucial stage in the processing of staple fibers. Many times, problems in carding have been attributed to the percentage add-on of finish on the fiber and its uniformity. This has impelled us to investigate the actual effect of finish and its uniformity in terms of mechanical processability of fibers. The function of fiber finish in the carding process is to reduce the fiber-to-metal friction and thus prevent abrasion and fiber damage. The finish must also optimize fiber-to-fiber friction for better web cohesion. In the case of low moisture content fibers like polyester, the finish should also control the static charge generation, which otherwise would lead to web bellowing and fibers clinging to machine parts and dust accumulation.

Fiber finish uniformity at a macro level can be defined as the level of distribution of finish on the fiberweb. Previous work in this field has identified many causes for finish non-uniformity on fibers such as applicator effects, spreading of finish film on fiber surface, which in turn depends on the surface tension of the finish and surface characteristics of the fiber [3]. Many problems caused by improper selection of finish, like low cohesion between the fibers in the fiberweb, overloading of card wire and excessive fiber breakage in the fiberweb, have been reported in Part I of this study. This calls for an optimization of the finish application for a given fiber type. For this, a thorough understanding of the role of fiber finish on carding processability is necessary.

The experimental design used in this project aims to study the effect of finish level and finish uniformity on a macro level on various response parameters such as fiber breakage, web uniformity, neps and static charge generation. The experiment was performed using two different fibers, namely polyester and polypropylene. The processing parameters are specific to each fiber. The fibers made with different finish levels and uniformity were processed on a carding machine under controlled conditions. The interaction of finish performance with respect to carding variables such as throughput and cylinder to doffer setting was also investigated.

Experimental Approach
The effect of finish level was studied by using a minimum of five different finish levels. The range of finish levels was arbitrarily chosen after consulting with industry. The fiber producers supply at least 3 bales of fibers of different finish levels. The remaining finish levels were obtained by blending these 3 primary levels. To study the effect of finish uniformity, the fibers from the high (H) and low (L) levels of finish are blended in the right proportion to achieve a theoretically same finish level as that of the medium (M). This blend (HL) should have a more
non-uniform finish application than that of the medium level (M). A comparison of the response parameters of the blend (HL) and medium (M) should provide a good indication of the effect of finish uniformity on finish performance. Two different levels of throughput and cylinder-to-doffer settings were used to determine any interaction effect of finish with respect to carding variables. The treatments were replicated thrice to eliminate bias. The throughput is expressed in terms of doffer surface speed rather than mass of fibers produced per unit time. As the mass of the fibers is dependent on the type of fiber, the use of doffer speed to represent throughput helps to perform more meaningful comparisons. The speed of the feed roller was kept at a fixed ratio to the speed of the doffer so as to maintain a constant basis weight of the fiberweb. Varying the carding parameters changes the amount of recycling time the fibers spend on the cylinder; i.e., the carding points per fiber per unit time is changed, which in turn affects the work done on the fibers by the cylinder and flat interaction. By having a wider cylinder-to-doffer setting, the recycling time of the fiber on the cylinder increases (carding points per fiber per unit time increases) and the effect is vice versa for a closer cylinder to doffer setting. In the same manner, by decreasing the throughput while the speed of the cylinder is left unchanged, the effective time spent by the fiber on the cylinder increases and vice versa for an increase in throughput with a constant cylinder speed. In effect, a combination of these two parameters would present a good representation of the finish performance with varying degrees of carding on the fiber.

The experiments were performed on a Hollingsworth M 2000 high-speed stationary flat top card (for polyester) and on a Saco- Lowell Card Master card (for polypropylene) at the Hollingsworth research laboratory, Greenville, SC. Five main response parameters have been identified. They are fiberweb uniformity, fiber breakage, web cohesion, neps and static charge generation. The test method used for collecting each of the above four response parameters is described below.

Measurement of Fiber Breakage

The fiber breakage during the carding process can be estimated by measuring the fiber length and its distribution of the fiber mass before and after its passage through the card. The Keisokki Classifiber, model KCF/LS (provided by Lawson-Hemphill) was used to study the fiber length distribution. Comparisons are made based on the 2.5% span length and the short fiber content for each treatment. The 2.5% span length is the length exceeded by 2.5% of the fibers in the entire distribution. It is the parameter used in the spinning industry to determine the settings of the various machine elements and hence is a good representation of fiber length. The short fiber content is described as the percentage of fibers in the distribution whose length is less than 1.27 cm (0.5”). Four samples were collected for each treatment and tested on the Keisokki Classifiber KCF/LS.

Measurement of Web Uniformity

The fiberweb produced at the card has very little cohesion and therefore requires great care not to disturb the web while measuring the basis weight distribution of the fiberweb. Offline measurement techniques are often inaccurate due to poor handling of material. Measurement of fiber loading on doffer is a good indicator of the fiberweb uniformity. For this many effective online measuring techniques have been developed. A thorough analysis of the various available techniques and instruments is given by Meng et al [4]. The Nonwoven Cooperative Research Center (NCRC) IR-based photometric instrument is used to measure the fiber load on the card elements. The device works on the principle that light generated by the IR LED is focused on the carding surface and the reflected light (specular reflection) is sensed by the photometric device. The voltage reading of the sensor is a direct function of the amount of light reflected, which in turn depends on the amount of fibers on the carding element. The schematic diagram of the IR-based device and the possible mounting positions on a card is given in Figure 1. A more detailed description of the principle and working of the NCRC IR-based photometric device are given by Seyam et al [5].

Seven IR LED and sensor assembly was mounted on the doffer at the recommended distance of 25 mm from the doffer surface and 25° to the axis perpendicular to the doffer surface [5]. The device needs to be calibrated for each fiber type used, as the reflectance property varies depending on the type of fiber and surface characteristics of the fiber. The calibration procedure consists of the following steps. The fiber was processed on the card at five different levels of web density. Carded sliver was collected over a period of 2 min. and the corresponding voltage reading from the IR device is recorded. The data is collected at a rate of 100 scans/sec. The linear density of the carded sliver was noted. At least five readings were collected for each level of web density. The output voltage was regressed on the weight per linear yard of the carded sliver to arrive at the calibration equation. Care should be taken to reach a steady state condition of carding before collecting any data. This calibration equation was later used to convert the voltage readings into basis weight of the fiberweb. The equation also determines the sensitivity of the IR sensors to the change in web density of the given fiber. It was found that the calibration equation did not vary with finish level for the two fibers used in this study.

Figure 1

SCHEMATIC DIAGRAM SHOWING THE MOUNTING AND DATA ACQUISITION SYSTEM OF THE NCRC IR-BASED PHOTOMETRIC DEVICES
Measurement of Neps

Neps by definition are small entanglements of fibers, which cannot be separated. The neps in the card web is measured by manually counting the number of neps in a specific area of the card web and calculating the neps per unit area of card web. Six measurements were made for each treatment. The results are expressed in terms of neps per gram.

Measurement of Web Cohesion

Two methods for measurement of web cohesion were considered. The first method requires the fiber web to be passed between two pairs of draft rollers. The draft between the rollers is slowly increased till the point of failure (breakage) of fiberweb. The draft forces were recorded. The fiber specimen was weighed and density calculated. The draft force per unit density of fiberweb was calculated and used as measure of fiberweb cohesion. The second method requires the fiber assembly in sliver form. Fiber cohesion test for sliver is given by the ASTM standard tests [1,2]. It consists both a static (< 1 cm/min) and dynamic test. The static test involves the measurement of the tensile loading of the sliver by a very sensitive load cell. The dynamic test is similar to the draft test mentioned above except that the specimen is in the form of a sliver. In this study the Rothschild Cohesion-Meter R-2020 was used to measure the sliver cohesion. The instrument measures the force required to draft a given sliver between two pairs of rollers. The draft between the pairs of rollers was kept constant at a recommended draft of 1.25 and the speed of the delivery rollers was 10 m/min. The draft force was recorded as an average force (N) over 2 minutes period. Three readings were taken for each treatment.

Measurement of Static Charge

As static charge generated on the card web gets dissipated before they can be collected and tested, the static charge measuring device must be of an online and non-contacting type. For this purpose, the Tantec non-contacting electrostatic voltmeter was used [6]. It is a hand-held self-calibrating electrostatic voltmeter making it convenient to measure the static generation at any region of the web without disturbing it and while the card is running.

Processing Parameters

POLYPROPYLENE

Polypropylene with 3 different finish levels were provided by Fibervision Inc. The fiber length is 38mm (1.5”) and fiber fineness is 9 denier. The finish levels were determined by performing 20 extractions on each fiber type. The finish levels are 0.11% (low), 0.61% (medium) and 1.97% (high). The finish applied on the polypropylene fibers is of a generic type prepared by Goulston Tech Inc. The finish is composed of 90% lubricant (PEG(400) Monolaurate) and 10% antistat (Amine neutralized linear alkyl phosphate). The fibers were processed on a Saco Lowell - Card Master flat top card whose specifications are given in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Element</th>
<th>Diameter (cm in)</th>
<th>Speed (rev/min)</th>
<th>teeth/cm² (teeth/in²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Roller</td>
<td>7.62 (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Licker-in</td>
<td>25.40 (10)</td>
<td>6.2 (40)</td>
<td></td>
</tr>
<tr>
<td>Cylinder</td>
<td>129.54 (51)</td>
<td>382 (max)</td>
<td>124.0 (800)</td>
</tr>
<tr>
<td>Doffer</td>
<td>68.58 (27)</td>
<td>14-73</td>
<td>26.0 (168)</td>
</tr>
</tbody>
</table>

Figure 2

CALIBRATION CURVE FOR POLYPROPYLENE

Less dense card clothing was used for the doffer to reduce damage to the 9 denier fiber. The IR sensors were calibrated using polypropylene with 0.61% finish level. The resulting calibration curve and equation is given in Figure 2. The high R² value indicates a good second order relationship between the web density and output voltage. Except for the low finish fibers, none of the other blends generated static charge. We did not use the high finish fibers directly as they deposit a significant amount of finish on the carding element. This may affect subsequent runs in the card. Hence, the 3 finish levels were blended to provide 5 different finish levels and one of the blends consists of the high and low finish fibers in exact proportion to arrive at a final finish level equal to that of the medium finish. We call this 0.61%(B) to differentiate it from the medium finish. A comparison of 0.61%(B) and 0.61% finish fibers should give a fair idea about the effect of finish uniformity on fiber performance. The finish levels and their blend composition are given in Table 2. The process parameters used for polypropylene are given in Table 3. The treatments were applied in a random manner. Data were collected for each treatment only after the card reached a steady state condition in terms of finish level and throughput.

POLYESTER

Polyester fibers of 3 denier and 38mm staple length, with four different levels of finish, were provided by Wellman Inc. The finish used for the polyester fiber is supplied by Goulston Tech. and is the same as that on the polypropylene fibers. The remaining finish levels are obtained by blending these4 primary levels. The final finish levels and their blend composition are given in Table 4. Here the blend # 3 and # 4 correspond to fiber with...
uniform finish distribution and fiber with less uniform finish distribution respectively.

The experiments were performed on a Hollingsworth M 2000 high speed stationary flat top card. The process parameters used for polyester are given in Table 5. The treatments were applied in a random manner. Data was collected for each treatment only after the card reached a steady state condition in terms of finish level and throughput. The sensors were once again calibrated for the polyester fiber and the resulting calibration curve and equation is given in Figure 3.

**Results and Discussion**

### POLYPROPYLENE

#### Fiber Breakage

*Figure 4* shows the change in 2.5% span length of polypropylene fibers with respect to finish level. There is a significant effect of finish level on fiber breakage. From *Figure 4* it is evident that fiber breakage decreases with an increase in finish level. *Figure 5* shows the change in short fiber content of polypropylene fibers with respect to finish level for all treatments. There is a significant effect of finish level and throughput on short fiber content. In general the short fiber content is a good indication of fiber breakage. But if fiber breakage occurs and the broken fibers are longer than 0.5 inches then short fiber content will not be able to reflect these broken fibers. Nevertheless it is still useful in understanding how the fiber breaks. Here the fiber breakage can be inferred to occur at higher fiber length and mostly the broken fiber end up being longer than 0.5". On comparing the effect of finish uniformity on fiber breakage, it is found that finish uniformity has no significant effect on both 2.5% span length and short fiber content of polyester as it can be seen from *Figures 6 and 7*.

#### Fiberweb Uniformity

*Figure 8* shows the change in CV % of the fiberweb basis weight of polypropylene. Statistical analysis shows a significant effect of finish level and throughput on fiberweb uniformity. On performing multiple comparisons between the means of finish level, the difference in fiberweb uniformity is evident only between the lowest finish level (0.36%) and the rest of the finish levels. In other words, fiberweb uniformity is affected only at very low levels of finish. On comparing the effect of finish uniformity on fiberweb uniformity, it is found that finish uniformity did not have any effect on fiberweb uniformity. This is shown in Figure 9.

---

### Table 2

**BLEND COMPOSITIONS FOR POLYPROPYLENE**

<table>
<thead>
<tr>
<th>Blend #</th>
<th>Desired finish level</th>
<th>High finish</th>
<th>Medium finish</th>
<th>Low finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.36%</td>
<td>1.97%</td>
<td>0.61%</td>
<td>0.11%</td>
</tr>
<tr>
<td>2</td>
<td>0.61%</td>
<td>50%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.61% B</td>
<td>27%</td>
<td></td>
<td>73%</td>
</tr>
<tr>
<td>4</td>
<td>0.86%</td>
<td>25%</td>
<td>56.5%</td>
<td>18.5%</td>
</tr>
<tr>
<td>5</td>
<td>1.11%</td>
<td>50%</td>
<td>13.5%</td>
<td>36.5%</td>
</tr>
<tr>
<td>6</td>
<td>1.36%</td>
<td>60%</td>
<td>26.8%</td>
<td>13.2%</td>
</tr>
</tbody>
</table>

### Table 3

**PROCESS PARAMETERS USED FOR POLYPROPYLENE**

<table>
<thead>
<tr>
<th>Process parameter</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish level</td>
<td>0.36%, 0.61%, 0.86%, 1.11%, 1.36%</td>
</tr>
<tr>
<td>Fiberweb basis weight</td>
<td>9.67108 g/m²</td>
</tr>
<tr>
<td>Cylinder to doffer setting</td>
<td>0.127 mm, 0.229 mm</td>
</tr>
<tr>
<td>Throughput (doffer speed)</td>
<td>15.9 kg/hr (27.4 m/min)</td>
</tr>
<tr>
<td></td>
<td>30.75 kg/hr (53 m/min)</td>
</tr>
</tbody>
</table>

### Table 4

**FINISH LEVEL AND BLEND COMPOSITION OF POLYESTER FIBER**

<table>
<thead>
<tr>
<th>Blend No.</th>
<th>Blended Finish Level</th>
<th>Original Finish Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.038%</td>
<td>0.111%</td>
</tr>
<tr>
<td>1</td>
<td>0.075%</td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>0.111%</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0.137%</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>0.137% B</td>
<td>10%</td>
</tr>
<tr>
<td>5</td>
<td>0.175%</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 5

**PROCESS PARAMETERS USED FOR POLYESTER**

<table>
<thead>
<tr>
<th>Process parameter</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish level</td>
<td>0.075%, 0.11%, 0.137%, 0.175%, 0.22%</td>
</tr>
<tr>
<td>Finish Uniformity</td>
<td>0.137%, 0.137% B</td>
</tr>
<tr>
<td>Fiberweb basis weight</td>
<td>5.2076 gm/m²</td>
</tr>
<tr>
<td>Cylinder to doffer setting</td>
<td>0.127 mm, 0.229 mm</td>
</tr>
<tr>
<td>Throughput (doffer speed)</td>
<td>25.72 kg/hr (82.3 m/min)</td>
</tr>
<tr>
<td></td>
<td>51.43 kg/hr (164.6 m/min)</td>
</tr>
</tbody>
</table>
Fiberweb Cohesion

Figure 10 shows the change in drafting force of the polypropylene sliver with respect to finish level. Once again there is a significant effect of finish level and throughput on the drafting forces. In general, the drafting force initially drops with an increase in finish level and then appears to increase for further increase in finish level and then level off. On comparing the 0.61% (B) and the 0.61% finish level for any effect of finish uniformity on drafting forces, it is found that finish uniformity has no effect on the drafting forces of polypropylene fibers. This is shown in Figure 11.

Neps and Static Charge

The polypropylene fibers, owing to their high fiber diameter (9 denier) and hence high bending rigidity, did not generate any neps during processing on the card. This may be because the higher diameter made them more prone to fiber breakage rather than being entangled. There was also no static charge generation observed for the range of finish level used in these experiments.

POLYESTER

Fiber Breakage

Figure 12 shows the change in 2.5% span length of poly-
ester fibers with respect to finish level. There is a significant effect of finish level and its interaction with cylinder-to-doffer setting. Multiple comparisons of the means show that the fiber breakage initially increases and then follows a wavy pattern with an overall drop in fiber breakage for further increase in finish level. The wavy pattern can be due to the interaction effect of finish and cylinder to doffer setting. Figure 13 shows the change in short fiber content of polyester fibers with respect to finish level. Here too there is a significant effect of finish level and the difference in mean effect of finish level is evident only at lower levels of finish. The short fiber content shows a higher fiber breakage at lower levels. This shows that though the fiber breakage in not evident while observing the 2.5% span length, it is clearly shown in the short fiber content. This may be because the fiber breakage occurs for fibers whose length is less than the 2.5% span length, as they spend more time on the cylinder than the fibers with length equal to or greater than 2.5% span length. Figures 14 and 15 show the change in 2.5% span length and short fiber content with respect to finish uniformity. No significant effect of finish uniformity on either 2.5% span length or short fiber content could be found.

**Fiberweb Uniformity**

Figure 16 show the change in CV% of fiberweb basis weight of the polyester fibers with respect to finish level. There is only a significant effect of throughput and cylinder-to-doffer setting on the CV% of the fiberweb basis weight and no effect of finish level. Though for one particular treatment (setting 0.127 mm and doffer speed 164.6 m/min), the fiberweb uniformity appears to improve with an increase in finish level. On comparing the effect of 0.137% (B) finish level and the 0.137% finish level on fiberweb uniformity in Figure 17, there appears to be no main effect of finish uniformity on fiberweb uniformity. But there is a significant effect of throughput and cylinder-to-doffer settings along with a slight interaction effect of finish uniformity and cylinder-to-doffer setting. This indicates that finish uniformity by itself has no effect on fiberweb uniformity and maybe at adverse settings they affect the fiberweb uniformity.
Figure 18 shows the change in draft force of polyester sliver with respect to finish level. There is a significant effect of finish level and its interaction with cylinder-to-doffer setting on the draft force of polyester sliver. Overall, the draft force decreases with an increase in finish level.

Figure 19 shows the effect of finish uniformity on draft force. Statistical analysis shows no effect of finish uniformity on the draft force of polyester fibers though the graphs indicate a higher drafting force for the original medium finish than for the blended medium finish.

Neps

Figure 20 shows the change in nep count of polyester fiber with respect to finish level. Only cylinder to doffer setting is found to have a significant effect on neps generated. On comparing the effect of finish uniformity of neps generated (Figure 21), there is no significant effect of any of the factors on nep generation. This shows that nep generation is independent of finish level and its uniformity.

Comparison Between Fiber Behavior

Finish add-on percentage or finish level has a significant effect on fiber breakage for the two fibers. Polypropylene fibers show a decrease in fiber breakage with an increase in finish level. The fiber breakage for polyester shows a different trend when compared to polypropylene. Also the short fiber content of polyester shows a reverse trend when compared to the 2.5% span length. It has to be noted that the finish levels for polyester are much lower when compared to polypropylene, and the diameter of polyester fiber is also finer (resulting in greater surface area per unit weight of fiber). Polyester also exhibits an interaction effect of finish level and cylinder to doffer setting on the 2.5% span length. This may cause the 2.5% span length to show deviations for very low levels of finish add-on percentage. The short fiber content of polyester shows that fiber breakage decreases with an increase in finish level. The trend of 2.5% span length seem to agree with that of the short fiber content on ignoring the results of the first two levels of finish add-on percentage. Further experiments with much higher finish add-on of

Fiberweb Cohesion

Figure 14 shows the change in 2.5% span length of polyester fiber with respect to finish uniformity.

Figure 15 shows the change in short fiber content of polyester fiber with respect to finish uniformity.

Figure 16 shows the change in CV % of fiberweb basis weight of polyester fiber with respect to finish uniformity.

Figure 17 shows the change in CV % of fiberweb basis weight of polyester fiber with respect to finish level.

Figure 18 shows the change in draft force polyester fiber with respect to finish level.
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Finish add-on percentage was found to have significant effect on fiberweb uniformity in the case of polypropylene fibers and no effect on fiberweb uniformity in the case of polyester fibers. Multiple comparisons between the finish levels of polypropylene fiber show that the significant change in fiberweb uniformity is only evident between the first two levels of finish. This change is not evident in polyester due to the less range in finish add-on percentage of polyester. Still Figure 16 indicates that the fiberweb uniformity increases initially for small increases in finish add-on percentage till it reaches an optimum level and then decreases for additional increases in finish level. Figure 8 shows that at much higher range of finish level there is no effect of finish level on fiberweb uniformity.

Finish add-on percentage was found to have a significant effect on fiberweb cohesion of both polyester and polypropylene fibers. In both cases, the drafting forces decrease with an increase in finish add-on percentage for low levels of finish and the polypropylene data suggests that at higher finish levels, an increase in finish level causes an increase in drafting forces. This shows that at low levels of finish the finish performs more as a lubricant, decreasing fiber-to-fiber friction and thus causing a decrease in fiber cohesion. At higher levels of finish the excess finish may act as a binding agent, causing fiber cohesion to increase.

Finish uniformity was found to have no effect on any of the response parameters for both polyester and polypropylene.

Although in some cases like fiber breakage and fiberweb uniformity, the original (more uniform) application shows a slightly better performance due to an interaction effect. However, the gain in performance is not found to be of significant difference. Also the effect of finish uniformity greatly depends on the extent of blending achieved while mixing two fibers with different finish levels.

Conclusion

Finish add-on percentage was found to have a significant effect on fiber processability on card and the influence of finish level depends upon the type of fiber. On the other hand, finish uniformity was found to have no effect on fiber processability on card. Nevertheless, the degree of blending is also shown to have an influence on the effect of finish uniformity on fiber processability.

Acknowledgement

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References

6. Tantec Electrostatic Voltmeter, user manual — INJ

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A Comparison Of Antimicrobials For The Textile Industry

By Robert A. Monticello Ph.D., AGIS Environments, Midland, MI; W. Curtis White, M.S., AGIS Environments, Midland, MI; and Patrice Vandendaele, Devan, Ronse-Renaix, Belgium

Introduction

The nonwovens industry supplies an unending variety of products to an endless array of end-uses and industries. This breadth of end-uses and products requires much attention to the large number of processing steps and variables. The versatility of raw materials, processes, and substrates available to the nonwovens industry, allows technical and marketing people to customize materials for their customers' needs.

Selecting the right product and process for the eventual end-use includes a wide variety of criteria. These include regulatory compliance, toxicity to people and the environment, feature and application specific performance, basic integrity of the product, and costs. The ability to determine the performance criteria of these customized nonwovens is not simple and must include a complete understanding of the end-use requirements and the strengths and weaknesses of the testing techniques that are to be used.

Although important for all kinds of end-uses and performance properties, the criteria above are critically important for specifying and applying antimicrobial treatment on nonwovens.

This paper will provide the reader with an evaluation of antimicrobial treatments on nonwovens. Examples will be used that include antifungal, antibacterial, and anti-mite performance.

Microorganisms

Mold, mildew, fungus, yeast, and bacteria (microorganisms), are part of our everyday lives. There are both good and bad types of microorganisms. The thousands of species of microorganisms that exist are found everywhere in the environment and on our bodies.

Consumer and commercial operators are challenged by the presence of these microorganisms and the negative effects they cause. Antimicrobial treatments for bacterial, fungal, and mite control, are proving to be popular among consumers, manufacturers, and building operators. These treatments not only provide protection from microorganisms they also add aesthetic and emotive values to a full range of products. Deterioration, defacement, odors, and “harboring” medically significant microorganisms, are all dramatic effects we see in buildings and products where microbial contamination is present. The ability to make surfaces and nonwovens resistant to microbial contamination has advantages and values in many applications and market segments served by the nonwovens industry.

Additionally, many nonwovens require the need to control microscopic arthropods such as mites. Mites are associated with dirt and dust and their presence in bedding and other home furnishing products has been linked to allergic responses in humans. Control strategies for these organisms are complex, taking into consideration the life habits of these organisms as well as their metabolic and reproductive habits.

Antimicrobials

The term antimicrobial refers to a broad range of technologies that can provide varying degrees of protection for products and buildings against microorganisms. Antimicrobials are very different in their chemical nature, mode of action, impact on people and the environment, in-plant-handling characteristics, durability on various substrates, costs, and how they interact with good and bad microorganisms.

Antimicrobials are used on nonwovens to control bacteria, fungi, mold, mildew, and algae. This control reduces or eliminates the problems of deterioration, staining, odors, and health concerns that they cause.

In the broad array of microorganisms there are both good and bad types. Antimicrobial strategies for bad organisms must include ensuring that non-target organisms are not affected or that adaptation of microorganisms is not encouraged. Antimicrobials, when properly applied, limit greatly the life habits and environments for the common dust mite.

Microorganisms cause problems with nonwoven raw materials and processing chemicals, wet processes in the mills, roll or bulk goods in storage, finished goods in storage and transport, and goods as they are used by the consumer. These effects are extremely critical to clean room operators, medical facilities, and food processing facilities. They are also an
Antimicrobial Finishes

Antimicrobials do not all work the same. The vast majority of antimicrobials work by leaching or moving from the surface on which they are applied. This is the mechanism used by leaching antimicrobials to poison a microorganism. Such chemicals have been used for decades in agricultural applications with mixed results. Besides the challenges of providing durability for the useful life of products, leaching technologies have the potential to cause a variety of other problems when used in nonwovens. These leaching properties can contact the skin and potentially affect the normal skin bacteria, cross the skin barrier, and/or have the potential to cause rashes and other skin irritations. A more serious problem with leaching technologies is that they allow for the adaptation of microorganisms.

An antimicrobial with a completely different mode of action than the leaching technologies is a molecularly-bonded unconventional technology. The bound unconventional antimicrobial technology, an organofunctional silane, has a mode of action that relies on the technology remaining affixed to the substrate, killing microorganisms as they contact the surface to which it is applied. Effective levels of this technology do not leach or diminish over time. When applied, the technology actually polymerizes with the substrate making the surface antimicrobial. This type of antimicrobial technology is used in textiles that are likely to have human contact or where durability is of value. [1] Dr. M. Bourgeois and researchers at the Institute Textile de France in Lyon have also accomplished this type of surface modification by electron beam grafting of acrylic monomers with quaternary ammonium compounds to hydroxyl active surfaces. In either case, durability to wear and laundering with broad spectrum antimicrobial activity have been demonstrated.

Antimicrobial Function and Adaptation

Antimicrobials primarily function in two different ways. The conventional leaching types of antimicrobials leave the textile and chemically enter or react with the microorganism acting as a poison. The unconventional bound antimicrobial stays affixed to the textile and, on a molecular scale, physically stabs (the lipoprotein components of the membrane) and electrocutes (the anionic biochemicals in the membrane) the microorganism on contact to kill it. Like an arrow shot from a bow or bullet shot from a gun, leaching antimicrobials are often effective, but are used up in the process of working, wasted in random misses, or complexed by other chemicals in the environments of use and abuse. Some companies incorporate leaching technologies into fibers and slow the release rate to extend the useful life of the antimicrobial, even adding to them chemical binders and claiming they are now “bound.” Whether leaching antimicrobials are extruded into the fiber, placed in a binder, or simply added as a finish to fabrics or finished goods, they all function the same. In all cases, leaching antimicrobial technologies provide a killing field or “zone of inhibition.” This zone exists in real-world uses if it is assumed that the right conditions are present for leaching of a lethal dose at the time that it is needed. The zone of inhibition is the area around the treated substrate into which the antimicrobial chemistry leaches or moves to, killing or inhibiting microorganisms. This killing or inhibiting action of a leaching antimicrobial is witnessed when an AATCC 147 test or other zone of inhibition test are run. These tests are used to measure the zone of inhibition created by a leaching antimicrobial and clearly define the area where the antimicrobial had come off the substrate and killed the microorganisms in the agar. As fabrics treated with unconventional leaching antimicrobial are washed, treatments are easily removed. Figure 1 presents graphically a typical zone of inhibition test method. The blue area represents a textile material treated with a leaching antimicrobial. The zone of inhibition is represented by the clear zone surrounding the substrate and the sublethal zone is shown in gray. The area at which the zones merge is presented as the zone of adaptation. This is the area at which the organisms are exposed to sub-lethal levels of the antimicrobial and may become resistant. Figure 2 shows actual results on the difference between the leaching and the non-leaching antimicrobial treatments on textiles both as first treated and then after five household launderings.

Microbes are living organisms and like any living organism will take extreme measures to survive. Microorganisms can be genetically mutated or enzymatically induced into tougher “super-strains” if they are exposed to sublethal doses (exposed to, but not killed) of antimicrobial agents. This ability of microorganisms to adapt to potential toxicants has been recognized in the medical community for years. Sublethal levels of antibiotics are generated in the patients who continue taking antibiotics once their symptoms subside instead of continuing through to the end of the period prescribed by the physician. The exposure of the microbe to a sublethal dose of an antimicrobial can cause mutation of their genetic materials allowing for resistance that is then replicated through the
reproductive process creating generations of microorganisms that are no longer affected by the chemistry. This phenomena is of serious concern to the medical community and food processing industries and should be a serious consideration for the nonwoven textile industry as it chooses the antimicrobials to which it will be exposing the public and their workers.

As with any chemistry that migrates from the surface, a leaching antimicrobial is strongest in the reservoir, or at the source, and weakest the farther it travels from the reservoir. The outermost edge of the zone of inhibition is where the sublethal dose can be found—this is known as the zone of adaptation (Figure 1). This is where resistant microbes that have been produced by leaching antimicrobials are found. The ongoing challenge for leaching technologies is the control of the leach rate from their reservoir such that a lethal dose is available at the time that it is needed.

This is demonstrated in the following images from experiments where a sample was taken from the outer edge of the zone of inhibition of a common leaching antimicrobial from treated carpet fiber (Figure 3a) and used to inoculate a new test plate. This second test plate (Figure 3b) shows the adapted microorganisms growing within the zone of inhibition. The adapted organism is taken from the second plate and used to inoculate a third plate (Figure 3). The microorganism used to inoculate this plate is fully adapted to the leaching antimicrobial and has overgrown the fabric. The ghost zone indicates the organism being slowed but not controlled by the leaching toxicant. All this occurred within just two generations of the test organism under these test conditions.

A significantly different and much more unique antimicrobial technology used in the nonwovens industry does not leach but instead remains permanently affixed to the surface on which it is applied. Applied in a single stage of the wet finish process, the attachment of this technology to surfaces involves two means. First and most important is a very rapid process, which coats the substrate (fabric, fiber, etc.) with the cationic species (physiisorption) one molecule deep. This is an ion exchange process by which the cation of the silane quaternary ammonium compound replaces protons from water or chemicals on the surface. The second mechanism is unique to materials such as silane quaternary ammonium compounds. In this case, the silanol allows for covalent bonding to receptive surfaces to occur (chemisorption). This bonding to the substrate is then made even more durable by the silanol functionality, which enables them to homopolymerize. After they have coated the surface in this manner, they become virtually irremovable, even on surfaces with which they cannot react covalently (Figure 4). [2]

Once polymerized, the treatment does not migrate or create a zone of inhibition so it does not set up conditions that allow for adapted organisms. Because this technology stays on the substrate, it does not cross the skin barrier, does not affect normal skin bacteria, nor causes rashes or skin irritations. This organofunctional silane technology has been used for over two decades to treat surfaces from leather and foams to virtually all types of fabrics and is not consumed by the microorganism. It does not poison the microorganism. When a microbe contacts the organofunctional silane treated surface of the fabric, the cell is physically ruptured by a sword-like action and then electrocuted by a positively charged nitrogen molecule (Figure 5). This antimicrobial technology has been verified by its use in consumer and medical goods including socks, surgical drapes, and carpets in the U.S., Asia and other areas in the world. This technology has been used for nearly twenty-five years without any human health or environmental problems inside manufacturing facilities or in actual end use situations.

Anti-Mite Treatments

In order to limit the increase of mite populations and the exposure risks associated with the presence of mites and their allergenic elements, treatments must be able to interrupt the life processes of the mites or alter their environment in ways that discourage their presence and reproduction. This is essen-
tial for nonwovens in pillows, bedding products, household products, flooring materials, stuffed toys, and other nonwoven products used in the indoor environment.

Millions of people suffer from allergies, skin irritations, asthma, or other respiratory diseases. The three major sources of indoor allergens associated with sensitization and subsequent allergic disease are dust mites, pets, and molds. Studies in different populations have shown that up to 85% of people have allergic asthma, but only 5-30% of the non-asthmatic population are allergy prick test positive to mites.

Mites belong to the Class Arachnida, as do spiders. Mites are small (300-400 mm) and are often found living in mattresses, sofas, carpets, and many other synthetic and natural fibers. 100,000 mites may live in one square meter carpet. Each dust mite will produce about 20 fecal pellets (10-40mm) per day, which is the known real allergenic trigger.

Mites feed on desquamated human skin. These skin cells are too dry for the dust mites to digest so they need to be broken down into a digestible food, which is facilitated by the fungus Aspergillus repens. By eliminating the Aspergillus repens, and therefore, the substance that dust mites feed on, the ÆGIS antimicrobial is controlling the increase of dust mite population.

To illustrate, ÆGIS AEM 5700/5772-treated mattress ticking was evaluated for dust mites by an independent laboratory (P.C.C.-Belgium) for six weeks in a semi-natural environment. A population reduction of 98% was observed compared to the population of an untreated mattress ticking (Table 1).

A similar test has been run by T.E.C. – France using the NF G-39011 French standard on acrylic fiber and polyester fiber. The ÆGIS treated fiber revealed a population reduction above 90% in both compared to an untreated sample.

For many years companies sought to control the common dust mite in bedding materials by using organotin chemistries provided by a number of suppliers. These leaching chemistries provided for actual killing of the mites when the difficulties of dose delivery could be controlled. Long held concerns about the negative impact of these chemicals on the environment have only recently been acknowledged by these suppliers. This useful but limited mite control tool is not in use today by stewardship conscious companies.

### Application Methods

Antimicrobial technologies are, as described above, quite varied and the demands for application are equally varied. Depending on the technology, the intended end-uses, and the mode of antimicrobial activity, one or another application point and procedure are favored. Adding to the fiber polymer melt, to the fiber during processing, or to the fabric or finished goods, are all available alternatives.

Addition to the polymer melt is fraught with problems that must be evaluated if this application point is being considered. The performance challenge presented by creating a toxicant reservoir inside of a fiber when the contact with the microbe will be on the surface is dependent on the solubility constant of the antimicrobial, the way that it is embedded into the polymer matrix, the chemicals ability to move in the polymer matrix, and the nature of the environment around the fiber during use. Other challenges revolve around the need for uniform mixing and subsequent dose release of the antimicrobial, changes in fiber properties, negative effects on color or reflectance, blocking of process filters, build-up on process equipment, odor, fuming, efflorescence or surface salting problems, or chemical conversion problems considering probable process temperatures of 230°C for 2-3 minutes. Also of concern is the health and environmental issues for personnel, users, and the environment. Cost of such a strategy must be considered because of the need to use levels of chemical in the reservoir suitable for providing a useful and effective dose during the life of the end-use product.

After a polymer is extruded into the fiber form, antimicrobials can be added with the drawing oils or spin finishes. This method has lots of merits if the issues of compatibility and

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<th>ÆGIS Treated</th>
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<td>Untreated</td>
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*Pest Control Consultants VZW-ASBL, Dorpsstraat 24, B-9320 EREMBODEGEM, Belgium. August 9, 2000. Test on the limitation of house dust mite populations in textiles Mattress Ticking treated with ÆGIS Microbe Shield.
uniformity can be solved and that properties of the spin finish are maintained. The fiber treatment must also be able to survive all of the downstream processing without interfering with the fiber processing or present any hazards to the workers, process equipment, or the environment.

In a similar fashion and with all of the same cautions, the antimicrobial treatment may be able to be added in one of the post drawing processing points. Adding at the crimper with or without the crimper oil can take advantage of the heat setting process to assure curing and durability of the antimicrobial binder or, in the case of the AEM 5700/5772 reactive silane antimicrobial, enhance the bonding reactions needed to maximize durability.

Some antimicrobials, as reactive treatments or ones that are in binders, can be added to a spun bonded product or to the fiber batt by spraying or pad bath. This can be done at the fiber processing plant or as a pre-step at the converters. This method allows for the treatment to be on the surface of the fiber yet still provides all of the needed compatibility and safety properties consistent with the process and the end-use. Simple deposition of the antimicrobial, although still practiced by some, is not a good alternative considering increased environmental and human sensitivities as well as concerns over sublethal antimicrobial doses allowing for microbial adaptation.

A final alternative is adding the antimicrobial on the final nonwoven substrate. This can be done with spraying technology or with a pad bath. Foam applications have also been used effectively with the AEM 5700/5772 reactive silane antimicrobial onto nonwoven batts. Again, all of the needed compatibility and safety properties consistent with the process and the end-use must be assured.

Safety Profile

It is critical to review all uses of chemicals used in nonwovens in light of the intended use and the toxicological profile of the chemical. This is especially relevant as one remembers that antimicrobials, by definition and function, inhibit and/or kill living things. The mode of biological involvement needs to be fully understood so that a proper balance between risks and benefits can be made. For illustration, the following safety profile on the ÆGIS AEM 5700/5772 Antimicrobial can be considered a minimum profile of needed data for qualifying antimicrobial treatments for use on nonwovens.

The ability of the silanequat, when properly applied, to chemically bond to the nonwoven substrate and still provide for the broad spectrum control of microorganisms, makes it well suited to the safety challenges encountered in the full range of applications used in the nonwovens industry.

The following studies have been conducted with the silanequat: (a) acute oral, (b) acute ocular, (c) acute and subacute dermal, (d) acute vapor inhalation, (e) primary skin sensitization and irritation, (f) sub-acute vaginal irritation, (g) four-day static fish toxicity, (h) teratogenic evaluation, (i) sub-acute human wear test (socks), (j) human repeated insult patch test, (k) in-vitro Ames Microbial Assay with and without metabolic activation, (l) in-vitro mammalian cell trans-formation in the presence and absence of exogenous metabolic activation, (m) in-vitro Host-Mediated Assay and (n) a percutaneous absorption study. Although certain handling cautions are indicated by data from the above tests, no untoward effects are notable regarding treated substrates.

Further to these studies, Olderman reported on studies done by American Hospital Supply (Baxter Health Care), for a surgical drape that had been treated with the AEM 5700/5772 treatment. These studies included the following pre-clinical biocompatibility tests that are considered appropriate for skin contact medical products: (a) Tissue culture (cytotoxicity), to determine if a tissue culture medium (with serum) eluate of the test material can induce a cytopathic effect on monolayers of human (WI-38) cell, (b) Acute systemic toxicity to evaluate the potential of a single injection of an extract of the test material to produce a systemic toxicity response, (c) Intracutaneous irritation to evaluate the potential of a single injection of the test material extract to induce tissue irritation, (d) Eye irritation to determine the response of the rabbit eye to the instillation of specific extracts of the test material, (e) Hemolysis to determine if a substance can be extracted from the material which is capable of inducing hemolysis of human red blood cells, (f) Human Repeated Patch Test to determine if the test material is capable of inducing skin irritation and sensitization under controlled patch test conditions and (g) Extensive leachability studies to evaluate the durability and non-leaching potential of the chemically modified fabric when exposed to copious amounts of physiological saline, water and simulated human sweat.

The final results of these biocompatibility studies from the Olderman report indicated that the AEM 5700/5772 Antimicrobial treated fabric is non-toxic, non-irritating and non-sensitizing to human skin, and has a permanent antimicrobial capacity that cannot be extracted in use. These preclinical studies provide sufficient information to allow us to predict the biocompatibility of the finished products and support their safe clinical use. As such, the treated fabric was considered safe for use in surgery. Years of clinical use with no untoward effects also supports the suitability of the treated fabric for its intended use. (3)

Antimicrobial Treatment Verification

Another important property of a useful antimicrobial is that its presence should be verifiable. In effect, it is the only way to know that an antimicrobial is really on the product. There is no easy way to tell whether leaching antimicrobials are present on a product. The only known verification technique for a leaching chemistry is to use exacting laboratory tests, which take days or weeks to perform. With the bound AEM 5700/5772 antimicrobial technology though, a simple staining test can be performed in a matter of minutes at the mill or in a store to verify proper treatment of a fabric or other surface. This is a very important part of a quality assurance program that gives manufacturers, retailers, and consumers, confidence that a feature, normally invisible to the senses, can be seen and is actually on the product providing the protection for which they have paid.
Antimicrobial Regulation

As we’ve discussed, not all antimicrobials are alike. There are technical differences between antimicrobials that affect their life, performance, safety and costs. But, one thing is true for all antimicrobials and sometimes the treated products. All antimicrobials are regulated by the US Environmental Protection Agency, the EEC Biocide Directives, or other regulatory agencies around the world. Antimicrobials must be registered with the EPA, the EU, and other regulatory bodies for the specific uses. In some cases, antimicrobials have been misapplied. In other cases, antimicrobial products have made errant claims resulting in fines, sometimes totaling in the hundreds of thousands of dollars. Products exported to regulated areas with unregistered treatments or errant claims were turned back and supply dates were missed and retailers were left without goods on the shelves.

A manufacturer’s antimicrobial of choice should be specifically registered for use on the end product being manufactured (i.e., an antimicrobial that is only U.S. EPA-registered for use in shoes should not be used for treating socks).

Nonwoven Application of Antimicrobial Treatments

Armed with knowledge of the strengths and weaknesses of antimicrobial treatments every marketer of nonwovens can assess their customers’ needs and the values that such treatments can bring to the marketing of their products.

Markets available include: wipes for medical, food services, and household use, air filtration and water filtration media, car and trunk liners, flooring materials, soil stabilization media, roofing materials, miscellaneous construction products, medical garments and goods, shoe liners, garments, fiber fill for pillows and crafts, mattress pad fills, tickings, and all goods that are used in environmental situations where microorganisms are a problem.

Summary

The first decade of the twenty-first century brings us to a unique convergence of marketplace needs and microbial control technology that offers effective reduction of germs, bacteria, mold, mildew, yeast, and mites, on all kinds of nonwovens for the useful life of the products.

The polls have indicated that the market is ready for antimicrobial products and the buying public has reinforced the polls with their pocketbooks. More than seven times as many anti-germ products were produced in 1998 than in 1992 [4] and consumers’ demands for antimicrobial products have grown dramatically since 1998. This increased demand for antimicrobial-protected products warrants increased scrutiny of the antimicrobials being put into the products. There are hundreds to thousands of chemistries on the earth that kill microorganisms. Many of these, like arsenic, lead, tin, mercury, silver, plant extracts and animal extracts, are “natural” but can also be highly toxic to people and the environment. An effective antimicrobial for the textile industry can’t just kill or repel microorganisms, it must do so safely, over the life of the treated product, and without negatively affecting the other important characteristics of the textile.

To benefit from the consumer demand for antimicrobial/antibacterial products as well as the antimicrobial/antibacterial performance needs of the textile world, manufacturers have a choice. In choosing, they should utilize a treatment that provides for a microbial control claim and an antimicrobial finish for their textile products consistent with their claims and the needs of their target consumers. This selection should be done by considering:

1) Adopting a non-leaching antimicrobial that doesn’t pose the risk of crossing the skin barrier or negatively affecting the normal microbial flora of the skin. If it creates a “zone of inhibition” or must integrate into the all to have function, it leaches or moves and has the potential to cause problems to people and the environment.

2) Adopting an antimicrobial technology with a proven history of use. This will help shorten the timelines in bringing products with an antibacterial/antifungal/odor-reducing, antimicrobial feature to market.

3) Adopting a non-leaching antimicrobial that doesn’t pose the risk of creating adaptive resistant microorganisms.

4) Adopting an antimicrobial technology that is registered with the EPA, the EU and other regulatory agencies for the specific product it is applied to.

5) Adopting an antimicrobial technology that can be tested for proper application at the mill or at the retailers. A verifiable quality assurance program should be a key component of any application process.

6) Adopting an antimicrobial technology that has technical and marketing support.

Numerous retail buyers have stated that the antimicrobial/antibacterial “feature” is quickly moving to a standard requirement for the products that they buy. Manufacturers that don’t currently treat fabrics with a durable antimicrobial finish should consider shielding their products from eroding value by incorporating microbial control. As manufacturers look to enhance the value of their products they should recognize antimicrobial finishes as a feature with a future and the future is now.

References


THE NONWOVEN WEB

Searching Versus Surfing

Surfing the web can be a lot of fun — going from one interesting site to another, like indiscriminately picking wild flowers in a field. Searching the web, on the other hand, is a different matter; you want information, the right information, all of the information and right now! Picking the right search site and using it properly is undoubtedly the best way to maximize desired results in web searching.

The job is not getting any smaller with time. Like one expert said, “The web is growing like a bad weed, with an estimated 2.7 billion publicly available, indexable pages and another five million added daily.” That was said last month, so it is already out-of-date!

In terms of efficiency, time spent in planning a search can be time well spent. Most experts agree that with conventional search capabilities, one should spend some time to define the particular search requirements. Then, a list of eight key words should be prepared, along with related terms, and synonyms that relate to the query. It is also helpful to establish time and page limits for the initial search. The search can then be initiated on three different commercial search engines; one expert suggests Alta Vista, Google, Ask.Jeeves or their equivalents. If these searches don’t result in a successful response in either the time or page limits you specify, then change or restructure the query.

Also, most searchers suggest that instead of trying to use a lot of different search engines, a person should limit the number used; this practice will ensure proficiency in the use of the search engines employed. Each engine will have advanced search capabilities that dramatically reduce the number of returns and increase search efficiency; with experience, these features can be exploited.

The efficient use of Boolean Operators can also dramatically reduce the number of pages retrieved and hence, expedite the search.

Occasionally there are comprehensive comparisons of search engine capabilities published. Such comparisons usually center on specific types of topics and areas of interest. A dedicated searcher may want to make their own comparison of useful search engines for a specific category. Also, it should be kept in mind that new versions of established search engines become available, and entirely new engines are introduced from time to time. As can be appreciated, the internet is not a static entity.

Finally, a wise searcher will also realize that not everything on the web is of high quality. Confirmation of information from other sources may be desirable, especially in critical situations.

The Ten Commandments of Internet Searching, according to Washington Researchers of Washington, D.C., (www.washingtonresearchers.com), an activity focused especially on competitive intelligence, are as follows:

1. Know your search engine, remembering that only a portion of all the websites are indexed by the best search engines.
2. Use multiple search engines (or metacrawlers).
3. Don’t count on being anonymous — Don’t forget about those cookies!
4. Search the sources, not just information — look for people you can call to get more detailed information.
5. Consider the source of what you find — just because it is in print, doesn’t mean it’s true; information can be typed incorrectly or copied from another source that was wrong; perhaps it was written just to be misleading.
6. Be prepared to spend some money with commercial searchers, to get the really good stuff.
7. Ask “Is there any reason to believe what I want is out there?” before going on-line.

Search Engine for Science Employment

An employment search engine specifically for science positions could be the way to short-cut the hunt for a suitable job or suitable job-hunter.

eLabRat.com is a play on words, but also is a serious site for job-seekers and job-hunters alike. The range of interests is broad — biotech, pharmaceutical, engineering, polymers, quality control, semiconductor, industrial, academic, governmental, and others — but all are science-oriented.

One-half of the site is devoted to job seekers, and the other half to employers/recruiters. For the job seeker, a number of features are offered as career resources, including helps in preparing the resumé, assistance in prepping for the interview and other helps. For the employer, numerous helps and suggestions are available to focus the search. It is claimed that the cost of listing is about one-fifth of newspaper cost, and about twice the cost of service placement fees. Placement packages are available that can cover various education levels and salary ranges. Up-dating is possible.

The site claims it attracts over 45,000 visitors per month, with more than 4,200 applicant files and over 800 registered users. Of the positions listed, 65% are for industrial concerns, 28% in academe and 7% in government. (www.elabrat.com).
8. Don’t use the Internet to do a database service’s work.

9. Know your outcome: Searching or Surfing? Searching has an outcome in mind. Surfing implies enjoying the ride — letting yourself be taken along where links lead you. Each has its purpose; understand the difference.

10. Buy a kitchen timer. If you don’t watch yourself, you will spend hours looking for something that can’t be found or you will end up surfing instead of searching.

If a person is really interested in studying this matter of search engines in greater detail, there is help available. There are several excellent reviews of search engine features and in-depth material to research this topic. The following may be of some help and interest:

• Search engine features and comparisons: www.notess.com
• Review of search engines: www.searchenginewatch.com
• Comparison of engine user interface capabilities: http://lisweb.curtin.edu.au
• How to choose an engine or directory/library.albany.edu/internet/choose.html

Good Searching!

Power To Compute
During the course of preparing this material on a computer today, a local power outage was experienced. The power was off for about two minutes, but that was much more than needed to shut down the activity and lose a lot of data!! Reminder: “Save” every few minutes.

The experience also caused some thinking and delving into the power requirements for computing. It isn’t as though any one machine takes a lot of power, but when the requirement for one machine is multiplied by a big, big number, the situation shifts. When the requirements for the giant server complexes that collect and disseminate data over phone lines and optic networks, along with the other peripherals involved in computer, there is no wonder that some of the local utilities are suffering from the strain. No wonder, also, that the demand for internet energy is highest in cities central to the technology industry — namely Seattle and San Francisco.

This demand for electric power is becoming a real threat to the growth of large data centers, which are getting larger and more numerous all of the time. A recent report stated that the data centers in the Silicone Valley are now consuming 25% of the area’s power, and the share is increasing every year. On a nationwide basis, one report recently indicated that 8% of the U.S. overall electricity supply was being used by internet-related equipment.

One expert recently used the analogy of the Eniac Computer of 1946, the first real powerhouse. It was an enormous machine, with 18,000 vacuum tubes that consumed 180,000 watts of electrical power. Today, you can find three times as much computing power in a 5-watt Nintendo 64 game machine. But one Nintendo per teenager adds up to a whole lot more demand for electric power, overall, than one Eniac per planet.

Another element of this situation is the need for uninterrupted, reliable power. The faster that a computer operates, the more exacting its demands for power quality. For a chip clocked at 1 gigahertz, a blackout is any interruption that lasts more than a billionth of a second. This has resulted in many critical users planning their own back-up system, to forestall any interruptions of power, despite the expense involved. These smaller generation plants are designed by size to meet the demands of a specific data center, so that reliance on the local power grid is eliminated. This power source that is decentralized and consists of off-grid electricity is being referred to as micropower. Needless to say, it has been growing at a rapid rate.

Long-range plans for any company or industry these days must involve the element of power requirements, both capacity and reliability. There is another entire aspect of this matter, and that is portable power, to run portable units of great diversity. More work needs to be done in this area as well. — INJ
INJ DEPARTMENTS

WORLDWIDE ABSTRACTS AND REVIEWS

A sampling of Nonwovens Abstracts from Pira International — A unique intelligence service for the nonwovens industry

Product development from more innovative ideas to contribute to environmentally friendly society

Since its entry to filter business in 1985, Frontier Sangyo KK, Japan, has responded to diversifying market demand by innovative product development and composite processing technology. Their product range includes dust-collecting filters for air conditioners, deodorant filters for humidifiers, dehumidifiers, ceramic heaters or extraction fans, activated carbon filters, activated carbon fibre filters, photocatalyst filters and aluminium-honeycombs. They also manufacture and process soundproof, vibration-proof, airtight and insulating materials.

A new product containing bicho-tan charcoal is increasing application in home electric appliances like vacuum cleaners and futon dryers, car air conditioners, clothes covers and shoe liners. A new humidifier using Frontier’s high-bred-type water absorptive filter is noted for its huge reduction in electricity consumption.

To meet further market demand, Frontier has introduced electret processing equipment and hot-melt foam-form system. Currently development is underway for hot-melt polyamide preventing creation of hazardous gases at incineration, and its production is expected to start in early 2002. Frontier is keen to explore new business opportunities, and anticipates a growing market for cabin filters for car interiors, which are standard for luxury cars but will be fitted in even middle-grade cars from spring 2002. (6 fig)

Responding to environmentally friendly society: Firedon air filters

Japan Vilene Co Ltd has been working on environmental solutions for their Firedon brand. As for general air-conditioner filters, “FR-585” halogen-free roll filter is used for primary air treatment, and “PS Series” are washable types for primary air treatment or pre-filter for middle-efficiency filters. Middle and high-efficiency filter, “Philo-topia,” allows easy replacement for filtration medium while the frame is reused, contributing huge waste reduction. In car paint shops FR-585 and PS Series can be used as primary filters, and chlorine-free bag filter “VG-40” is available for secondary filters. PA/305 and PA/350N are used as tertiary filters, also chlorine-free and effective to prevent dioxin and damaging incinerators. New chemical filter for semi-conductor manufacturing has been developed using sheet-forming technology for activated carbon grains, and all the materials used for the filter, frame, adhesives, packing and packaging were checked to avoid secondary contamination. Japanese Vilene’s recycling system manufactured has been developed using sheet-forming technology for activated carbon grains, and all the materials used for the filter, frame, adhesives, packing and packaging were checked to avoid secondary contamination. Japanese Vilene’s recycling system manufactured has been developed using sheet-forming technology for activated carbon grains, and all the materials used for the filter, frame, adhesives, packing and packaging were checked to avoid secondary contamination.

Nonwovens have 3-dimensional net structure, and by utilising this feature nonwoven filters have been developing. Either surface or inner filtration takes place in air filters, and the latter mechanism is applied to high efficiency filters while the former is used for ordinary air conditioner filters, bag filters and membrane filters. Void formation in filter material, and type, structure and form of fibres making the material are key factors for filter characteristics, and according to requirements fibre size is selected and complex manufacture is designed. Manufacturing filter materials is roughly divided into wet and dry nonwoven types. Wet nonwovens are made from sheet forming of short fibres and pulp bonded by hydrogen or adhesives, and used for automobile engine air filters, oil filters and vacuum cleaner filters. Various types of dry nonwoven manufacturing methods, technology of making very fine fibres and combined use of processes have produced a wide range of filter materials from large-particle use to extremely high-efficiency types. For forthcoming development of dry nonwoven filters, safety of filter disposal will be more emphasised as well as energy saving by reducing filter pressure loss. Also, prolongation of filter life and solution for filter cleaning to allow reuse must be explored. (2 fig, 3 ref)

About air filters

Air filters can be classified into four grades according to dust collection performance: filters for large particles (pre-filters), middle efficiency, high efficiency and extremely high efficiency filters.
Dry nonwovens are generally used for large-particle use in the form of panels or rolled filters. Washable and disposable types are available. For middle or high-efficiency filters, glass fibre nonwovens, dry nonwovens of fine fibres, wet nonwovens, meltblown nonwovens and electret nonwovens are common materials, and take shape of bags or “fold-in” units. These filters are normally single-use only, but as ultrasonic cleaning technology advances, reusable filters are under review. Extremely high efficiency type particulate air (HEPA) or ultra low penetration air (ULPA) filters have appeared in household air conditioners and air purifiers. Like middle and high efficiency types, pleated filters are folded into the unit.

The Travelon air filter range from Kanai Juyo Kogyo KK, Japan, emphasises resource-saving and environmental protection. Travelon pre-filters include halogen-free filters and heat resistant types for dryers in car paint-shops. For middle/high-efficiency grade, filters with large air capacity and small depth size are available, saving space and extending filter life. Gas-removal filters for semi-conductor manufacturing, Pure Home N and H, have been launched in cooperation with Nihon Pure Tech. Anti-bacterial filters are also available. (3 tab)

Author: Isohashi K
Source: Jpn Nonwovens Rep.

Production and demand for synthetic fibre and thread in the world and in Russia

From data based on the year 2000, the demand for all types of textile fibre was about 48mt but by 2003 it will have risen to 50mt (28.7mt of chemical fibre and 26.4mt synthetic). Among the regional leaders, China is the foremost in the area of chemical fibre. In North and South America, West Europe, Africa and the Middle East the development will be moderate. A world textile market is awaited in 2010. There is a lowered demand for cotton, for example from 2000-2010 from 38 to 32%. Statistical tables give a break-down of world supply and demand for textile fibre and chemical fibre; the output of synthetic fibre in the world giving the share contributed by Asia; the USA production is shown for chemical fibre, cotton and wool; the properties of basic reinforced fibres and lastly the share of demand for cars, carpets, furniture, office materials, textiles and knitting wool, material and technical needs. (16 tab)

Author: Eisenstein E M
Source: Text. Ind.
Issue: no. 3, 2001, pp 25-33 (In Russian)

The future development of the markets of natural raw material in Russia

The textile industry, which supplies the market with goods for consumer demand and a significant volume of products which are used in all branches of the economy for technical specialist and medical section, clothing stock for the Russian army and Ministry of Internal Affairs and budget organisations in the period 1999-2000 has a stable growth of production. For example, in the southern districts of the Russian Federation in recent years good results have come from cotton grown in the experimental sector. A small group of enthusiasts among agronomist and professors have created the first Russian fast-grown cotton using ecologically clean technology, and the quality satisfies the Russian textile industry. With the active participation of a section of enterprise, a fund has been formed to accumulate the means to resolve problems of technology and the development of the raw material base such as selecting new kinds of flax. Russia must work boldly on the assortment of competitiveness and liquidity of the internal and external markets.

Author: Shumilin C M
Source: Text. Ind.
Issue: no. 3, 2001, pp 42-48 (In Russian)

Fleissner sells seven AquaJet spunlace machines in first half

The shipment of seven machines to Western and Eastern Europe, the Middle and Far East and South America in the first half of 2001 raised Fleissner’s total output of AquaJet spunlace machines to more than 40. The units produce one-layer smooth, perforated or structural nonwovens as well as composite and sandwich pulp/tissue constructions. (Short article)

Author: Anon
Issue: no. 5, 2001, p. 8 (In German)

JM Europe starts up new spunbonded polyester line

Johns Manville GmbH, Germany, has commenced production on a new DEM30m line to meet the growing demand for spunbonded polyester tissue. Johns Manville acquired the Berlin-Zehlendorf plant from Hoechst Trevira in 1999. The new 2.50m wide line uses jet technology to form 1-12dtex fibres, allowing more even, higher strength nonwoven tissues to be produced. The product range now includes tissues of less than 15gsm substance. The new CombiFil multilayer spunbonded filter materials comprise both fine and coarse polyester filaments, the fine surface filaments improve particle retention with the coarse filaments ensuring minimum pressure loss.

Author: Anon
Issue: no. 5, 2001, pp 10-11 (In German)

Concert’s turnover is ahead of schedule

Concert’s new DEM130m Prignitz, Germany, plant has raised its turnover from DEM28.9m in 1999 to DEM85m in 2000. A further 18% increase is expected for 2001. End uses for its 28,000tpy airlaid tissue production capacity include feminine hygiene and incontinence products, as well as wipes and absorptive pads for meat packaging. The global market for airlaid products is expected to show double digit growth rates. The Concert Group’s total produc-
PIRA ABSTRACTS

Lenzing group

Following a successful 2000, Lenzing Group’s consolidated turnover of Euro334.3m in the first half of 2001 is 7.2% higher than that for the first half of 2000. Operating profit is 13% higher at Euro24.4m. Since 1990, Lenzing’s share of the global viscose fibre market has grown from 9%-20%. The improvement is the result of product mix optimization and cost reduction, as well as the development of speciality fibres for the nonwovens industry. A new viscose fibre line at the Lenzing plant supplies spunlace processors using water jet bonding for hygiene, medical and cosmetics applications. New products include flame retardant fibres for use by fire brigades and in aircraft, and antibacterial fibres for sports clothing.

Author: Anon
Issue: no. 5, 2001, p. 13 (In German)

Japan Vilene KK, three types of industrial mask that meet the new national standards

Japan Vilene KK, Chiyoda-ku, Tokyo, Japan, launched three new lines for its Vilene mask in August 2001. All three products are made of a high-performance three-layered filter which achieves a superb particle capture capacity, and meets the new national standards for industrial use masks introduced in 2000. Its double fitting system also achieves the tight fitting of the mask on face. The three grades are: X-2159 for anti-metal particles and fumes; X-2162 with active carbon particles; and X-2201 for general industrial dusts. The combined sale of those three products in the first year is expected to be JPY1,000m.

Author: Anon
Source: Jpn Nonwovens Rep.
Issue: no. 9, Sept. 2001, p. 28 (In Japanese)

Toyo Eizai KK, Lifree Pants-use Pittari Pad for incontinent users

Toyo Eizai KK, Kawaoe-City, Ehime, Japan, has modified and re-launched the Lifree Pants-use Pittari Pad, a pad for incontinence. This new product was designed for the combination use of paper diaper and pad, or normal underwear and pad. The target market includes combination users of paper diapers and pads; people who have frequent but light incontinence problems; and people who can change a pad regularly by her/himself. The characteristics of this product include a good fitting structure to both body and underwear (or nappy); a just fit size for the Lifree-diaper; compact size (36cm) and high absorbency (0.2l); a long and wide fixing tape to prevent twisting and mispositioning; and an application of anti-odour polymers. (1 fig)

Author: Anon
Source: Jpn Nonwovens Rep.
Issue: no. 9, Sept. 2001, pp 28-29 (In Japanese)

P&G KK, new lines for Panpase Cotton Care including new-born and small size baby

Procter & Gamble, Kobe-City, Hyogo, Japan, has launched Panpase Cotton Care for newborn and small sized babies. The softness of the surface sheet was modified to achieve a cotton-like soft texture, and the flexibility around legs was improved. Panpase Cotton Care is planned to be launched in September 2001 with colours and illustrations printed on them. The new Panpase Sukusuku Pants are improved with the application of the Sukkiri Soft Mesh (fresh and soft mesh), and its nationwide launch is in October 2001: the product is the first pants-type paper diaper for large size babies (8kg body weight). Wisper Neo Asamade Guard is a sanitary pad designed for night-time use, and is highly absorbent. Habahiro Backguard (wide backguard) prevents leakage and Shinayaka Stretch Wing (flexible stretch wing) prohibits twisting and mispositioning. Its launch is in September 2001. (1 fig)

Author: Anon
Source: Jpn Nonwovens Rep.
Issue: no. 9, Sept. 2001, p. 29 (In Japanese)

Nonwovens for filters from our company’s range: Anvic KK

Anvic KK, Japan’s leading nonwoven manufacturer with 40 years’ experience, offers a wide range of filters, including dust-collecting filter bags, industrial air conditioner filters, air purifier filters, automobile air filters, dust respirators and liquid filtration cartridges. Fibre diameter, density and surface treatment of nonwovens will determine dust-collection efficiency, and Anvic employs optimum design for filter manufacturing according to the required purpose. Surface treatment is particularly important to improve dust-removal properties, and other functions like anti-corrosiveness or water/oil repellency can be achieved through coating or dipping.

Anvic and Nitto Denko have developed “Microtex F” where polytetrafluoroethylene (PTFE) film with very fine pores is laminated to a nonwoven surface, boasting the highest dust-collection efficiency ever among filter bag materials. “GP felt” has been made through cooperation with Unitika Glass Fibre, challenging the impossible of making filter bag nonwovens from glass fibre. Mixing a little PPS fibre into glass fibre actually makes highly functional filter bag material, and PPS fibre treated with special resin resists high heat. GP felt filters are widely used for gas emission treatment for waste incinerators. Anvic’s “Techno Fellon” achieves higher efficiency and smaller pressure loss compared to other electret nonwovens, and is used for dust respirators and air purifiers. (6 fig, 3 tab)

Author: Anon
Source: Jpn Nonwovens Rep.
(In Japanese)

— INJ
Deceptive Advertising Aimed At Inventors

Earlier this year, the United States Patent and Trademark Office (USPTO) unveiled a television and radio campaign in five large media markets to counter the flood of deceptive advertising aimed at America’s independent inventors. The take from such deceptive advertising is not pocket change; rather such exploitation costs small business people over $200 million annually.

The USPTO’s media spots, which will run through March 31, 2002, in San Francisco/San Jose, Tampa, Pittsburgh and New York, and in Spanish in Southern Florida, warn small inventors about organizations who offer, but do not deliver on, costly schemes to patent and market inventions. The agency also will be placing print ads in Popular Science, Popular Mechanics, The Family Handyman and Inventors Digest magazines during the first quarter of the year.

“USPTO’s ads caution inventors that ‘if it sounds too good to be true, it is,’” said James E. Rogan, Under Secretary Of Commerce for Intellectual Property. “Our ads offer practical information, guiding inventors to USPTO’s Office of Independent Inventor Programs, where they can get real help with patenting and marketing their inventions.”

The spots feature an actual situation and an actual inventor, Edward Lewis, who lost several thousand dollars in utilizing outside firms who promised to get patents and assist in the marketing of his concepts. Such ads are often flagrant in the promises made, but very minimal in any useful results.

The USPTO’s Office of Independent Inventor Programs has set up a special toll-free telephone number (866/767-3848) which offers to provide detailed information to inventors about invention promotion firms and also realistic options available through the USPTO Independent Inventor Program.

Patent Model Exhibit Showcases American Ingenuity.

In early February, The United States Patent and Trademark Office unveiled its newest periodic exhibit. The opening of this exhibit, entitled “Patent Models: Icons of Innovation,” coincided with the celebration of the 155th anniversary of Thomas Edison’s birthday.

In the 19th Century, the United States was the only industrialized nation that

Top Ten Patent Recipients

The USPTO recently announced the top 10 private sector patent recipients for the 2001 calendar year. Listed below are the 10 corporations receiving the most patents for inventions in 2001, along with their ranking for last year.

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<td>1,166</td>
<td>Fujitsu Limited</td>
<td>(10)</td>
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* Patent information reflects patent ownership at patent grant and does not include ownership changes that occur after the patent is granted. Where more than one assignee (owner) exists, patents are attributed to the first-named assignee.

For the ninth consecutive year, IBM received more patents than any other private sector organization. Eight of the top 10 companies are Japanese firms, which is about the same proportion as last year. All 10 companies are engaged in electronics, computer technology, telecommunications or related activities.
required patent applicants to submit a model along with a description and detailed drawing of their invention. This requirement resulted in thousands of crafted miniature machines to illustrate the operation of a utility patent concept. Those models that survive today compose a national treasure chest that captures a very specific chapter of American history - a treasure chest the USPTO is committed to preserving. The USPTO exhibit showcases some of the more interesting patent models from this era.

Patent models were first housed in Blodgett’s Hotel in downtown Washington after the Patent Office moved there in 1810. Two fires and the general chaos of the Civil War threatened their future before their enormous quantity made them an unwanted nuisance in the 1880s. In the next century, the miniature machines changed hands many times, surviving more fires, auctions and general neglect.

The Smithsonian Institution received some historically significant models in 1907 and 1924, but many boxes were never opened. Today, thousands of patent models have ended up in the hands of New York businessman Alan Rothschild. The model collector and inventor in 1998 opened the Rothschild Petersen Patent Model Museum, the largest accessible private collection of patent models in the country.

Among the 50 models on display are some of the most significant in the Rothschild collection, plus Thomas Edison’s light bulb, (US Patent No. 223,898). Although Edison did not invent the light bulb, he dramatically improved it by developing carbonized filaments that would glow for hours inside their oxygen-emptied glass globes.

Nelson Goodyear’s India Rubber (#8075) is also displayed. Other models of significant inventions on display include the Washing Machine (#90416), the Steam Generator (#80543), the Telegraph (#76748), the Universal Joint (#197541), the Refrigerator (#88468), the Sewing Machine (#16434), and the Plow (#369727).

A patent signed by President Thomas Jefferson and Secretary of State James Madison will also be displayed.

Established in 1995, the Patent and Trademark Museum strives to educate the public about the patent and trademark systems and the important role intellectual property protection plays in our nation’s social and economic health. The museum features a permanent exhibit that explains what intellectual property is and how it is protected. It is now run by the National Inventor’s Hall of Fame.

“Patent Models: Icons of Innovation” runs through May 2002 and can be seen at the U.S. Patent and Trademark Office Museum, 2121 Crystal Drive, Suite 0100, Arlington VA.

**Changes in the U.S. Patent System**

Recent changes in the laws of the United States rather substantially affect the procedures of the U.S. Patent and Trademark Office. The Inventor’s Protection Act of 1999 was enacted in an attempt to meet the needs of new technology during the next century; also, this action was designed to bring U.S. patent law closer to the prevailing world patent laws (Harmonization Action).

Here is a brief review of some of the changes resulting from this activity:

- New procedures require that invention promotion companies provide historical information on the effectiveness of their services.
- The PTO will provide Congress a report on the potential risks to the U.S. biotechnology industry relating to biological deposits in support of biotechnology patents.
- The PTO is limited from providing copies of the specifications and drawings of U.S. patents and applications to non-NAFTA or non-WTO member countries.
- The fees for patent applications and other activities will be adjusted to cover costs.
- Users of a technology are protected from infringement litigation when they can show that they have employed the technology one year prior to the filing date of a patent application.
- The term of a patent will be 20 years, and may be adjusted for application processing delays.
- New procedures provide a mechanism to allow comments from third parties on patent applications.
- There will be a continuing effort to streamline the communication processes using electronic means for application submissions, maintenance and the publication of patents.

With the new patent law, the U.S. PTO will now generally publish patent applications that have not yet been granted, but have been in the PTO for 18 months; this publication prior to final approval is the practice in other countries throughout the world. These published-but-not-approved applications are easily identified, by a document number that begins with the year of submission. Thus, a specific patent sequentially will have an application number, a pre-issue publication number and a final issued patent number.

Unfortunately, these published U.S. patent applications do not require that the assignee be identified until the patent is allowed and published. Such published patent applications will indicate the assignee as “not available.”

For additional information on changes in the U.S. patent law, visit: http://www.uspto.gov/web/offices/dcom/olia/aipta/summary.htm

**Breathable Film With Organic Filler**

Breathable films can be employed in a variety of absorbent products and in many other useful applications. In today’s advanced diaper, a breathable film is laminated to a nonwoven web and serves as a superior backsheet.

The most widespread method of making a polymeric film vapor permeable involves mixing a matrix polymer with a substantial quantity (e.g., 10-70% by weight) of an inorganic particulate filler, most frequently fine calcium carbonate powder, and extruding a film from the
blend. After extrusion, the film is heated and subjected to biaxial stretching, causing voids to form in the areas surrounding the filler particles. The voided film is characterized by thin polymer membranes and a fine pore network which permit the molecular diffusion of water vapor through the film, but which block the passage of liquids. In essence, a tortuous path is created from one film surface to the other, which permits transfer of vapors but not liquids.

Such breathable films are normally made from a thermoplastic polyolefin. The calcium carbonate filler is relatively easy to disperse in a polyolefin matrix, and the resulting film can have good breathability. However, calcium carbonate and other inorganic fillers have a disadvantage in that the filler tends to accumulate around the lip of the extrusion die during manufacture of the film. To alleviate this, a center layer filled with calcium carbonate can be coextruded with much thinner surface layers which contain little or no filler. This approach reduces filler build-up at the die, but often results in a less breathable product because the unfilled skin layers are less microporous than the filled core layer. Inorganic fillers are also somewhat expensive, due in part to their high density.

Attempts have been made to make suitable breathable films using organic fillers, as such fillers can have less density and be less expensive. Organic fillers may also reduce the problem of die build-up. However, organic fillers have a tendency to either agglomerate to form large particles, or to disperse too finely or actually dissolve in the polymeric medium.

This patent discloses a process that uses an organic filler system which overcomes these problems. The organic filler has a higher melting point than the polymer matrix, and is preferably incompatible with the thermoplastic polymer, thereby preventing dissolution or excessive dispersion in the polymer matrix. A compatibilizing agent is used with the organic filler, which agent has a tendency to prevent agglomeration of the organic filler in the polymer matrix, and a tendency to break up existing agglomerates of the organic filler.

To achieve these results, the inventors reveal that polystyrene particles are a suitable organic filler when used with a styrene-butadiene copolymer compatibilizing agent. The styrene-butadiene copolymer may be included in the polystyrene filler, and may be either chemically reacted to or blended with the polystyrene in the beads. The compatibilizing system should be present in an amount sufficient that the organic filler particles are at thermodynamic equilibrium in the polymer matrix in a dispersed particle phase having a mean particle diameter of about 0.1-2.5 microns.

U.S. 6,348,258 (February 19, 2002); filed March 12, 1999. Assignee: Kimberly-Clark Worldwide, Inc. (Neenah, WI). Inventors: Vasily Aramovich Topolkaraev; Kevin Matthew Harrington; Glynis Allicia Walton; Sandy Chi-Ching Ying; Kevin George Hetzler.

**Superabsorbent Polymer-impregnated Wetlaid Nonwoven with Smooth Surface**

The use of superabsorbent polymer (SAP) in disposable diapers and other sanitary protection products has been a significant innovation. It has resulted in design and product capabilities that would have been impossible otherwise.

The typical way to use the SAP is to insert the solid powder into the absorbent woodpulp core of the product, while removing a substantial amount of the pulp absorbent. This often results in a core with 50% or higher loadings of particles of SAP.

The resulting core thus formed has a rough texture, which can be felt in a disposable article having a topsheet. The rough texture is telegraphed through the article and may provide undesirable feeling for the user. Also, the particulate SAP material tends to shift and sift out of the selected position within the absorbent core. These problems can be solved to a degree by the use of SAP fiber; however, such fiber is very expensive, limiting use of this form of SAP.

This patent provides an economic way of obviating these problems, offering an economic route to an SAP-impregnated structure that exhibits unexpectedly good absorbency. This patent discloses a non-woven, wetlaid fibrous structure which is impregnated with SAP; it has a smooth surface texture and is free of binder polymer.

Typically, the structure comprises about 50 weight % of an ion-sensitive SAP having a particle size of less than 250 microns, and about 40 weight % of a fiber furnish and about 10 weight % of an inorganic salt, preferably sodium sulfate.

The fiber portion of the structure comprises about 80-95 weight % of woodpulp fiber and 5-20 weight % cellulose acetate fiber (1.8 dpf, 0.25-inch length). A portion of the fiber furnish can also be composed of short-cut bicomponent binder fiber (PE/PET) or short-cut polyester fiber (1.5 dpf, 0.5-inch length).

The slurry (0.2-2.5 g. solids/liter) can be formed into a wet web on a Fourdrinier wire or an inclined wire machine. The white water contains about 4% sodium sulfate, and the wet web has a composition of about 5-10 % solids. The wet web is then washed in an in-line curtain wash zone to reduce the salt content of the final web to about 10-20 %. The weight of the final, dried wetlaid web is about 150 gsm. It shows an Absorbency Under Load (AUL) of greater than 23 g./g. and has a very smooth surface texture.


**Coverstock With Separate Liquid Pervious and Impervious Regions**

Efforts have been made to prepare a nonwoven fabric that can serve as a diaper topsheet and possess regions of liquid permeability and liquid imperme-
ability. Design and assembly of diapers and related products would be greatly simplified and the costs of production would be reduced if a single fabric could be satisfactorily used at relatively low basis weight for both containment (impermeable zone) and easy strikethrough (permeable zone). Such a fabric could be used in assemblies that were not prone to leakage, and that had a balance of properties so that the strikethrough region had acceptable low rewet characteristics and the barrier region had acceptable breathability and low rewet.

This patent discloses a composite nonwoven structure of such a design. The nonwoven is useful as coverstock for disposable absorbent articles and can be used to form a one piece topsheet and barrier fabric for use in diapers. Barrier leg cuffs and other containment structures or barrier zones can be formed in the composite nonwoven fabric adjacent to strikethrough portions of the fabric for simplified garment construction without leakage.

The barrier regions can be formed by judicious placement of fine fibers having barrier characteristics within the composite. Alternatively, the entire composite can be prepared as a barrier fabric and the structure can be treated with a suitable surfactant to permit fluid flow in selected regions. Capillary movement within the fluid flow region can be achieved by choice of filament diameters and by controlling the size of the pores formed between adjacent filaments.

In one embodiment of the invention, the composite nonwoven structure is a SMS fabric (a spunbond-meltblown-spunbond trilaminate) with superior fluid barrier properties. A rewet-type surfactant is selectively applied to the fabric to create the fluid flow regions and liquid promote strikethrough in the desired zones.

In another embodiment, a composite structure is produced in which substantially a meltblown web is selectively placed in longitudinal stripes between layers of spunbond webs. A composite fabric is produced that has barrier properties in selected regions in which the meltblown fibers are deposited in longitudinal stripes that extend the length of the spunbond layer in the machine direction. The regions without meltblown fibers do not have the barrier properties. A surfactant can be selectively applied to the fabric in the regions devoid meltblown to create the fluid flow regions and to promote strikethrough.

Alternately, the fabric can be produced from continuous spunbond filaments, with the filaments in the longitudinal barrier zone having a very fine denier (less than 1.0 dpf) and the filaments in the pervious zone having a relatively large filament denier (greater than 1.8 dpf). A rewet agent applied to the pervious zone assists in strikethrough and fluid flow. Such a structure can be formed by depositing fibers between angular baffles disposed above the fiber collection surface so as to control the depositing of appropriate fibers on the selected longitudinal regions.

TAPPI’s ‘Ask the Experts’
One of the interesting features of TAPPI’s newly revised Internet site (www.tappi.org) is an online service entitled “Ask the Experts.” This service connects TAPPI members with industry experts who can and are willing to provide ideas, resources, and hopefully, solutions to problems and questions that are submitted.

The expert agrees to respond to the question within two days. If an expert is going to be unavailable for a period, a note is placed by that name, indicating when the expert will be available again. At a point two weeks after inaugurating the site, 64 experts had signed up for service. The association is actively seeking additional experts to participate in the service (Contact Jennie Lazarus, Knowledge Management Administrator jlazarus@tappi.org; 770-209-7237; Fax 770-446-6947.)

INDA Test Methods Kit
When two nonwoven technologists from opposite sides of the world get together, they can usually understand each other on technical points. This is possible because of standardized test methods — methods that are equivalent whether you are from Moscow/Idaho, Moscow/Russia, Manila, Milan, Madrid, Manchester or Miami.

INDA has a resource that compares nonwoven test methods developed by six international and authoritative organizations, including AATCC, ASTM, EDANA INDA, ISO/CEN and TAPPI. The is entitled 2000 Global Comparison of Test Methods. When this item is combined with the latest INDA test methods manual — INDA Standard Test Methods Manual (STM) 2001 — it is the 2001 Test Method Kit, a combination that insures wide technical communication without the usual confusion.

These two publications are available as a unit, 2001 Test Methods Kit, at a special price ($300 to INDA members, $415 to non-members) from INDA headquarters. Also, the individual publications can be purchased separately. The table of contents of each book can be viewed and the books can be purchased at the INDA website — www.inda.org.

Co-Location of Textile Shows
Discussions are underway by several North American trade associations to adopt the concept of “Co-location” for related trade shows at some time in the future. “Co-location” involves the concept of single-location and same-time presentation for closely related trade shows, exhibitions and conferences.

While such coordinated efforts will involve closeness in time and location, individual events will not lose their identity. Each show will maintain its own uniqueness and physical separation from the cooperating exhibition or exhibitions. Attendees will benefit by saving time and expenses involved in traveling to different locations at different times of the year. It is anticipated that such an arrangement will appeal not only to North American participants, but especially to visitors and attendees from foreign countries.

Current plans call for the concurrent presentations to take place in Atlanta, GA, with its excellent exhibition facilities at the Georgia World Congress Center, and also the very strong infrastructure of transportation, hotel, dining and entertainment facilities in Atlanta.

Positive responses for using this umbrella concept have come to the original organizers, the sponsors of American Textile Machinery Exhibition-International (ATME-I) and the Annual Exposition of Industrial Fabrics Association International (IFAI Expo). These positive responses have come from numerous textile, apparel and industrial groups such as INDA, AATCC, American Fiber Manufacturers Association, Knitted Textile Association, The Hosiery Association and several others.

Because of the transition steps required and the necessity of advanced planning, initiation of this approach is proposed to occur by November of 2006. As can be appreciated, much work will have to be done before Co-location is a reality. With the substantial interest in the concept and the recognized need for such new management approaches, it is to be hoped that these concepts can reach fruition. — INJ
INDUSTRY MEETINGS

April 2002


Apr. 9-12. Techtextil North America. Atlanta, GA. For more information, contact: Albrecht Rieger, Mess Frankfurt Service GmbH, Ludwig-Erhard-Anlage 1, D-60327, Frankfurt am Main, Germany; Tel.: 49+69/7575-6415; Fax: 49+69/7575-6950. Internet: www.usa.messefrankfurt.com


May 2002


May 29-30. Annual Meeting - Nonwovens Cooperative Research Center. NCRC, College of Textiles, North Carolina State University, Raleigh, NC 27695. For more information, contact: Dr. Behnam Pourdeyhimi, Tel.: 919/515-1822; Fax: 919/515-3733; bpourdey@unity.ncsu.edu.

June 2002


Seotember 2002


October 2002


Oct. 20-24. Insight Conferences. Tampa Marriott Waterside Hotel, Tampa, FL. For more information, contact: Marketing/Technology Services, Inc., 41 South Seventh Street, Kalamazoo, MI 49009, USA; Tel.: 616/375-1236; Fax: 616/375-6710.