The Fiber Society

for the advancement of scientific knowledge pertaining to fibers, fiber based products, and fibrous materials

Spring 2004
International Symposium on Fibers, Fibrous Structures and Filtration

May 18–20, 2004
Radisson Hotel Clayton
St. Louis, Missouri

Conference Co-chairs

Dr. Kyung-Ju Choi
AAF International

Prof. Da-Ren Chen
University of Washington

The Fiber Society is a Society of Volunteer Professionals

P R O G R A M

Monday, May 17

19:00–21:00 **Registration**
19:30 **Early-bird Congregation** *(cash bar)*

Tuesday, May 18

07:00 **Registration and Continental Breakfast**
07:45 **Welcoming Remarks**
Kyung-Ju Choi, Program Co-chair and Day Chair
William A. Haile, President, The Fiber Society

On Nanoparticles
Session Chair: Kyung-Ju Choi, AAF International

08:00 Experimental and numerical tools for investigating nanoparticles
D. Chen
Mechanical and Aerospace Engineering, Washington University, St. Louis, MO, USA

09:45 **Break**

On Fibers
Session Chair: Michael Jaffe, New Jersey Institute of Technology

10:00 Transverse behavior of anisotropic polyamide monofilaments
G. Stamoulis, C. Wagner-Kocher, M. Renner
LPMT, University de Haute Alsace, Cedex, France

10:30 Ethylenediamine/potassium thiocyanate cellulose systems: dissolution, rheological properties and thin-film formation
[1]H. Chan, [2]M. Frey
[1]Department of Materials Science and Engineering, Cornell University, Ithaca, NY, USA
[2]Department of Textiles and Apparel, Cornell University, Ithaca, NY, USA

11:00 High modulus polypropylene filaments by gradient drawing
S. Mukhopadhyay, R. Alagirusamy, B. Deopura
Department of Textile Technology, India Institute of Textile Technology, New Delhi, India

11:30 Effect of the L- and D-isomers of lactic acid on the resistance to hydrolysis of polylactide fiber
[1]D. Karst, [1,2]Y. Yang
[1]Department of Textiles, Clothing and Design, University of Nebraska, Lincoln, NE, USA
[2]Department of Biological Systems Engineering, University of Nebraska, Lincoln, NE, USA

12:00 **Lunch** *(provided)*

On Fibrous Structures
Session Chair: Behnam Pourdeyhimi, Nonwovens Cooperative Research Center

13:30 Modeling heat and moisture transfer with sorption, phase change and mobile condensates through fibrous insulation
J. Fan
Institute of Textiles and Clothing, Hong Kong Polytechnic University, Kowloon, Hong Kong

14:00 Medical applications: new fibrous structures for improved comfort
M. Nunes, M. Geraldes, N. Belino
Textile Department, University of Beira Interior, Covilhã, Portugal

14:30 Structure and properties of thermally bonded cotton-based nonwovens
H. Rong, G. Bhat
Department of Materials Science and Engineering, University of Tennessee, Knoxville, TN, USA

15:00 **Break**

On Fibers

Session Chair: Thomas Godfrey, US Army Systems Center

15:15 Fabrication and electrical conductivity of PAN nanofiber-PANI composite
T. Kang, C. Yang
School of Materials Science and Engineering, Seoul National University, Seoul, Korea

15:45 Spinning a novel natural cellulosic fiber from corn stover
[1]N. Reddy, [1,2]Y. Yang, [3]D. McAlister
[1]Department of Textiles, Clothing and Design, University of Nebraska, Lincoln, NE, USA
[2]Department of Biological Systems Engineering, University of Nebraska, Lincoln, NE, USA
[3]USDA Cotton Quality Research Station, Clemson, SC, USA

16:15 Textile fibers from corn stover: properties and advantages
[1,2]Y. Yang, [1]N. Reddy
[1]Department of Textiles, Clothing and Design, University of Nebraska, Lincoln, NE, USA
[2]Department of Biological Systems Engineering, University of Nebraska, Lincoln, NE, USA

16:45–19:00 **Poster Session (refreshments served)**

Session Chair: Dominique Adolphe, ENSITM

Wednesday, May 19

07:00 **Registration and Continental Breakfast**

07:55 **Opening Remarks**

Day Chair: Da-Ren Chen, Washington University

On Filtration

Session Chair: Raymond Naar, General Electric Plastics (Retired), Consultant

08:00 Air filtration through fibrous nonwoven materials: a comprehensive review
K. Choi
AAF International, Louisville, KY, USA

9:45 **Break**

On Fibrous Structures

Session Chair: Memis Acar, Loughborough University

10:00 Modeling for fiber self-crimping
M. Canbolat, A. Demir
Department of Textile Engineering, Istanbul Technical University, Istanbul, Turkey

10:30 Experimental study of the open-end spinning conditions to the production of wool/cotton yarns
M. Geraldes, N. Belino, M. Nunes
University of Beira Interior, Covilhã, Portugal

11:00 Application of computational fluid dynamics for studying the properties and processes of fibrous materials
[1]D. Karst, [1,2]Y. Yang
[1]Department of Textiles, Clothing and Design, University of Nebraska, Lincoln, NE, USA
[2]Department of Biological Systems Engineering, University of Nebraska, Lincoln, NE, USA

11:30 Statistical methodology of image texture analysis for needlepunched nonwoven structure definition
[1]N. Belino, [1]M. Nunes, [1]P. Fiadeiro, [1]M. Geraldes, [2]M. Silva
[1]Textile Department, University of Beira Interior, Covilhã, Portugal
[2]University of Minho, Guimarães, Portugal

12:00 **Lunch** *(provided)*

On Filtration

Session Chair: Young Ok Park, Korea Institute of Energy Research

13:30 A statistical model of pesticide penetration through woven work clothing fabrics
S. Lee, K. Obendorf
Department of Textiles and Apparel, Cornell University, Ithaca, NY, USA

14:00 Simultaneous removal of nitrogen oxides and particulates using a catalytic filter
[1]Y. Park, [1]H. Park, [2]W. Shim, [1]S. Jeong
[1]Clean Air Technology Research Center, Korea Institute of Energy Research, Daejon, Korea
[2]Department of Environmental Engineering, Chungnam National University, Daejeon, Korea

14:30 Measurement of electrical charge density of meltblown-type electret filter
M. Lee, P. Biswas, D. Chen
Mechanical and Aerospace Engineering, Washington University, St. Louis, MO, USA

15:00 **Break**

15:15 Modeling particle filtration by glass fiber filters
H. Tafreshi, B. Maze, B. Pourdeyhimi
Nonwovens Cooperative Research Center, North Carolina State University, Raleigh, NC, USA

15:45 A new issue of filtration by using porous laser-sintered filters produced by rapid tooling
L. Frommann, S. Kirchberg
Institute for Polymerwerkstoffe and Kunststofftechik, Clausthal-Zellerfeld, Germany

16:15 Experimental study of pleated fabric filters in pulse-jet dust collectors
[1]L. Lo, [2]D. Chen, [1]D. Pui
[1]Mechanical Engineering, University of Minnesota, Minneapolis-St. Paul, MN, USA
[2]Mechanical and Aerospace Engineering, Washington University, St. Louis, MO, USA

16:45 Development of oil binding structures made by leather-filled polymers
[1]L. Frommann, [2]U. Peuker
[1]Institute for Polymerwerkstoffe and Kunststofftechik, Clausthal-Zellerfeld, Germany
[2]Institute for Chemische Verfahrenstechnik, Clausthal-Zellerfeld, Germany

18:00 **Reception and Banquet**

Thursday, May 20

07:00 **Registration and Continental Breakfast**
07:55 **Opening Remarks**
Day Chair: William A. Haile, President, The Fiber Society

On Electrospun Fibers, Filtration and Fibrous Structures

Session Chair: Margaret Frey, Department of Textiles and Apparel, Cornell University

08:00 The effect of cooperative charging of electrospun nanofibers of electrically dissimilar polymers on filtration properties
[1]H. Schreuder-Gibson, [1]P. Gibson, [2]P. Tsai, [3]P. Gupta, [3]G. Wilkes
[1]US Army Research, Development and Engineering Command, Natick, MA, USA
[2]TANDEC, University of Tennessee, Knoxville, TN, USA
[3]Department of Chemical Engineering, Virginia Tech, Blacksburg, VA, USA

08:30 Effect of spinning parameters on filtration performance of electrospun nanofiber webs
H. Park, S. Jeong, J. Bae, Y. Park
Clear Air Technology Research Center, Korea Institute of Energy Research, Daejeon, Korea

09:00 Loading characteristics of nanofiber filters
E. Chay, D. Chen
Mechanical and Aerospace Engineering, Washington University, St. Louis, MO, USA

09:30 **Break**

09:45 Numerical study of airflow and heat transfer through air bonding of nonwovens
M. Hossain, M. Acar, W. Malalasekera
Mechanical and Manufacturing Engineering, Loughborough University, Leicestershire, UK

10:15 Current challenges in testing and characterizing degradation in respirator electret filters
W. Jasper, R. Barker, D. Thompson, J. Hinestroza, R. Grimes, J. Kim, A. Mohan, M. Gunay
College of Textiles, North Carolina State University, Raleigh, NC, USA

10:45 An experimental methodology and a computer simulation to study penetration and capillary flow through medical textiles
[1]E. Unsal, [1]P. Schwartz, [2]J. Dane
[1]Department of Textile Engineering, Auburn University, Auburn, AL, USA
[2]Department of Agronomy and Soils, Auburn University, Auburn, AL, USA

11:15 Electrospun polyvinyl alcohol fibers on the substrates
K. Choi
AAF International, Louisville, KY, USA

11:45 Closing Remarks

12:00 **Lunch** *(on your own)*

13:00–15:00 Tour of Professor Chen's nanoparticle and environmental engineering labs, and the Washington University campus

Note: If you plan to take the tour, let us know as soon as possible.

Experimental and Numerical Tools for Investigating Nanoparticles

Dr. Da-Ren Chen
Department of Mechanical and Aerospace Engineering,
Join Program in Environmental Engineering,
One Brookings Drive, Washington University in Saint Louis, MO

Nanoparticle/nanotechnology, focus of an on-going international initiative, will be a strategic branch of science and engineering for the 21st century. Experimental tools play an important role in developing the nanoscale science and engineering. These tools bring together researchers from multiple disciplines, e.g., material scientists, engineers, biologists and chemists, to pursue the common goal of investigating nanoscale phenomena. In the aerosol field, several tools have been developed to generate, measure, classify and manipulate nanoparticles in the size range of 3 to 100 nm. The development of these experimental tools has been greatly facilitated by sophisticated numerical models. Several recently developed experimental and numerical tools will be described in this presentation.

Using flow and particle trajectory models, we have developed a nanometer differential mobility analyzer (Nano-DMA) to measure and classify 3 to 100 nm nanoparticles. Molecular dynamic simulation has provided valuable insight into the mechanism of particle-surface interaction, which in turn has guided the experimental study in nanoparticle filtration. A fast-scan size analyzer, which incorporates a data inversion algorithm selected from a comparison of six algorithms, has demonstrated the high resolution capability to measure bimodal nanoparticle distributions from jet engine emissions. By means of electric field analysis, we have successfully developed a high efficiency nanoparticle charger. An electrospray system has also been developed to produce monodisperse nanoparticles in the 2 nm to 2 µm size range. Finally, our development of a continuous gene-gun based on the electrospray principle, illustrates the importance of multidisciplinary approach in nanotechnology.

Transverse behavior of anisotropic polyamide monofilaments

G. STAMOULIS, Ch. WAGNER-KOCHER and M. RENNER

Laboratoire de Mécanique et Physique Textile (LPMT) - FRE CNRS 2636
Université de Haute Alsace - Ecole Nationale Supérieure des Industries Textiles de Mulhouse
11 rue Alfred Werner, 68093 MULHOUSE Cedex, FRANCE

Highly oriented polyamide monofilaments, like those we study, are frequently used as reinforcements, especially when implanted in polymer matrices, or as yarns for filtering woven products. Their anisotropic behaviour is of particular interest in order to estimate the mechanical properties of woven structures for example (Figure 1). Although the longitudinal properties can be easily measured, the transverse behaviour is more difficult to study [1 - 4]. For this reason, we present a special apparatus that we developed in order to access the transverse properties (Figure 2) of oriented monofilaments.

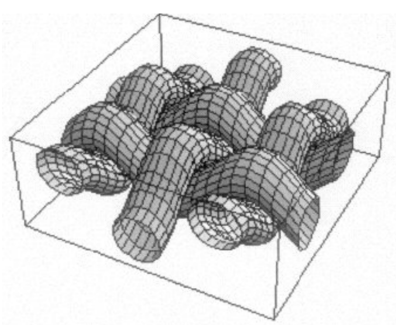

Figure 1 : A woven structure

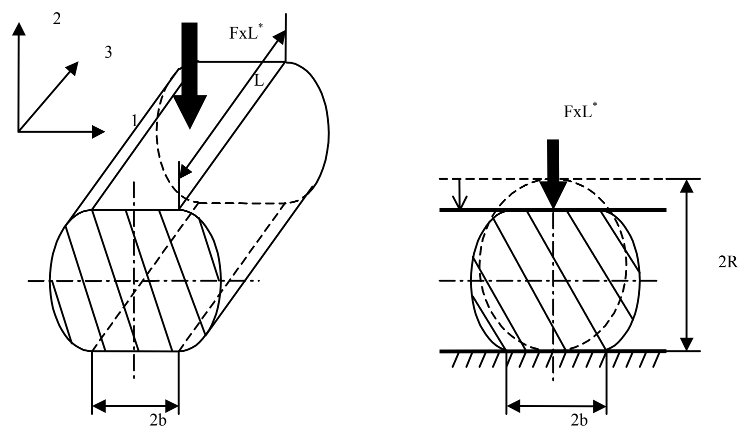

Figure 2 : Monofilament transverse compression

In this paper, we study the transverse viscoelastoplastic behaviour of polyamide monofilaments of important diameters (superior to 400µm). In most cases, such monofilaments are treated as isotropic elastic cylindrical structures. However, many tests show a strong anisotropy and also a non-elastic behavior. In the beginning, we present a special experimental setup conceived to realize such tests. This transverse compressive apparatus was inspired by the Kotani et al. [5] assembly. Its operation is clarified in [6]**.** Secondly, we analyze transverse compression experimental curves at different speeds along with transverse relaxation curves obtained using the previous setup. We show that the transverse behaviour of these monofilaments seems to be strongly elastoplastic and we confirm their high anisotropy.

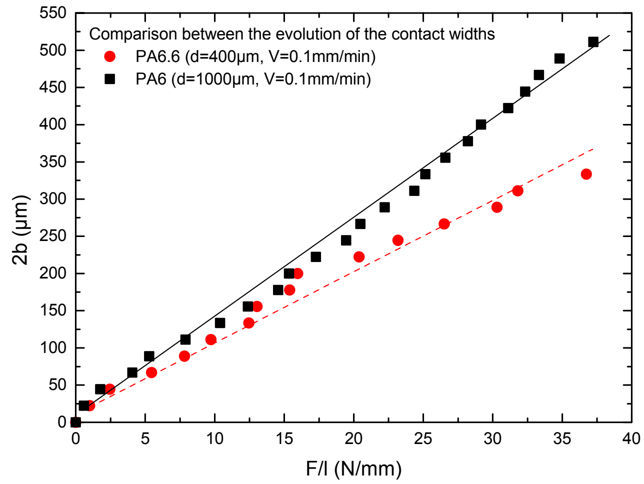

Figure 3 : Evolution of the monofilament contact width during a compressive test

Figure 3 shows a comparison between the evolution of the contact width for two different types of monofilaments (a PA 66 monofilament with a 400 µm diameter and a PA 6 monofilament with a 1000 µm diameter). Such curves can be plotted using the image acquisition of the evolution of the contact surface during a transverse compressive test. We can see that the contact width follows a linear evolution until the end of the experiment. This linear fit is plotted by using the least squares method and it is represented by the black and red curves in the same graph. By using this linear fit, we can calculate the missing values of the contact area for every value of the force measured. Making the hypothesis that the mean true stress value inside the monofilament can be approximated by:

$$\sigma_t = \frac{F}{2b \cdot l}$$

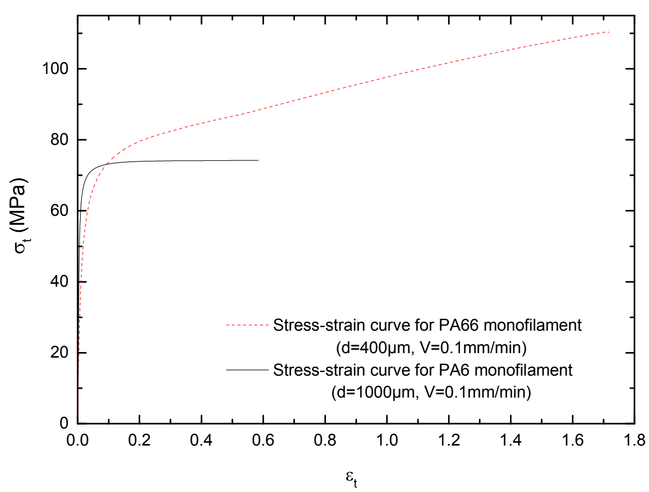

Figure 4 : True Stress/strain transverse compressive curves for PA66 and PA6 monofilaments

where l=51mm is the diameter of the lower base of the glass cone, b is the half-contact width and F is the compressive force per unit length, we obtain the curves shown in figure 4. We use as abscises the true strain values $\left(\varepsilon_i = \frac{l_i - l_{i-1}}{l_i}\right)$. From this graph we can tell that the monofilament has an elastoplastic behaviour with a Young's modulus being very high and much bigger than the one calculated by the tensile experiments. Thus, the high anisotropy of this kind of monofilaments is confirmed. We also examine the evolution of the force as a function of time by means of transverse relaxation experiments. A comparison between two tests at different initial loadings is given. We can conclude that the relaxation behaviour is slightly viscous, since very rapidly we attain a residual stress, contrary to the longitudinal case. This confirms that the transverse behaviour is viscoelastoplastic and that the elastic area is very short.

This work can be the beginning of a large field of investigation. Further studying of the problem will consist of determining more accurately the transverse behaviour of such specimens, mostly by applying a known tensile force at the monofilament's ends just before the compression experiment.

1. D.W. HADLEY, I.M. WARD, J. WARD, *"The transverse compression of anisotropic fibre monofilaments"*, *Proceedings of the Royal Society of London A*, 285 (1965), p. 275-286.
2. S.L. PHOENIX, J. SKELTON, *"Transverse compressive Moduli and Yield Behavior of Some Orthothropic, High-Modulus Filaments"*, *Textile Research Journal*, 44 (1974) p. 934-940.C.
3. D.W. HADLEY, P.R. PINNOCK, I.M. WARD*, "Anisotropy in Oriented Fibres from Synthetic Polymers", Journal of materials science*, 4 (1969) p. 152-165.
4. S.A. JAWAD, I.M. WARD, *"The transverse compression of oriented nylon and polyethylene extrudates", Journal of materials science*, 13 (1978) p. 1381-1387.
5. T. KOTANI, J. SWEENY, I.M. WARD, "*The measurement of transverse mechanical properties of polymer fibres*", *Journal of Materials Science*, 29 (1994) p. 5551-5558.
6. G. STAMOULIS, CH. WAGNER-KOCHER, M. RENNER, *"Characterization of the transverse and longitudinal behaviours of PA 6.6 monofilaments", 14th International Conference on Composite Materials - ICCM14 Conference San Diego (E.U.)* July 2003.

Ethylenediamine/Potassium Thiocyanate Cellulose Systems: Dissolution, Rheological Properties and Thin Film Formation

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ABSTRACT

The intent of this study was to examine ethylenediamine/potassium thiocyanate ($C_2H_8N_2$/KSCN) as a possible solvent system for the direct dissolution of cellulose. In addition, rheological properties were characterized and possible coagulants were identified. Thin cellulose films were fabricated and subjected to tensile and tear strength test. This research is the first step towards a new system for spinning fibers from cellulose solutions.

Known amounts of cellulose, $C_2H_8N_2$ and KSCN were used to create solutions, each with a unique combination, and subjected to a freeze/thaw cycle to aid in complete dissolution. Resulting solution composition ranged from 2 – 9% w/w cellulose and 10 – 50% KSCN. The solutions were characterized based on their room temperature appearance 48 hours after dissolution was complete as either flowing solution of gel. It was found that all the gels were thermoreversible. Each solution was examined with a polarizing light microscope to ensure that all the cellulose and KSCN were completely dissolved as well as to examine the possibility of liquid crystalline phase formation. None of the solutions exhibited birefringence which would have indicated liquid crystalline phases.

Only those solutions with a 5 –9% w/w cellulose and a 40 – 50% KSCN concentration were subjected to rheological testing. Each solution was subjected to an oscillatory frequency sweep and a constant shear rate test. Frequency sweep tests were conducted with a constant strain amplitude of 5% with a angular frequency of 0.01 – 600 Hz. Time tests were conducted with a constant shear rate of 0.01 Hz. All experiments were conducted at room temperature using a cone and plate fixture.

The cellulose solutions were divided into two groups: 1) constant cellulose concentration to study the effect of increasing KSCN and 2) constant KSCN concentration to study the effect of increasing cellulose. Preliminary results indicate that all the solutions are pseudoplastic or shear thinning. Tan δ values were small and positive, pointing more towards liquid-like behavior than solid-like behavior. Results of the shear rate tests seem to imply that the solutions have a more viscous nature than elastic nature. There may also be some indication that the samples are undergoing a structural change during experimentation.

Possible coagulants were identified via the preparation of thin films. A small amount of cellulose solution was poured and smoothed onto a glass plate in which film thickness was controlled. The plate was then immersed, individually, into an ethanol (CH_3CH_2OH) and methanol (CH_3OH) coagulation bath. In terms of preparing and peeling the films from the plate, there was no difference. However, films made with CH_3CH_2OH had a Paraffin wax appearance, while the CH_3OH films had a saran wrap appearance.

Preliminary mechanical testing results seem to indicate that films produced with CH_3OH are stronger than those produced with CH_3CH_2OH. For the 5, 6, 7 and 8% w/w cellulose samples, those with a 40% KSCN concentration exhibited a higher tensile strength than the other two KSCN concentrations. At a constant KSCN concentration of 45%, the tensile strength seems to increase with increasing cellulose content. The same relationship is seen with the 50% KSCN samples. Due to a lack of sufficient tear test data at the present time, it is difficult to make a correlation between strength and cellulose/KSCN concentration.

High Modulus Polypropylene Filaments by Gradient Drawing

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Abstract

High modulus and high tenacity Polypropylene (PP) filament have been produced by drawing as-spun filaments on a heater having a gradient of temperatures. Two different MFI PP of 35 and 17 are studied. Results show that filament properties are significantly affected by gradient heater settings i.e. nature and extent of gradient and end temperatures. Very high draw ratios could be obtained through gradient drawing process.

Gradient heater could be considered to consist of a series of a large number of heaters one after the other with increasing temperature. At each heater point the filament is drawn due to higher temperature than the previous point. This allows an increase in the level of orientation with low relaxation of molecules. Thus an incremental drawing over the heater plate is achieved. The drawing is possible at temperatures in the melting range. It was possible to drawn the PP filaments in the gradient of temperatures in the range of (150-160-165)° C. On a constant temperature heater plate, maximum temperatures attainable are limited to below melting point. Alternately a very large number of heater plates will be required in a typical multistage drawing process.

The gradient drawn PP samples showed high crystal perfection and crystallinity. A sample with x-ray crystallinity values of 73%, crystalline orientation function of 0.96, amorphous orientation value of 0.84 has been obtained. The melting half widths are typically in the range of 4° C, indicating very narrow crystal size distribution. Fibers having initial modulus of 17.5 Gpa and tenacity of 750Mpa have been prepared. A very low thermal shrinkage of 7% at 150° C indicates excellent dimensional stability.

These filaments are arrange in uniaxial direction and hot compacted under temperatures of ~ 155° C and pressure, to make a sheet like structure. Initial experiments show retention of properties of filament to around 80% of the starting samples. This approach could be used to design filters with a range of specifications.

Effect of the L- and D-Isomers of Lactic Acid on the Resistance to Hydrolysis of Polylactide Fiber

David Karst [a] and Yiqi Yang [a, b], (Oral Presentation)

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Polylactide (PLA) fiber is a new fiber for the textile industry. One concern with this fiber is that it is relatively easy to be hydrolyzed at high temperatures used in many textile processes and especially at alkaline conditions. Hydrolysis leads to substantial strength loss in the fiber. When PLA is blended with cotton, the fabric most likely needs to be scoured, mercerized, and bleached, but PLA may undergo hydrolysis due to the high temperature and/or alkaline conditions for these processes. PLA must be disperse dyed at high temperatures for good dye exhaustion, but there at sufficiently high temperature, hydrolysis of the fiber is likely. The objective of this study was to find which arrangement and proportional amounts of the L- and D-isomers of lactic acid in PLA make the polymer less susceptible to hydrolysis.

PLA with a high degree of crystallinity has a higher melting point compared to amorphous PLA. Studies have shown that if the proportion of the D-isomer in PLA is greater than 15%, the fiber structure has low crystallinity and a melting point as low as 120°C. If the proportion of the L-isomer is greater than 85%, the fiber is highly crystalline. If the polymer contains the L or D-isomer alone, the melting point of the crystalline structure is about 185°C. When the fiber consists of a blend of polymers with mainly the L-isomer and polymers with mainly the D-isomer, PLA forms a stereocomplex, and in the resulting crystal structure, the L and D-isomer polymers are adjacent to each other and interlock. The structure has greater crystallinity and a higher glass transition temperature, and its melting point is about 210°C.

In this study, molecular modeling simulations were used to determine how the hydrolysis of PLA is affected by its structure. Various PLA structures were built using the molecular modeling computer software Materials Studio available from Accelrys. Each structure that was built consisted of four molecules of PLA packed into an amorphous cell, and each molecule had a degree of polymerization of 20 with the repeating units connected head-to-tail. For each structure, a molecular modeling simulation was run to calculate its potential energy before hydrolysis. One of the ester bonds in the structure was then cleaved, and another molecular modeling simulation was run to calculate the potential energy of the structure after hydrolysis. The change in potential energy due to hydrolysis was then calculated as the potential energy of the structure after hydrolysis minus the potential energy of the structure before hydrolysis minus the potential energy of one water molecule. The structure that had the least tendency to be hydrolyzed gave the least negative change in energy for hydrolysis, and the structure with the greatest tendency to be hydrolyzed gave the most negative change in energy for hydrolysis.

The structures that were created differed by the proportional amount of the L- and D-isomers in the polymers and by their arrangement within the molecules and between the molecules. For structure 1, all four molecules in the amorphous cell were 100% L-isomer, and for structure 2, each molecule was 100% D-isomer. For structure 3, two of the molecules were 100% L-isomer while the other two molecules were 100% D-isomer. For structure 4, each molecule contained a block of ten L-isomers connected to a block of ten D-isomers. In structure 5, each molecule contained the L-isomer and D-isomer alternating along the length of the polymer chain. For structure 6, each molecule had 17 L-isomers and three D-isomers randomly arranged along the length of the chain to make the PLA 15% D-isomer. In structure 7, each molecule had three L-isomers and 17 D-isomers randomly arranged along the length of the chain to make the PLA 15% L-isomer. For structure 8, each molecule contained 14 L-isomers and six D-isomers randomly arranged along the length of the chain to make the PLA 30% D-isomer. For structure 9, each molecule had six L-isomers and 14 D-isomers randomly arranged along the length of the chain to make the PLA 30% L-isomer.

The effect of the L- and D- isomers on the resistance to hydrolysis of PLA will be discussed. The PLA structure with the highest resistance to hydrolysis will be proposed.

Modeling Heat and Moisture Transfer with Sorption, Phase Change and Mobile Condensates through Fibrous Insulation

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Abstract

Understanding of heat and moisture transfer through fibrous materials is important, not only to clothing insulation, but also to many engineering applications such as building insulation, refrigerated space envelopes, etc. Coupled heat and moisture transfer with phase change in fibrous insulation was first considered by Henry in his theoretical model in 1930s. Since then, and particularly after 1980s, a number of theoretical models were proposed as a result of growing interests from the textile and other engineering disciplines. Past work, however, has not modeled the heat and moisture transfer together with the dynamic moisture absorption and the movement of liquid condensates as interrelated and dynamic phenomena. There was also a great lack of experimental data to test the proposed models.

The new model to be presented in the paper considers for the first time the moisture bulk flow induced by the pressure gradient, a super saturation state in condensing region as well as the dynamic moisture absorption of fibrous materials and the movement of liquid condensates. The model has been applied to clothing assemblies, consisting of porous fibrous battings sandwiched by an inner and outer layer of thin covering fabric, usually used in cold environment. Theoretical results of the new model were compared with experimental results tested on a novel sweating guarded hot plate in a frozen condition at -20 ^{o}C. Very good agreements were found.

Based on the theoretical modeling and experimental investigation, it was found that most of the changes in temperature distribution within the fibrous insulation took place within 1/2 hours of the tests and moisture absorption by the hygroscopic viscose fibres affects the temperature distribution. The water content accumulates with time and higher water content was found at the outer regions than that at the inner regions of the battings. The accumulation and distribution of water content is a combined result of moisture absorption, condensation and liquid water movement. For thermal comfort, fibrous battings having higher fiber content, finer fiber, greater fiber emissivity, higher air permeability, lower disperse coefficient of surface free water, and lower moisture absorption rate would be beneficial since they cause less condensation and moisture absorption.

MEDICAL APPLICATIONS: NEW FIBROUS STRUCTURES FOR IMPROVED COMFORT

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Abstract

Comfort is something very complex because depends on one's sensibility, culture, environment, etc.. Although depending from person to person, comfort has been deeply studied looking for objective characteristics, in order to avoid the subjective influence, always very difficult to quantify. From all these efforts it is quite clear that comfort can be measured taking in account some important and different components, that can be physiological, physical-chemical and/or psychological ones. Anyway the existence of good comfort conditions is never noticed but its lack is always very stressing.

Under the physical point of view, comfort is strongly influenced by relations such as temperature/humidity and liquid/humidity transmission. Most of the products inside the hygiene group are strongly dependent on liquid/humidity transmission. A high liquid/humidity transmission means materials with good absorbency. There are some applications where high absorbency is absolutely needed. In general, most hospitals still use conventional fabrics for applications, such as mattress protection, involving adults suffering from occasional incontinence or the particular case of childbirth room where expectant mothers wait for their babies.

Absorbency is a very important property but in many cases it is necessary but not sufficient. Someone out of health that also has lost of some drops of urine, feels very poor if the bed stays humid. A woman expecting her baby in a childbirth preparation room, suddenly breaks her water. This may happen as a large gush or in a continuous trickle. Staying wet is a very stressing situation for someone that is about to have a child, particularly if she is about to be mother for the first time.

For the mentioned applications there are some particularities that should be taken in account, once these problems are dealing with old and sick people, normally with problems related to urine retain, or with very stressed women in a childbirth phase. In both cases high standards of comfort must always be present and this passes through new materials and technologies. Of course there are already in the market products that partially or entirely may cover these problems, but using expensive technologies and, consequently, with higher costs. Nowadays hospitals are no longer directed only to the

excellency of the welfare of the patients but also taking in account economic constraints, independently if they are public or private, because health cares are very expensive.

In this project we propose a technically better alternative to standard fabrics, using nonwoven techniques, with costs at least equal or even lower. The main idea is to use a sandwich of two different webs, one made of a high hydrophilic fibre such as viscose and the other made of a high hydrophobic fibre like polypropylene. These two webs are linked by a needling process only in one side: the hydrophilic one.

In a needling process two different sub-structures are formed: a horizontal structure formed by the fibres of the original webs and a vertical structure constituted by the tufts of fibres inserted by the barbs of the needles. Needling only the hydrophilic side, tufts of viscose fibres are inserted between the hydrophobic fibres of the other side and constitute like sucking channels that promote the water/humidity transmission from the hydrophobic face to the hydrophilic one, where it is retained.

The effectiveness of the composite is tested using two different methods. First the samples, in both faces, are tested in terms of water/vapour permeability, using a Permetest. To corroborate the results, we used an expeditious method, consisting on the direct measurement of the amount of water transferred from one side to the other. For this effect two cubic millimetres of water are dropped inside each one of two glass boxes with a thick paper in the bottom. The samples, completely desiccated and weighted, are placed inside these glass boxes, one with face hydrophilic down and the other with the hydrophobic side down. After 15 minutes both samples are weighted and the evidence remarked.

To protect the mattress, the hydrophilic side is coated with a highly hydrophobic film like PVC, that prevents the excess of water/humidity to damage the mattress.

Structure and Properties of Thermally Bonded Cotton-Based Nonwovens

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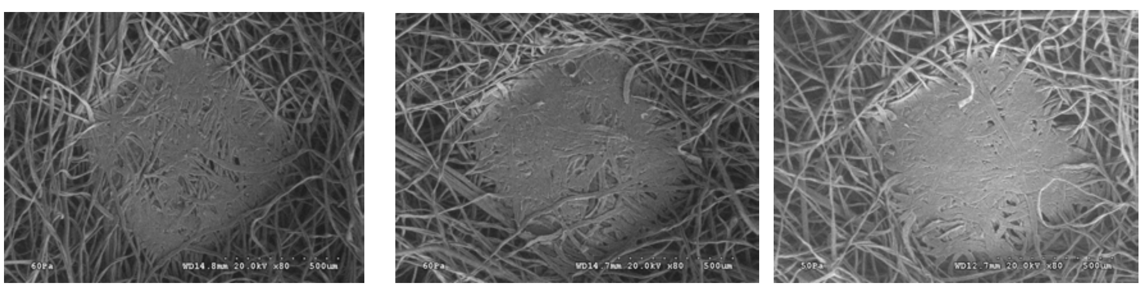
There is increasing interest in biodegradable/compostable cotton-based nonwovens, especially with the expansion of nonwovens into novel applications. Cotton-based nonwoven products can be processed by carding with the binder fibers and then point-bonded using a thermal calendering machine. For producing good quality cotton-based thermally point-bonded nonwovens, it is important that the binder fibers and the processing conditions be appropriately selected.

In this work, different binder fibers were used to produce cotton-based nonwovens. Structure and the properties of the resulting fabrics were studied. The effect of bonding temperature and binder fiber content on the bond morphology (Fig. 1) was investigated. The fracture and failure mechanism of the fabrics produced at different bonding temperature were analyzed.



(A) BONDED AT 100°C (B) BONDED AT 110°C (C) BONDED AT 120°C

Fig. 1 Bond Structure for cotton/(Eastar/PP)=70/30 with basis weight of 40g/m^2.

One of the major factors affecting the structure and properties of these webs was the binder fiber distribution. Binder fiber distribution was determined by both qualitative and quantitative methods. The results show that differential scanning calorimetry (DSC) is a useful method to quantitatively characterize the binder fiber distribution in the carded cotton-based nonwovens. By determining the specific enthalpy from crystallization of one of the binder fiber component in the (multi-component blend) fabrics, it is possible to calculate the fiber composition.

Tensile properties of the resultant nonwovens under different processing conditions were studied. The optimal processing conditions for the nonwovens processed using different binder fibers were determined based on their tensile properties. Effects of binder fiber type, binder fiber content, and bonding temperature on the tensile property of the nonwoven fabrics will be discussed. Tensile strength values of nonwovens with different binder fibers under the experimental conditions are shown in Figure 2.

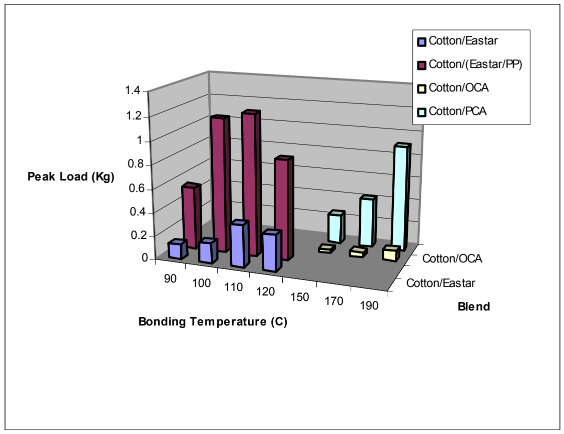


Fig.2 Peak Load values for Cotton Webs produced with different Binder fibers.

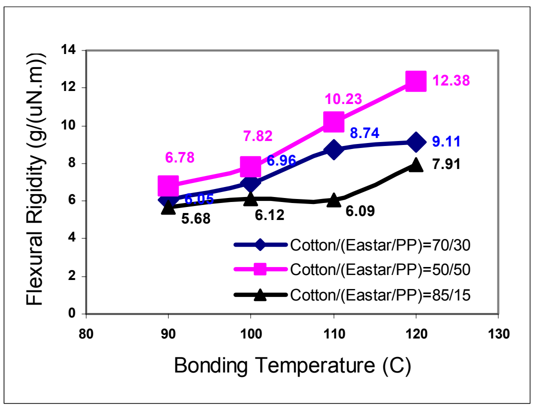


Fig. 3 Flexural rigidity of cotton/(Eastar/PP).

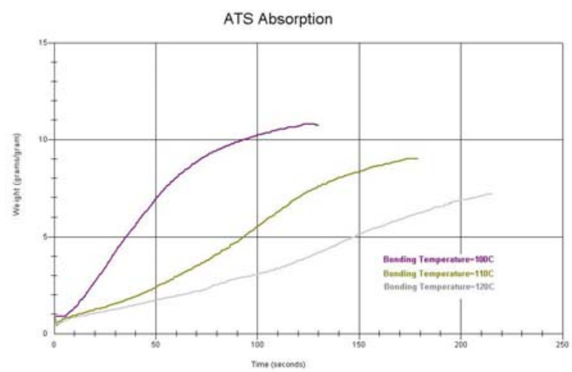


Fig. 4 Absorption of cotton/(Eastar/PP)=50/50 webs.

The flexural rigidity (Figure 3) and absorbent behavior (Figure 4) of the nonwoven fabrics bonded by one of the binder fibers were investigated. The results indicate that the fabrics have good flexibility and absorbency, which show that these nonwovens have potential applications as absorbent materials.

Fabrication and Electrical conductivity of PAN Nanofiber-PANI composite

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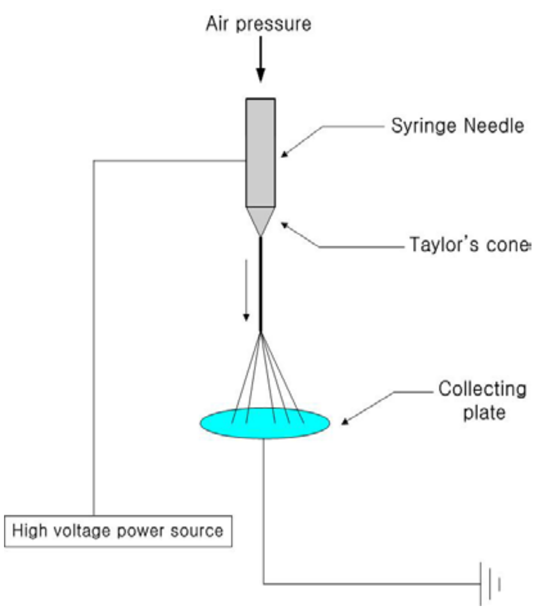
Abstract:

Conductive polymer(CP) is one of functional polymers that has better electrical conductivity than other polymers, but it has poor processibility. To improve their processibility, we made composite structure as a means of physical modification through electrospinning process. Electrospinning is a process that produces continuous polymer fibers with diameters in the sub-micron range through the action of an external electric field imposed on a polymer solution or melt(Fig.1).

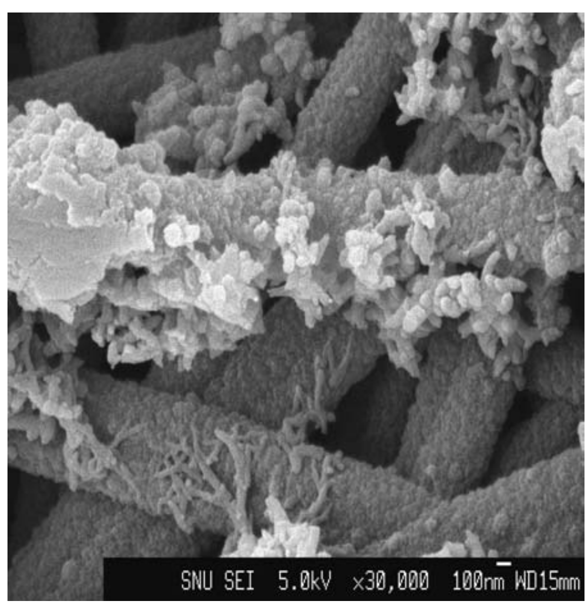
The mats of PAN(PolyAcrylonitrile) nanofiber, with diameter ranging between 150~300 nm, have small interstices between the fibers and the large surface area per unit mass. Therefore, PAN electrospun mats can be a good material for gas sensoric application because their large surface area can give high sensitivity.

To gain electrical conductivity, PANI(polyaniline) was in-situ polymerized on surface of PAN nanofiber mat at low temperature(4□)(Fig.2,3). And this PAN Nanofiber-PANI composite showed good electrical conductivity(10^{-3}~10^{-1}S/cm)(Fig,4). As a result, it will be able to be used for the sensoric application.

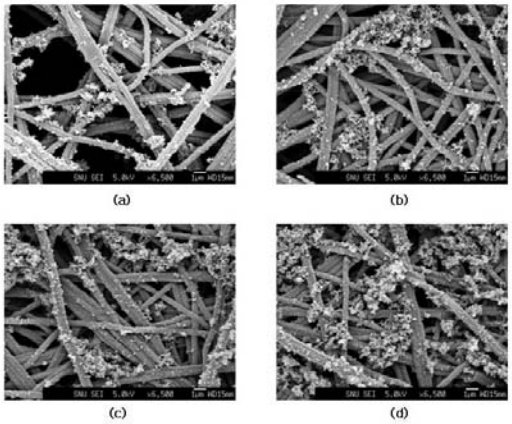
Key words : conductive polymers, nanofiber, electrospinning, PAN, PANI, gas sensor



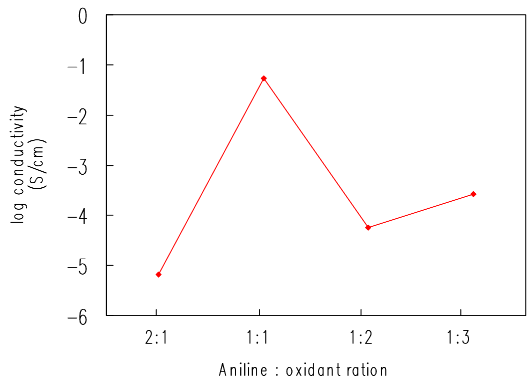
< Figure 1. Schematic view of electrospinning>



< Figure 2. SEM photographs of PAN nanofiber/PANI complex >



<Figure 3. SEM photographs of PAN nanofiber/PANI complex polymerized with (a) 0.1M, (b) 0.2M, (c) 0.5M and (d) 0.7M aniline concentration for 8min>



<Figure 4. Effect of oxidant concentration on the conductivity of PAN nanofiber/PANI complex polymerized by 0.5M aniline.>

Spinning A Novel Natural Cellulosic Fiber from Corn Stover

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For the first time, textile grade fibers have been obtained from corn stover with properties between cotton and flax. These fibers are expected to be easily processable on conventional textile machinery and the products made are expected to have unique properties. This paper reports the process parameters and properties of corn/cotton (35/65) and corn/polyester (35/65) blended yarns in comparison to 100 % cotton and 35 % cotton/65 % polyester yarns produced using the same processing conditions. Processing was carried out on a miniature spinning line at USDA-CQRS, Clemson, S.C.

Raw Materials
The properties of the raw material used are given below.

Corn Fibers:	Length	- 4.0 cm
	Strength	- 2.5 grams per denier
	Elongation (%)	- 10 %
Cotton:	Length	- 3.6 cm
	Strength	- 2.9 grams per denier
	Elongation (%)	- 7.2 %
Polyester:	Length	- 38 mm
	Denier	- 1.53

Processing
Corn fibers were hand blended with cotton and polyester in the ratio of 35 % corn to 65 % cotton and 65 % Polyester. The fiber blends were processed through a modified card and a drawframe. The corn/cotton blend was spun on an open end (OE) spinning machine to produce a 7^s Ne yarn and the corn/polyester blend was spun on a miniature ring spinning machine to produce a 22^s Ne yarn. Control yarns of 100 % cotton and 35 % cotton/65 % polyester were made with the same processing conditions. The process parameters used for open end spinning are given below.

Open End Spinning:

Rotor speed: 60,000 rpm
Opening roller speed: 7,000 rpm
Rotor type: 46 U
Opening Roll: S 21DN
Twist Multiplier: 5.3

Testing

Yarn strength and elongation was measured using a Statimat M test with a gauge length of 254 mm, load cell of 10 N and a test speed of 254 mm/min. 40 reading were taken for each type of yarn. Uniformity and imperfections in the yarns were measured using a DS- 65 Evenness tester at a speed of 25 yards/min for 1.0 min. Imperfections measured are at – 50 % for thin places, + 50 % for thick places and + 200 % for neps. The properties of the yarns are given in table 1.

Table 1: Yarn Properties

Yarn Property	7^s OE Corn/Cotton (35/65)	7^s OE 100 % cotton	22^s RS Corn/Polyester (35/65)	22^s RS Cotton/Polyester (35/65)
Evenness (U %)	19.4	10.79	45.6	25.1
Strength (g/tex)	8.70	13.54	17.6	15.0
Elongation (%)	6.9	8.3	15.7	15.1
Imperfections				
-Thin Places	95	0	155	52
- Thick Places	175	3	159	94
- Neps	272	6	275	84

OE - Open End Spun Yarn RS - Ring Spun Yarn

The spinnability of corn fibers on both the ring and rotor spinning machines has been demonstrated. Strength of the corn: polyester yarn is higher than the cotton: polyester yarn with similar elongation. Imperfections and unevenness are higher in the corn blended yarns. Further work is in progress to produce yarns with 100 % corn fiber and finer count blended yarns with higher proportion of the corn fiber on both the ring and rotor spinning systems.

Textile Fibers from Corn Stover: Properties and Advantages

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Abstract

For the first time, high quality textile fibers have been extracted from corn stover in our laboratory. These fibers have properties between cotton and flax and are suitable for all textile applications. Physical, mechanical and morphological properties of the corn fibers are different from the natural cellulosic fibers from fiber crops. Textile products can be made using corn fibers in 100 % form and also by blending with other common textile fibers such as cotton and polyester. Products made from corn fibers could have unique properties and will be biodegradable. Producing textile fibers from a currently useless and annually renewable byproduct of a major food crop will reduce the dependence on fiber crops and benefit the farmers and the environment. About 3.6 million tons of the fiber can be produced every year from the annually renewable byproduct. Assuming a selling price of $ 1.00 per pound of the fiber, competitive to the current cotton and flax prices, the new fiber offers a potential sale value of $ 7.9 billion every year with a value addition of $ 5.5 billion.

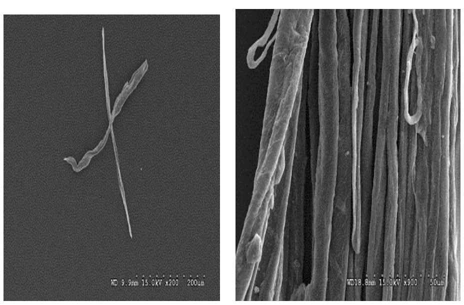
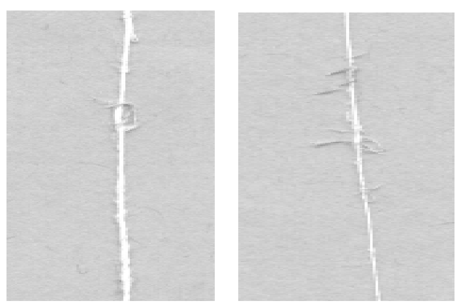


Fig 1 (a) 1 (b) 2 (a) 2 (b) 3 (a)

Figure 1 (a): Hydrolyzed single corn fiber
1 (b): Bundle of fibers suitable for textile applications, extracted using our unique method
2 (a): 7^s Ne, Open End spun corn: cotton yarn (35% corn: 65 % cotton)
2 (b): 26^s Ne, Ring spun corn: polyester yarn (35% corn: 65 % polyester)
3 (a): Knitted garment made from corn fibers (35% corn: 65 % cotton)

Growing environmental concerns and the problems associated with natural fiber crops have increased the attention on using agricultural byproducts for textile applications. Attempts have been made to extract textile quality fibers from sugarcane rind, pineapple and banana leaves. No literature is available on the extraction or use of textile quality fibers from corn stover. We have observed that the existing methods of fiber extraction from the stalk of plants are not suitable to produce high quality fibers from corn stover. These methods hydrolyze the corn stover, making the fibers too short and too weak for textile applications (Fig 1 a). We have developed a unique process of extracting fiber bundles (Fig 1b) from corn residues with the length, strength and elongation required for textile applications.

Table 1 compares the properties of the corn fiber with other natural fibers. It can be seen that corn fibers have properties similar to the common textile fibers.

Table 1: Comparison of the properties of corn fiber with other natural fibers.

Fiber or Fiber Bundle	Length (cm)	Denier	Tenacity (g/den)	Breaking Elongation (%)	Color
Coir	15-20	30.0-200.0	2.0	16.0-30.0	Dark Brown
Corn Fibers	**2-20**	**≥12.0**	**2.3**	**9.0-12.0**	**Yellowish**
Cotton	1.5-5.5	1.0-3.3	2.7	6.0-9.0	Off-white
Flax (Linen)	20-140	1.7-17.8	5.8	2.0-3.0	Grey
Hemp	100-300	3.0 – 20	6.3	1.0 – 6.0	Grey
Jute	150-360	13.0-27.0	3.2	0.9-1.17	Brown
Kenaf	200- 400	50.0	3.0	2.0-6.0	Dark Brown
Pineapple	55-75	23.0-34.0	2.5	2.7 – 3.2	Golden yellow
Ramie	10-180	4.6-6.4	7.3	4.0	Off-White
Sisal	75-120	42.0	5.3	2.0-3.0	Brown
Sugarcane	2.5-5.0	200-400	2.5	5.5-10.3	Yellowish
Wool	3.0-7.0	15.0	2.1	30.0-40.0	Yellowish

Moisture regain of cornhusk fibers at 65 % relative humidity and 70º F is about 9 %, similar to that of cotton (about 8 %). Fibers produced by our unique method have been spun into yarns by blending them with cotton and polyester (fig 2 a, 2 b). The cotton/corn blended yarn has been knitted into a garment (fig 3 a) which demonstrates the usefulness of corn fiber for textile applications.

Annual world textile fiber consumption is 60 million tons, in which 26 million tons are cellulosic materials. The consumption of 3.6 million tons of cornhusk fiber means a share of 6.0 % on the current fiber market, or a share of 13.8 % on the current cellulose fiber market. Due to the unique properties of the cornhusk fiber and the generation of the fiber from an almost useless byproduct of a renewable resource and a possible solution to the decrease in already insufficient arable lands, this fiber will be acceptable in the fiber market. Being a natural cellulosic fiber, corn fibers can be easily processed on the conventional textile machinery and will be comfortable to wear.

Air filtration through fibrous nonwoven materials

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Abstract

Recent years, protecting environments from airborne biological, chemical, and radiological matters along with other harmful contaminants has been a key issue. People spend most of their time indoors. Indoor pollutant levels are generally two to five times higher than the outdoor's. As the EPA pointed out the importance of human health effect associated with environment, Indoor Air Quality (IAQ) is a dominant concern for us. Following the implementation of the $PM_{2.5}$ standards along with PM_{10}, people pay more attention to the fine particles. There is a strong correlation between the level of particles in outdoor ambient air with the level found in the indoor environment. Since there are much more particles indoors than in the ambient, an effective filtration system is needed to remove these particles.

This plenary session covers the principles of air filtration and fibrous nonwoven filter materials.

MODELLING FOR FIBRE SELF CRIMPING

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1. INTRODUCTION

Due to inevitable limitations such as inconvenient climatic conditions as well as diseases on natural fibers, the future of textiles will be much more dependent on synthetic fibers than ever before. It is a well-accepted fact that the natural fibers have fineness, flexibility, softness as well as necessary strength. Nevertheless they usually lack with regard to reliability and reproducibility. However, the synthetic fibers do possess most of these properties but touch and warmth that appreciated by most of the users. Nevertheless, this may only be valid for untreated synthetic fibers.

Texturing process applied to synthetic filaments adds the desired hand, warmth and similar properties that most of the natural fibers offer by nature. Nevertheless, due to huge speed differences between independent spinning and texturing processes, there is a great demand to carry out texturing i.e. crimping on-line with spinning operation.

Texturing imparts specific structures known as crimps or curls to the fibers that make the fibre natural like. Texturing is a well accepted and tolerated method for most of the synthetic filament yarns, yet it is a costly process for modern industry. This very high cost of texturing process is forcing both the research institutions as well as fiber manufacturers to develop means of imparting crimp to fibers without additional cost. Bicomponent and biconstituent fiber structures may somewhat be interpreted as the results of such studies. This so called self crimping fibers develop textured structures after the fiber manufacturing process. The crimping principle is mostly based on the use of two different polymers or two different internal properties of same polymers with shrinkage differences.

Bicomponent fibers may be defined as "extruding two polymers from the same spinneret holes so that both polymers are contained within the same filament”. One of the main method for obtaining bicomponent fibers is so called “side by side bicomponent fibre technique”. Side by side bicomponent fibers are generally used as self-crimping fibers.

There are several techniques for developing self-crimp in a fiber. One of them is based on different shrinkage characteristics of each component. All commercially available fibers are of this type. There have been attempts to produce self-crimping fibers based on different elastomeric properties of the components; however, this type of self-crimping fiber is not commercially used. Some types of side by side fibers crimp spontaneously as the drawing tension is removed and others have “latent crimp”, appearing when certain ambient conditions are obtained. Some literature [1-5] mentions “reversible” and “non-reversible” crimp, when reversible crimp can be eliminated as the fiber is immersed in water and reappears when the fiber is dried. This phenomenon is based on swelling characteristics of the components.

The following factors are crucial to the fiber curvature development:

- The difference in the shrinkage between the components,
- The difference between modulus of the components,
- The overall cross-sectional fiber shape and individual cross-sectional shapes of each components, and
- The thickness of the fiber.

Bicomponent fiber technology is a well established method which readily enables to design and improve the desired fiber properties. It creates crimp effect without any additional operation process. This advantage may also be seen as disadvantage as dyeing of these fibers inevitable creates shading effects after dyeing. The extrusion equipment is also very complex.

2. METHODS OF SELF CRIMPING

The paper describes the work for the development of an alternative self crimping technique. It is targeted to reduce the cost of crimping by eliminating the additional texturing operation whilst utilizing only one component, i.e., monocomponent. The underlying principle is nearly the same as bicomponent fibers and bimetallic strips. By changing the internal structure of fiber by creating different orientation levels, it is perceived to get helical dispositions and hence crimps.

In order to create internal structure variation in a fiber, the following methods are theoretically available [6-7];

a) Asymmetrical cooling of fibers by means of a sharp quench to create different crystallization levels,
b) Asymmetrical spinneret cross-sections result in an asymmetrical shaped fibre cross-section and thus an irregularity in the inner structure of a fiber is aimed,
c) Inducing controlled turbulence in the melt flow is reported to result in different internal structure in the fiber,
d) Physically deforming the fiber during spinning by passing it over a hot edge or by shaving or pressing to create internal structure differences.

Technical literature with regard to especially monocomponent self crimping is quite limited if at all exists any. This work reported here is therefore considered as a pioneering work and hoped to initiate a long lasting research and development activity.

3. EXPERIMENTAL WORK: Modeling of the Monocomponent Self Crimping

In order to understand the crimp development due to internal structure difference, the following series of experiments have been devised and carried out. The result of the experiment is also intended to improve the visual understanding of the fiber crimp by scaling up. Rubber bands with 4 mm width and 2 mm thickness are used as working material. A certain length (60 mm) of rubber band is taken as the base and a second band with the same properties is glued on the base with differing extensions. The results of the experiment are given in Table 1 carried out with 60 mm base length.

Table 1: The result of the experimental simulation with base length of 60 mm

	Extension Ratio			
	5%	**10%**	**15%**	**20%**
Base length, L1 (mm)	60	60	60	60
Crimp length, L2 (mm)	5,38	3,55	1,45	-0,82
Crimp Depth, L3 (mm)	1,27	2,26	2,17	2,3
Crimp Ratio, (L1-L2)*L3/L1	**1,16**	**2,13**	**2,12**	**2,33**

The experimental work clearly showed that the extension difference creates curvatures on the whole assembly. It is therefore surmised that by creating asymmetric internal orientation differences, crimps may be imparted to the filaments. Since the whole assembly is consisting of the same polymeric material, it will be a “monocomponent self crimping fibre”.

4. CONCLUSION

It is theoretically discussed and experimentally verified on scaled-up models that by creating orientation difference during the spinning operation, a self crimping monocomponent fibre may be obtained. Such a development may not perhaps replace the traditional texturing technologies but will certainly be a viable alternative with certain applications.

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EXPERIMENTAL STUDY OF THE OPEN-END SPINNING CONDITIONS TO THE PRODUCTION OF WOOL/COTTON YARNS

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The Clothing and Textil Industries has been always a support of the national economy. However, the textile rank needs to search and produce new products, with high economic value added, based on existent technology to increase its competitiveness.

Talking about spinning technology, we know that the non-conventional processes are shorter, are more productive processes, the structure and behaviour of the non-conventional yarns are differents and produced with low costs.

Unfortunatly, no progresses were done in the production of non-conventional yarns, specially when produced through different fibers, with very different properties, like cotton and wool fibers.

The aim of this work was the experimental study of the optimal open-end spinning conditions, in a way to produce a 50% wool / 50% cotton yarn at a low price and with a good performance, through the utilization of excellent raw materials, like cotton and wool fibers.

The experimental work of this project was carried out according the following phases:

1. Production of 50% wool / 50% cotton OE yarns through different spinning conditions;
2. Vaporization of the differents yarn, produced;
3. Experimental evaluation of different yarns physical properties;
4. Double twisting of the yarns;
5. Experimental evaluation of the double twisting yarns;
6. Production of knitted structures;
7. Experimental evaluation of the physical and thermophysiological properties of the knitted samples.

After that, it was possible to conclude about the best values for the rotor diameter, the best kinder of buse, the speed of the detaching cilinder, the torsion value, the optimal dawing value and the speed machine.

This project was developed with the Somelos Industries collaboration, wich give us the raw material (drawing sliver, 50% wool / 50% cotton).

After this, we intend to go on with this work, studying the following parameters :

- The best relation between the cotton and wool fibers length;
- Determination of the best micronaire indice;
- Evaluation of the optimal components fibers percentage.

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Application of Computational Fluid Dynamics for Studying the Properties and Processes of Fibrous Materials

David Karst [a] and Yiqi Yang [a, b], (oral presentation)

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Computational Fluid Dynamics (CFD) is a tool for modeling and analyzing fluid flow in a variety of conditions. It was first used in the aerospace industry to model the aerodynamics of aircraft, but now many industries use it. In the textile industry, CFD has been utilized to study various properties and processes of fibrous materials such as fiber, yarn, fabric, and clothing. This article discusses the application of CFD in textiles based on the research being done in our laboratory and from the literature.

For the manufacturing of optical fiber, CFD has been used to model the fluid dynamics for a neck-down profile of optical fiber under conditions of various fiber drawing speeds, furnace wall temperatures, and preform diameters. The predictions for the temperature for the gas-preform interface were similar when it was treated as a Fresnel surface and as a diffuse surface. In addition, it has been found that the aerodynamic diameter of fiber can be calculated with the aid of CFD based on the fiber orientation, aspect ratio, and circumscribed diameter.

CFD has been used to model blood flow on a surface containing evenly-spaced micro-fibers. The sheer stress on the base surface and on the fibers due to blood flow over the surface was calculated. It was found that the shear stress on the base surface was lower when micro-fibers were present on the surface compared to no micro-fibers on the surface. The maximum shear stress on the fibers was much greater than that for the base surface. In addition, the permeability of the micro-fiber region was greater for shorter fiber lengths. The lower shear stress on the base surface was thought to be the reason why blood elements had a greater tendency to be deposited on the surface when micro-fibers were present.

For filament yarn, dye liquor flow through yarn packages in package dyeing has been studied. The authors have used CFD to find that non-uniform package density profiles allow for more uniform dye liquor flow through yarn packages compared to a uniform package density profile. Other research has found that the flow profiles calculated with CFD agree with the flow profiles observed in dyed yarn packages.

For capillary flow through filament yarn, a CFD study found that non-round filaments or less void area between the filaments allowed for greater maximum liquid height and a lower rate of penetration.

CFD also has been used to study staple yarn spinning machines. For air jet spinning, it was found that increasing the nozzle pressure increased the axial and tangential air velocity in the nozzle, which increased the tenacity of the yarn. The jet orifice angle affected the axial velocity and the negative pressure at the air jet inlet. For open-end rotor spinning, it was found that a larger cross-section at the inlet of the transfer channel corresponded to a lower mean velocity at the inlet and strengthened the primary recirculation zone, which allowed for fiber curving and buckling. When the ratio of the circumferential velocity of the opening roller to the mean air flow velocity was constant, the drag force increased with increasing Reynolds number, but the flow profile was unchanged. When the ratio was too high or too low, significant recirculation at the outer cover side or opening roller side occurred.

For woven fabric, the authors have utilized CFD to model the flow of dye liquor through beams of fabric in beam dyeing. It was found that non-uniform beam density profiles allow for more uniform dye liquor flow through fabric beams compared to uniform density profiles. The authors also have found that uniform liquor flow through fabric beams may be promoted by the use of end-caps to seal-off the sides of the fabric beam and by the use of metal collars to block perforations in the metal beam at the edges of the fabric beam. In addition, for very porous fabrics, liquor tends to take a short-cut through the fabric and flow directly towards the drain of the beam dyeing kier. The authors have found that the use of outer beam wrapping may be used to direct liquor more uniformly through the beam of fabric.

Other research has used CFD to study woven filter fabric. It has been found that plain weaves provided greater resistance to flow compared to satin weaves for a give fabric count. For tightly woven fabric, flow was found to pass mainly through the yarns, and for loosely woven fabric, the flow was directed mostly around the yarns. This phenomenon was more significant for yarns with tighter twist. In addition, the flow of water through a woven fabric in a vertical open-width washing machine has been modeled, and the efficiency of the washing machine was optimized.

The manufacture of non-woven fabrics has been modeled with CFD. The porosity has been calculated for various regions of a fiber web arranged by air-laying, and the porosities necessary to obtain an even distribution of fiber were calculated and confirmed by experiment. For fiber mat formation, the effect of air jet velocity and jet angle on the pressure, drainage, and velocity profiles in the jet impingement zone has been modeled. The fiber web formation process has been modeled to determine the optimum flow parameters for the machine geometry, permeability of the perforated screen, and the boundary conditions at the flow inlet.

The flow properties for protective clothing have been predicted using CFD. The heat transfer, flow of gases and vapors, capillary transport of liquids, sorption of vapor and liquid, and permeability of the various layers of protective clothing items have been modeled under various environmental conditions such as different gases and temperatures. The calculations in CFD successfully predicted these properties of the protective clothing.

STATISTICAL METHODOLOGY OF IMAGE TEXTURE ANALYSIS FOR NEEDLEPUNCHED NONWOVEN STRUCTURE DEFINITION

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A b s t r a c t

Although there is no strict definition of the image texture, it is easily perceived by humans and is believed as a rich source of visual information, about the nature and three-dimensional shape of physical objects.

Feature extraction is the first step of image texture analysis, and the results obtained from this phase, are used to produce the texture discrimination and texture classification. The most important techniques used for texture analysis are:

- Structural;
- Statistical;
- Model based;
- Transform.

The purpose of this work is the use of statistical methodology to extract image texture features, (first order histogram based features and co-occurrence matrix features), of needlepunched nonwovens images. This data may provide a useful approach to characterize structural information.

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A Statistical Model of Pesticide Penetration through Woven Work Clothing Fabrics

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Statistical models estimating the level of protection and thermal comfort performance of woven fabrics were developed to serve as the basis for recommendations on the selection of woven work clothing for pesticide applicators, using simple fabric and liquid parameters. We evaluated eighteen woven fabrics commonly used for work clothing for agricultural workers or having the potential for such use, and twelve pesticide mixtures of atrazine and pendimethalin at different concentrations. Using three pesticide mixtures that represent a range of both surface tension and viscosity, percentages of pesticide penetration are measured, along with fabric thickness, weight, solid volume fraction, fabric cover factor, yarn twist factor, yarn packing factor, and air permeability. Statistical analyses are performed to examine the relationship between liquid/fabric parameters and pesticide penetration. Statistical analyses show that fabric thickness is the most influential single factor affecting liquid penetration of woven fabric, followed by fabric cover factor and yarn twist factor. However, further statistical processing involving multiple variables reveals that the influence of fabric thickness decreases once other fabric parameters are entered into the model, which indicates that the fabric parameters are interrelated. Consequently, in the further modeling processing, the fabric thickness was replaced by a combination of fabric cover factor and yarn twist factor. Cover factor and twist factor were better parameters in describing the geometry of woven fabrics than solid volume fraction. Modeling of comfort performance of woven fabric based on simple textile parameters shows that the combination of fabric thickness, cover factor, yarn twist factor and yarn packing factor can be used to estimate air permeability of woven fabric, which is important in thermal comfort. The study indicates that textile and pesticide parameters measured by simple tests or readily available in the literature can be used in the statistical model to estimate the level of protection and thermal comfort. This could be used for developing selection charts or tools as guidelines for the selection of PPE for use in hot, humid environments.

Simultaneous Removal of Nitrogen Oxides and Particulates Using a Catalytic Filter

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Introduction

Removal of NO_x and particulates from exhaust gas is crucial for solving the problems air pollution. Most of the works on NO_x and particulates removal focus on processes either for particulates removal and NO_x reduction only, while few studies on simultaneous de-dust and denitrification exist. A new type of reactor has been suggested for savings in energy, space and cost. The resulting multifunctional reactor such as catalytic filter allows substitution of two or more process units with a single reactor, where all the operations of interest are executed simultaneously. The present work reports the evaluation of catalytic filter for the removal of NO_x and particulates simultaneously.

Experimental

P-84 was used as catalytic filter substrate. The catalyst, V_2O_5-WO_3/TiO_2, was used a commercialized product (MaGreen Inc.), which exhibited high SCR activity in the low temperature range (150 ~ 250°C). Incorporation of a catalyst into the fabric filter substrate was performed by impregnation with vacuum suction. The reactor arrangement for the removal NO_x is shown in Figure 1. The SCR activity measurement was carried out in a parallel type reactor. The reactor (55 mm I.D.) was heated to the desired reaction temperature by an electric furnace. Flue gas was simulated with 400 ppm NO, 400 ppm NH_3, 10 vol.% O_2, and balance N_2. The inlet line of reactor system was heat to prevent formation and deposition of ammonium nitrates. The NO and NO_2 concentration were continually monitored by non-dispersed infrared type NO/NO_x analyzer (Ultramat23, Siemence Co.). All data were obtained after 2 hrs when the SCR reaction reached steady state.

Results and Discussion

The degree of adhesion of catalyst to fabric filter was evaluated in the VDI experimental device. Figure 2 shows detached catalyst weight from the catalytic filter as a function of number of reverse pulse jet. The weight of detached catalyst is very small. Additionally, flexibility of catalytic filter is similar to P-84.

Figure 3 shows the SCR activity of catalytic filter as a function of temperature and loaded catalyst weight. The NO_x conversion can be defined as

$$NO_x \text{ conversion} = ([NO_x]_{in} - [NO_x]_{out})/[NO_x]_{in} \text{ X } 100$$

In the case of fixed bed reactor NO_x removal efficiency shows almost constant value through all reaction temperature range. However, NO_x removal efficiency of catalytic filter increases with increasing reaction temperature and loaded catalyst weight. It is considered that the amount of catalyst for the reaction between catalyst and NO_x is deficient. But the increase in quantity of catalyst leads to increase pressure drop. We keep on the study for the new method to improve NO_x removal efficiency without increasing pressure drop.

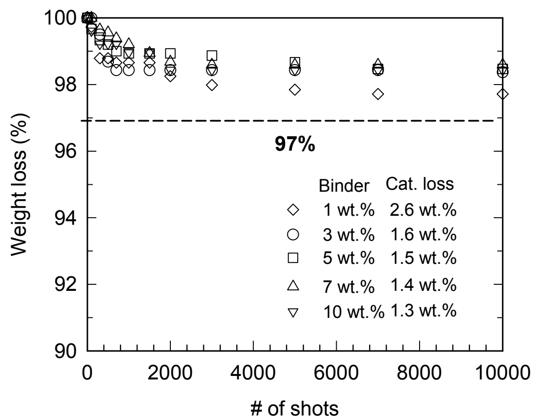

Figure 2. The detachment of catalyst from cat. filter as a function of reverse pulse jet.

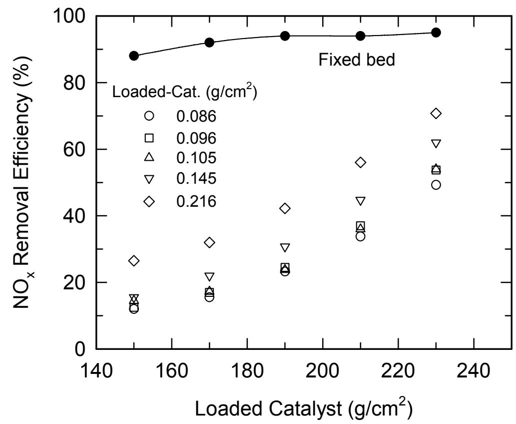

Figure 3. Effect of temperature and loaded cat. on NOx conversion.

Measurement of Electrical Charge Density of Melt-Blown Type Electret Filter

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Electret filters are usually used in air cleaners and respirators because of their low pressure drop and high collection efficiency. Manufacturers of electret filters have tried to increase the electrical charge density of electret fibers in order to improve the collection performance. Although electrical charge density is a critical parameter in determining the collection efficiency of electret filter, the measurement technique for the electrical charge density has not been well established yet. Especially, in the case of melt-blown fiber, it is difficult to measure the electrical charge density because the orientation of dipole axis of the fibers is random and net charge on the electret filter is nearly equal to zero. Brown (1993) and Romay *et al.* (1999) proposed a method of electrical charge density of meltblown fiber using bipolar ions. However, it requires the penetration data of the treated electret filter to check whether the filter is neutralized. Furthermore, Romay *et al.* regarded the neutralizing time as the time until which the penetration of electret filter neutralized by bipolar ions reaches at that of alcohol-soaked electret filter. It was shown that the charges of recently-developed electret filter are not completely neutralized by organic solvent (Lee *et al.*(2002)). A simple method to measure the electrical charge density of melt-blown filter is discussed, and a set of experiments proposed.

The system to measure the charge density is illustrated in the inset in Figure 1(Lee *et al.*, 2003). The electret filter is neutralized by bipolar ions generated by alpha-rays from Am-241 or Po-210. The melt-blown filter is exposed to alpha-ray and the ion current penetrating through the filter during neutralization is measured. The electrical charge density of the filter is calculated with the ion generation rate and the irradiation time of alpha-ray for neutralization. The measured density is compared with that obtained from particle penetration measurements.

As a result, electrical current change during alpha-ray exposure is well associated with neutralization of electret filter. The change in electrical current and penetration during neutralization is shown in Fig.1. The ion current is constant for 18 hours from beginning of neutralization and then it increases from 18 to 35 hours. The time at which the second plateau in the ion current seems to correspond the time at which no further increase in particle penetration is observed. The measured electrical charge density is 2.4×10^{-4} C/m^2, which is twice the charge density determined by the particles penetration data. The overestimation of charge density may be attributed to the recombination of bipolar ions in the filter. Nevertheless, the measurement of ion current through the electret filter may give useful information on the electrical charge retained by the electret filters.

The advantage of this method is that charge density of filter can be readily evaluated. Using this information, the collection efficiency characteristics can be elucidated without having to perform extensive and cumbersome particle capture experiments.

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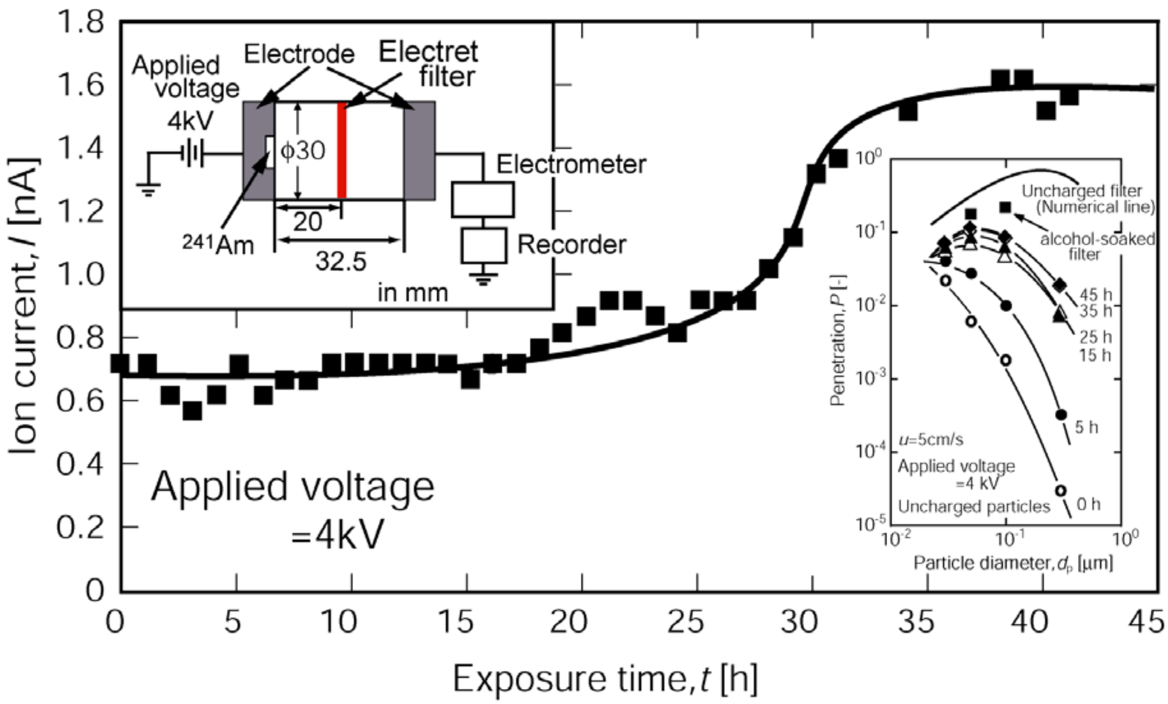

Fig.1. Change in ion current and penetration of filter as a function of exposure time.

Modeling Particle Filtration by Glass Fiber Filters

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Abstract

The most common method of filtration is via fibrous filters. Fibrous filters are generally characterized by their collection efficiency and pressure drop. Previous computational studies in this are typically based on unrealistic 2-D geometries with the fibers simply placed in a lattice (regular array) perpendicular to the flow. We will present some preliminary data on 3-D model nonwovens and their ability in filtering nano particles. We will report the effect of filter density, fiber diameter, and fiber orientation distribution on the collection efficiency. We will also discuss the role of particle size on filtration as a function of fiber diameter.

A new issue of filtration, by using porous laser-sintered filters produced by rapid tooling

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Abstract:

The term Rapid Tooling (RT) is typically used to discribe a process which either uses a Rapid Prototyping (RP) model as a pattern to create a mold quickly or uses the Rapid Prototyping process directly to fabricate a tool for a limited volume of proto-types. RT is distinguished from conventional tooling in that:

- Tooling time is much shorter than for a conventional tool. Typically, time to first articles is below one-fifth that of conventional tooling.

- Tooling cost is much less than for a conventional tool. Cost can be below five percent of conventional tooling cost.

- Tool life is considerably less than for a conventional tool.

- Tolerances are wider than for a conventional tool.

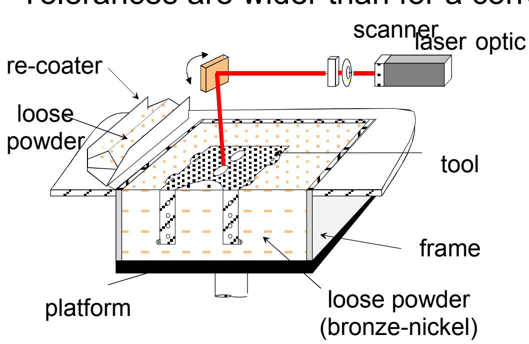

Figure 1: Rapid tooling process

In the plastic processing this tools will be infiltrated by epoxy resin. If there is no infiltration, the tool keeps porous and water can penetrate through it. This effect could be used for paper injection moulding. According to the allready known plastic injection moulding process, an aqueous fiber suspension could be pressed in closed porous cavities. At high pressure, the water penetrate through the pores of the permeable, pressure-tight membrane and the fibers stays as an structural element inside the cavity, as shown in figure 2.

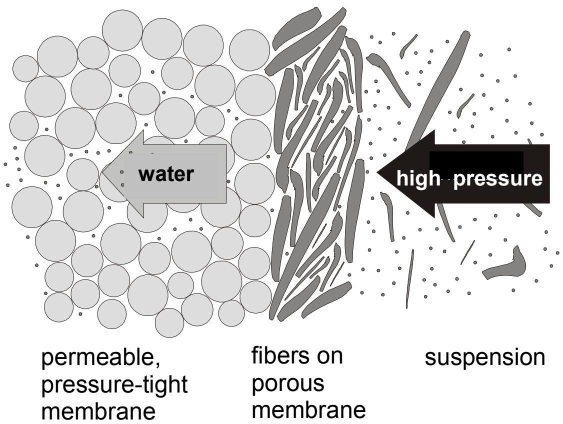

Figure 2: Scheme of the paper injection moulding process

The porousity of the cavity can be modified by the sintering velocity. High velocity induce large pores, but minor strength of the material. The poresize is depending on the fiber geometry. To prevent the astringency of the pores, the cross section of the pores must be smaler than this of the fibers.
First tests have shown, that the injection moulding with porous cavities is possible.

The aim of the project is the modification of the injection moulding technology which is already being applied since a long time for the plastics technology, so that aqueous fibrous material suspensions can be processed. Thus a process is to be developed, through which a prototypical fabrication of a marketable product (complex paper structures) can be achieved. This material is suitable for packaging of compact as well as loose substances. This technique is not designated to replace conventional technologies as fiber moulding, for example, but it should allow new complex geometries that are not produceable through the existing traditional methods.

The process development includes the optimization of the fibrous material suspension in addition to the production of suitable filter bodies as injection moulding cavities. Hereunto one planned point is to determine the maximum densification rates of filtrated fiber suspensions, the rheology and shear rates of fibrous material suspensions under high pressures, in addition to the abrasion behaviour of fibers against machine parts in an aquaous carrier media. The filter bodies are to be examined for self infiltration and porosity.

The multi-level manufacturing process of complex paper structures can be made much more easy by using injection moulding and producing the parts in just one single manufacturing step without any finishing processes. Thus the intention of this project is to combine knowledge and skills of polymer technology together with paper technologies in order to reach new innovative products with high chances in the competing markets. The environmental friendliness of the manufactured products is reflected in their recycleability and biological degradability. From an economic point of view the project also aims at the fabrication of paper-based products, that can replace at least part of the plastic packaging materials.

Experimental Study of Pleated Fabric Filters in Pulse-Jet Dust Collectors

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Keywords: Pulse-Jet Cleaning, Pleated Fabric Filter Cartridges

In many industry applications fabric filters are used either for particulate control or product recovery. The basic principle of fabric filtration is to introduce dusty air flows into a large box (i.e., dust collector) containing suspended flat-sheet filter bags or pleated filter cartridges. When a particle-laden air flow enters the filters, particulates can be captured and often form a dust cake on the filter surfaces. During the particulate collection process the pressure drop across the filters increases. To keep dust collectors working under the reasonable level (tolerated by the vacuum pump for the long-time operation), different cleaning methods such as shaking, reverse-air, and pulse-jet are adopted for dislodging the dust cake periodically. Comparing with other cleaning methods, the pulse-jet technique, with which short bursts of compressed air is applied into the fabric filters in the reverse filtration flow direction, is more popular due to its operating dependability and cleaning effectiveness.

In this study, pleated fabric filter cartridges are used for investigating the relationship between cleaning effectiveness of pulse-jet dust collectors and filter media. The experiment was designed to collect data such as the system pressure drop and particle penetration with changing operation conditions (cleaning modes, filtration velocity, tank pressure, and pulse duration) and filter media. The experimental data show that filter geometry (pleat depth and pitch) is an important factor of cleaning performance. The different surface treatments of filter media also have a great influence on the cleaning performance. The detail result of this study will be presented in this conference. Based on the information obtained we can gain more insides of the application of pleated fabric filters in pulse-jet cleaning system.

Development of oil binding structures made by leather filled polymers

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Abstract

Next to natural desasters, while oil is feathering to the ground, allthough in other technical application we have the problem of leakage oil. For example during refueling your car with petrol some drops fall alongside. This sound not evil but if you emagine how many cars will be refueled in a day or weak than we discuss a bigger problem. The research work, which will be presented, try to add on here. In a project the development of an oil binding structure is analysed and the first results will be presented.

In a first step the manufacturing of a material composite by natural leather fiber and a thermoplastic polymer is shown as well as the properties of these materials and their possibility to bind oil. Further more on the one hand side the using of this material in the press forming machine to process it to testing samples for different tests is shown. On the other hand side the different results for the tests in addiction to the processing parameters (time, presure, temperature) will be described. For the test the authors will introduce the results of storage the samples in oil, water and petrol and show the addiction of the binding quality to the storage time on the one hand side and on the other hand side to the leather fiber content in the thermoplastic embedding system. It can be shown that a high percentage of the material which has to be bond (i.e. oil) was absorb at the beginning. As well the binding quality increase with the leather fiber content which was expected.

But we have a maximum for the binding quality as well as for the production. Here we need a minimum of the embedding matrix system to bind the fibers into the polymer and to get a continuous joint surface. After processing the compound material it is tested in its filtration properties. Small plates of the compound containing different ratio polymer binder and leather fibers are used. The permeability of an unloaded compound material is measured as a function of the binder content for air and water as well. Furthermore the

properties of the loaded compound material are investigated. Different samples are loaded with water, gasoline or gear oil. The maximum load and the regeneration properties are measured.

The characterization of the filtration and oil absorbing properties are necessary to quantify the functionality of the compound material. The experiments show that the oil-phase can be immobilized inside of the compound. This is due to the hydrophobicity of both the polymer binder and the leather fibers. Filtration experiments show that the oil phase even remains inside of the pores of the compound when an external pressure difference is applied. Furthermore a water flow through the pores of the compound is not able to remove the oil phase by washing effects.

The investigations clearly prove the applicability of the compound material of leather fibers and polymer binder for oil and gasoline absorbing purposes. Last but not least the processing of this composite material will be shown and the properties in addiction to the processing parameter will be presented as well as the possible geometry for these kind of oil binding components. Possible fields of application and samples will be shown as well as the limitations of this oil binding structures.

The Effect of Cooperative Charging of Electrospun Nanofibers of Electrically Dissimilar Polymers on Filtration Properties

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Abstract

Electrical charging and the decay of residual charges on electrospun nonwoven webs of two electrically dissimilar polymers were studied in an effort to enhance the filtration properties of electrospun filter media. Electrospinning of polystyrene (PS) and polyacrylonitrile (PAN) was performed by utilizing three different approaches to produce thin fibrous webs: PAN and PS were electrospun individually in a 'single component' fashion; in a 'layer-by-layer' configuration (four alternating single component layers: PAN/PS/PAN/PS); and simultaneously in a side-by-side 'bicomponent' apparatus to yield bicomponent fibers.

During electrospinning of the PS and PAN polymer solutions, the fibers were found to become positively charged when a positive voltage (+16kV) was applied to the solution-filled spinning nozzle and were found to become negatively charged when a negative voltage (-16kV) was applied to the spinning nozzle. This study allowed the examination of the effect of the electrospinning on inducing charges of different polarity on two electrically dissimilar polymers (viz. PAN and PS) and to determine the effect of the three types of web constructions ('single component', 'layer-by-layer' and 'bicomponent') on charge retention and filtration properties of the resulting nanofibers. It was found that the residual charge of 'layer-by-layer' webs increased over a 2h period when the fibrous web was laid on a conductive surface, then diminished over a 24h period to a relatively high charge plateau value (346 V). Residual charge of the 'layer-by-layer' (PAN/PS/PAN/PS) and the 'bicomponent' (PAN-PS) webs decayed by 80-85% after 24 hours. The 'layer-by-layer' web retained charges above 300 V after 24h. For bicomponent PAN-PS, the initial charge of 203 V decayed to 97 V after 24 hours (reflecting a loss of 52%). Air filtration properties were found to be exceptionally high. The 'layer-by-layer' PAN/PS/PAN/PS and the 'bicomponent' PAN-PS webs both possessed low pressure drops (3-5 mm H_2O at a filtration velocity of 5.3 cm/s) and high filtration efficiencies (FE) of 99.95% for 'layer-by-layer' PAN/PS/PAN/PS, and 98.96% FE for 'bicomponent' PAN-PS webs after 24h.

Effect of Spinning Parameters on Filtration Performance of Electrospun Nanofiber Webs

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INTRODUCTION

In this study, the filtration characteristics of electrospun nanofiber webs were systematically examined. Nanofiber webs were manufactured with various spinning conditions by a lab-scale electrospinning apparatus. The effect of processing variables of electrospinning on fiber size distribution and pore size distribution of the nanofiber webs was analyzed. Finally, the filtration properties of the electrospun webs were measured and compared with a commercial air filter media composed of glass fibers.

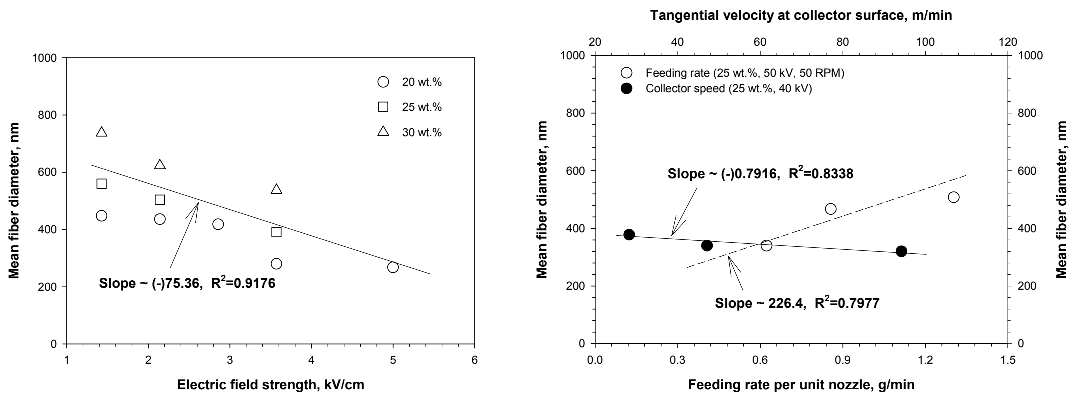
FIBER SIZE DISTRIBUTION

The mean fiber diameter of electrospun webs is deeply related to the electrospinning parameters such as the spinning voltage, solution feeding rate, solution concentration, and collector speed. Therefore, it is expected that there will be certain relationships between the mean fiber diameter and spinning parameters.

Fig. 1 shows the effect of electrospinning parameters on the mean fiber diameter. From Fig. 1(a), it can be seen that the overall tendency of fiber diameter decrease with increased spinning voltage is nearly constant. The slope of the regression line over the whole data is about (-)75.46. The minus sign indicates the inverse relation between the fiber diameter and electric field strength applied. Consequently, it is known that the mean diameter (nm) of electrospun fibers is linearly decreased as a factor of 75.46 per unit kV/cm of electric field strength. Fig. 1(b) shows the correlations of the mean fiber diameter with the feeding rate of polymer solution and collector speed, simultaneously. As seen in Fig. 1(b), the effect of collector speed on the mean fiber diameter is very small. On the other hand the feeding rate of polymer solution has a great effect on fiber size. The correlation factors, which are the slopes of the regression lines, are (-)0.7916 for the collector speed and 226.4 for the feeding rate.

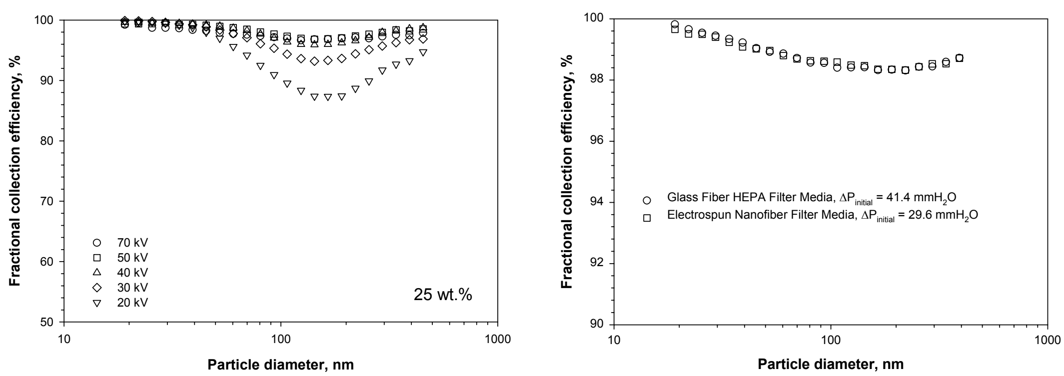
FILTRATION PERFORMANCE

Fig. 2(a) shows the fractional collection efficiency of electrospun filters made at various spinning voltages. As can be seen, the efficiency of electrospun filters is increased with increasing applied voltage. The collection efficiency of a filter is associated with the fiber size, pore size, thickness of the filter. Since a filter electrospun at higher voltage has finer fibers and smaller pores, the collection efficiency of the filter becomes higher that that of filters made at lower spinning voltages. In Fig. 2(b), the collection efficiency of an electrospun filter media is compared with that of a glass fiber HEPA filter media. The pressure drops of the two filters at filtration velocity of 5 cm/s are 29.6 mmH_2O for electrospun filter and 41.4 mmH_2O for glass fiber HEPA filter, respectively. The collection efficiency of the electrospun filter media is almost same with that of the glass fiber HEPA filter media, but the pressure drop of the electrospun filter is only 75 % of that of the glass fiber filter.



(a) Electric field strength (b) Feeding rate and collector speed

Fig. 1. Effect of spinning parameters on the mean fiber diameter of electrospun webs.



(a) Effect of spinning voltage (b) Comparison with HEPA filter media

Fig. 2. Collection efficiency of electrospun fiber webs.

ACKNOWLEDGEMENT

This work was funded by the Center for Nanostructured Materials Technology of 21st Century Projects supported by the Ministry of Science and Technology, Korea. The authors gratefully acknowledge the financial support.

Loading Characteristics of Nanofiber Filters

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Abstract

The objective of this study is to experimentally investigate the performance characteristics of filters with nanofibers on the mass loading capacity. By comparing the loading performance between filters with and without nanofibers one can distinguish the advantages and disadvantages of using filters with nanofibers. To achieve the goals, seven different filter media, one with nanofibers on the surface and the others with no nanofibers, were tested using particles of three different materials, e.g., sodium chloride, Fine Arizona test dust and Alumina. The relative humidity was varied from 5% to 90%.

The pressure drop across filter media during the loading process was recorded as a function of loading time. With the assumption of constant mass loading rate the curve of pressure drop vs. the loaded mass per unit filter area can thus be obtained. The result shows that the filter media with nanofibers behaves very differently when compared to others without nanofibers. Further, the relative humidity has a very pronounced effect on filters when sodium chloride particles were loaded. The effect is much less significant for the loading tests of Arizona road dust and Alumina particles. The experimental data and possible explanation will be presented at the Fiber society conference.

Numerical Study of Airflow and Heat Transfer during Through Air Bonding of Nonwovens

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Use of nonwovens in a variety of disposable and durable end use products segment including hygiene, filtration, bedding, furniture, carpet backings, wipes are growing tremendously. Nonwovens are made of directionally or randomly distributed fibres and are bonded together by friction or cohesion or adhesion. Nonwovens web can be manufactured by a number of different techniques including carding, spunbonding, melt blowing, air laying and wet laying. The fibres in the web is then bonded together using different processes such as needle punching, hydro entangling, chemical spray bonding, hot calendaring and through air bonding. The through air bonding process, the subject of the current research, involves wrapping a nonwoven web around a perforated drum and passing hot air through the web to heat and bond the web. Most through air bonded webs are consist of bicomponent fibres. The high melting point core fibres provide uniformity and rigidity of the web and the low melting point sheath fibres easily melts and bonds the fibres together. The control of air temperate, flow distribution and heat transfer to the web are very important for the through air bonding process. However, the though air bonding process has not received significant attentions from researchers despite its importance.

The present study seeks to provide a numerical model using CFD that will provide a better understanding of airflow and heat transfer in the through air bonding process. The model is based on the solution of continuity, momentum and energy equations along with equations for turbulence model. The commercial CFD code FLUENT was utilised for the numerical calculations. Though the FLUENT software provides many built in capabilities, it does not offer all of the physical models required to address the complex processes that occur in the through air bonding process. For example, the FLUENT's defaults model for thermal energy equation does not include a source term based on melting of fibres. A new thermal energy equation was developed taking into account the heat of melting of fibres. The thermophysical data for the fibres are supplied by KoSa for Celbond® bicomponent fibres of polyethylene (PE) and polypropylene (PP). For the proof of concept and problem solving capability, we applied the mathematical model for a simulation of airflow of 1.5 m/s through a stationary web of 68mm thickness. The web was made of randomly distributed sheath-core type bicomponent fibres of polyethylene (PE) sheath and polypropylene (PP) core. We assumed the porosity of the web did not change during heating and melting of fibres and was fixed at 0.9.

Figure 1 shows the temperature distribution in the nonwoven web at different time steps. Figures 2 shows the interface of progress of melting of fibres inside the web. It can be seen from the graphs that it takes about 1 second to melt the fibres throughout the web. Details of the result will be presented at the symposium.

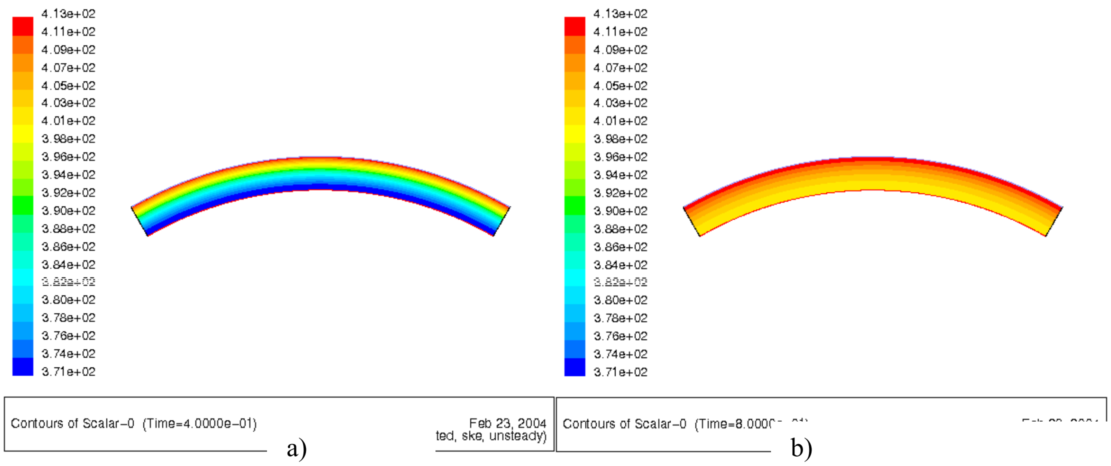

Figure 1: Temperature distribution inside a nonwoven web. a) t= 0.4 second b) t=0.8 second

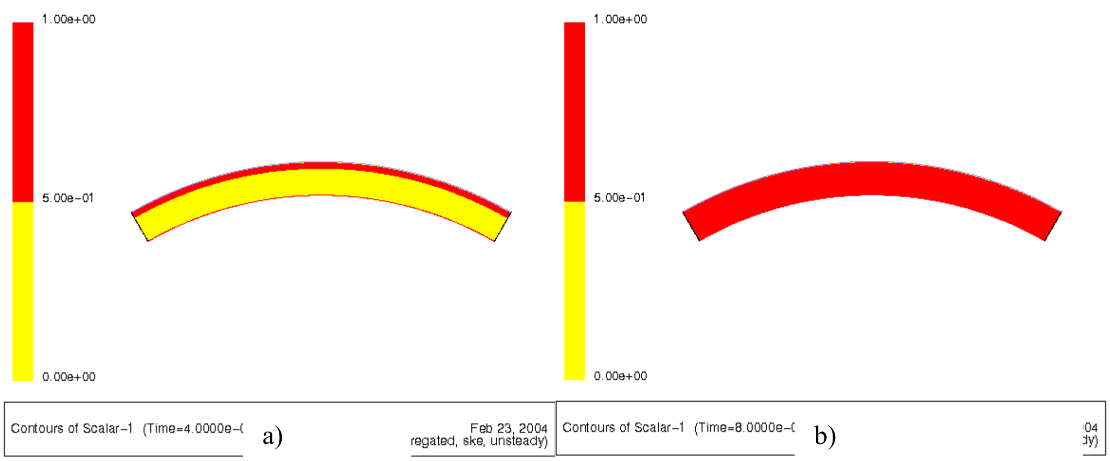

Figure 2: Interface of the melting front inside a nonwoven web. a) t= 0.4 second b) t=0.8 second

Current Challenges in Testing and Characterizing Degradation in Respirator Electret Filters

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Abstract

One of the major components comprising a commercially available respirator filter is a layer of electrically charged material. The statically charged fibers attract airborne particles in a range of .01 microns to a few tens of microns. The major advantage of electret filters over mechanical filters is their ability to attract particles with high filter efficiency while maintaining a low pressure drop or resistance across the filter. Many types of aerosols have been used to test filter efficiency (percent penetration) and resistance to predict the performance and to certify the effectiveness of these filters in the industrial environment. Two common aerosols that are used to test electret filters are salt (NaCl) and Dioctyl Phthalate (DOP), an oil.

Many theories attempt to explain the physics and mechanics of the capture mechanisms. All the theories depend upon the distribution of charge along and around the fiber. Despite the importance of charge distribution on the capture efficiency of electret filters, there are no published reports of mapping the charge on the nanometer scale for either the electret filter or the fibers that comprise the filter. It has also been reported in the literature that certain chemicals, when they come in contact with the electret filter, could degrade its performance. The exact mechanism of performance degradation, whether by the chemical challenge agent causing a morphological change in the fiber, or masking the charge, or bleeding the charge off the fiber, is an area of active investigation.

An Experimental Methodology and a Computer Simulation to Study Penetration and Capillary Flow through Medical Textiles

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The movement of liquids into fibrous networks is called liquid penetration. It depends on both the molecular and bulk properties of the liquids, the geometric and surface properties of the porous media. If liquid is able to wet textile surface, it can also penetrate into fibrous network by means of capillary forces, without any external force; it is called spontaneous uptake. The capillary forces are a result of interaction between the molecules of the liquid and pore surfaces. If there is no such wetting, then an external force is required for penetration. It is called forced penetration. Liquid penetration into a porous material is distinct from other types of fluid/material interaction in that it involves a displacement pressure and saturation of a material and thus many of the equations used to describe saturated flow are not applicable.

Textile materials are engineered to meet different specifications depending on the area at which they are used; for barrier materials the liquid must be physically forced through the porous material. The forced entry of fluids into fibrous materials plays an important role in several applications such as protective clothing, filtration, geological applications etc. The protective textiles used for medical and surgical applications are surgical gowns, caps, masks, patient drapes, and cover-cloths designed; they are designed to meet a combination of strength, flexibility, protection and sometimes liquid and air permeability.

In the form of barriers, hydrophobic fibrous media provide protection to its user against hazardous fluids. Important aspects to consider are the pressure at which liquids (nonwetting fluids) will penetrate into the fabric and the rate at which it will flow through. Other than the protection requirements, comfort level should also be considered since perspiration is important. One of the objectives of this study was to develop an experimental technique to determine (1) the displacement pressure of medical barrier fabrics in combination with aqueous solutions, (2) the flow rates once the aqueous solutions had penetrated, i.e. the fabric failed to resist. A pressure/flow cell was used for measurements during sequences of increasing and decreasing pressures applied to the nonwetting fluids (aqueous solution). The resulting flow rates-pressure curves exhibited hysteresis, i.e., lower flow rates existed during increasing pressures (increasing liquid contact) than during decreasing pressures (decreasing liquid contact) at corresponding pressure values. The reasons for this hysteresis were investigated. The flow rate-pressure curves also provided information about the pore size distributions of the fabrics.

The movement of liquids in fabrics was examined based on the theory of capillary penetration. Effect of liquid features, such as surface tension, viscosity and liquid/fabric contact angle were studied. Surface tension effects were studied by using water and two other solutions with lower surface tensions. From measurements of flow rates of samples, it was shown that liquids with lower surface tensions have lower displacement pressures, consequently exhibit higher flow rates. To study viscosity effects, water and two other solutions with higher viscosities were used. It was observed that higher viscosity does not only decrease the flow rate, but may also cause an increase in pore sizes.

The other objective was to model the penetration and flow. A modified model of percolation that gives a detailed description of fluid penetration through hydrophobic nonwoven fabrics was developed. The fabric was modeled as parallel cylindrical capillaries in two different ways: one with uniform diameters, and a modified version with different diameters along the length. The flow behavior under different liquid pressures was simulated. The numerical results were validated with experimental data. Both forced flow models were shown to be consistent with the experimental results.

Electro-spun polyvinyl alcohol fibers on the substrates

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Abstract

This research is to improve the filtration efficiency by introducing environmentally safe electro-spun nanofibers on the conventional filter media. Nano size fibers around 50 to 100 nm in diameter would greatly help to capture very small particles that have not been filtered through the conventional air filter media.

The technique of electrospinning has been investigated for more than 70 years. However, actual industrial application of this technique is very limited.

The nanofibers studied in this research are mainly prepared with polyvinyl alcohol solution, which is non-toxic to human health. Therefore, polyvinyl alcohol has been selected for this research over current elecro-spun nanofiber production by using toxic chemical solvents. A small percentage of Glyoxal is mixed with polyvinyl alcohol solution as a cross-linking agent. The cross-linking agent is very important because it helps to stabilize the polymer, and it increase the water resistance of the nanofibers. Without the cross-linking agent, the nanofibers produced would dissolve into the water applied to the substrates.

A vacuum rotating drum is used to produce electro-spun fibers on the moving substrates. The uniformity of electro-spun fibers on the substrates is observed through SEM photomicroscopies. Having fibers above the glass transition temperature and annealing are very important for the research in order to make stable nano fibers on the substrates.

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