2019 Poster Contest

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In recognition of an outstanding poster presentation

NONWOVENS INNOVATION ACADEMY – POSTER SESSION

October 16 – October 17, 2019

Denkendorf, Germany

Ajinkya Powar
Textile & Engineering Institute (DKTE)

Poster: *Studies on Effect of Blend Proportion on Thermal Bonded Nonwovens*

Akshay Rathi
Indian Institute of Technology Delhi

Poster: *Development of Absorbent Core for Evaporative Cooling Garments to Enhance Thermal Protection against Extreme Climates*

Hafiza Hifza Nawaz
University of Manchester

Poster: *Graphene Oxide/PVDF Nonwoven Membranes for Textile Waste Water Treatment*

Imon Khan
North Carolina State University

Poster: *Fundamental Study of Polymer Compatibility of Polymer Blends and their Effects on Melt-Spinning Process and Fibre/Nonwoven Properties*

Kinyas Aydin
HAYAT KİMYA SAN. A.Ş

Poster: *Meltblown Fibres Constituting SM_xS Nonwoven from 100% Reclaimed Spunmelt Nonwoven Via In-Line Method*

Marcel Hofmann
Sächsisches Textilforschungsistitut (STFI)

Poster: *rCF-Organic Sheet – Thermoplastic composites from recycled carbon fibres*

Matin Rostamitabar
Maastricht University

Poster: *Development of a Multi Functional Wound Dressing using Cellulose Aerogel Fibers*

Michael Philipps
University of Leeds

Poster: *Nonwoven-Reinforced Elastomers for Repair and Regeneration of Soft Tissue*

Muhammad Umar
University of Manchester

Poster: *Advanced Respiratory Filters for Prevention of Byssinosis*

Munir Hussain
Zhejiang University, Hangzhou

Poster: *Denier Reduction of Polypropylene Fibres for Spunbond Nonwoven via Low Modulus Polypropylene Incorporation*

Patrick Engel
Sächsisches Textilforschungsistitut (STFI)

Poster: *Stitchbonded Nonwovens for Hot-Melt Coating – Development of nonwoven-based Carrier Materials for Technical Adhesive Tapes*

Pranil Vora
North Carolina State University

Poster: *Critical Evaluation of Bio-based Polymers for Spunbond and Meltblown Nonwovens*

Rebecca Cooper
University of Leeds

Poster: *Nonwoven Delivery Systems Comprising Capsule Fibres for Medical Devices*

Siddharth Shukla
Indian Institute of Technology Delhi

Poster: *Micro-Structural Analysis of Absorptive Glass Mat (AGM) Nonwoven Separators Via X-Ray Computed Tomography Analysis*

Sohail Yasin
Heriot-Watt University

Poster: *Blends with Modified Polypropylene for Softer Nonwovens*

Sten Döhler
Sächsisches Textilforschungsistitut (STFI)

Poster: *Digitization for the Process of Carbon Fibre Recycling – from rCF to Organic Sheets*

Tarun Kumar Agrawal
University of Borås, Sweden

Poster: *Blockchain-Based Framework for Traceability – A Case Example of Nonwoven Supply Chain*

Yu Song
North Carolina State University

Poster: *Effects of Filter Media Structure on Particle Capture and Dust Holding Capacity*

2019 Poster Contest

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NONWOVENS™ INNOVATION ACADEMY

HOSTED BY DITF DEUTSCHE INSTITUTE FÜR TEXTIL+FASERFORSCHUNG

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Nonwoven-Reinforced Elastomers for Repair and Regeneration of Soft Tissue

Nonwoven-Reinforced Elastomers for Repair and Regeneration of Soft Tissue

ed10m3p@leeds.ac.uk

M. Phillips, G. Tronci and S.J. Russell

Clothworkers' Centre for Textile Materials Innovation for Healthcare

Context

Diabetic foot ulcers are a common complication arising from diabetes and are developed by patients due to factors such as diabetic peripheral neuropathy, peripheral arterial disease and infection with an occurrence rate of 15%[1,2] (Fig. 1).

The follow-on complications can compromise the structure and function of the foot causing chronic pain. While treatments are available they are costly, have poor success rates and the outcome is often disappointing.

Nonwoven materials composed of new synthetic biomaterials are being developed to enable load-bearing function as well as tissue regeneration, following implantation the materials will facilitate the repair and restoration of damaged tissue function, while maintaining structural and functional integrity.

Fig. 1 : Schematic of typical ulceration sites

Current Clinical Treatment

Fig. 2 : Current clinical treatment for diabetic ulcers.

Periodic injections of silicone (PDMS) to the affected area (Fig. 2), which form an inert support structure with the aim of:

- Offsetting the loss of tissue.
- Providing mechanical support for standing forces.

The issues with the current clinical approach are:

- No regenerative capacity.
- Disintegration of the PDMS leading to microbeads and migration away from the wound site, eventually requiring surgical removal.[1]
- Short lifespan (< 2 Years)
- Mechanical incompatibility with the plantar fat pad and surrounding foot tissues.

Fibre & Nonwoven Assisted Treatment

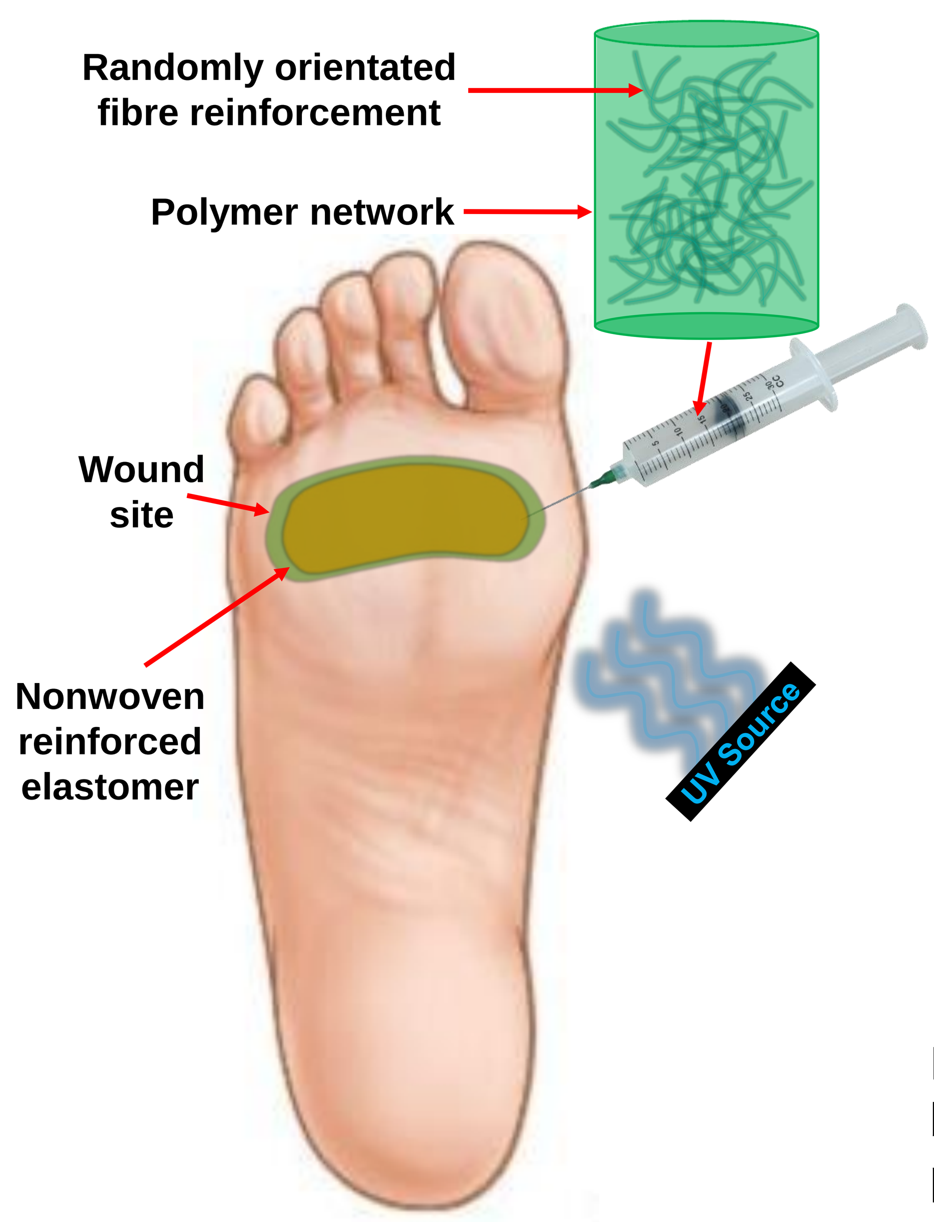

Fig. 3 : Target clinical procedure for diabetic ulcers.

An aqueous solution of a UV-curable biocompatible elastomer encapsulating a fibre/nonwoven component is injected in to the wound site to fill the defect before UV curing *in-situ*, to induce cross-linking (Figs. 3,4).

The result is load-bearing regeneration, which avoids the need for surgical implantation.

A composite strategy is being investigated to allow the treatment to be tailored on a more individual basis. Various formulation parameters can be adjusted to modulate the mechanical properties:

- Variation of polymer matrix components in the elastomer.
- Fibre composition and dimensions.
- 3D fibre orientation and solid volume fraction.

Fibre reinforced composites are present in native biological tissues such as cartilage where a proteoglycan gel is reinforced with collagen fibres.

Experimental: Fibre/Nonwoven Reinforced Elastomer

An in-house synthesised UV-curable polyglycerol sebacate (PGS) based elastomer (Figs. 5,6,7) with excellent mechanical and physiological compatibility is combined with either dispersed degradable fibres or small rolled sections of nonwoven fabric made from the same material.

Embedding of a nonwoven structure or aligned fibres within a biocompatible, high modulus synthetic elastomer, is a potential method of modulating bulk mechanical properties to improve physical function after implantation. The fibres and nonwoven components can comprise elastin, fibrin or collagen, as well as synthetic materials, depending on the mechanical properties that are required, and the need for regenerative as well as mechanical function.

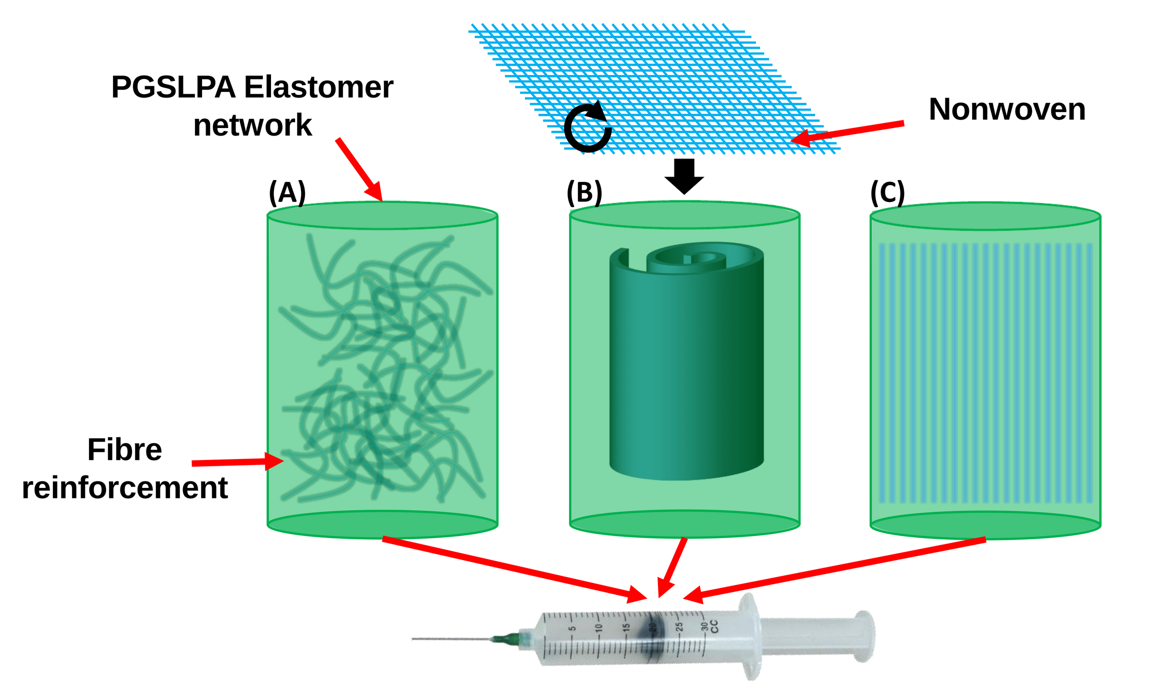

Fig. 4 : Methods of injectable fibre/nonwoven reinforcement. (A) Randomly oriented fibres. (B) Rolled fabric reinforcement. (C) Vertically oriented fibre reinforcement

Synthesis of the UV-curable PGS-based elastomer

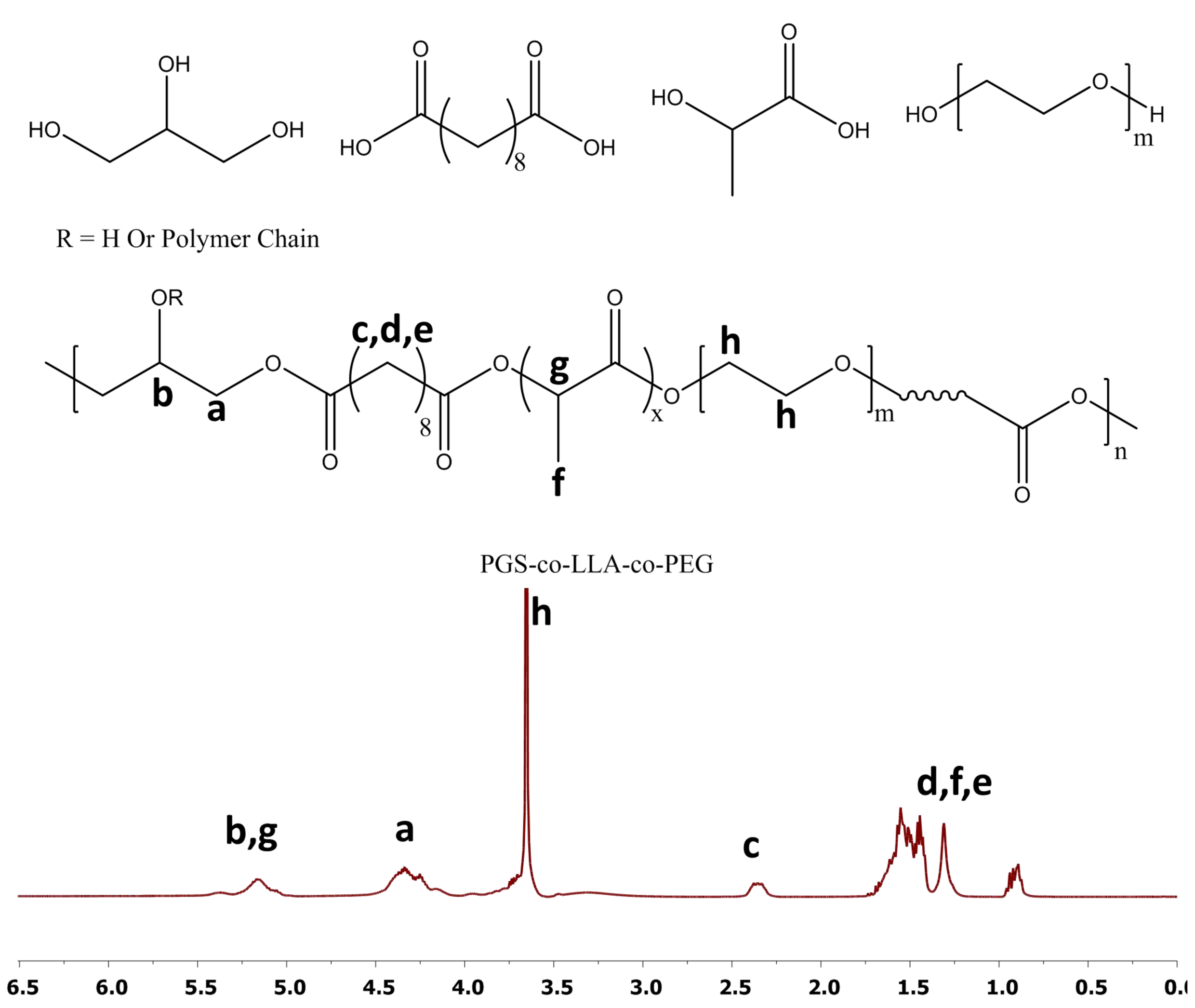

Fig. 5 : H[1] NMR Spectrum of PGS-co-LLA-co-PEG

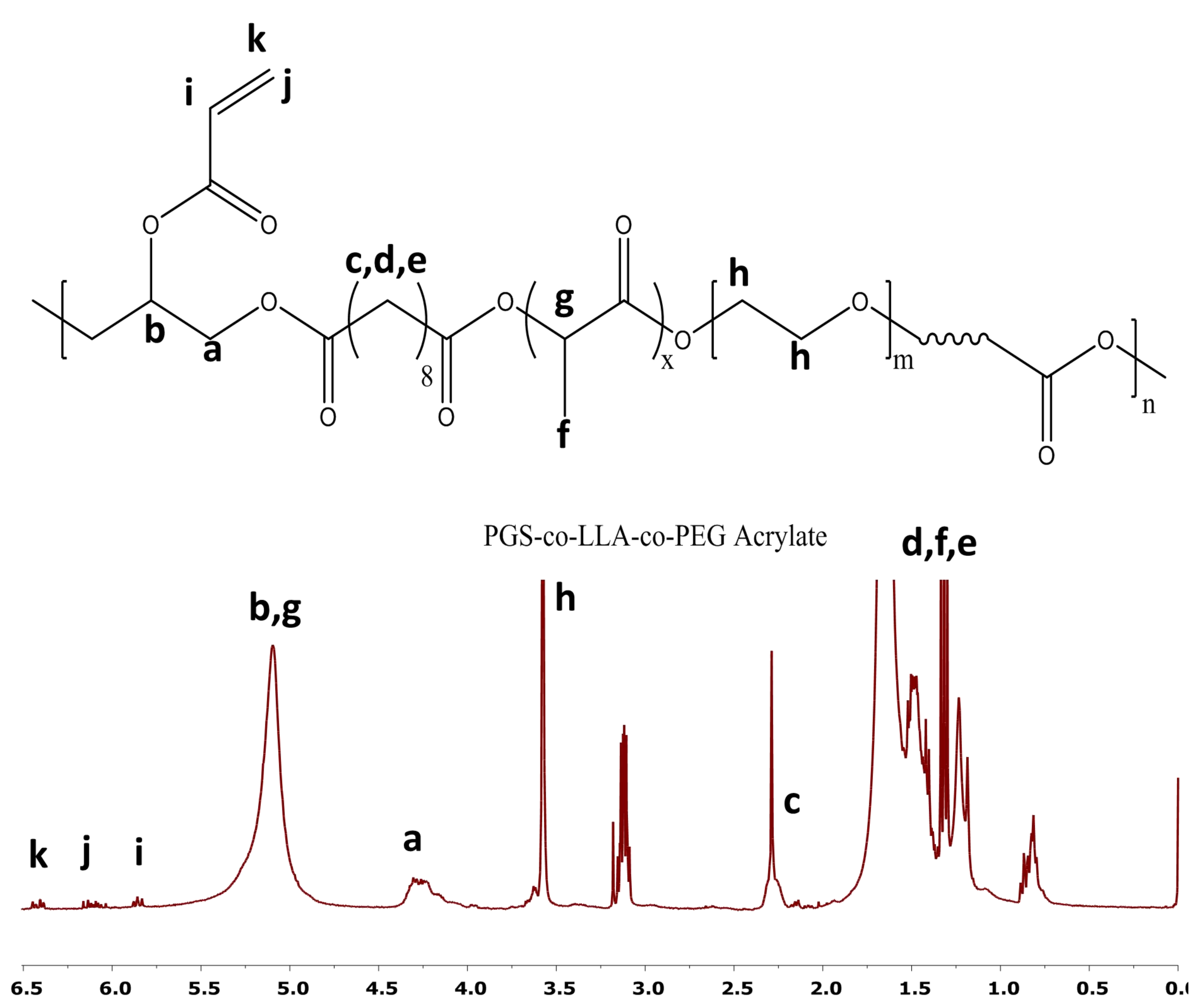

Fig. 6 : H[1] NMR Spectrum of PGS-co-LLA-co-PEG Acrylate

Fig. 7 : Injectable crosslinked PGSLPA elastomer

References & Acknowledgements

1. Turns, M. The diabetic foot: an overview for community nurses. British Journal of Community Nursing. 2012, 17(9), pp.422-433.
2. Brem, H. and Tomic-Canic, M. Cellular and molecular basis of wound healing in diabetes. The Journal of Clinical Investigation. 2007, 117(5), pp.1219-1222.

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Micro-Structural Analysis of Absorptive Glass Mat (AGM) Nonwoven Separators Via X-Ray Computed Tomography Analysis

MICRO-STRUCTURAL ANALYSIS OF ABSORPTIVE GLASS MAT (AGM) NONWOVEN SEPARATORS VIA X-RAY COMPUTED TOMOGRAPHY ANALYSIS

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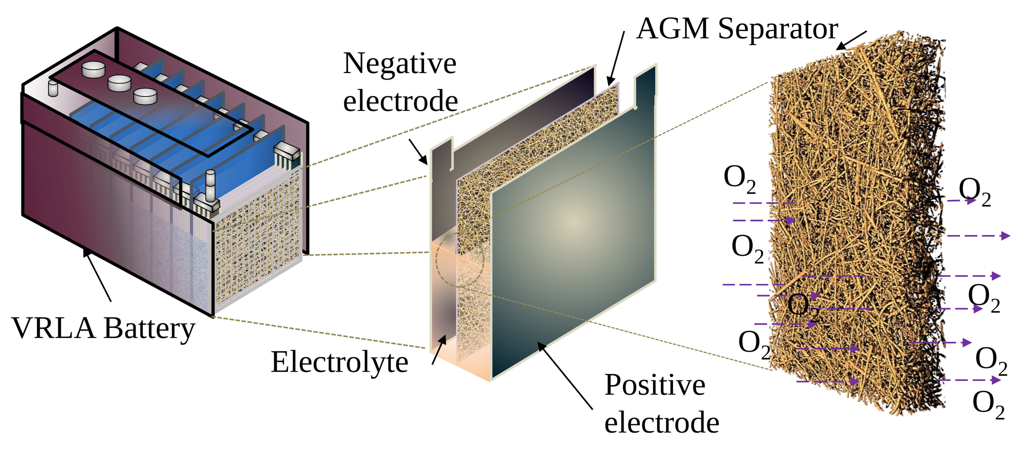
Abstract:

Absorptive glass mat (AGM) nonwoven separator is one of the key components of a valve regulated lead acid (VRLA) battery. It is a well-known fact that the fiber and structural parameters of AGM separator modulate the life-cycle of VRLA battery. This research work is therefore directed towards the characterization and analysis of 3D morphology of AGM nonwoven separators. Specifically, the fiber orientation distribution (FOD), porosity, pore size distribution (PSD) and hydraulic tortuosity of AGM separators were analysed with the aid of X-Ray micro-computed tomography (micro-CT) analysis. In this regard, the images obtained via micro-CT were analysed using commercial software to obtain the 3D morphological parameters. Furthermore, a simple analytical model for computing the hydraulic tortuosity has been proposed and validated with an absolute permeability simulation performed using a commercial image processing software (Avizo®).

Introduction:

The AGM in the VRLA battery essentially comprises of a three-dimensional (3D) network of glass fibers prepared through a conventional wet laying process. Apart from the separation of electrodes, it serves a multitude of functions such as :

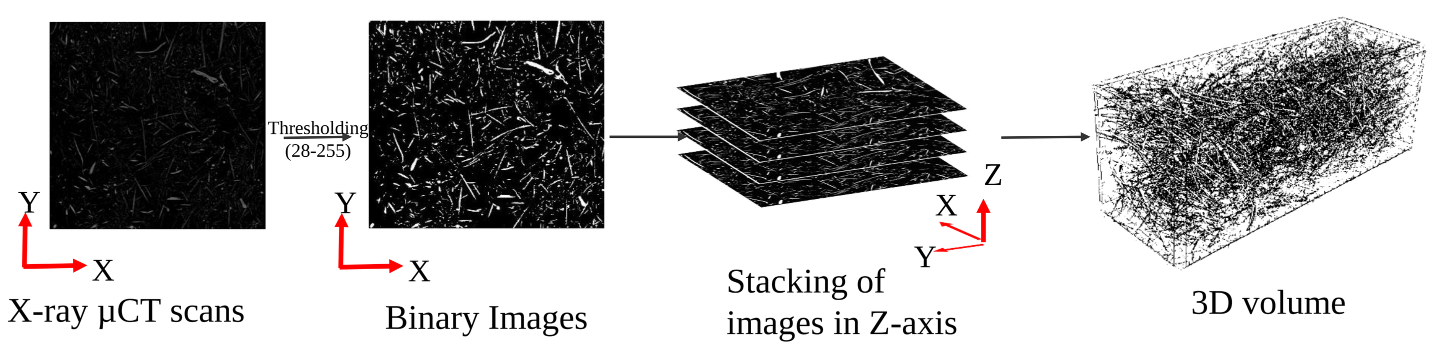
- Retention of electrolyte in a uniform manner
- Promote oxygen recombination efficiently
- Provide the necessary resistance to the plate-group pressure
- Control dendrite growth

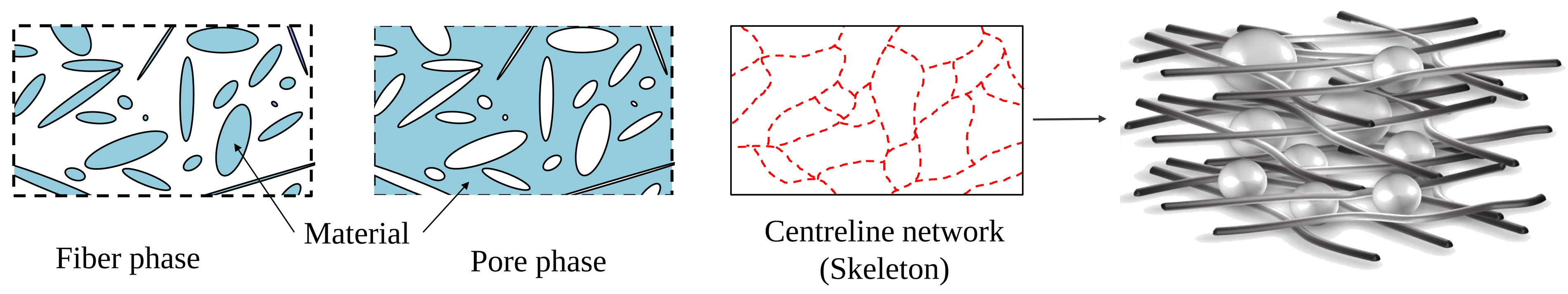


AGM Separator in a VRLA battery[1]

Therefore, it becomes essential to unravel the intricate porous morphology and 3D anisotropy of an AGM separator without morphing the internal structure of the fiber network. X-ray micro-computed tomography (microCT) proved to be a viable non-destructive method to extract the pore size distribution (PSD), tortuosity and the other porous characteristics of AGM separators without the need to modify any structural features.

Experimental Approach:

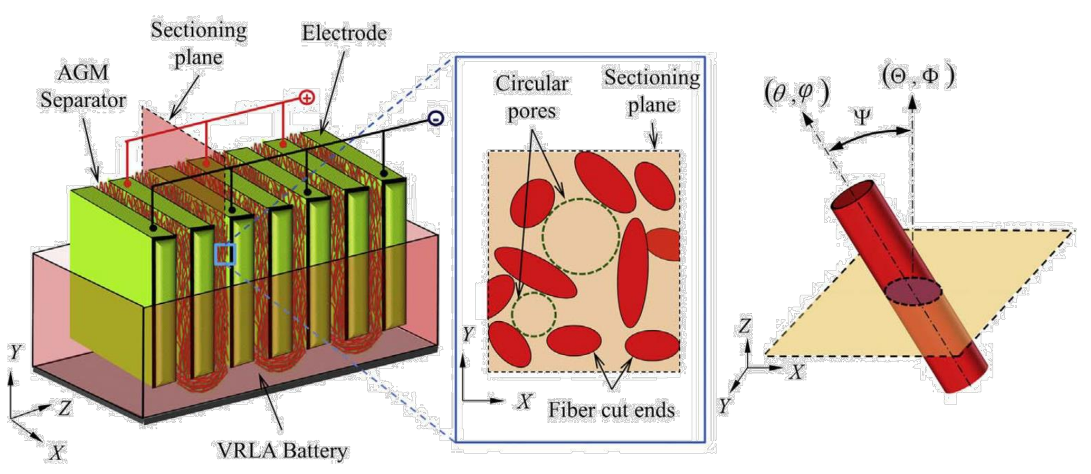




Extraction of pore size distribution

Theoretical Approach:

- Validation of pore size distribution obtained via X-ray microCT was done with existing pore size distribution model[2] where Cumulative probability of finding a circle of diameter "d", moving through an AGM of thickness T_g is given by $F_f(d)$ as



AGM separator and electrodes in a VRLA battery which is sectioned by an imaginary plane displaying magnified view of (a) circular pores and (b) a single fiber cut end.[2]

$$F_f(d) = 1 - \left[\left(1 + \omega d + \frac{\omega^2 d^2}{2}\right) e^{-\omega d}\right]^{\frac{T_g}{d_f}}$$

Where ω is the coverage parameter

$$\omega = \frac{8V_f}{\pi d_f^2} \int_0^{\pi} d\varphi \int_0^{\pi} |\cos\theta \sin\theta|\, \Omega(\theta,\varphi) d\theta$$

- An expression of hydraulic tortuosity was also derived relating it to fiber diameter (d_f), fiber orientation distribution ($\Omega(\theta,\varphi)$), porosity (ε) and absolute permeability (k) of the material[3]

$$\tau = D_h \sqrt{\frac{\varepsilon}{32k}}$$

Where D_h is the hydraulic diameter[4]

$$D_h = \frac{d_f \varepsilon}{(1-\varepsilon) \int_0^{\pi} d\phi \int_0^{\pi} \Omega(\theta,\varphi)\, |\cos\chi|\, \sin\theta\, d\theta}$$

References:

[1] Shukla, S., Kumar, V., Rao, P. V. K., Sharma, S., Sebok, D., Szenti, I., Rawal, A., Kukovecz, A. (2019), Probing the three-dimensional porous and tortuous nature of absorptive glass mat (AGM) separators. *Submitted to Journal of Energy Storage*

[2] Rawal, A., Rao, P. V. K., & Kumar, V. (2018), Deconstructing three-dimensional (3D) structure of absorptive glass mat (AGM) separator to tailor pore dimensions and amplify electrolyte uptake. *Journal of Power Sources*, Vol. 384, 417–425

[3] Epstein, N. (1989). On tortuosity and the tortuosity factor in flow and diffusion through porous media. *Chemical engineering science*, 44(3), 777-779

[4] Mao, N., & Russell, S. J.(2008). Capillary pressure and liquid wicking in three-dimensional nonwoven materials. *Journal of Applied Physics*, 104(3), 034911.

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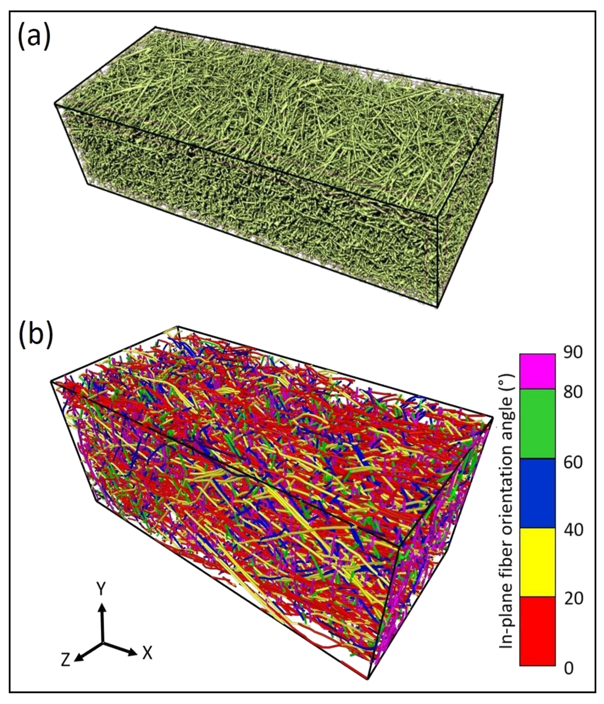
Objectives:

The primary objective of the research work is to analyse the 3D morphological characteristics of AGM separators via X-ray micro-computed tomography (microCT) analysis.

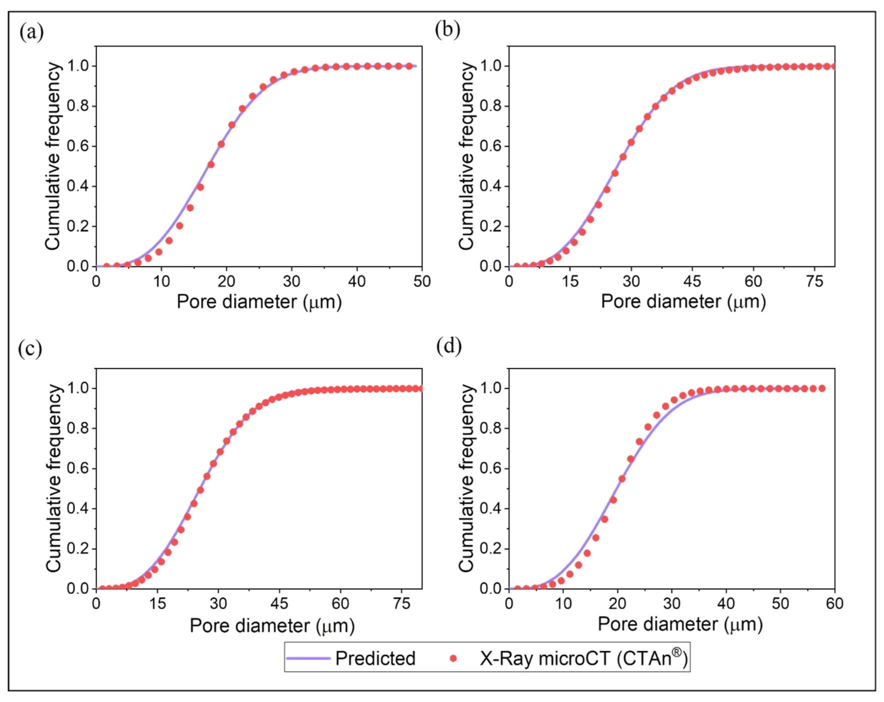
The specific objectives of the research work are given below:

- To obtain and analyse the structural parameters of AGM separators including fiber orientation distribution, pore size distribution, porosity, tortuosity and pore interconnectivity.
- To validate the existing model of pore size distribution of AGM separators using the structural parameters obtained via X-ray µCT analysis.
- To propose a simple model of hydraulic tortuosity of AGM separators.

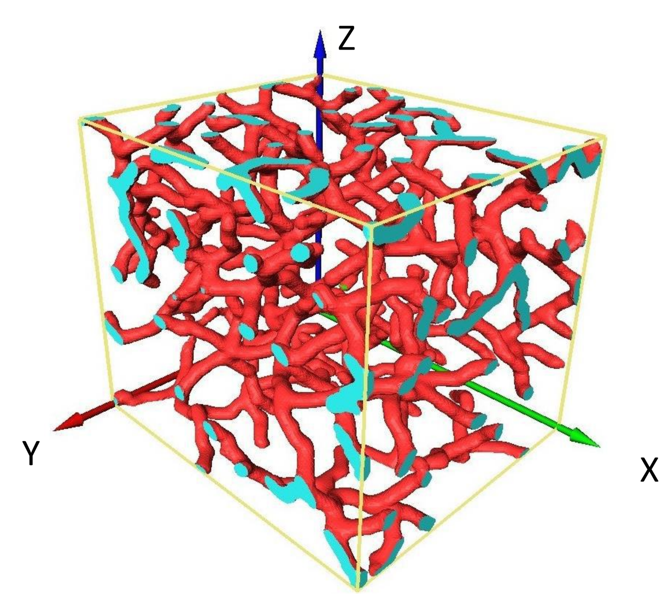
Results Obtained:



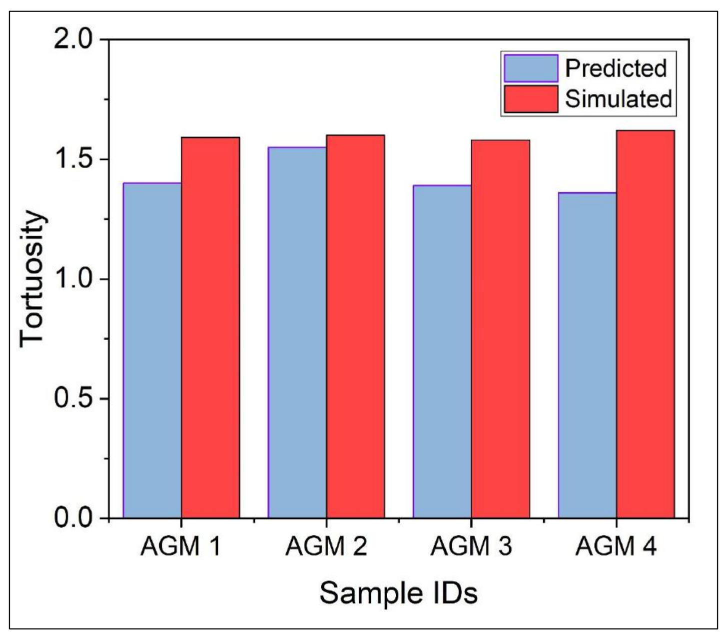
(a) 3D fiber network of AGM separators with (b) fibers colour-coded according to their orientation in the 3D network[1]



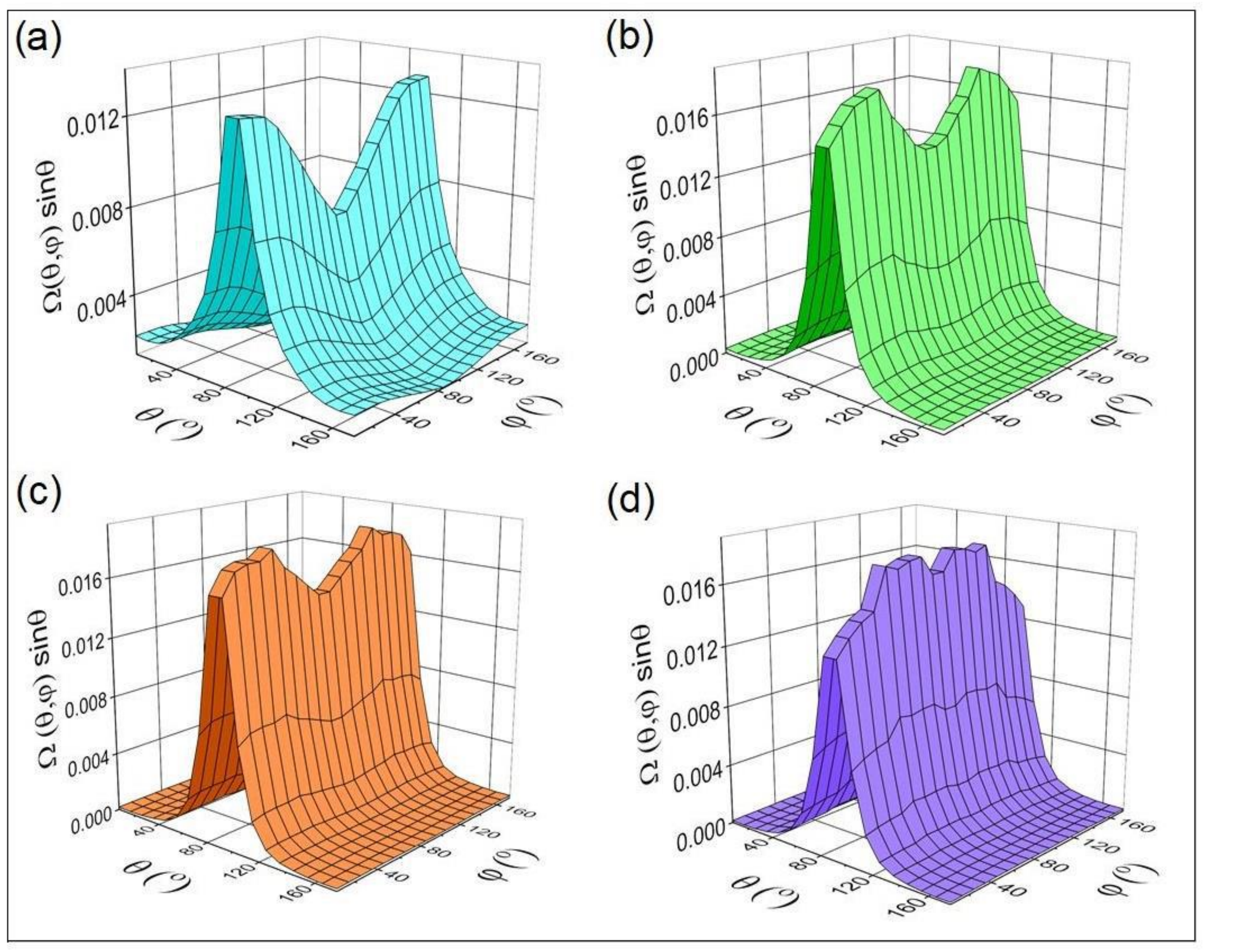
Comparison of predicted PSD with the PSD obtained via X-Ray microCT data of AGM sample (a) AGM 1 (b) AGM 2 (c) AGM 3, and (d) AGM 4[1]



Interconnected porous network obtained via dilation of pore centerlines



Comparison of predicted hydraulic tortuosity with the tortuosity obtained via X-Ray microCT data for four different AGM samples



3D fiber orientation distributions of AGM sample (a) AGM 1 (b) AGM 2 (c) AGM 3, and (d) AGM 4[1]

Summary:

- ✓ X-ray micro computed tomography is an effective technique to obtain a true 3D replica of fibrous structures.
- ✓ A good agreement was obtained between the pore size distribution obtained from X-Ray microCT data and through existing predictive model
- ✓ Hydraulic tortuosity is a function of fiber diameter, fiber orientation distribution, porosity and absolute permeability of the structure. Experimental results were used to verify the theoretical model and a were found to be in agreement.

STUDIES ON EFFECT OF BLEND PROPORTION ON THERMAL BONDED NONWOVENS.

DKTE
Promoting Excellence in Teaching, Learning & Research

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Université de Lille

Introduction : Thermal bonding is the process in which a web consisting of thermoplastic and non-thermoplastic fibers are heated to the melting or softening temperature of the constituent thermoplastic fibers followed by cooling to solidify the bonding area. The thermal bonding process is environmental-friendly, as no latex binder is required. The thermal bonding process consumes less energy compared to foam bonding or hydro entanglement bonding. Through-air thermal bonding involves the use of hot air to the surface of the nonwoven fabric to bind the fibers. Products manufactured using through-air nonwovens tend to be bulky, open, soft, strong, extensible, breathable and absorbent.

Material

The thermal bonded nonwoven fabrics of 120 GSM is produced by using polyester recycled fibre and low melt fiber of melting point 100°C.

Recycle polyester Denier	Low melt fibre proportion (4D) 15 %	20 %	25 %
1.2 D	S1	S5	S9
3.0 D	S2	S6	S10
6.0 D	S3	S7	S11
9.0 D	S4	S8	S12

Testing

Property	Standards	Make
GSM	IS 15891	SDL Atlas, Hongkong
Thickness mm	ASTM D5729	SDL Atlas, Hongkong
Compressibility %	ASTM D5024	SDL Atlas, Hongkong
Compression Recovery %	ASTM D5024	SDL Atlas, Hongkong
Stiffness cm	ASTM D4587	SDL Atlas, Hongkong
Fiber Orientation	----------------	Lenzing, Austria
Breaking Stress Kg	ASTM D2256	Instron, USA
Breaking Strain %	ASTM D2256	Instron, USA
Air permeability $cm^3/cm^2/sec$	ASTM D737	TEXTEST AG, Switzerland

Data was analyzed by using statistical technique ANOVA with two factors using Mintab

Manufacturing Process

Volumetric Opening, Tuft blending & Cleaning (Truetzschler, Germany)
↓
Double Doffer Roller Card with GSM Control System (Truetzschler, Germany)
↓
Crosslapper (Truetzschler, Germany)
↓
4 Chamber Belt Dryer - Hotair, Thermal Bonding (Yamuna, India)
↓
Winding

Results

Property	Recycle Polyester Denier	Low melt fibre proportion (4D) 15 %		20 %		25 %	
Fabric Thickness (mm)	1.2 D	7.9		8.4		8.6	
	3.0 D	9.0		9.1		9.5	
	6.0 D	9.9		10.2		10.6	
	9.0 D	11.1		11.6		11.9	
Fibre orientation in the fabric (MD/CD)	1.2 D	0.46	1.66	0.44	1.71	0.44	1.44
	3.0 D	0.43	1.43	0.52	1.48	0.61	1.54
	6.0 D	0.44	1.44	0.66	1.47	0.26	1.56
	9.0 D	0.33	1.56	0.44	1.44	0.49	1.55
Stress (Kgf) in MD/CD	1.2 D	0.22	0.90	0.26	1.39	0.36	1.67
	3.0 D	0.27	1.04	0.30	1.21	0.51	1.95
	6.0 D	0.45	1.54	0.52	1.95	0.59	1.72
	9.0 D	0.24	0.92	0.42	1.63	0.58	2.13
Compressibility & Recovery of fabric (%)	1.2 D	45.23	77.05	39.50	76.00	38.95	72.14
	3.0 D	42.11	80.23	35.42	78.60	35.80	75.13
	6.0 D	38.91	85.17	36.14	81.18	35.04	77.89
	9.0 D	34.68	87.80	32.40	84.00	29.19	80.18

Conclusion

- Fabric thickness and stiffness is increasing with increase in denier and low melt fiber content.
- Denier and low melt fiber percentage has significant effect on compressibility and recovery property of the fabric. Compressibility and recovery in fabric is better with coarser fiber and less low melt fiber percentage and this is important in wadding application.
- Fiber orientation in fabric is mainly in cross direction CD than the machine direction MD, significant effect is not seen for denier and low melt fiber percentage.
- Breaking stress is higher in CD than MD and it shows momentous effect of fiber denier and low melt fiber percentage. Breaking strain % is higher in MD than CD.
- Bending length i.e. stiffness is very less in MD than CD.
- Air permeability is significantly affected by fiber denier and low melt fiber percentage and shows increasing trend.

Scope of Research

- Exact market application will be identified.
- Knowhow of machine parameters and material characteristics for engineering innovative thermal bonded products and improve existing one.
- Cost saving as finer denier fibre is costlier than coarser one.

Applications


Comforter


Jacket


Mattress

Acknowledgement : The authors gratefully acknowledge EDANA for awarding a student grant to Mr. Ajinkya Powar to participate in NIA-2019, also thankful to Prof. (Dr.) P. V. Kadole Director, DKTE TEI and DKTE Centre of Excellence in Nonwoven for his extended support during research.

Development of Absorbent Core for Evaporative Cooling Garments to Enhance Thermal Protection against Extreme Climates

Akshay Rathi and Dipayan Das

Department of Textile Technology, Indian Institute of Technology Delhi

Abstract:

Thermal discomfort is one of the major challenges that we face during discharge of our duties in hot and humid environments that include but are not limited to mines, foundries, desert regions, etc. The persons working in such environments may also suffer from heat stress which can even lead to death. Heat and moisture management is the key to prevent human beings from heat stress. Heat protective garments alone are not sufficient. Cooling garments are also required to maintain the body temperature while working in extreme climates.

The objective of this project was to study the thermal protective performance of absorbent materials that can be used in evaporative cooling garments.

Introduction: Heat Stress

Ideal core body temperature ≈ 37 ºC

Any significant rise or fall in this temperature is fatal.

$$M - W = K + C + R + E + S$$

where

M is metabolic rate of a human body

W is mechanical work done

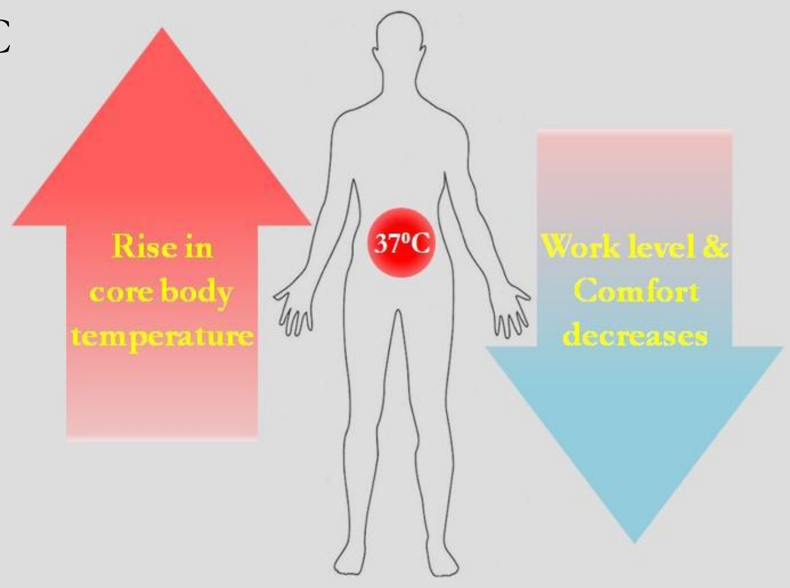
K is dry heat transfer by conduction

C is dry heat transfer by convection

R is dry heat transfer by radiation

E is heat transfer by Evaporation of sweat

S is heat storage



Ideal Body Condition :

Heat Produced = Heat Lost

Heat Stress !

23 ºC
Comfortable working temperature

40 ºC (104 ºF)
Average temperature in India during summers

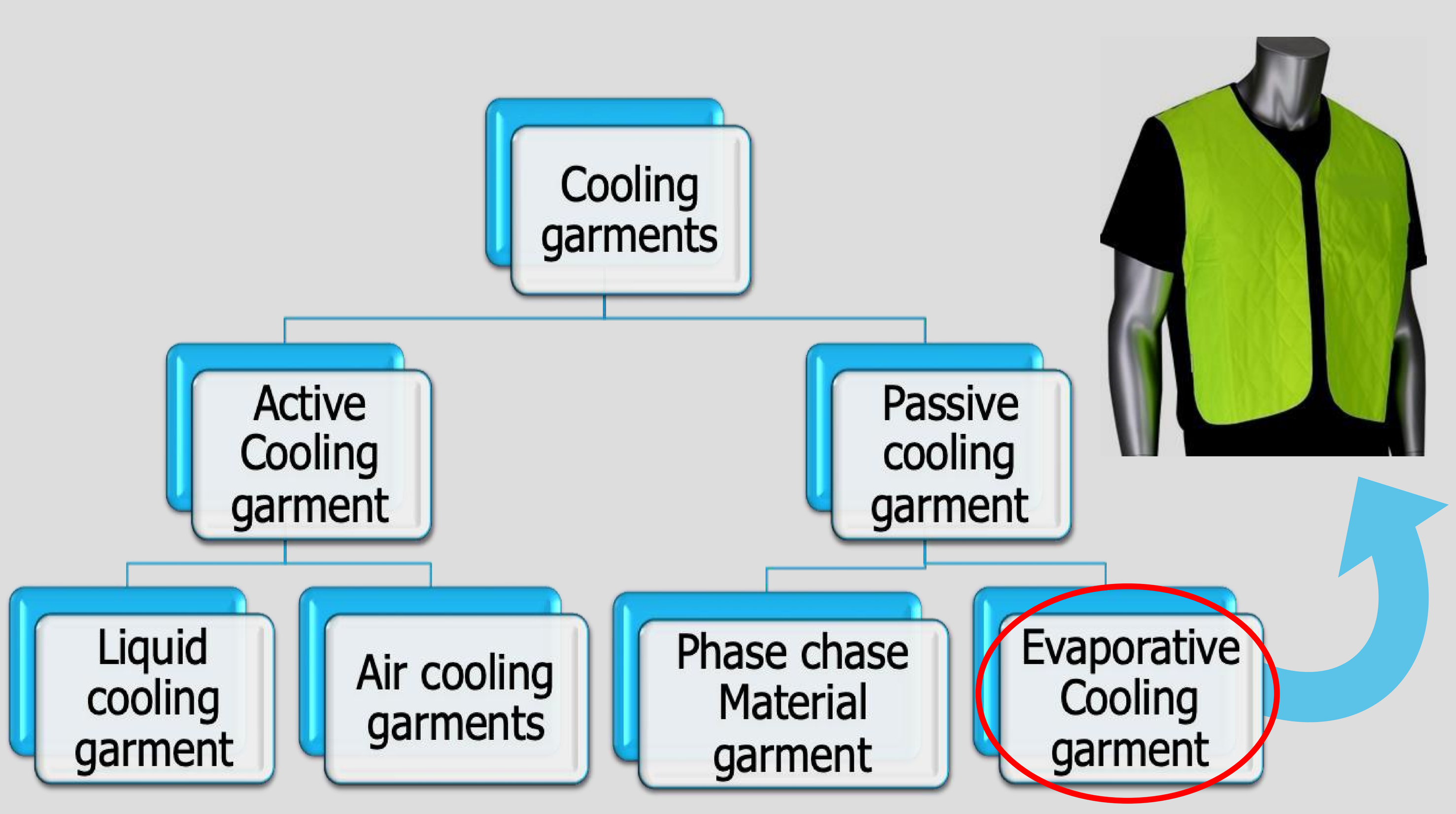
410 mn
Workers working in hot climatic conditions

1% - 3%
Reduction in working efficiency per ºC rise in temperature

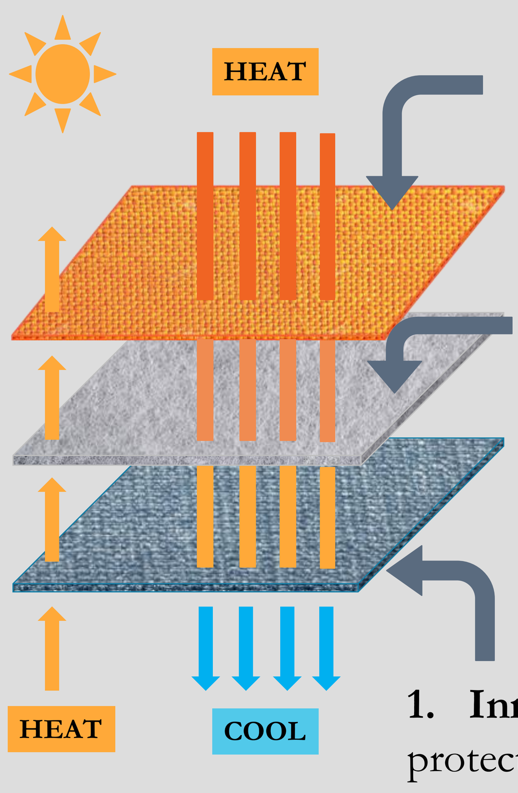
1100
Deaths due to Heat stress in India in 2018

2.5 mn
Patients suffering from HED and MS

Solution: Cooling Garments



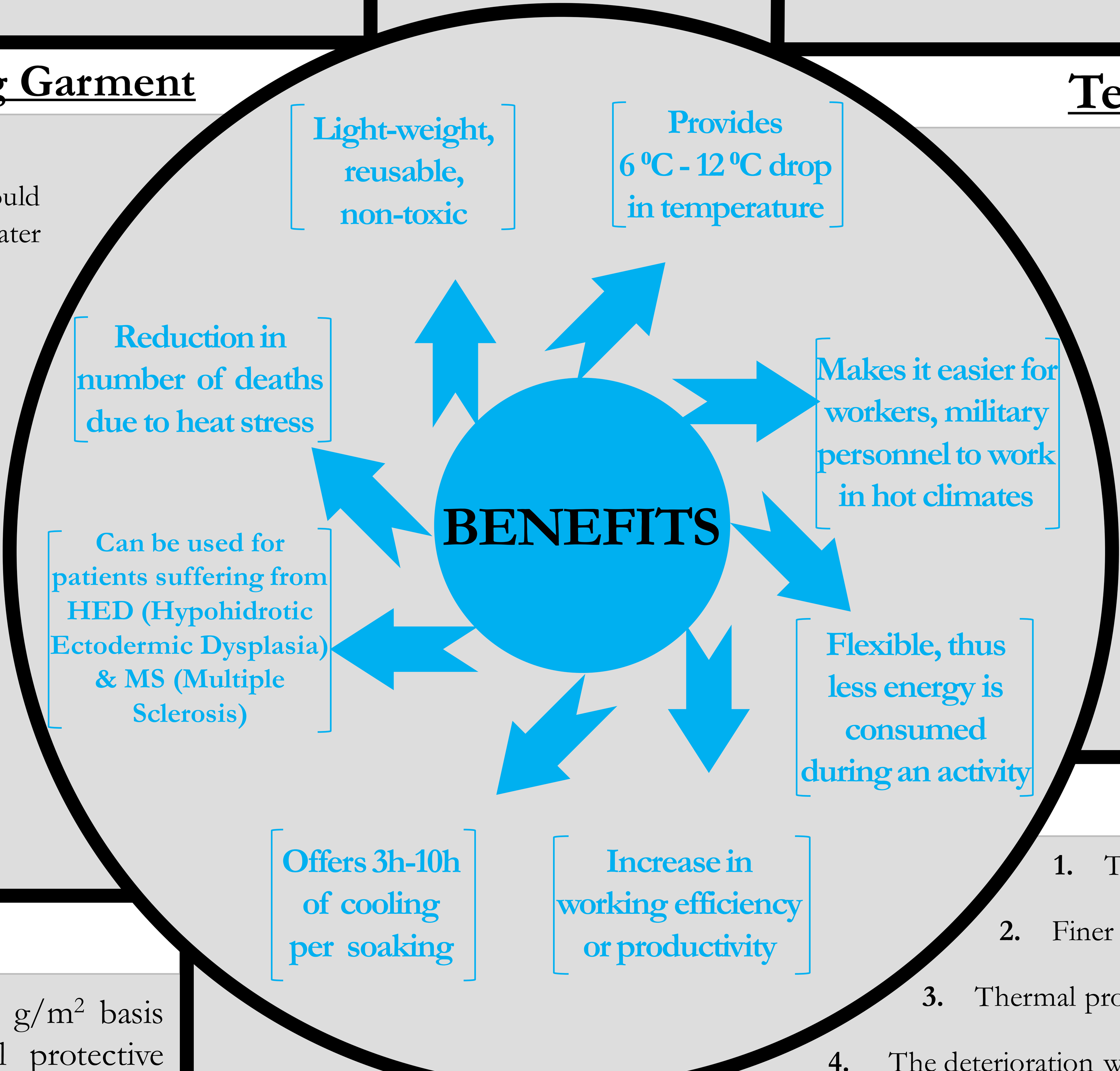
Three-layered Evaporative Cooling Garment



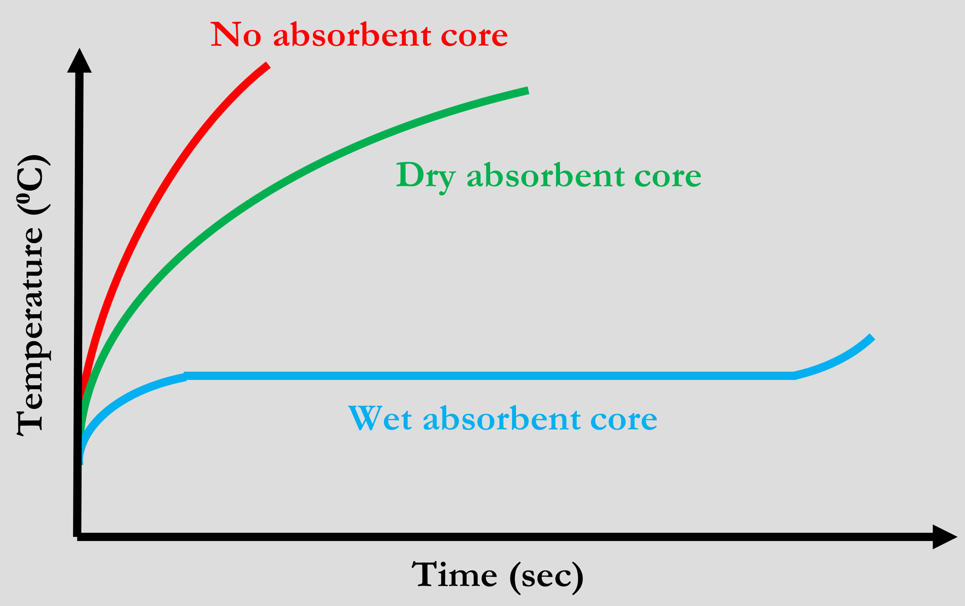
3. Outer Layer – It should allow free passage of water vapor and liquid water.

2. Absorbent Core – It is a porous material made up of mainly super-absorbent fibers (SAF) that can wick, absorb and hold water.

1. Inner Layer – It should protect the wearer from dampness but provide good thermal transfer between wearer and garment.



Testing of Thermal Protection



Key results : Time taken to reach 45ºC; Time taken to reach plateau

Experimental Study

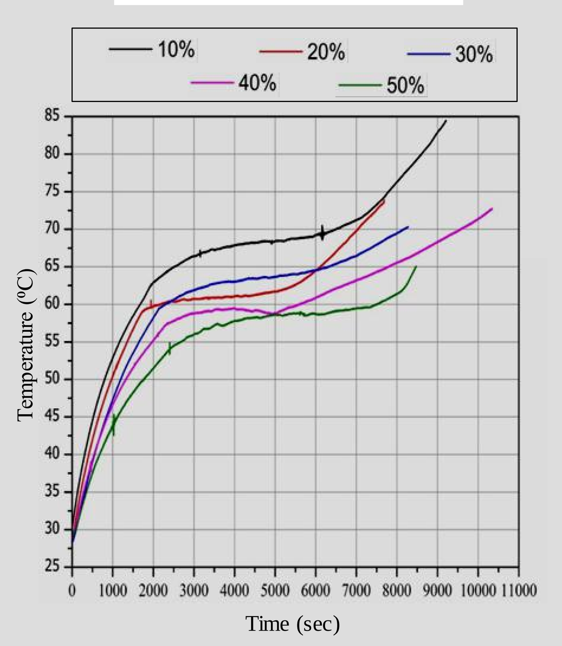
A series of thermal bonded nonwovens of 150 g/m² basis weight were prepared and tested for thermal protective performance.

- ✪ Effect of SAF content (10% - 50%) on thermal protection performance was investigated.
- ✪ Effect of fiber fineness (0.9 denier and 6 denier) on thermal protective performance was examined.
- ✪ Effect of fiber blending (homogeneous mixing and layer-wise stacking) on thermal protective performance was established.
- ✪ Durability of the absorbent cores in terms of consistency over multiple immersion cycles was examined.

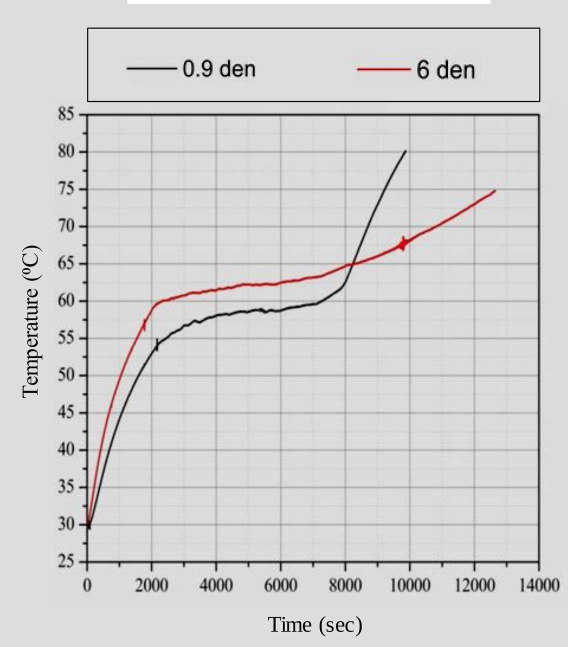
Results and Discussion

1. Thermal protection was longer with higher SAF content.
2. Finer fiber offered 40% better thermal protection than coarser fiber.
3. Thermal protection deteriorated over multiple immersion cycles.
4. The deterioration was less with finer fiber nonwovens than coarser counterparts.
5. The deterioration was less in homogeneously mixed nonwoven as compared to layer-wise stacked nonwoven.

Effect of SAF content



Effect of fiber fineness



Effect of multiple immersion cycles

Effects of fiber blending and fiber fineness over multiple immersion cycles

Specifications of nonwovens	Reduction in thermal protection performance after 10 cycles (%)
0.9 denier homogeneously mixed	29
6 denier homogeneously mixed	31
0.9 denier layer-wise stacked	42
6 denier layer-wise stacked	52

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Thank you for showing your interest in this work.

Graphene Oxide/PANI/PVDF Nonwoven Membranes for Textile Waste Water Treatment

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Aim

To check the effect of Graphene oxide and polyaniline on PVDF nonwoven membrane for the removal of dyes from textile waste water treatment.

Introduction

Water pollution and scarcity are global problems. Indeed, researchers have taken this matter seriously and have begun to find alternative ways of treating wastewater. The conventional method for treating wastewater has been found to be un-economical, and the polymeric materials used were not environmentally friendly. Polyvinylidene fluoride (PVDF) is used due to its significant properties such as good film-forming ability, mechanical strength, high thermal stability, excellent aging resistance and chemical stability. For textile waste water treatment PVDF based membranes have been gaining a great attention by a number of researchers due to its good separation performance.

Research Gap

Most of the previous research work done on chemical method for textile waste water treatment which produce other toxic material that may harmful for our aquatic ecosystem. These chemicals interact with dye molecule and form the complex system that was enable for degradation. By using this advanced techniques, we modified the nonwoven membrane with graphene oxide and polyaniline that act as adsorbent for dye material. These chemical techniques are not commercially suitable because it generate high amounts of sludge and by products. Due to this, these methods can not be relied heavily for the textile waste water treatment.

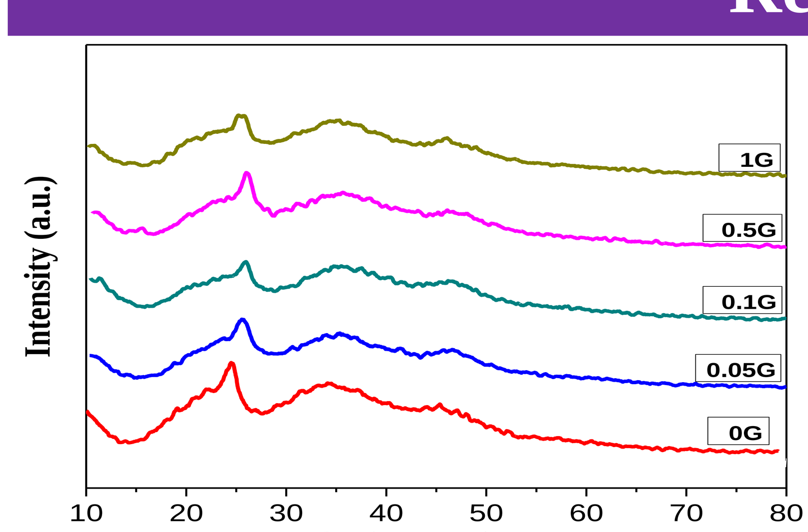
Materials and Methodology

- Oxidation of natural graphite powder was performed for preparation of GO by using modified hummers method with removal of $NaNO_3$ from the reaction mixture.
- PANI (3wt. %) and GO were dissolved to DMF (85wt.%) and then solution was stirred for 24 hours at 59 ^oC. Degassing was done by keeping the solution into vacuum oven at 40 ^oC for 1 hour.
- Polyvinylidene fluoride nonwoven membrane was dipped into the above solution for two hours and dried it into vacuum oven at 60 ^oC for 2 hours.
- Then coated membrane was dipped into the distilled water for 24 hours during this time, the hydrophilic additive act as pore former and dissolved in distilled water to form the porous membrane for the filtration process.

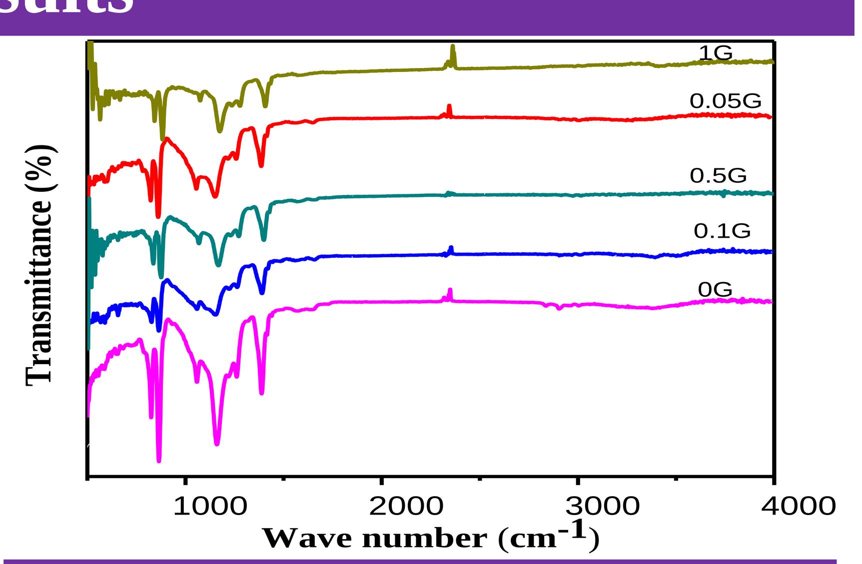
Table 1 Code of PANI-GO composite

Code	PANI (Wt %)	GO (Wt %)	DMF (Wt %)
0.05G	3	0.05	85.0
0.1G	3	0.1	85.0
0.5G	3	0.5	85.0
1G	3	1	85.0

Results



XRD of PVDF/PANI/GO composite membrane



FTIR of PVDF/PANI/GO composite membrane

Codes	Td	Temperature at: 5% wt. loss	10% wt. Loss	Max.wt. Loss	Residue (%)
0G	460	460	490	495	12
0.05G	463	484	499	499	21
0.1G	467	452	501	501	28
0.5G	469	474	505	505	30
1G	470	370	507	507	31

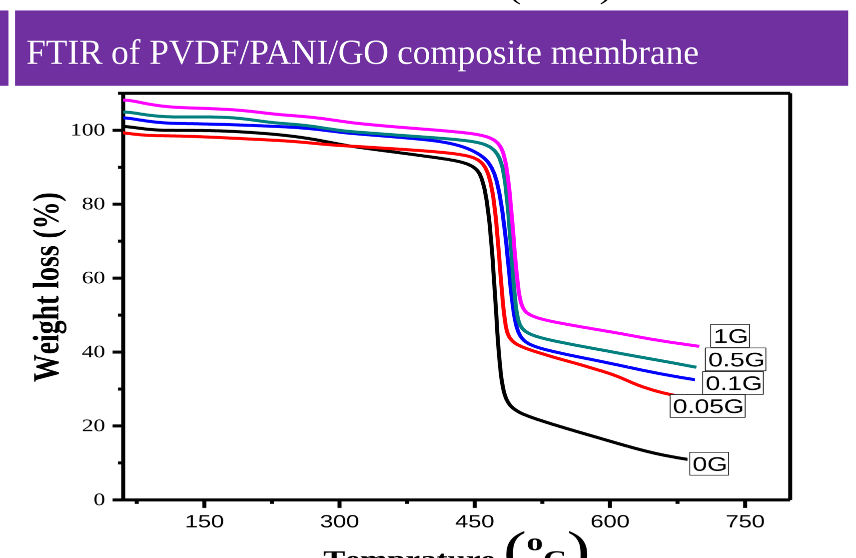


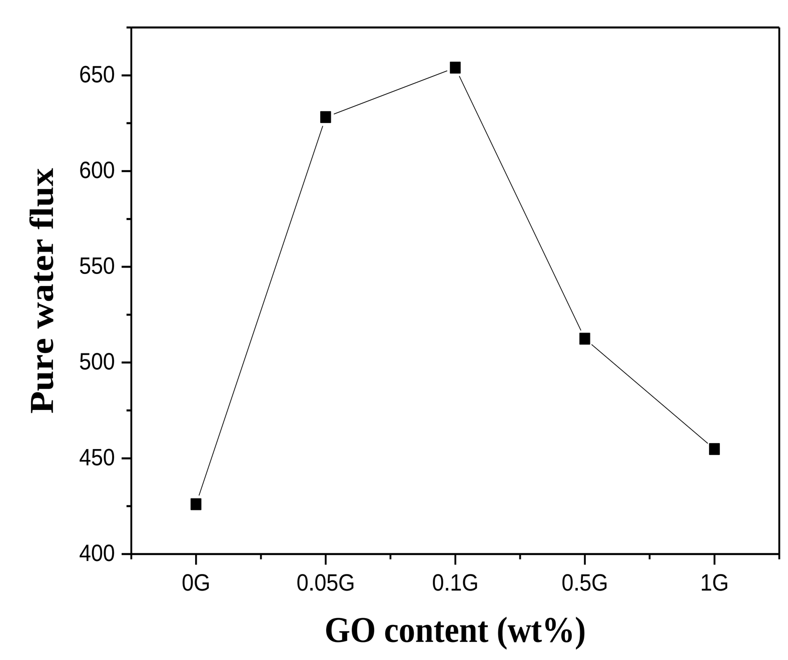
Table 2 TGA calculated parameters of GO composite membrane

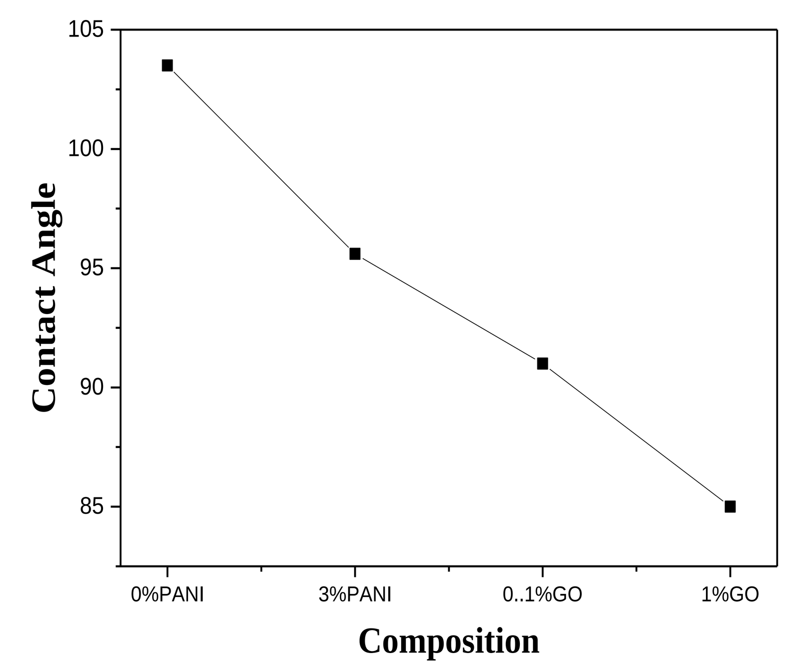
Industrial Scope

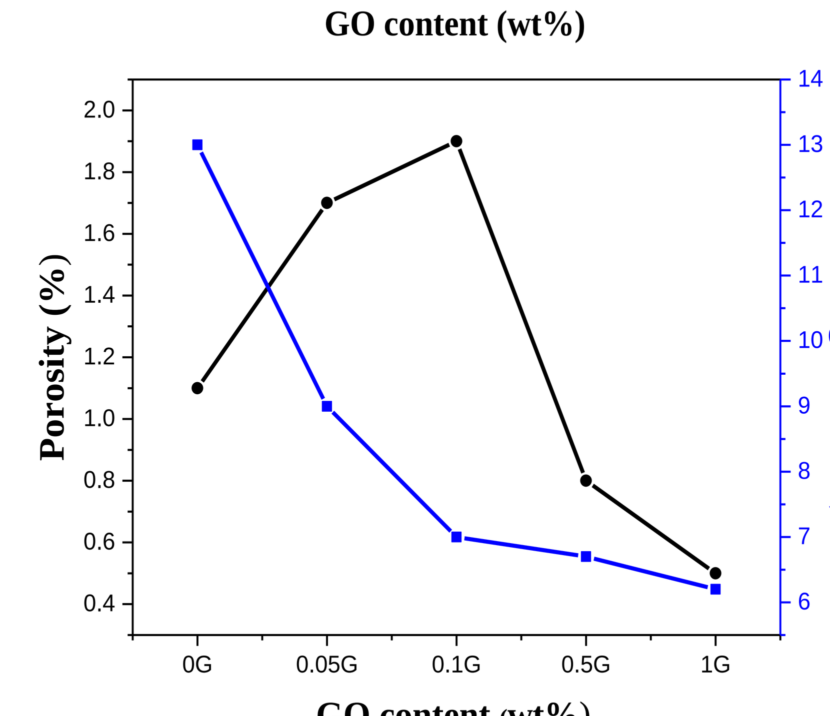
Followed by rapid development of the textile industries since 19th century the dyeing technology is thriving ever since. However, its progress is followed by lack of responsibility and knowledge in treating the dye-containing wastewater. There are some emerging technologies in treating such kind of wastewater, where membrane technology is one of those technologies that has uniqueness in the performance of separating dyes from wastewater, accompanied with small amount of energy. The development of membrane technology is one of several eco-engineering developments for sustainability in water resource management.

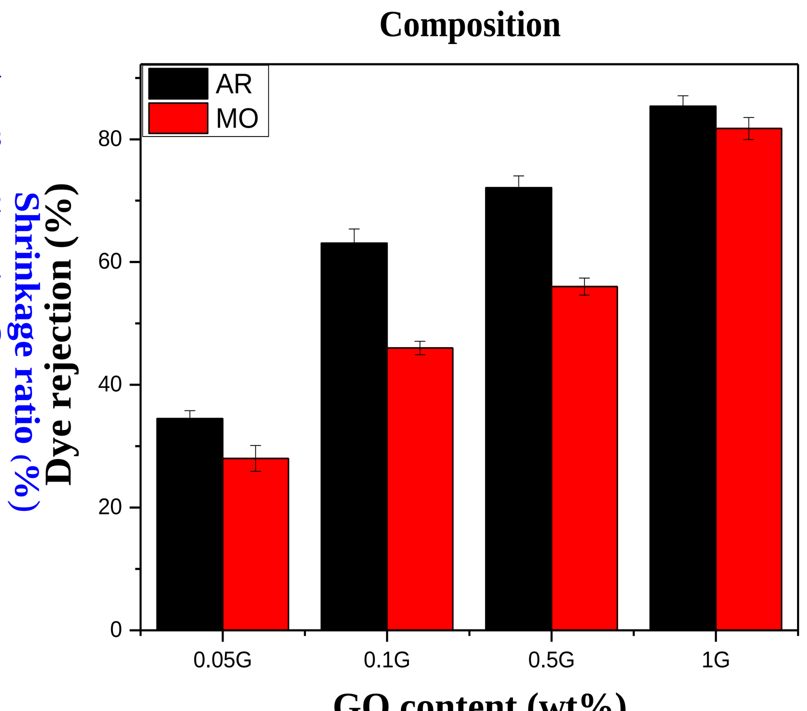
Permeation Studies

- Addition of GO resulted in enhancement of the hydrophilicity, fouling recovery ratio and mechanical strength.
- 0.1wt% of GO exhibited high water flux and high rejections of methyl orange and alora red about 97%.
- These results imply that and PVDF/PANI-GO membranes can be used to resolve the problems of waste water such as textile dyes removal.









Permeation Studies of GO Composite Membrane

Sample	Pure water flux(mLcm^{-2} h^{1})	Fouling recovery ratio (%)	BSA Rejection (%)	Dye rejection (%) Alora Red	Dye rejection (%) Methyl Orange
P0	112.5±1.22	33.3±0.45	38.6±0.67	34.5±0.2	28±0.11
P1	300±1.37	77.7±0.24	44.3±1.22	63.09±0.61	46±1.46
P2	356.25±0.55	89.4±1.17	51.32±0.14	72.13±1.22	56±1,23
P3	418.75	94.7±0.67	73.8 ±1.04	85.4±0.54	81.76±0.15
0.1G	494±0.28	98.1±1.17	83±0.45	97±0.38	93±0.67

Table 3 Pure Flux, Dye Rejection and Fouling Recovery Ratio of composite membranes

Conclusions

PVDF based membrane modified with graphene oxide is highly desirable for removing dyes from textile waste water because it has the advantages of energy efficiency, easy processing and low maintenance cost. This study investigated the applicability of membrane distillation (MD) to treat dyeing wastewater discharged by the textile industry.

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NC STATE UNIVERSITY

Fundamental Study of Polymer Compatibility of Polymer Blends and Their Effects on Melt-Spinning Process and Fiber/Nonwoven Properties

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Objectives

Study polymer-polymer interactions in polymer blends and relate their impacts with fiber formation process and structure/properties of fibers and nonwovens.

- Evaluate effects of materials and processing parameters on polymer-polymer interactions in blend
- Investigate effects of polymer blend compatibility on fiber spinning process, fiber structure and properties
- Investigate nonwoven properties of selected blend systems

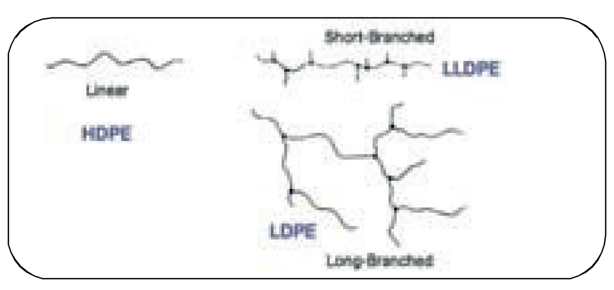
Research Approach

Polymer blend compatibility affected by:

Material Factors

- Chemical Composition
- Chain Configuration
- Molecular Weight/Viscosity

Chemically similar or different structure

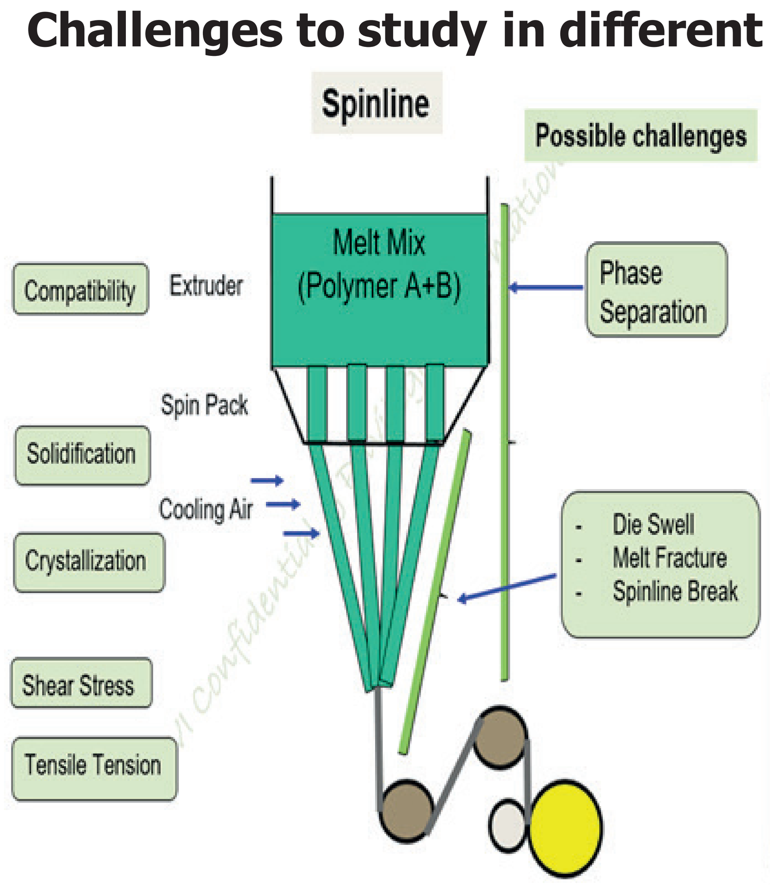


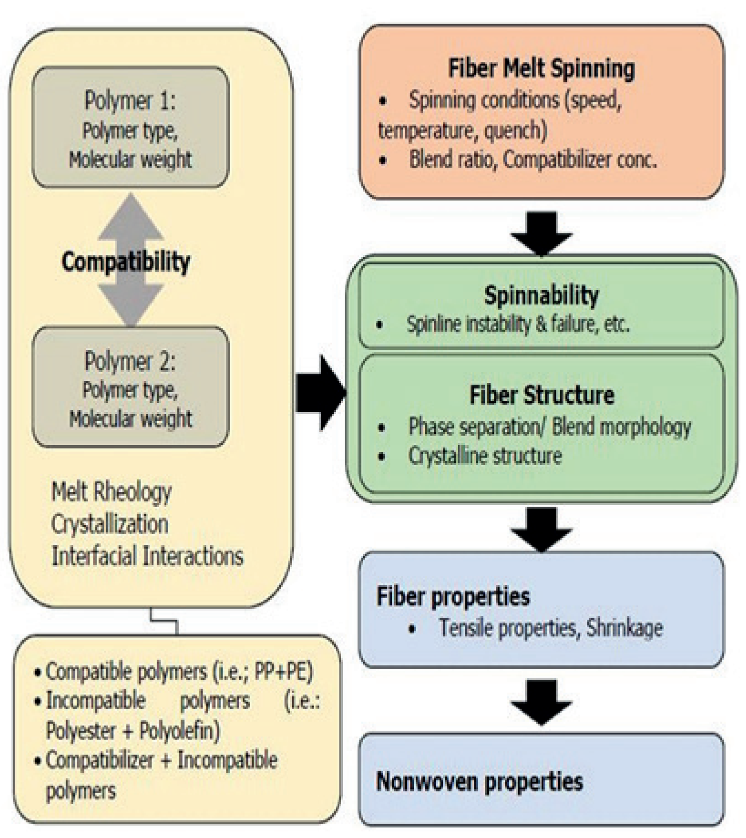
Processing Factors

- Temperature
- Throughput
- Quench
- Spinning Speed

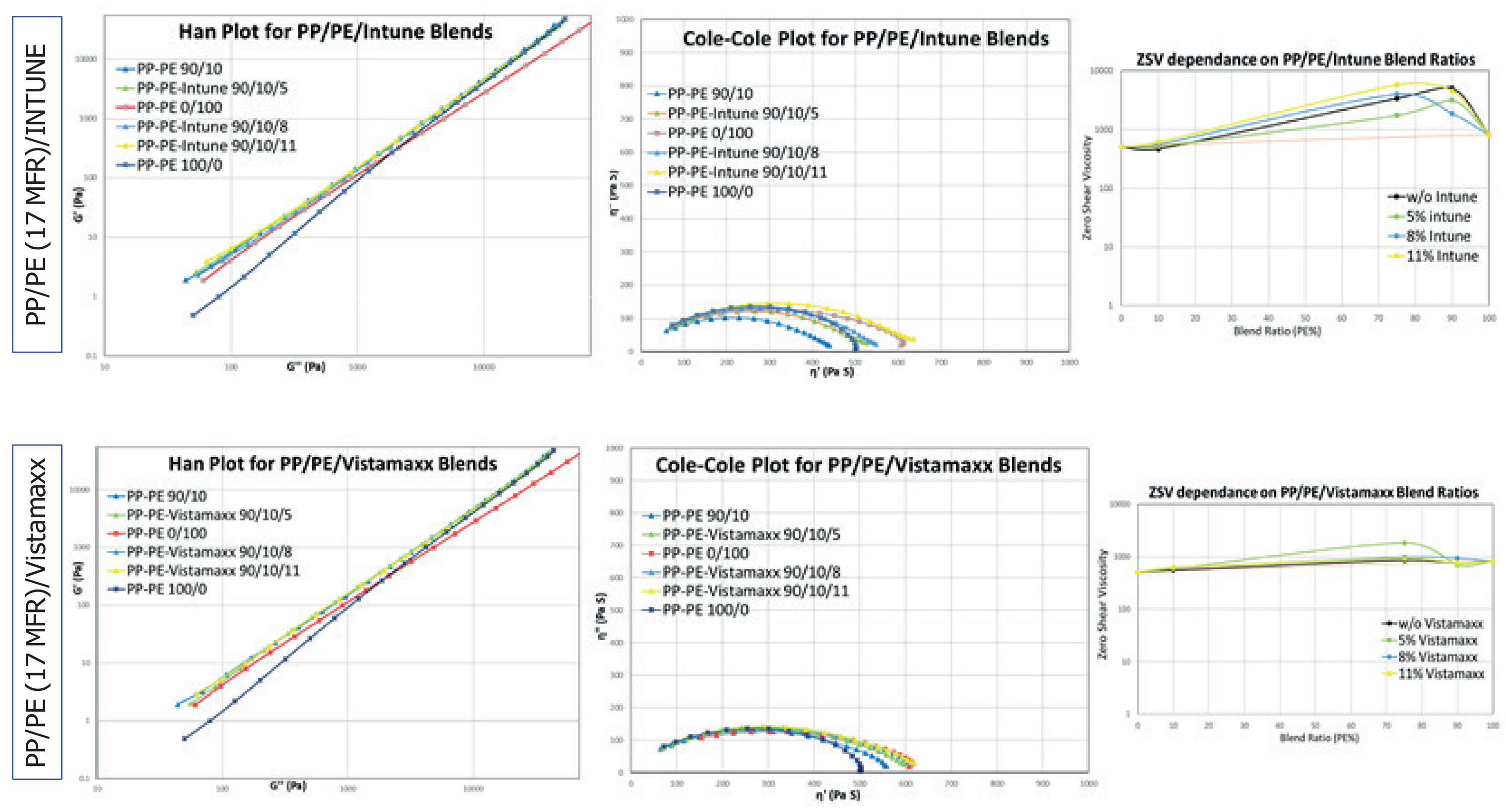
⇒Viscosity
⇒Shear rate
⇒Crystallization
⇒Solidification

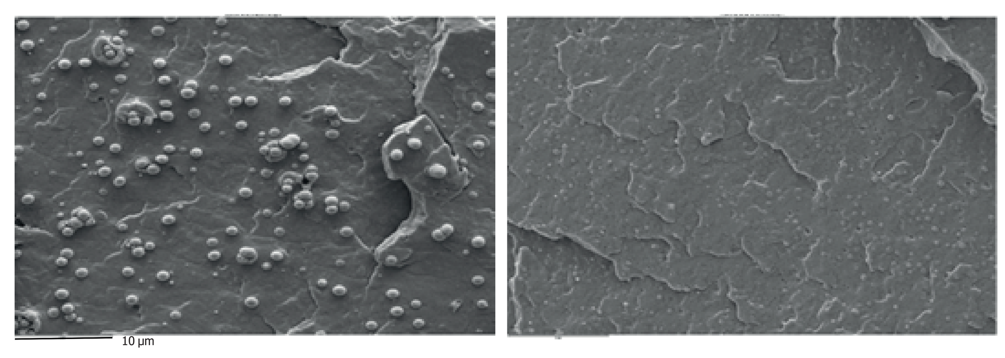
Challenges to study in different stages of fiber spinning:



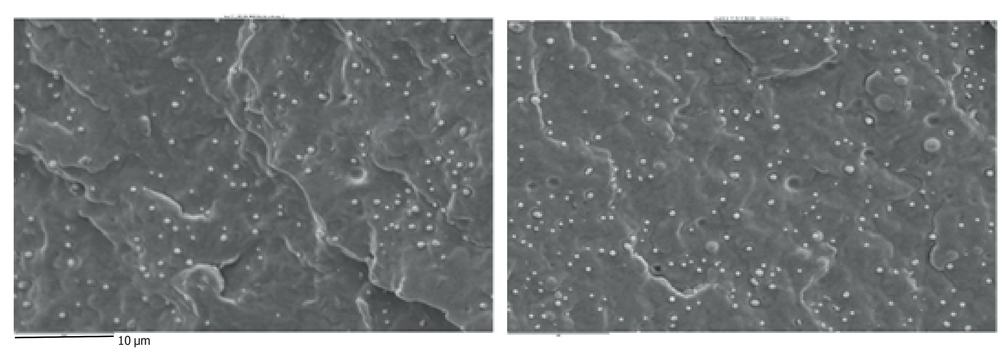


Results





PP/PE 90/10 Blend without (left) and with 5% INTUNE (right)



PP/PE 90/10 Blend without (left) and with 5% Vistamaxx (right)

Figure: Compounding set up

Conclusion and Future Work

- PP/PE blends are mostly incompatible with probable compatibility of PP/LLDPE blends with 90/10 blend ratio.
- Investigated blends of a spunbond grade PP and an LLDPE (MFR 17) with two different compatibilizers (INTUNE™ D5545.00 and Vistamaxx™ 6202).
- A significant reduction in PE droplet size in the PP dominant blends (PP/PE 90/10) with INTUNE incorporation.
- Vistamaxx does not contribute to any significant improvement in the rheological and morphological properties of the PP/PE blends.
- The blends approach miscibility when the PE% of in the system is below 25%.
- Analyze fiber structure and properties of the spun fibers, select materials for Polyolefin/Polyester blend system.

THE NONWOVENS INSTITUTE

MELTBLOWN FIBRES CONSTITUTING SM$_x$S NONWOVEN FROM 100% RECLAIMED SPUNMELT NONWOVEN VIA IN-LINE METHOD

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INTRODUCTION

There has been a desire to produce ecologically friendly products comprised of increased sustainable content in order to reduce the content of petroleum based materials. This concept should not be understood as to use materials directly coming from natural sources but also sustainability can be considered as any product or article reduces petroleum based stocks.

During the production of polypropylene(PP) nonwoven(NW) fabrics, significant waste PP is generated during start-up process, from trimming left when the NW web is slit to customer's specification, and from rolls that may have been slightly damaged or otherwise out of specifications. However, since this is very clean PP it can be remelted for recycling back to through spunbonding process. Recycle thus meets two goals, saving pf cost of wasted PP and reduced solid waste to downgrade the natural environment.

DETAILS OF THE WORK

There has been attempts to convert virgin spunbond grade polymers, more specifically recycled NW granules into meltblown grade through reactive extrusion systems; however there has been several main challenges;

- impurity level of granules,
- non-controllable rheological behaviour of polymeric substrate
- non-homogeneous web formations.

With the present development it is possible to convert spunmelt NW waste and streams, preferably SMxS types into meltblown fibres via a in-line method during production of SMxS NW for possible disposable hygiene applicationns with help of radical forming extrusion reaction.

The aim of this work is to produce meltblown fiber from spunmelt reclaimed granule via in-line method constituting SMxS type NW.

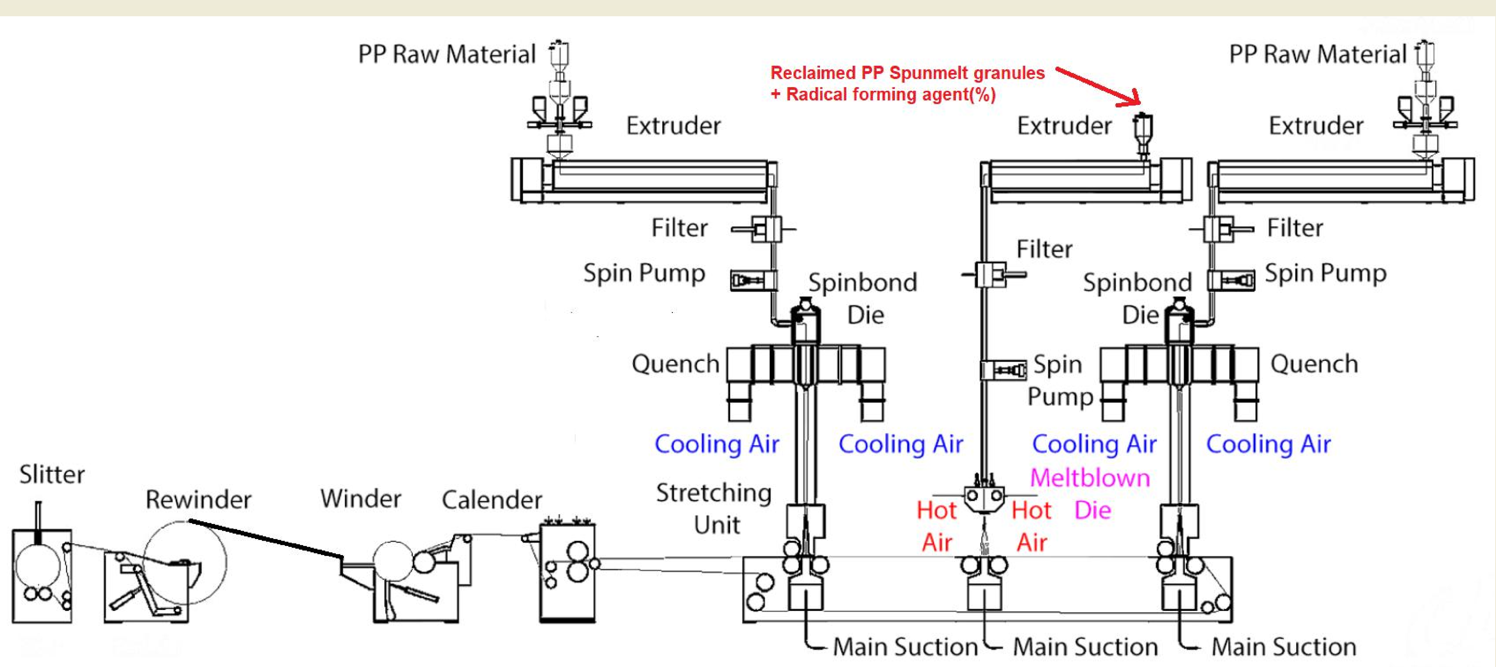

Figure 1. A general scheme for project proposal to produce SMxS NW which contains meltblown fiber from reclaimed spunmelt NW granule.

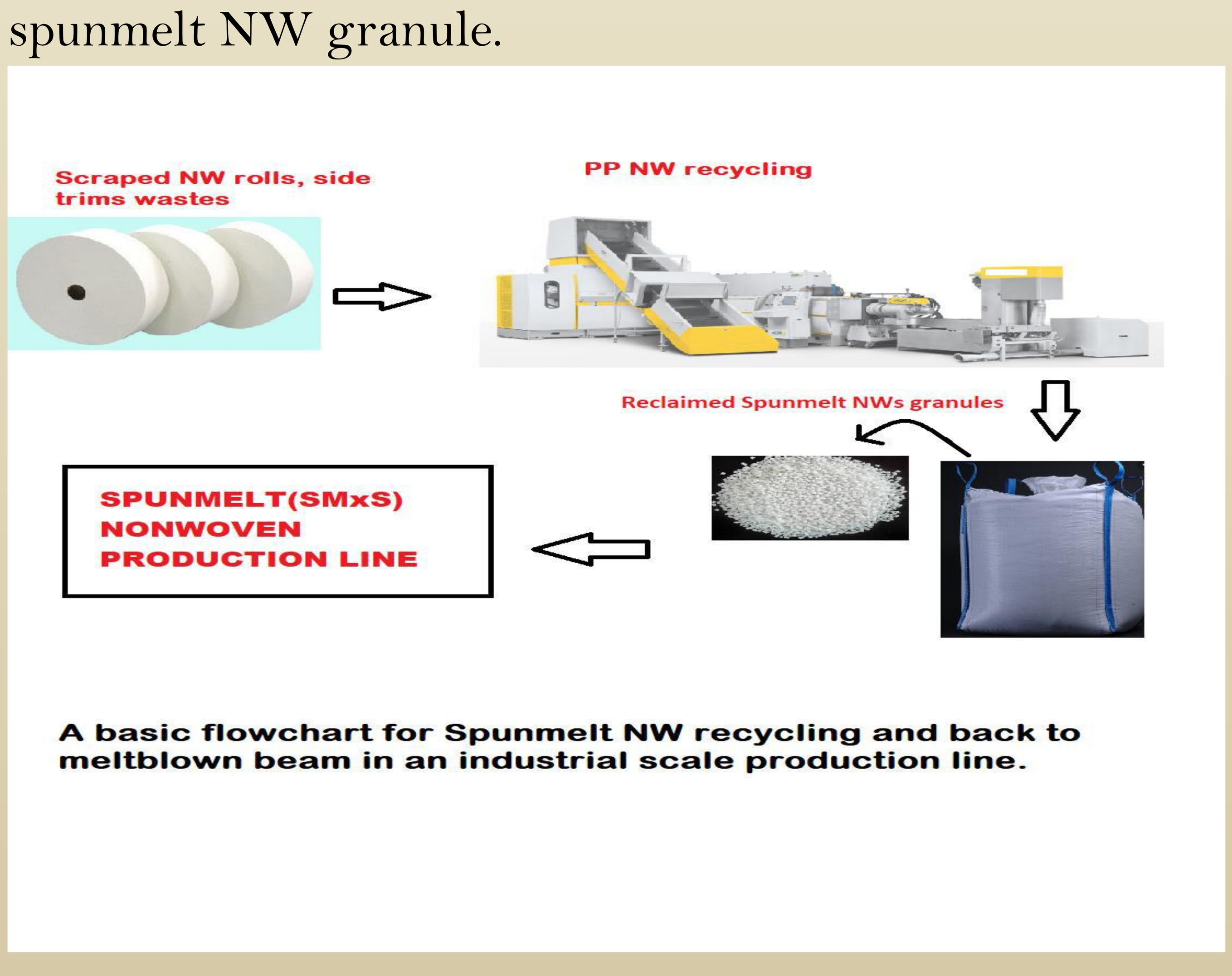

Figure 2. A basic flowchart for Spunmelt NW recycling and back to meltblown beam in an industrial scale production line.

RESULTS

One of the important articles for a disposable diapers is leg cuff NW which is expected to present high liquid barriers and formulated in terms of fibre types mostly including high amount of fine meltblown layers. Throughout the present work we developed a procedure industrially to convert spunmelt NW into granules which is called reclaimed NW without any additivity like stabilizers etc. Then, these reclaimed pellets are subjected to vis-breaking process to form a meltblown fire via line method up to 100% and deposited on previously produced spunbond layers in order to prepare SMxS composite NW and thermally point bond afterwards.

SAMPLE ID	Hydrohead (mm-water) ontime @10mbar	Hydrohead (mm-water) 3-month aged @10mbar	Maket test
Hayat 100%Recycle Leg Cuff Regular White 14gsm Single layer Maxi size ÇB11	210-240	190-210	187 - front/back leakage
Hayat Reference Leg Cuff Regular White 14gsm Single layer Maxi size ÇB11	180-210	160-190	181 - front/back leakage

Table 1.Comparation of Hydrohead(mm-water) values of SMxS NW from project and current mass production.

RF5 08.10.2018 18.06.1184 14gsm	CD							MD						
	E MOD	SEC %1	SEC %2	%5 N	%10 N	Fmax	E Break	E MOD	SEC %1	SEC %2	%5 N	%10 N	Fmax	E Break
Aging date:10.01.2019	115,80	122,30	122,30	10,30	32,60	12,30	66,10	880,10	747,90	747,90	1,20	3,10	28,70	48,50
Ontime measurements	136,40	150,06	150,06	9,43	30,21	13,43	74,76	579,10	568,41	568,41	1,92	4,20	30,23	59,68
change (%)	-17,801	-22,697	-22,697	8,457	7,208	-8,963	-13,174	34,201	23,997	23,997	-64,571	-37,637	-5,188	-22,924

27.08.2018 Hayat Referans 14gsm Leg Cuff	CD													
	E MOD	SEC %1	SEC %2	%5 N	%10 N	Fmax	E Break	E MOD	SEC %1	SEC %2	%5 N	%10 N	Fmax	E Break
Agign date:11.01.2019	121,04	121,83	121,83	11,60	35,54	11,91	66,31	978,11	833,46	833,46	1,04	2,59	28,83	49,51
Ontime measurements	188,50	168,75	168,75	10,15	32,04	13,39	74,19	558,70	565,72	565,72	1,82	4,02	31,45	57,50
Change (%)	-35,79	-27,8	-27,8	14,32	10,95	-11,09	-10,62	75,07	47,33	47,33	-43,07	-35,51	-8,31	-13,89

Table 2&3 Comparation of ontime and aging mechanical testing of SMxS NW from project and current mass production.

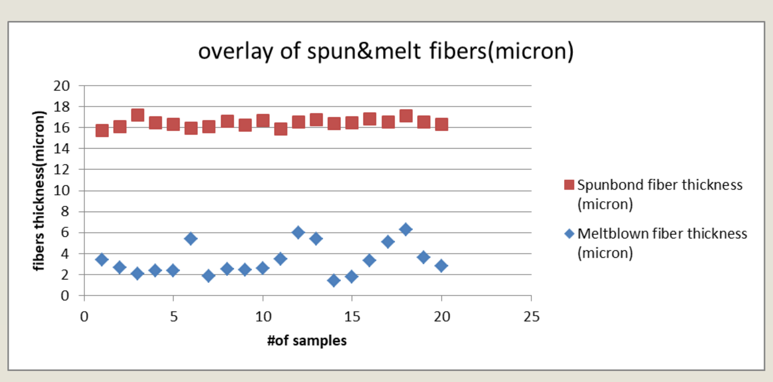

Table 4. An overlay curve of spubond fibers and meltblown fibers obtained from SMxS NW from project.

CONCLUSION REMARKS

Through this industrial scale project developed from pilot line environment we can conclude below given points;

- Recycling of spunmelt nonwoven composite internally
- Production of meltblown fibres from spun grade reclaimed material up to 100%
- A variety of fine fibre production which constitute a fibre gradient would be reason for improved barrier properties
- A way of sustainable nonwoven production which reduces petroleum based sources
- A ecological friendly production

Sächsisches Textilforschungsinstitut e.V.

An-Institut der Technischen Universität Chemnitz

rCF-Organic Sheet

Thermoplastic composites from recycled carbon fibres

Purpose

- Continous production of organic sheets based on novel textile semi-finished materials
- Use of carbon fibre waste and reclaimed carbon fibres in blends with thermoplastic staple fibers for production of hybrid nonwovens
- Complete Impregnation and full consolidation of organic sheets based on hybrid nonwovens

Experimental

- Development of thermoplastic hybrid nonwovens out of recycled carbon fibres and PP-, PET- und PA6-fibers
- Production of carded and airlayed nonwovens with area weights between 100 – 500 g/m²
- Used mixing ratio 40 wt.-% carbon fibers and 60 wt.-% thermoplastic staple fibers
- Comparsion of different manufacturing processes for organic sheets out of the hybrid nonwovens

Results

- Purchase of a compression molding system for continous organic sheet production out of hybrid nonwovens

Technical Data

- 6 unwinder for textile stocks or thermoplastic films
- Dipping edge mold 610 mm working width
- Hydrauilc press with max. 2000 kN press force
- Temperature range up to 450 °C
- Positioning accuracy ± 0,02 mm
- Position and pressure controlled or combined managment system

Fig. 1: Nonwoven production line at STFI

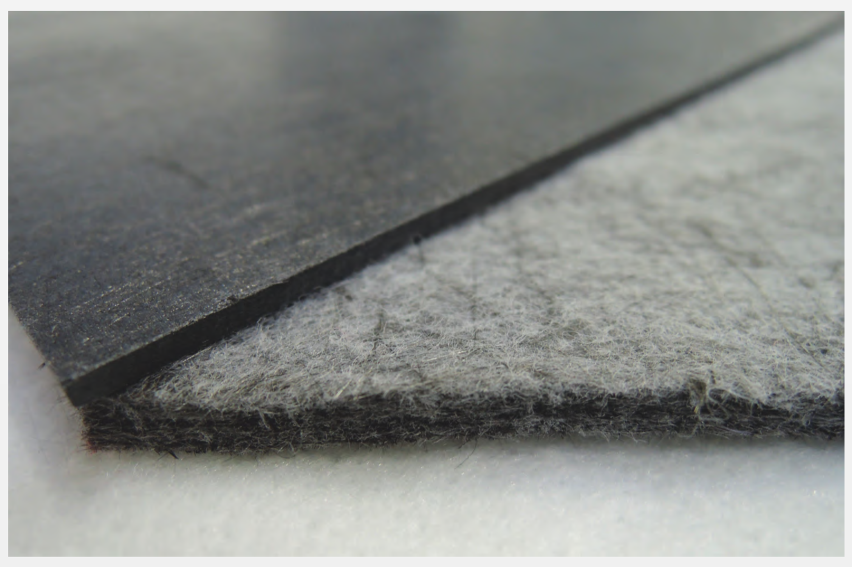

Fig. 2: Organic sheet (left), hybrid nonwoven (right)

ZENTRUM FÜR TEXTILEN LEICHTBAU

RUCKS

Tab.1: Mechanic values of PA6-based rCF-Organic sheets

Specific value	Value	rCF-Organic sheet
Tensile strength (MD)	[MPa]	325
Tensile strength (CD)		620
Tensile Modul s (MD)	[GPa]	18
Tensile Modulus(CD)		40
Flexurale strength (MD)	[MPa]	340
Flexurale strength (CD)		660

Fig. 3: Continous compression molding system at STFI

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INNO-KOM

FibreNet

Maastricht University

Development of a Multi Functional Wound Dressing using Cellulose Aerogel Fibers

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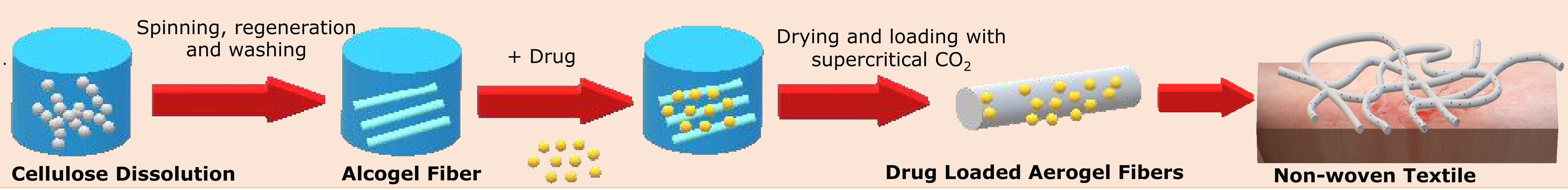
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 764713

Objective and Graphical Abstract

The goal of this project is to **develop a multi-functional dressing using porous cellulose aerogel fibers to cover multiple phases of wound healing**.



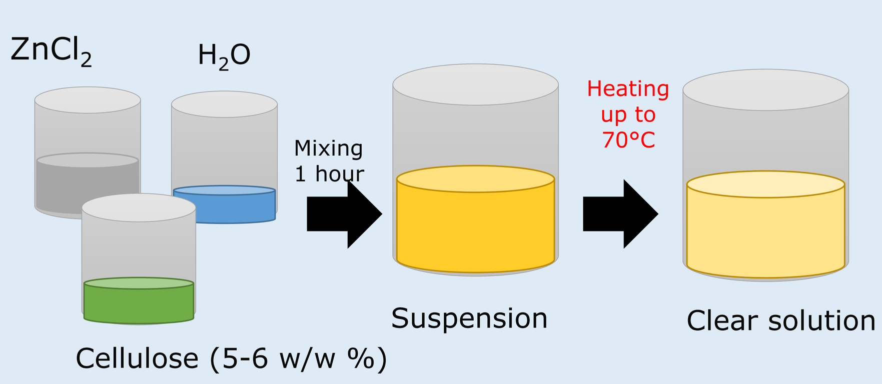
Ideal properties of textile:

- Controlled drug release
- Thermal insulation
- Drainage of wound exudate

Fiber Production

Solution Preparation

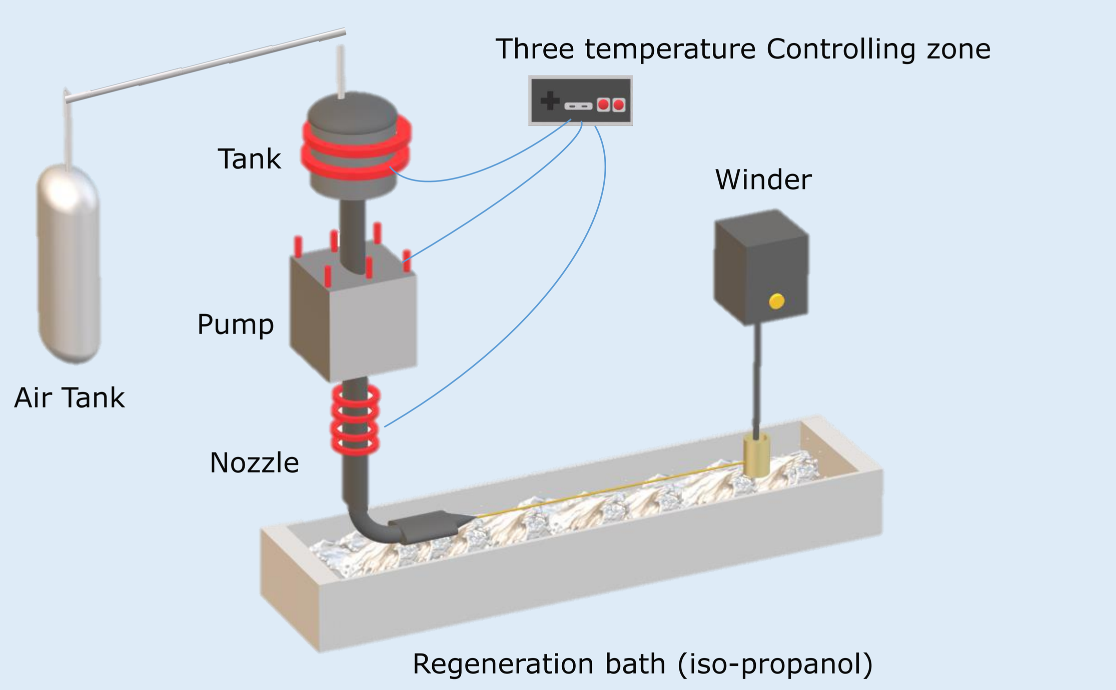
- Solution: Molten salt hydrate of $ZnCl_2$ and Cellulose



- Drug models: Rhodamine B, Fluorescein, Methyl Blue

Wet Spinning

- Customized Wet spinning line of DIENES LabLineCompact



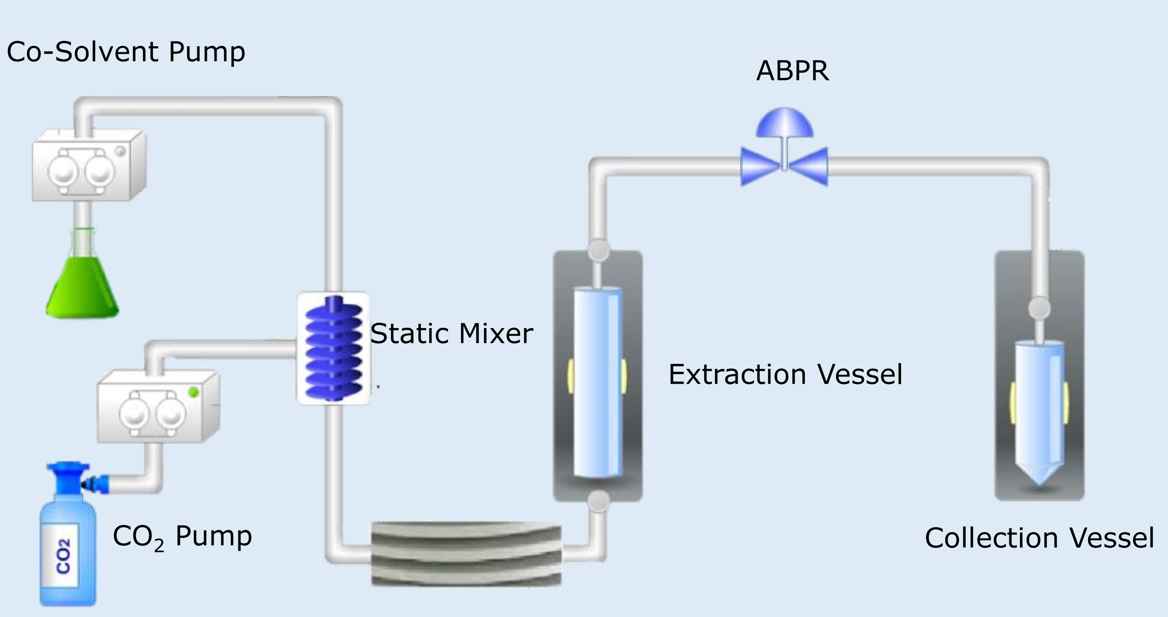
- Mono and Multifilament production (102 holes, φ=100 µm)
- Air pressure:2-3 bar
- Pump speed :2 ml/min
- Winding speed: 10-30 RPM

In-situ Drying And Drug Impregnation Using Supercritical CO_2

i) Static mode: replacing the solvent by liquid CO_2 (12h, 20 °c , 65 bar)

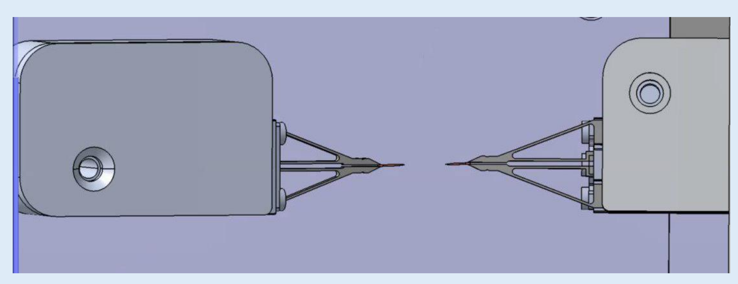
ii) Dynamic mode: extraction of the solvent by SCO_2 (5h, 40 °c , 90 bar)

iii) Depressurization (0.75 bar/min)

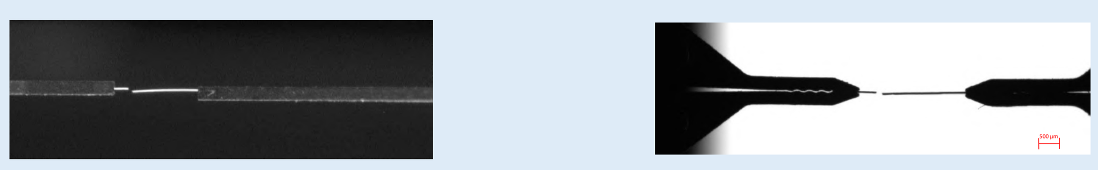


Results

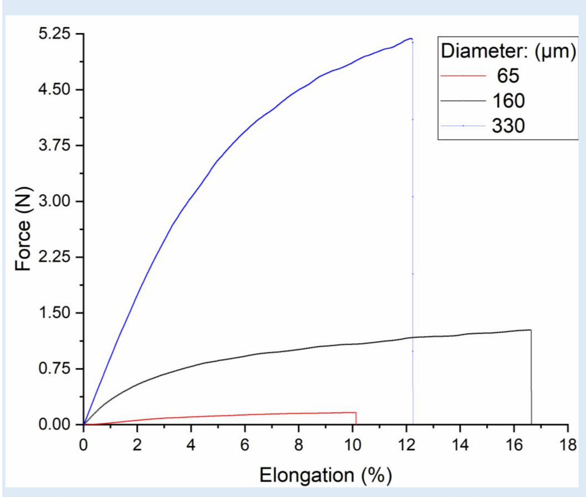
The Mechanical Properties



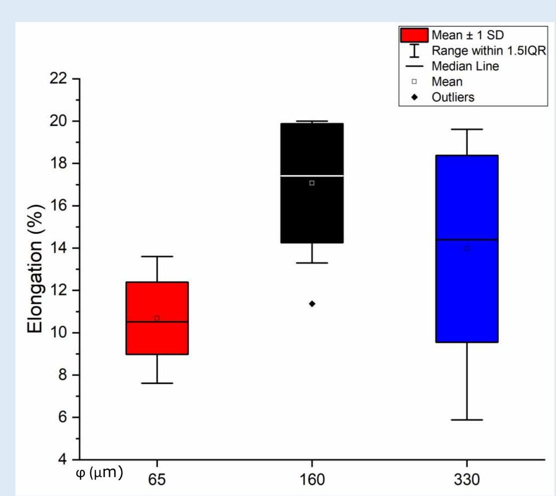
Lab designed micro-robotic single fiber tester; Comprising two microscopic cameras and two micro-actuators equipped by micro-grippers .



Microscopic images; side view (left) and top view (right), after fiber fracture



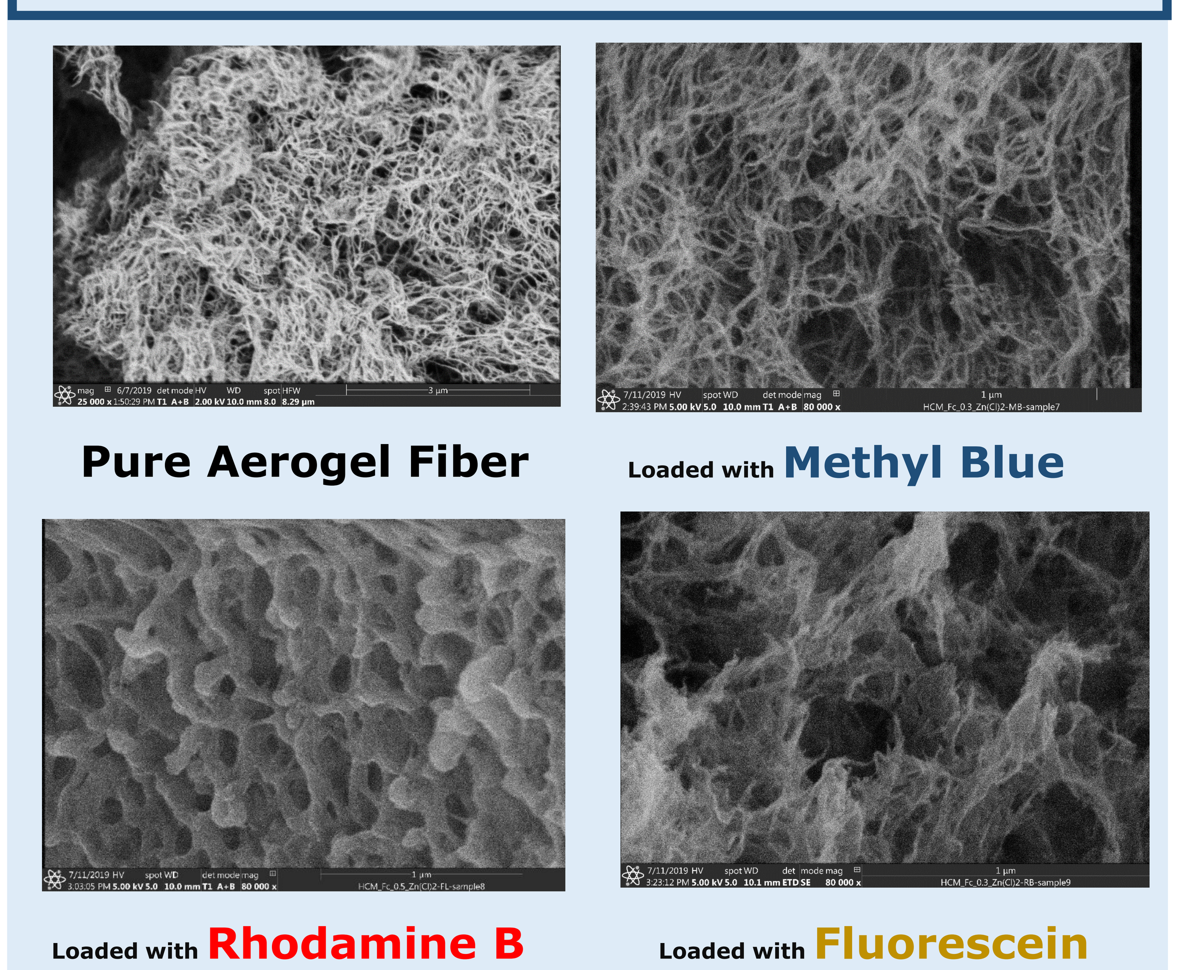
- *The representative curves of force-elongation of cellulose aerogel fibers with different diameters.*



- *Elongation variation of different fiber diameters. Anisotropic nature of material and defects in the filaments lead to deviations in elongation.*

The result of each filament data showed a linear regime is followed by an irreversible plastic deformation until final fracture occurs . In addition, with increasing the diameter, the maximum tensile strength increases noticeably.

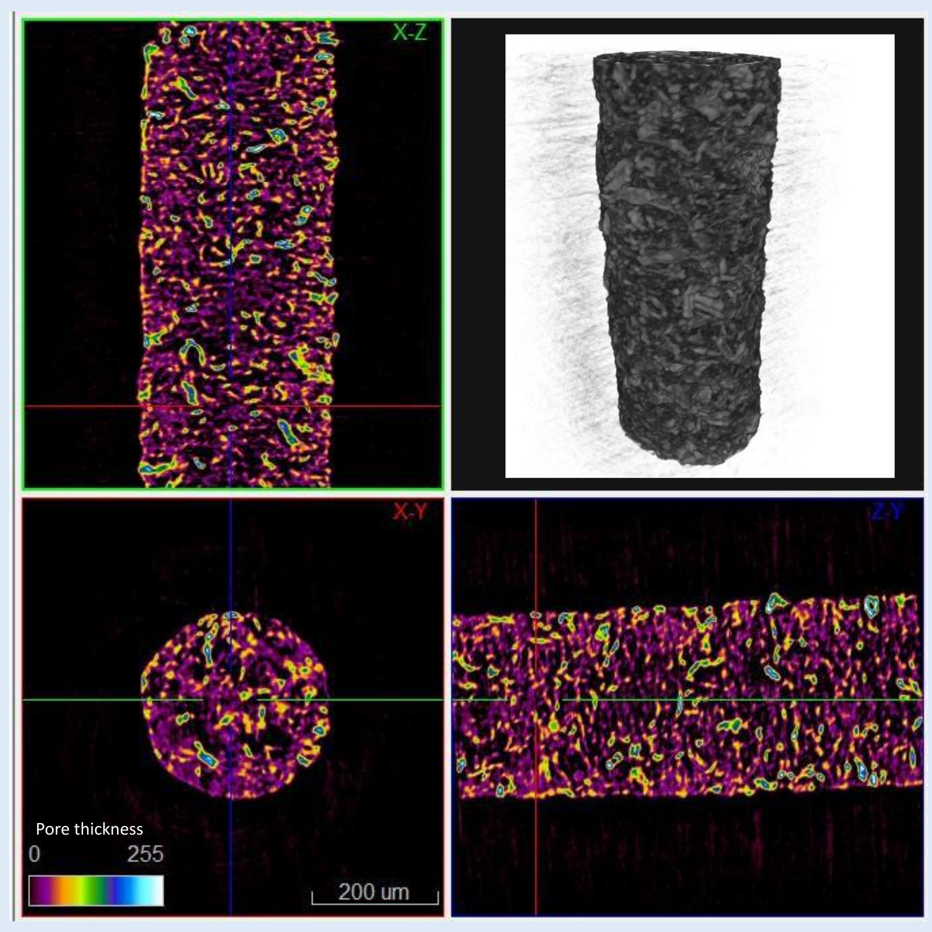
Scanning Electron Micrographs (SEM)



The morphology of aerogel fibers consists of pores mesh of randomly oriented nano-fibrils connected in 3D. Methyl Blue loaded fibers have similar morphology to aerogel fibers. However, Rhodamine B and Fluorescein have a different morphologies due to interaction between their drug solution and cellulose chains.

X-ray Microtomography

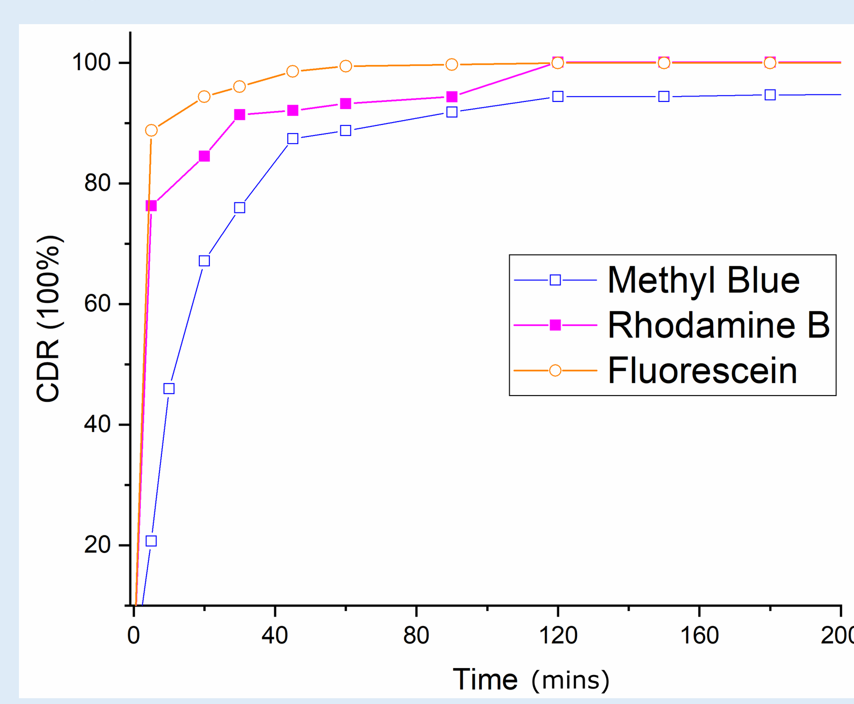
Cellulose aerogel fibers have open interconnective porosity around 63 ± 5 % and closed pores of 0.01%.



- *MicroCT image of cellulose aerogel fiber; 0.8 micrometer resolution and reconstruction using CGLS with 10 iterations*

The Drug Release Profiles

More than 85% of drugs concentration is released in less than 200 mins. Methyl blue comparing to Rhodamine B and Fluorescein has a lower rate of release due to a non-distorted and highly nano-porous structure similar to pure aerogel fibers.



- *The concentration of released drug of loaded aerogel fibres (ϕ=330 µm); measured by UV-VIS spectrometer in PBS (pH 7.4 and 37 °C).*

Conclusion

- Cellulose aerogel fibers (5-6 w/w%) can be obtained by wet spinning and In-situ SCO_2 drying-loading.
- Morphology of loaded fiber depends on interactions between cellulose and drug solution. As a result, distorted morphologies lead to faster drug release. Therefore, post treatment is a better loading method to avoid morphological variations.
- In further studies, the drug release of the fibers can be extended by surface functionalization or encapsulation in hydrogels.

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Nonwoven Innovation Academy 2019

Advanced Respiratory Filters for the Prevention of Byssinosis

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Aim

Development of respiratory filters with nanofibers and fibre surface modification for improved protection against cotton fine dust particles and their endotoxins to reduce the effect of Byssinosis.

Introduction

Cotton is the most widely used textile fibre, but cotton spinning produces fine dust particulate and bacterial contamination in the working environment. Inhalation of these fine dust and bacterial endotoxins leads to symptoms of byssinosis.

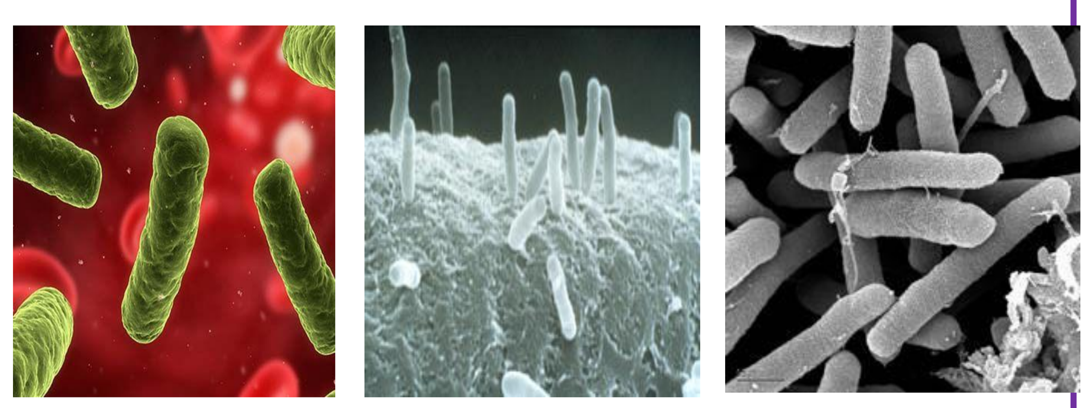
The Harvard School of Public Health pointed out that over 60 million people from textile industry are exposed to the risk of chronic lung diseases.

The basic objective of this research is to develop suit respiratory filter (PPE) which should be effective against cotton dust and their pathogenic species.

This type of research will be help to provide some type of relief to textile cotton mill workers in terms of byssinotic or lung disease issues.

Research Problem

The effect of byssinosis is due to the non-availability of suitable respiratory filter for the protection against cotton dust and their pathogens in the textile sector.

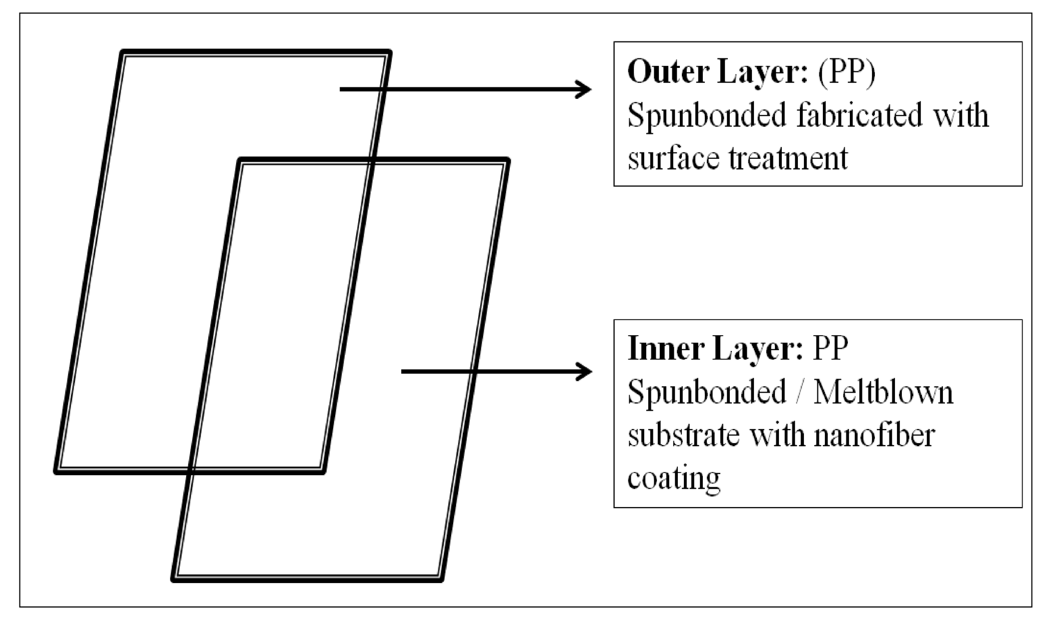


Enterobacter Agglomerans | Agrobacterium spp. | Pseudomonas syringae

Cotton dust ranges from 100nm to 1micron and three associated gram negative bacterial species are the main causes towards the symptoms of byssinosis in textile cotton workers. Successful filters need to protect against these fine contaminants and maintain adequate breathability.

Experimental

Chitosan nanofibers were developed by dissolving low molecular weight chitosan in 90% glacial acetic acid with the help of electrospinning. 3% chitosan were electrospun by applying 20kv voltage.

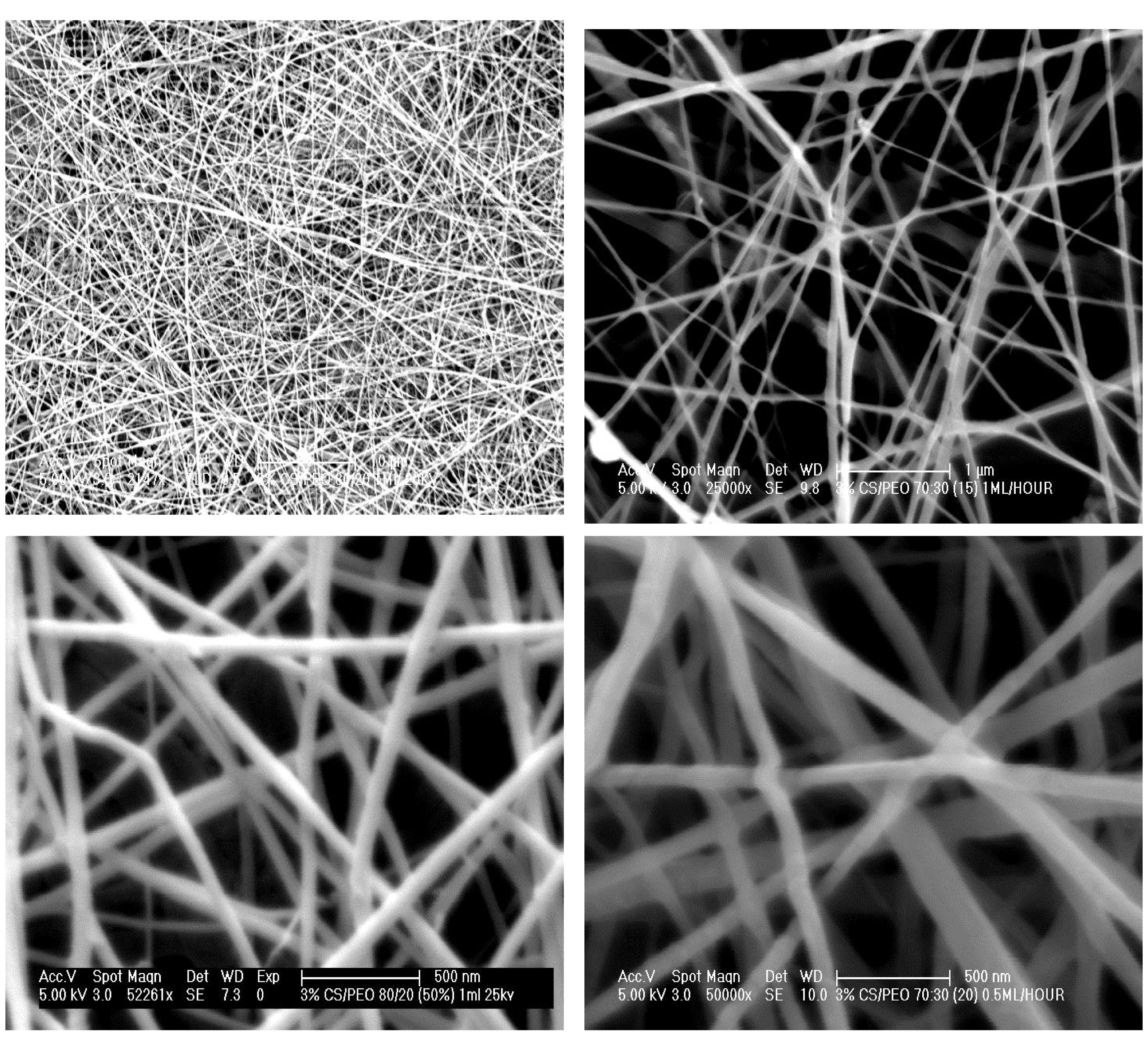


Plasma Surface modification are planned for surface activation of the PP layers, which will enhance the capturing ability of the developed filter.

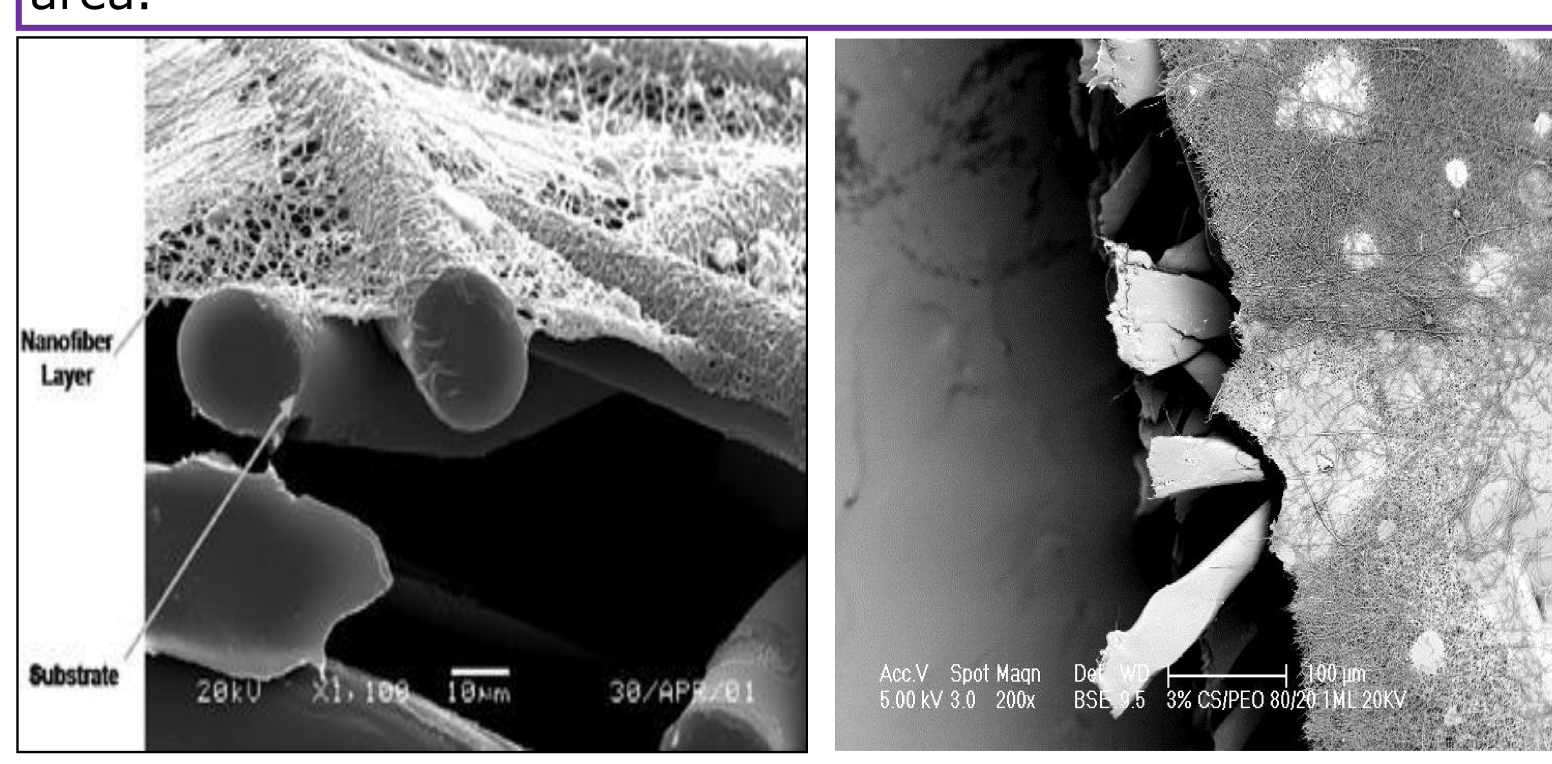
Results

A number of experiments were executed to optimize the electrospinning process variables for the development of chitosan nanofibers. Diameters of the produced nanofibers were ranges from 75nm to 200nm while average diameter was 150nm.

During the electrospinning of chitosan, molecular weight is very important because with the increase of molecular weight electrospinning possibilities will become more limited due to the formation of long chains, helical structures and high positive charge density.



Chitosan based nanofibers were coated on a polypropylene nonwoven substrate to increase the surface area and anti-bacterial properties of the filter layers. After the coating, air permeability of the layer significantly decreased from 1300 l/m2/s to 400 l/m2/s, due to significant increase of surface area.



Future Work

1. Testing of antibacterial properties of the filter against pre-described species of gram negative bacteria.
2. Formation of respiratory filter by assembling the coated layer with the outer PP spunbonded layer.
3. Characterization of filter against the filtration efficiency and pressure drop variables
4. Theoretical modeling of different coated layers of the filter against the filtration efficiency
5. Optimization and standardization the overall performance parameters of developed filter

The authors gratefully acknowledge PEEF for awarding a scholarship to Mr. Umar to pursue his PhD.

Denier Reduction of Polypropylene Fibers for Spun bond Nonwoven via Low Modulus Polypropylene Incorporation

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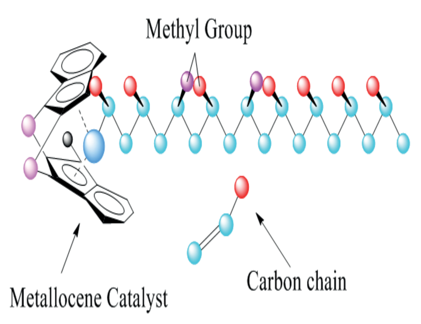
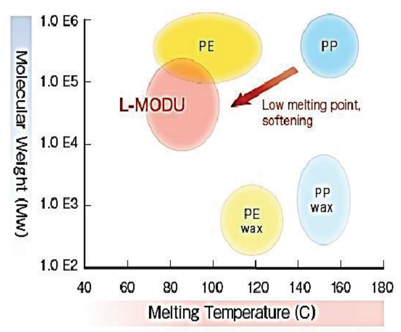
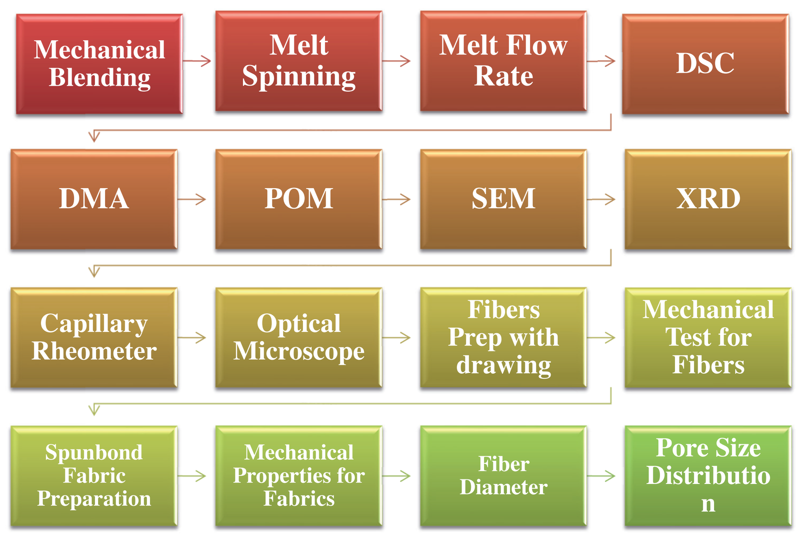
Abstract

The spun bond nonwovens fabrics containing different weight percentage of isotactic polypropylene (iPP) and low isotacticity and low modulus polypropylene (LMPP) having different molecular weight are prepared. In preliminary fiber preparation, the melt flow rate (MFR) results showed LMPP have higher MFR value as compared to the all others blends. With increasing mass ratio of LMPP, iPP/LMPP blends MFR has increased, the blend of 25% of the iPP/LMPP of MFR increase more obvious. Different temperatures were used to understand the iPP/LMPP blends rheology properties, with the change in the shear rate the apparent viscosity curve substantially similar for all samples. As the temperature increases the apparent viscosity of the sample has decreased and viscosity decreases. As the LMPP mass ratio increases, the fiber diameter changes significantly compared with undrawn fiber, fiber diameter reached 0.17mm. Which makes the gram weight of spun-bonded nonwoven fabrics increase, and the average fiber diameter reduces 2-4μm. The iPP/LMPP spun bonded nonwovens fracture strength, elongation at break increased significantly, with the increase of that LMPP.

Materials and Methods

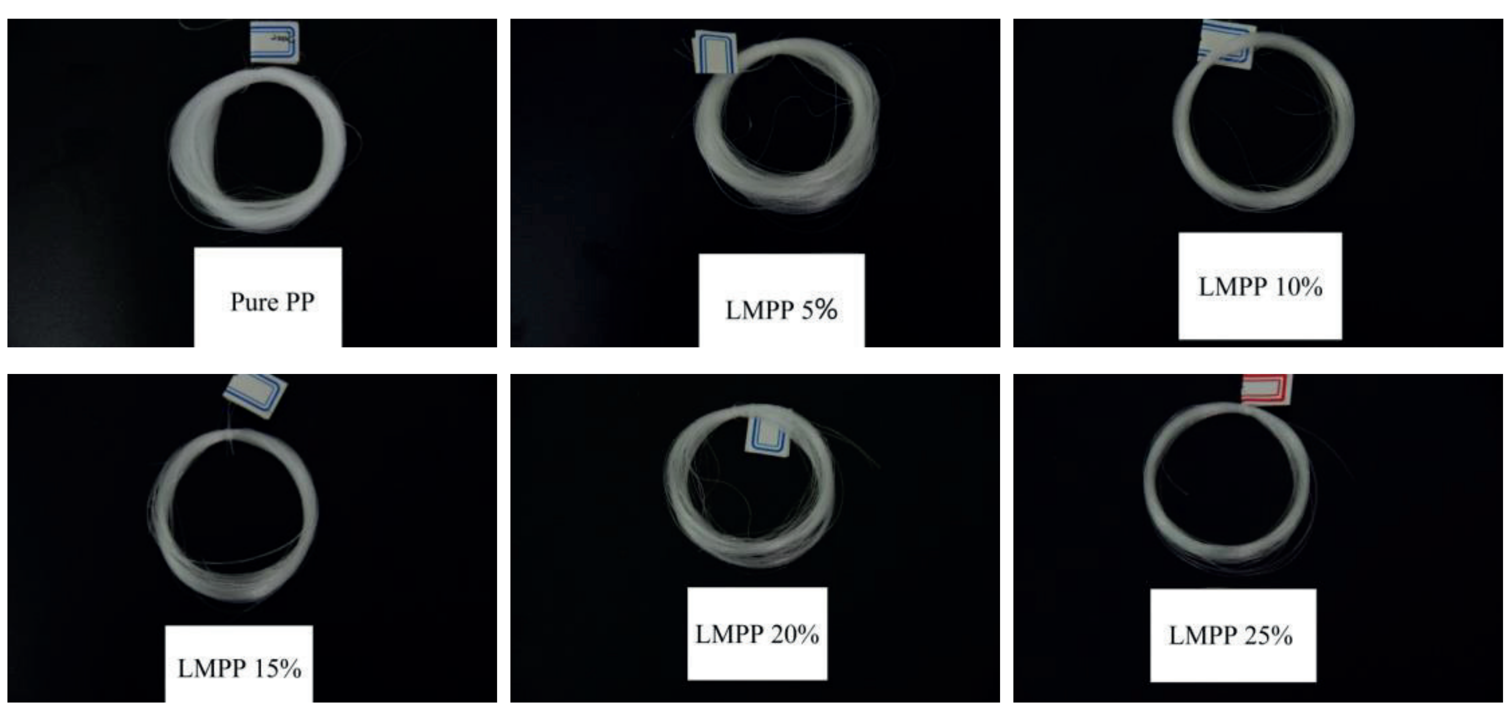


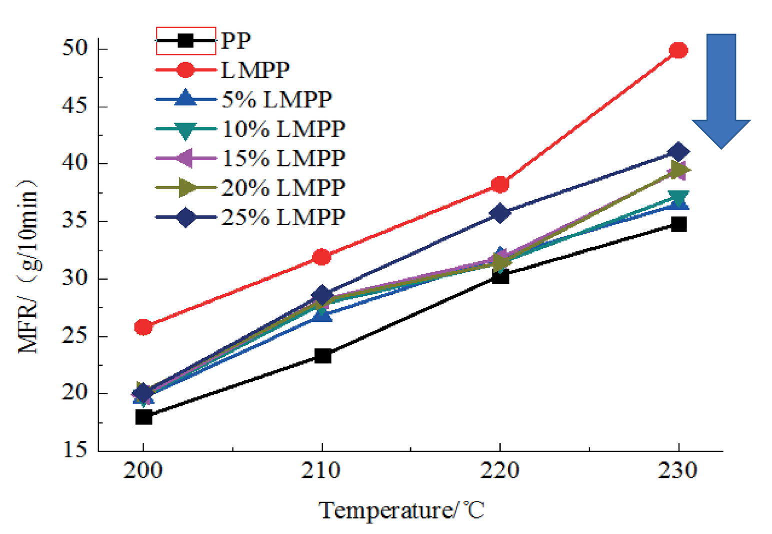




The low molecular weight and low modulus polypropylene (LMPP s901) was provided by Idemitsu Kosan Co, Ltd. Japan, with molecular weight 1.3×105g/mol and isotactic polypropylene (iPP), s2040 with a molecular weight 2.0×105g/mol was provided by China. To investigate the mechanical properties of the iPP and iPP/LMPP blends, their spunbond nonwovens were prepared with HD-SM machine (Huada company, Shandong, China). The processing parameters of spunbond nonwovens were extrusion temperature 210° C, extrusion quantity 200ml/min, drawing air temperature 40° C, suction pressure 4KPa, transmission speed 7.5m/min, pre-pressing temperature 45° C, hot pressing temperature 110° C, and hot processing pressure 1200kgf.

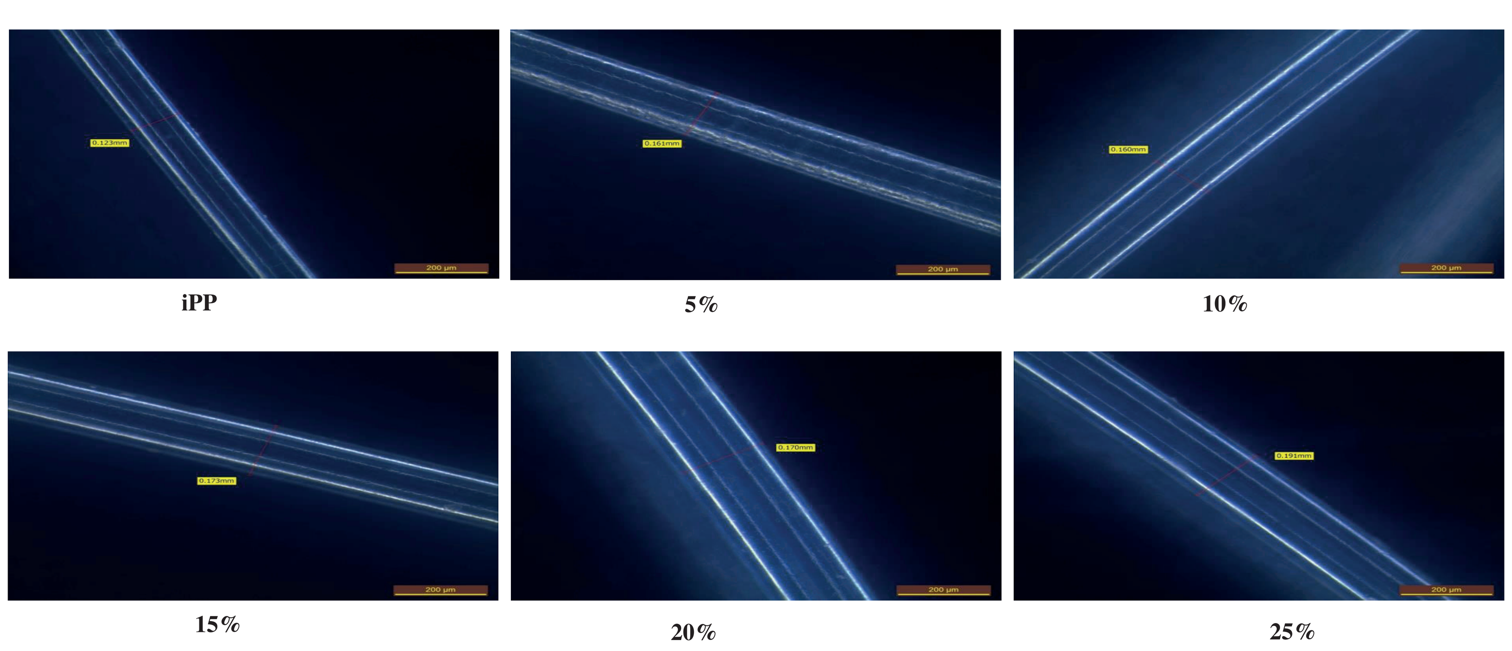
Results and Discussion





Addition of LMPP reduce the diameter of fibers at low drawn speed and increase the MFR significantly.

Denier Reduction iPP/LMPP blends fibers



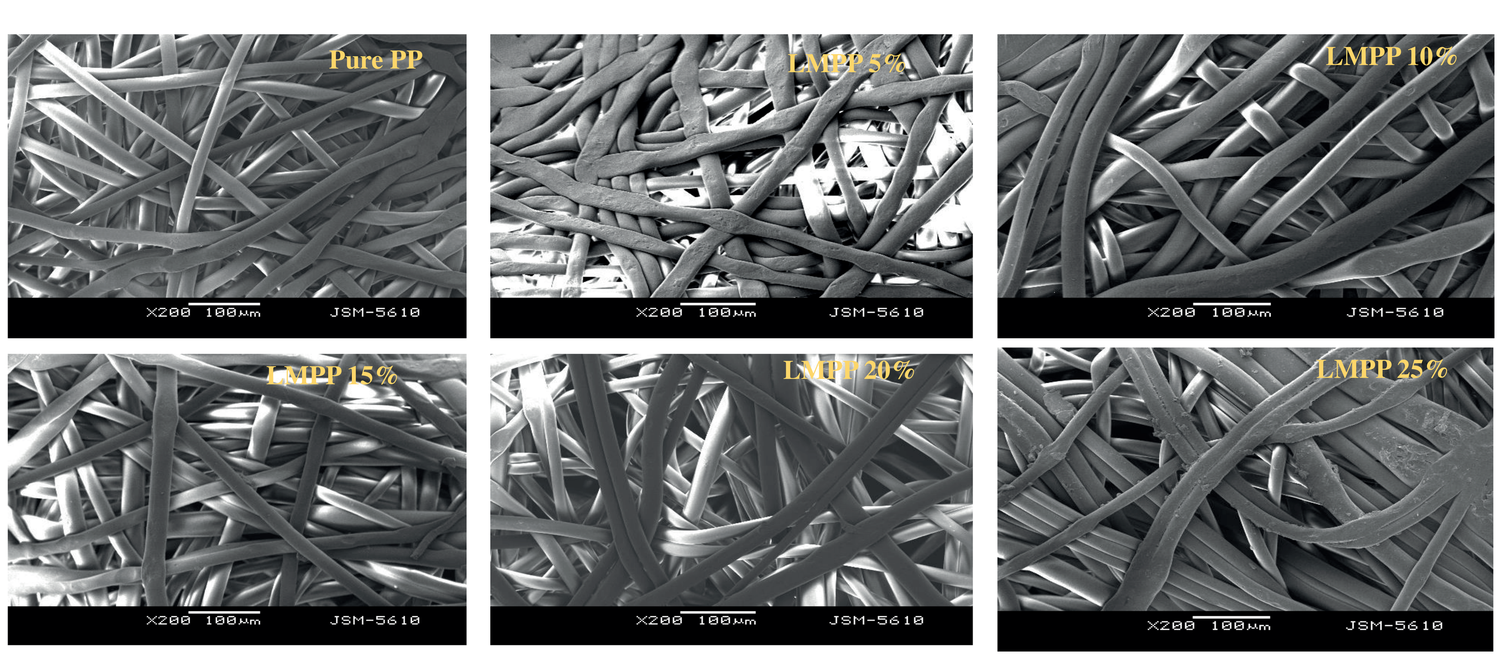
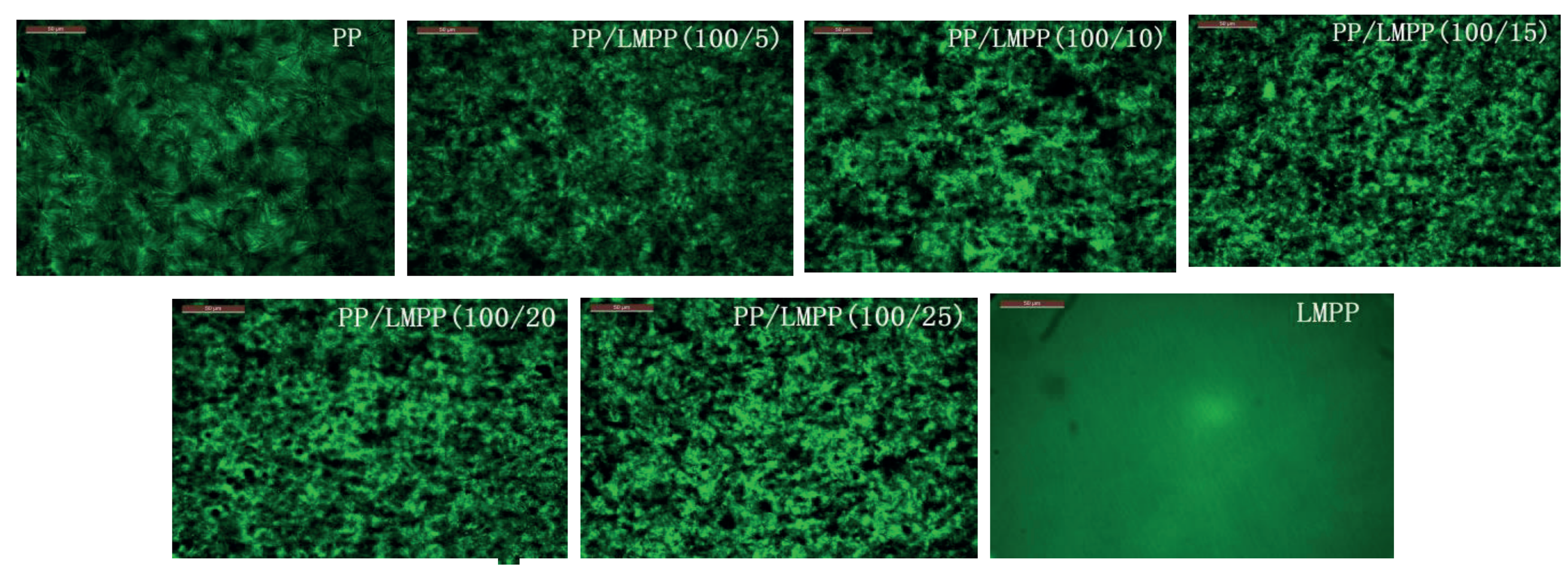


Table 1. Calculated values of crystallinity of iPP/LMPP blends using by XRD

iPP/ LMPP	100/0	0/100	95/5	90/10	85/15	80/20	75/25
Crystallinity (%)	40.2%	16.5%	43.2%	43.9%	42.5%	38.8%	38.3%

Small amount of LMPP increase the crystallinity of blends due to plasticizer, dilution, and enhance the mobility of the iPP molecular chain during crystallization.



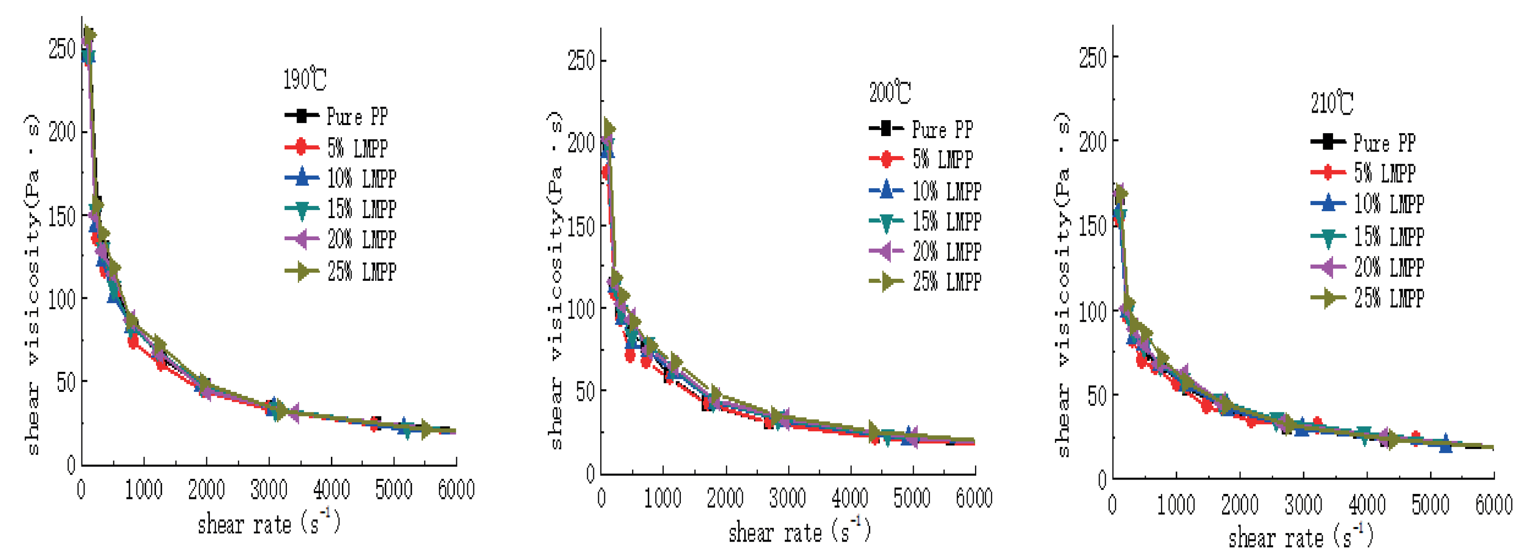


Table 2. Mechanical properties of iPP/LMPP fibers under low drawing speed

Sample	Tensile strength/MPa	Elongation at break/%	Elastic /MPa
PP	52.8±1.2	220.2±12.2	753.7
5% LMPP	53.1±2.1	900.6±35.4	735.2
10% LMPP	59.3±3.3	1036.4±32.6	613.5
15% LMPP	50.6±1.3	1076.1±41.7	599.7
20% LMPP	52.1±1.8	1162.5±53.3	563.4
25% LMPP	55.6±2.3	1295.4±83.1	447.3
LMPP	25.3±0.5	950.7±91.1	89.4

Conclusion

In this work, we prepared the Spun bond nonwovens fabrics containing different weight percentage of isotactic polypropylene (iPP) and low isotacticity and low modulus polypropylene (LMPP) having different molecular weight. The melt flow rate (MFR) were increased as mass ratio of LMPP in blends increased particularly the blend of 25% of the iPP/LMPP is higher than other blends. At different temperatures were used to understand the iPP/LMPP blends rheology properties. With the change in the shear rate the apparent viscosity curve substantially similar for all samples. As the temperature increases the apparent viscosity of the sample has decreased every rise 10 ℃, and viscosity decreases about 50 Pa • s. Finer and smother nonwovens were attained via incorporation LMPP into iPP, and great reduction denier of iPP/LMPP fibers was seen through optical microscope and SEM. The mechanical properties of both, iPP/LMPP blend fiber increased compared to control samples. The breaking elongation of pure PP fiber is the lowest but the elastic modulus is the highest. The breaking elongation increased with the increasing of LMPP amount, the maximum breaking elongation of LMPP 25% blend can reaches 1295.2% and shows excellent stretchability, the elastic modulus of iPP/LMPP blends also decrease with the adding of LMPP which indicate that the fibers become softer.

Acknowledgements

This research work was supported by Prof. Han Jian and Prof. Song Yihu

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Sächsisches Textilforschungsinstitut e.V.

An-Institut der Technischen Universität Chemnitz

Stitchbonded Nonwovens for Hot-Melt Coating

Development of nonwoven-based carrier materials for technical adhesive tapes

Project aim

- Better drapability and softness in comparison with spun bonded fabrics
- Weight range up to 75 gsm
- Thickness up to 0,3 mm
- Acoustic behavior

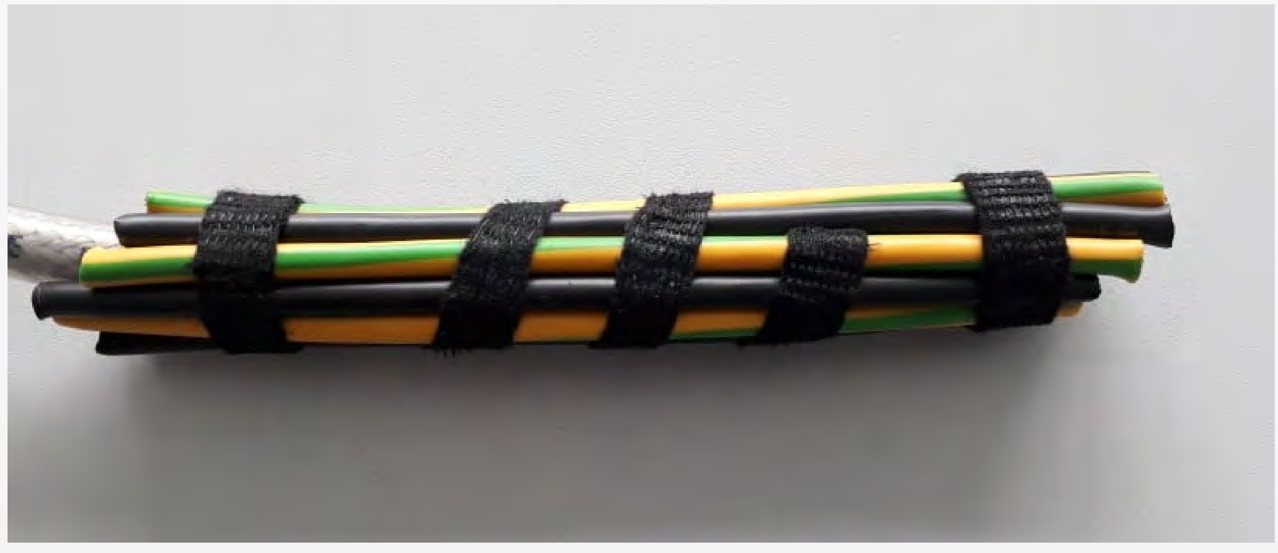
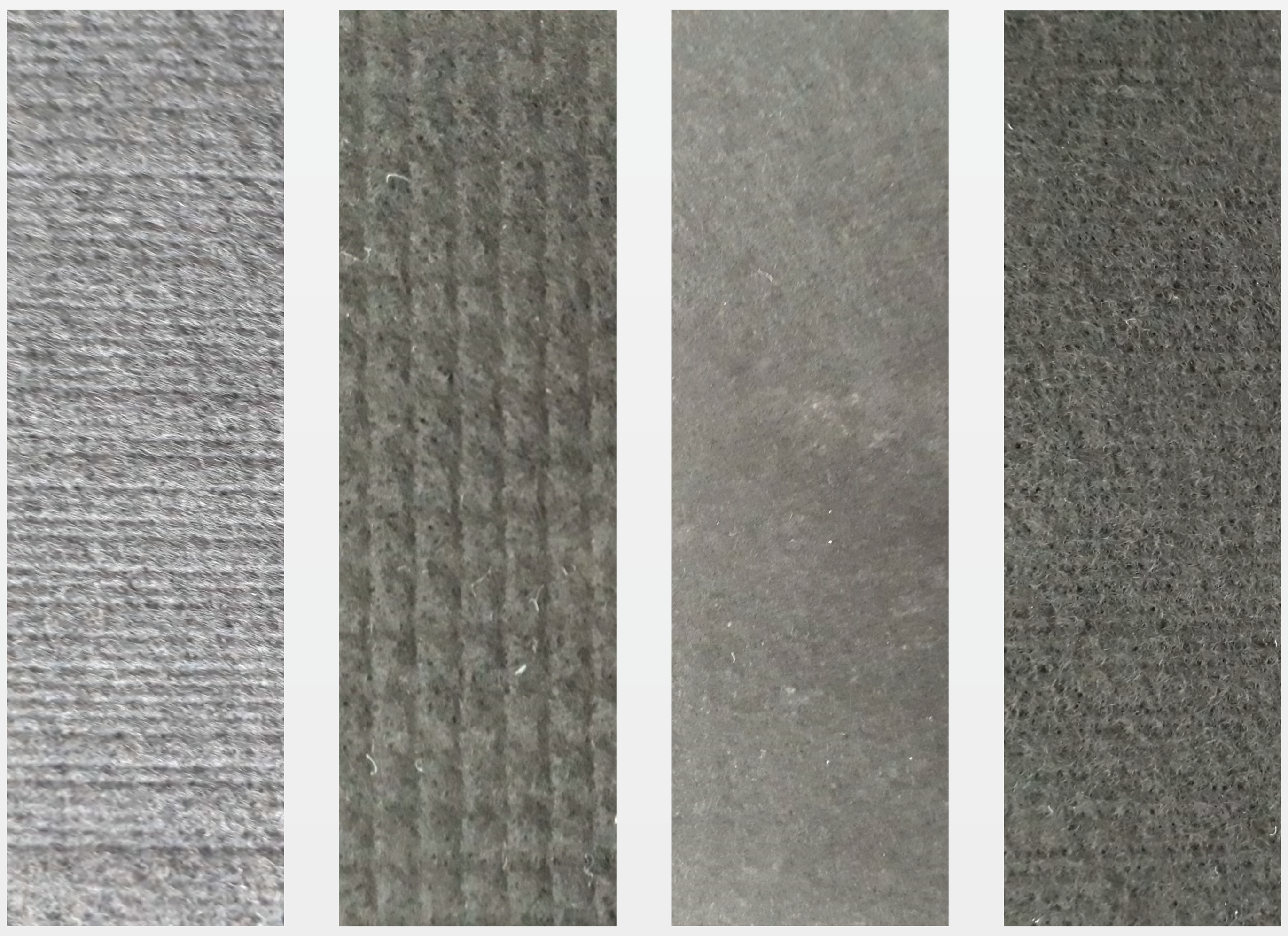


Fig. 1: Cable harness with nonwoven based adhesive tape

Approach

- Web formation with cross and random fibre orientation
- Web bonding by: needle punching, thermal airthrough, calendering, steamjet technology
- Testing of textile-physical properties like: weight, thickness, tensile strength, drapability, flexuosity
- Additional bonding, using the Maliwatt stitch-bonding technology
- Adhesive coating with a hot-melt line
- Testing for suitability: adhesive strength tape on tape, tape on steel, flagging, drapability



Steamjet | Thermal-bonding | Calender | Needle punched

Fig. 2: Bonded surfaces of nonwoven material

Results

- Cross laid nonwoven (42,72 gsm)
- Calendering for calibration and consolidation
- Stitch-bonding for sufficient tensile strength
- Achieved material properties:

Less flagging	0,3 mm
Weight	49,86 gsm
Thickness	0,2 mm
Tensile strength	41,98 N in MD
Flexuosity length	2,24 cm
Tearable by hand in transverse direction	

Fig 3: Nonwoven based adhesive tape as role

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INNO-KOM

Critical Evaluation of Bio-based Polymers for Spunbond and Meltblown Nonwovens

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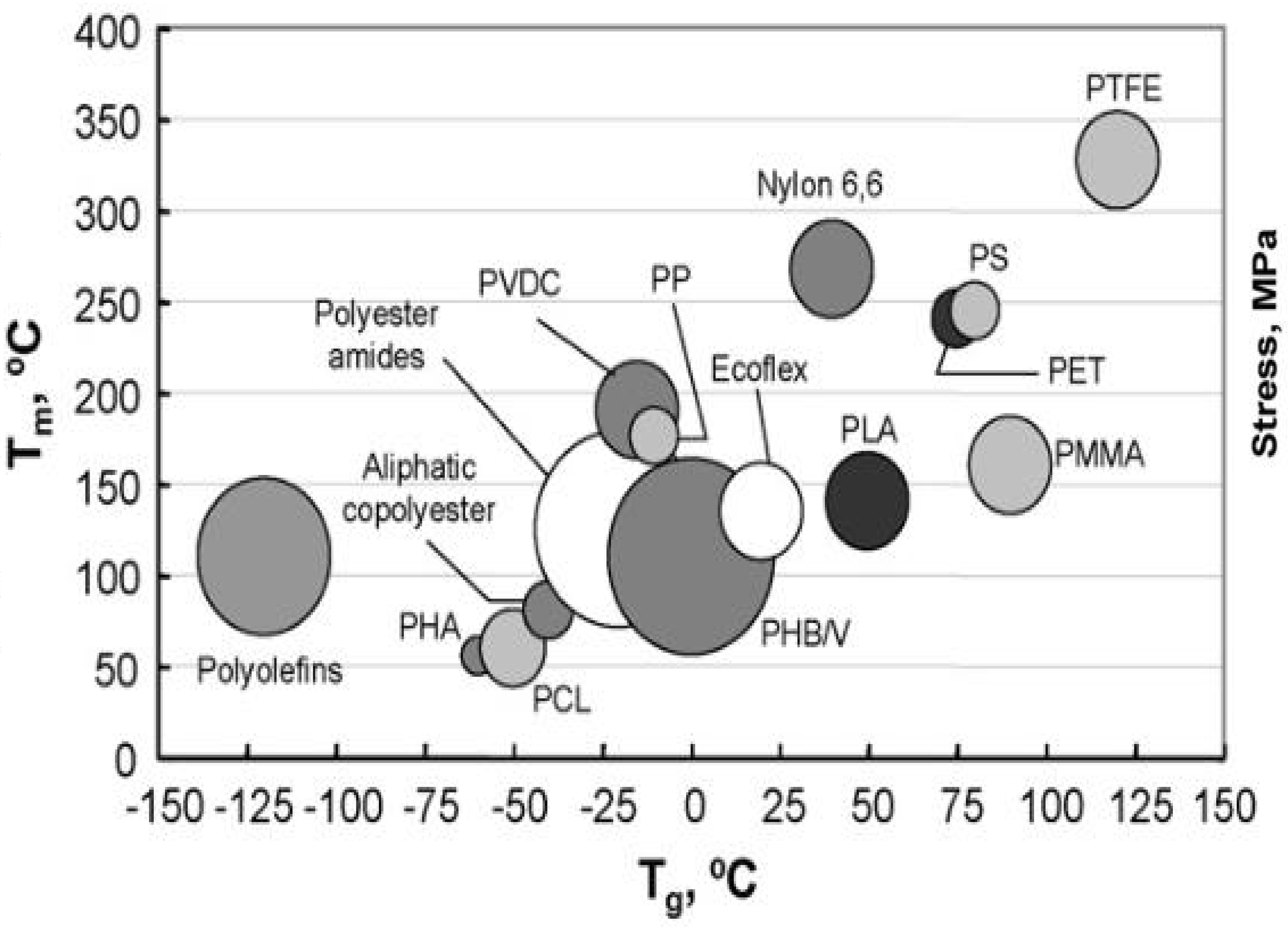
Wilson College of Textiles, North Carolina State University

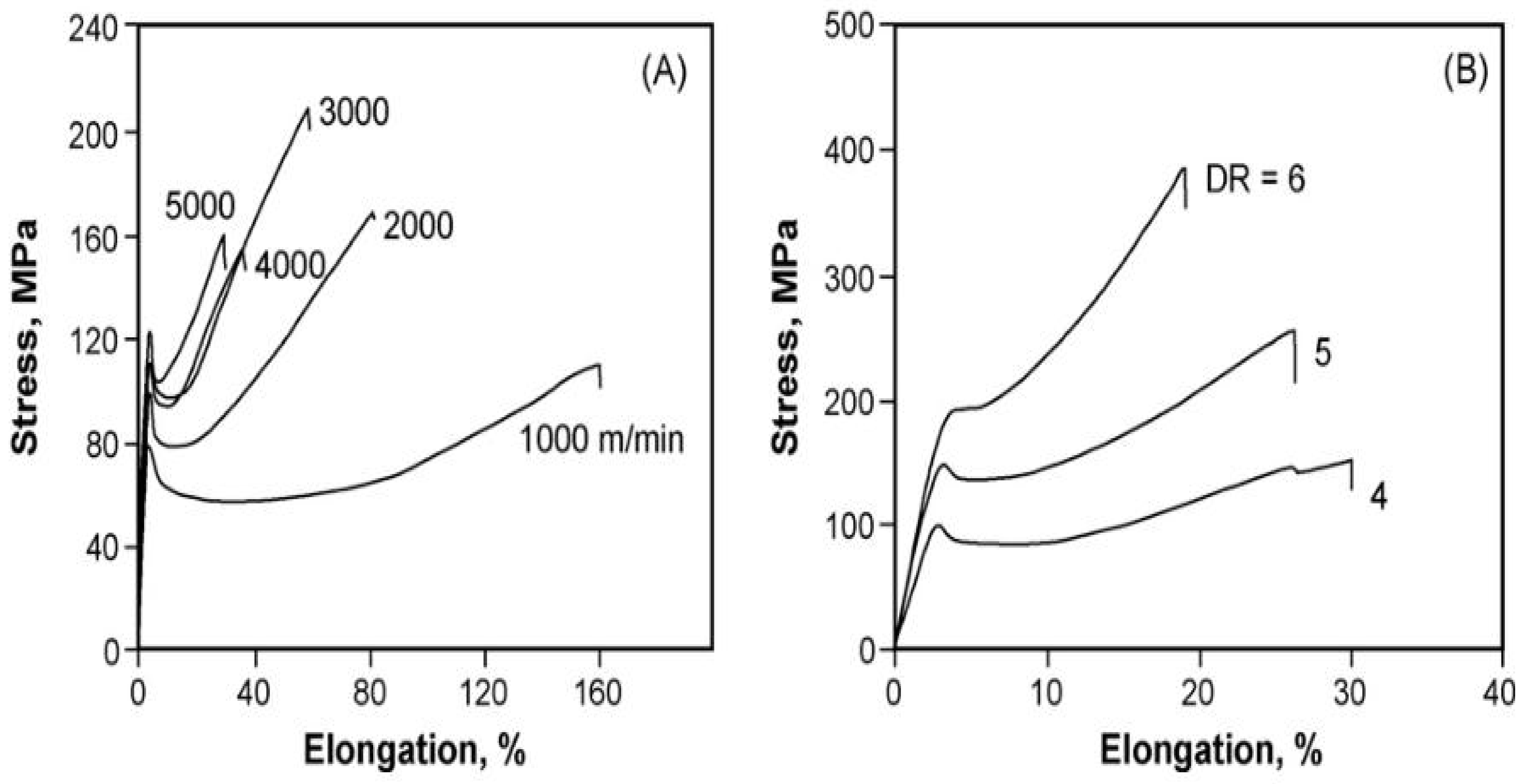
Introduction: Bio-based polymers are sustainable polymers synthesized from renewable resources such as biomass instead of the conventional fossil resources like petroleum oil and natural gas, preferably based on biological and biochemical processes.

Biodegradable /Bio-based Polymers

- Petroleum/Fossil Fuel
  - Aliphatic Polyester, Polyester Amide, Poly Carbonate
- Mixed Resources
  - PLA + Starch Plastic, PLA + PHB, PLA + PCL
- Renewable Resources
  - Starch, Cellulose, PLA, PHA, PA 11, PGA



L.-T. Lim et al. / Progress in Polymer Science 33 (2008) 820–852



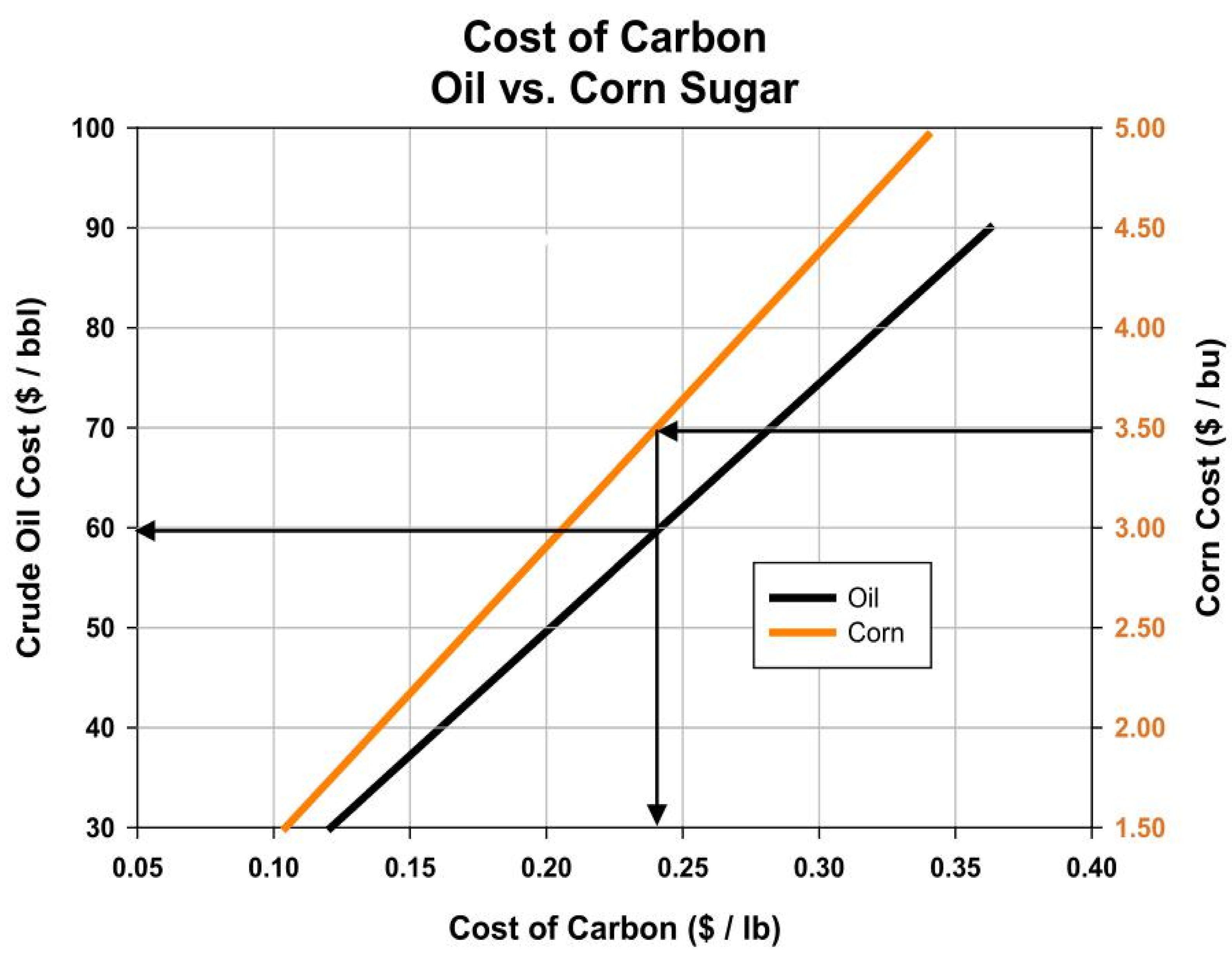
L.-T. Lim et al. / Progress in Polymer Science 33 (2008) 820–852

PROS

- Biodegradability
- Improved Compostability
- Lower Carbon Footprint
- More efficient—Feel/Taste
- Solution for Micro plastics
- Sustainability
- Consumer Demand

CONS

- Costlier
- Low - Moderate Strength
- Some are Brittle in Nature
- Low Heat Distortion Temp.
- Less Elongation



Source: Jim Lunt & Associates, LLC (2010)

POTENTIAL APPLICATIONS

COFFEE FILTER

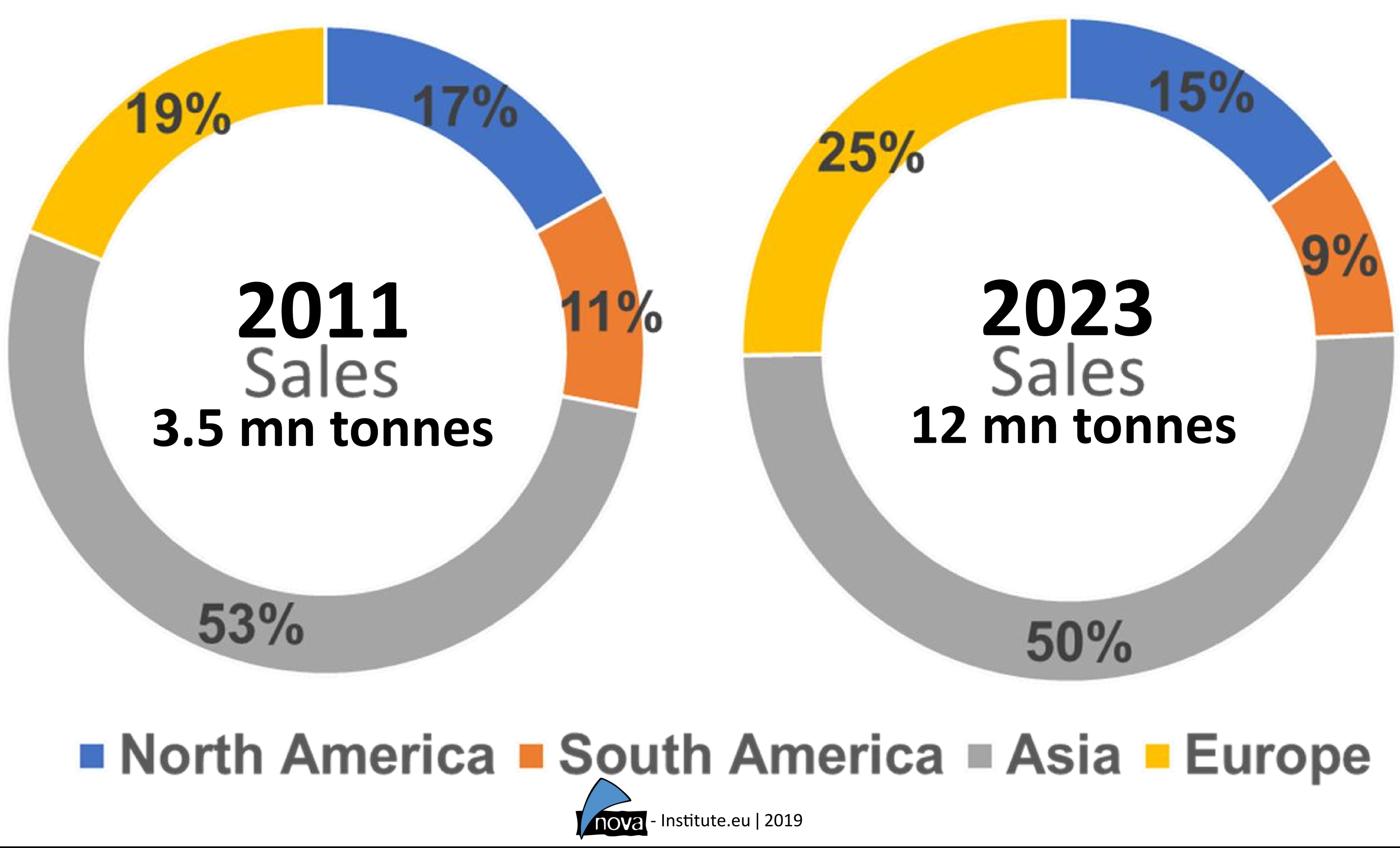
HOT TUB FILTER

WIPES

PLA CARRY BAG

HYGIENE

Global Production Capacities of Bio-based Polymers



Acknowledgements: Special thanks to Dr. Eunkyoung Shim and Dr. Behnam Pourdeyhimi for their support through out this project. Also, I would extend my thanks to the team members of the Nonwovens Institute (NWI) and Wilson College of Textiles, North Carolina State University.

Nonwoven Delivery Systems Containing Capsular Fibres for Medical Devices

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Research Context

Increasing rates of obesity and diabetes, in addition to the ageing population is driving significant global demand for more effective and economical wound dressing products (Boateng and Catanzano, 2015). Noninvasive methods of assessment and therapeutic management of wounds and diseased tissues are needed to reduce the burden of care, tackle patient morbidity and reduce healing times. The future strongly relies on the development of multifunctional dressings to regulate and control biochemical wound shifts (Dargaville et al., 2013). Nonwoven fabrics containing capsular fibres provide a way of encapsulating functional chemistry in solid, gel or liquid phases for specific management functions.

Main Aim

- To produce thermoplastic-free capsular fibres for inclusion in nonwovens encapsulating new formulations for integrated wound management.

Fibre Architectures

Encapsulation of heat sensitive actives within discrete voids or elongated capsules inside fibres has commonly relied on core-sheath electrospinning methods (Naeimirad et al., 2018). Major challenges include consistency and uniform dispersion of encapsulated components (solid or liquid) within the fibre whilst maintaining the desired fibre morphology.

Briefly, McCann et al (2006) encapsulated solid phase change materials (PCMs) into fibrous structures using a one-step melt electrospinning process using a co-axial spinneret (Figure 1).

Later, Viry et al (2012) created capsular fibres with elongated voids (Figure 2) in the core of electrospun fibres to engineer drug reservoirs via emulsion electrospinning.

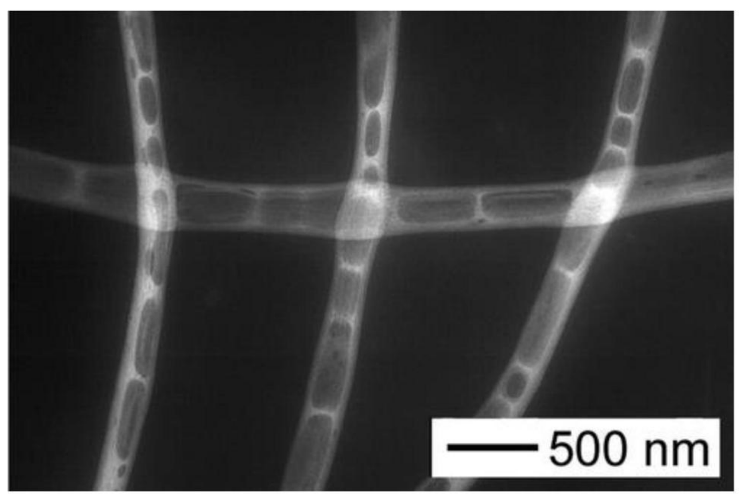


Figure 1. TEM image of PCM encapsulated within fibres (McCann et al., 2006, p. 2869).

Diaz et al (2006) created beaded fibres from a hydrophilic polymer encapsulating a hydrophobic liquid via co-axial electrospinning (Figure 3).

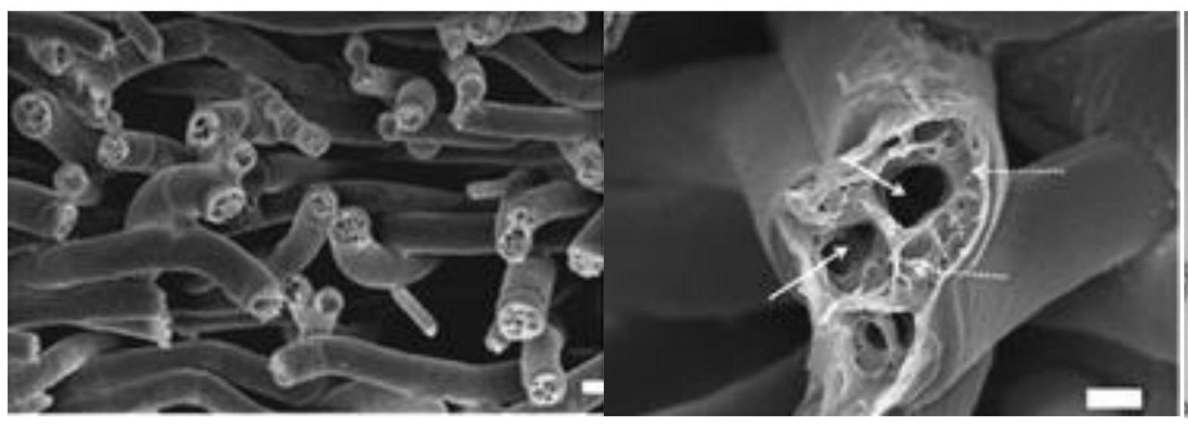


Figure 2. SEM images of emulsion co-axial spun fibres showing internal microstructure (Viry et al., 2012, p. 11350).

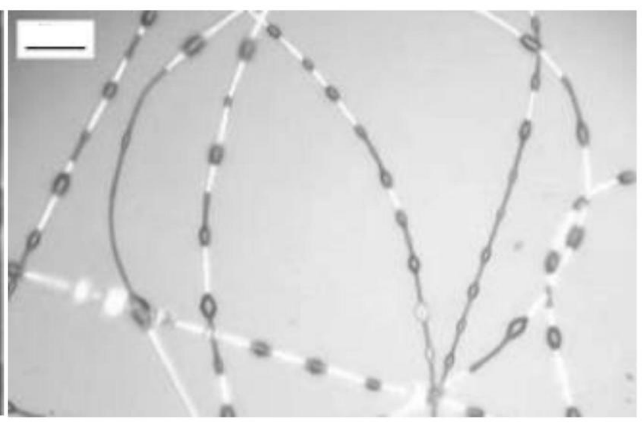
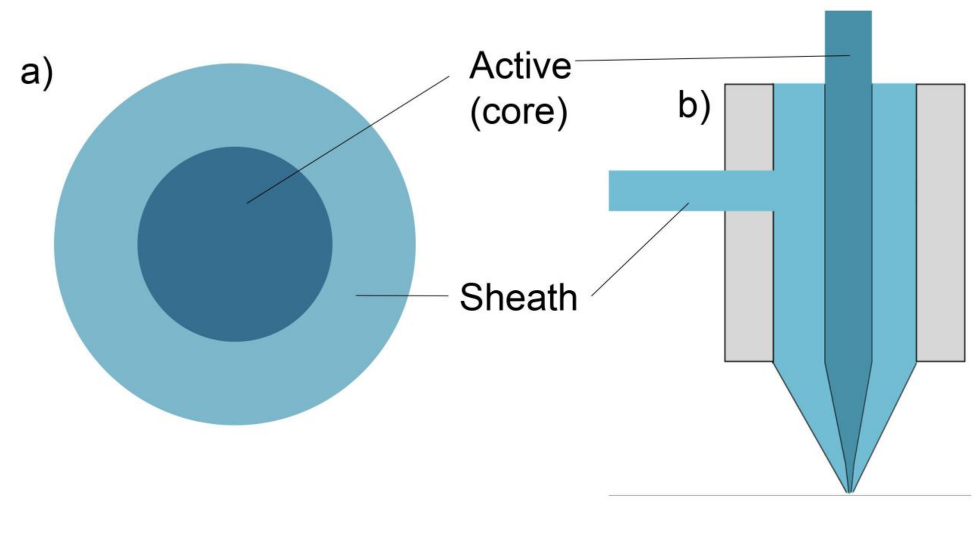


Figure 3. Hydrophilic fibres containing hydrophobic liquid, showing beaded structure (Diaz et al., 2006, p. 2114).

Experimental Approach

At Leeds, wet-spun-core-sheath fibre manufacturing has been adapted to produce fibres from FDA-approved biomaterials with discrete internal cavities filled with a second phase in the form of an active ingredient. These actives are compounds capable of diagnostic sensing, via for example a visual colour change due to interaction with bacteria, or provide therapeutic function. Production is in a single step without the need for additional post-processing. Once the fibres are incorporated into nonwoven fabrics (at relatively low blend ratios), multiple biochemical analytes can be targeted.



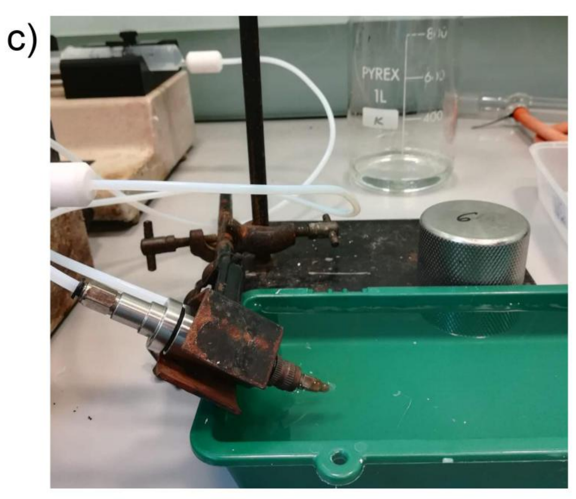


Figure 4. a & b) Schematic illustration of a basic core-sheath fibre cross-section and co-axial spinneret configuration, c) Image of a small, lab-based co-axial wet spinning rig set up with coagulation bath for proof-of-concept experiments

Nonwovens with Biochemical Functions

Reservoir-based and matrix-based encapsulation of actives are being targeted. A hygroscopic shell polymer acts as a diffusion layer that interacts with the wound environment, controlling the release of the active from the interior or alternatively, the transport of molecules into the interior (Paulo and Santos, 2017) (Figure 5).

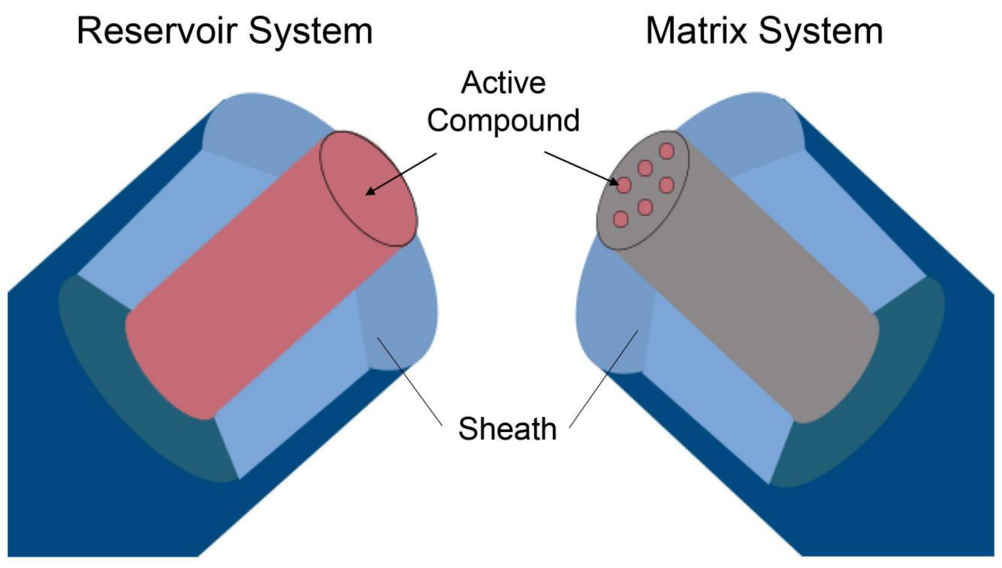
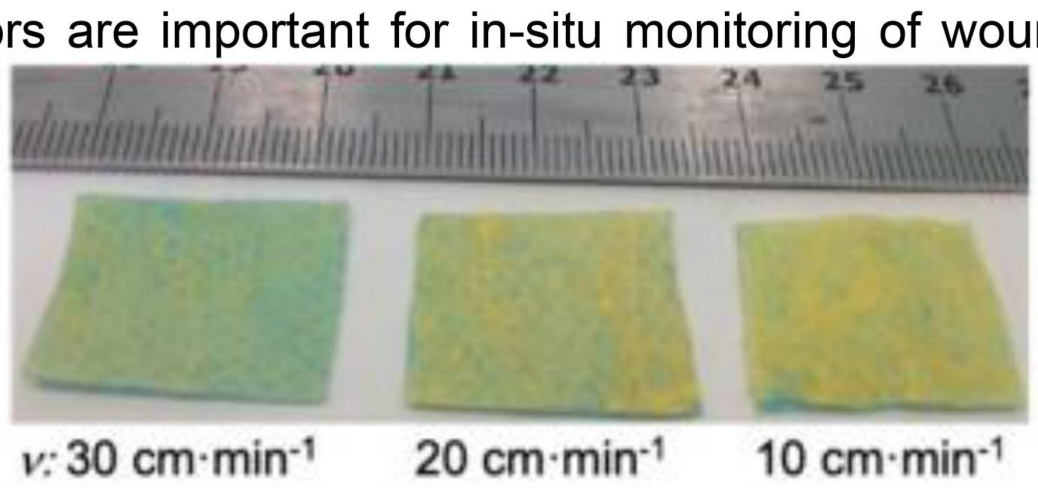


Figure 5. Schematic of two different modes of encapsulating actives

Infection-Sensing Functionality

A variety of biochemical factors are important for in-situ monitoring of wound healing condition, including:

- Temperature
- pH
- Lactate
- Hydrogen Peroxide



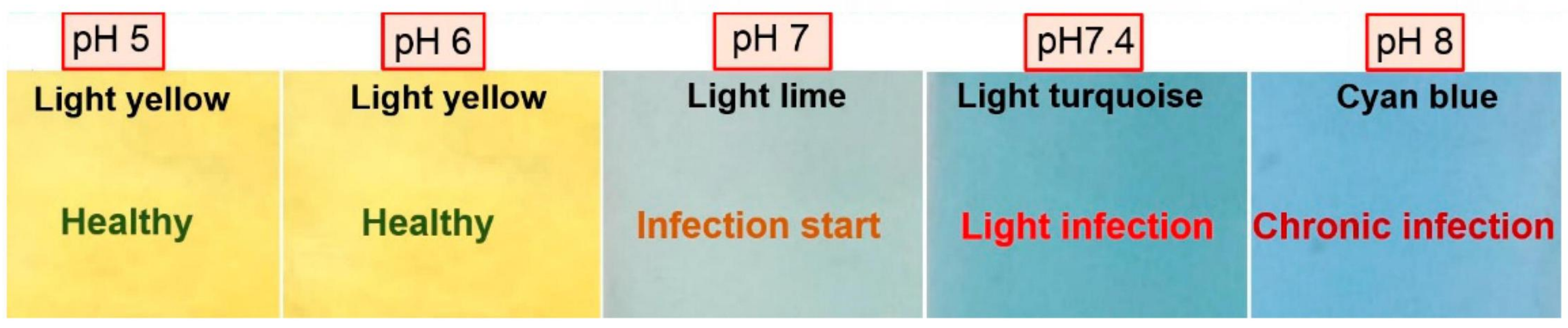


Figure 6. pH-responsive colour change nonwoven fabrics produced in Leeds, and identification system for wound status influenced by pH (Bazbouz and Tronci, 2019, p. 15)

This work targets the encapsulation of compounds that initiate a visual cue, e.g. a colour change subject to change in the wound environment, providing diagnostic function. For example, upregulation of bacterial activity is a potential indication of a wound infection. Work in our lab has also demonstrated that a change in the colour of the fabric, prompted by an alteration in exudate pH is also possible (Figure 6) (Bazbouz and Tronci, 2019). Simple sensing outputs could provide a definitive, non-subjective observation of wound condition thereby preventing unnecessary dressing changes, and disturbance of the wound site. (Dargaville et al., 2013).

Integrated Release Capability

In addition to infection management, the sheath is readily engineered to modulate controlled release drug delivery (Figure 7, Elahi et al., 2013).

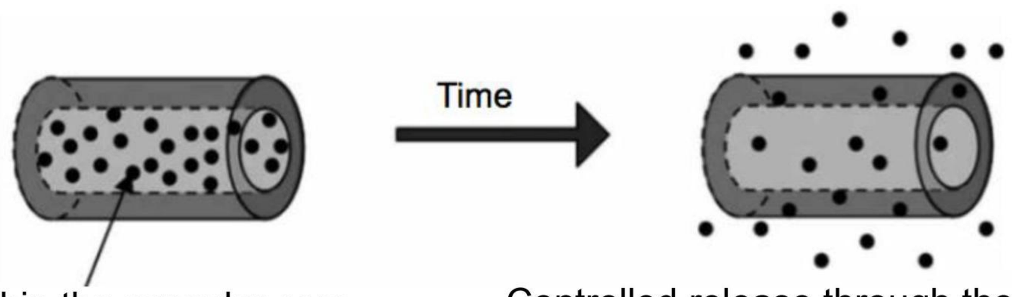


Figure 7. Schematic of encapsulation and release of actives in fibres (Elahi et al., 2013, p. 8).

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Blends with modified polypropylene for softer nonwovens

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Abstract

In this work, the morphological and mechanical characterization of blends having isotactic polypropylene (iPP) and relatively new/modified polypropylene, low isotacticity and low modulus polypropylene (LMPP) with low and high molecular weight is carried out. The prepared spunbound nonwovens showed great softness and elasticity, due to lowered crystallinity with the addition of LMPP into iPP blends. Mechanical properties of the spun bound nonwovens increased 15-20% with moderated addition of LMPP also iPP/LMPP fabric held strength for a longer time while testing. The tacticity of LMPP can be controlled by manipulating the metallocene catalysts, thus can be successfully applied in nonwoven industry to attain fabrics, elastic fibres and adhesives.

Significance

- ❖ Relatively new/modified polypropylene, LMPP is blended with iPP.
- ❖ The blends of iPP and LMPP showed immensely increased mechanical properties with mere 5% addition of LMPP.
- ❖ The prepared nonwovens were softer and more elastic.

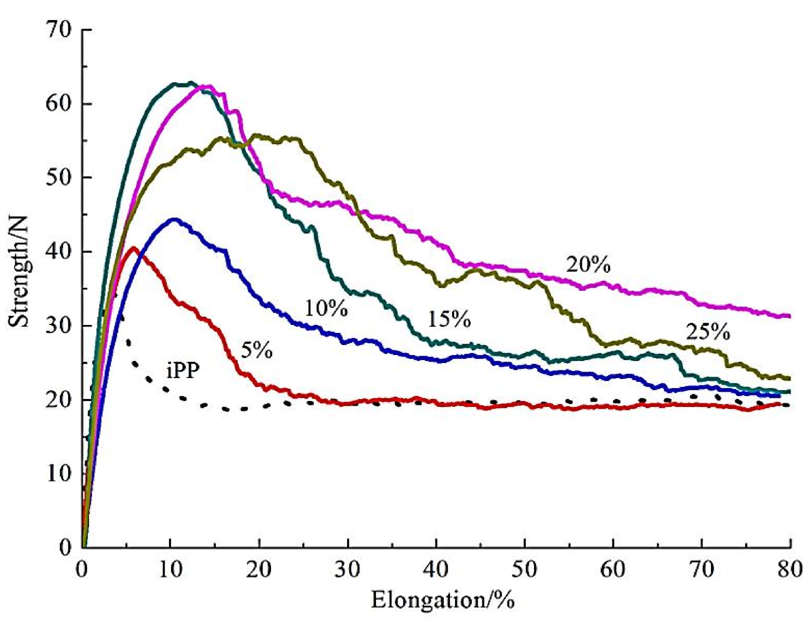
Material & Methods

iPP, s2040 (Ziegler–Natta) with molecular weight 2.0×105 g/mol by SECCO Petrochemical limited, China. LMPP (s901) provided by Idemitsu Kosan Co, Ltd. Japan, with molecular weight of 1.3 × 105 g/mol was used. Blend mixing ratios of iPP/LMPP defined as 5%, 10%, 15%, 20%, and 25% [1, 2]. Properties were compared to 100% PP and 100% LMPP.

Spunbond nonwovens of blends were prepared with HD-SM machine (Huada company, Shandong, China). Processing parameters of spunbond nonwovens were; extrusion temperature 210°C, extrusion quantity 200ml/min, drawing air temperature 40°C, suction pressure 4KPa, transmission speed 7.5m/min, pre-pressing temperature 45°C, hot pressing temperature 110°C, and hot processing pressure 1200kgf. The mechanical properties were tested with extension speed 50 mm/min using a Instron 3369 series mechanical tester (Instron company, USA).

Results & Discussion

Mechanical Properties

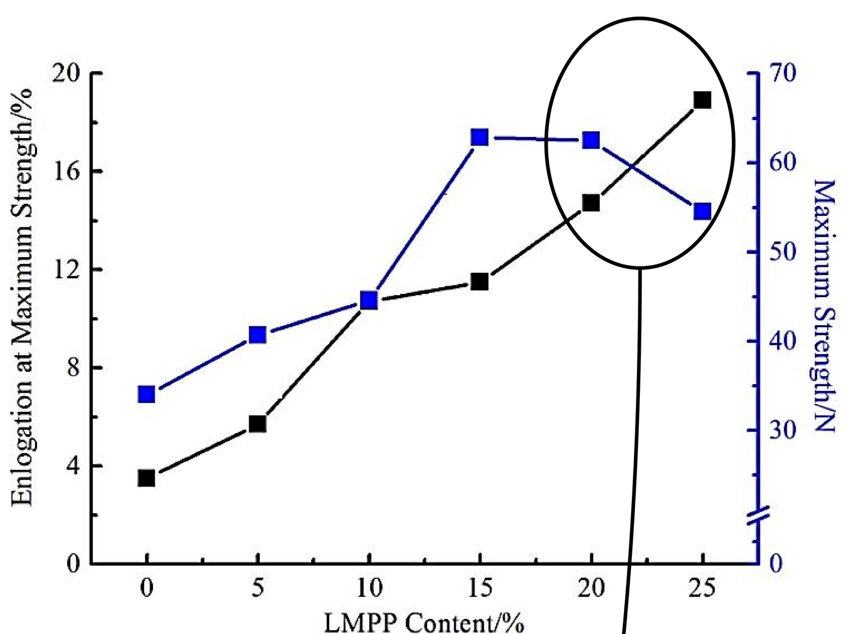


Elongation @ break

- Nonwovens starts showing increase in mechanical properties with min content used (5%).
- Maximum elongation at break was seen for the samples with 15-20% contents of LMPP.

Max strength–Max elongation @ break

- Maximum strength of iPP nonwovens was at 3-4%.
- Maximum elongation increase with LMPP content.
- Maximum strength drops with higher LMPP contents.

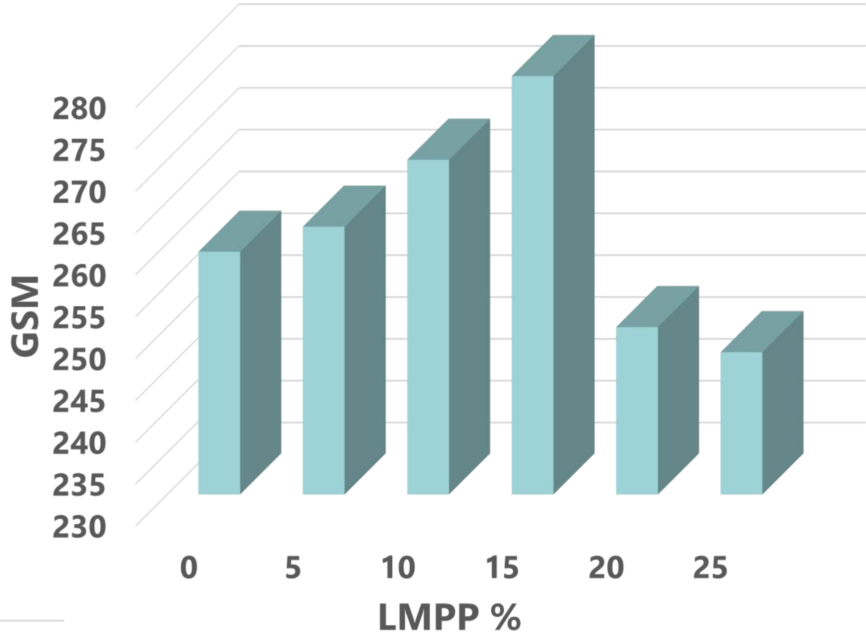


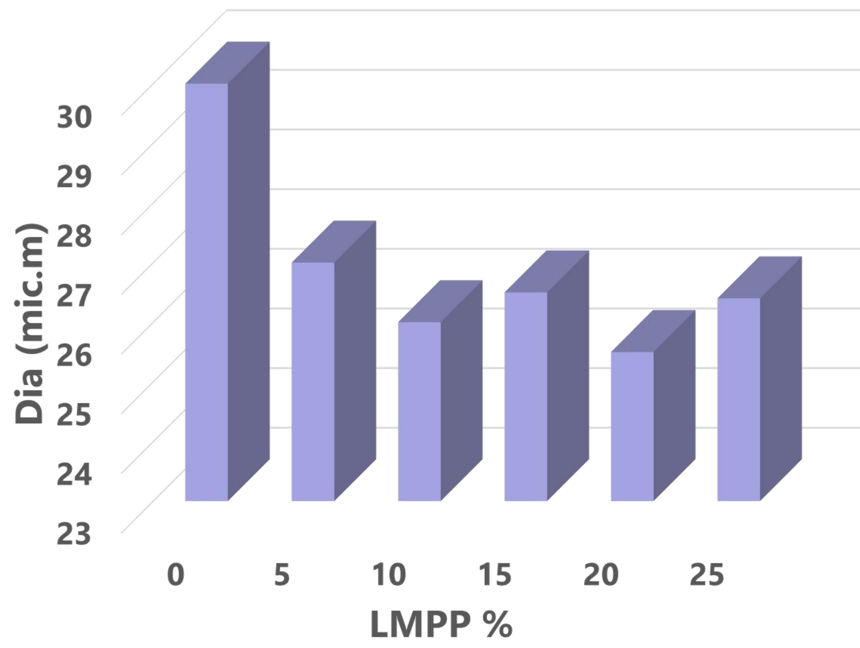
While nonwovens being stretched, the force on the yarns make them longer and the diameter gets smaller, simultaneously. The force transfer to cohesive points and drop-off accumulated to certain strength. Later, the stretch reaches to an equilibrium stage

Morphological Properties

GSM of nonwovens

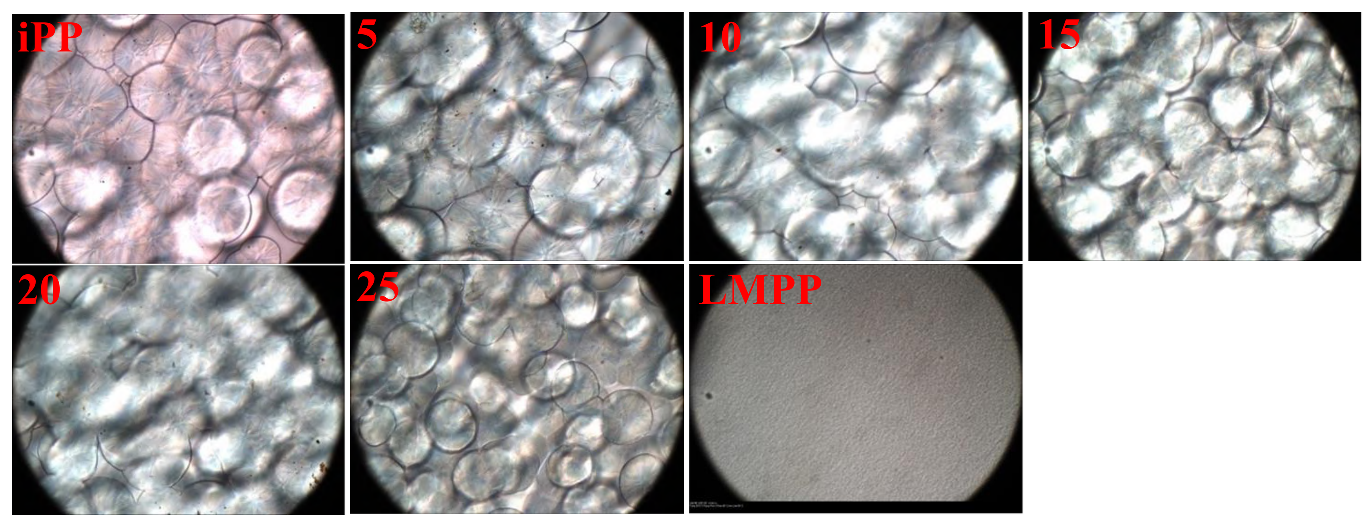
- GSM increase with LMPP content but drops later on.
- Higher the GSM, higher the tearing strength of nonwovens.





Mean diameter of nonwovens

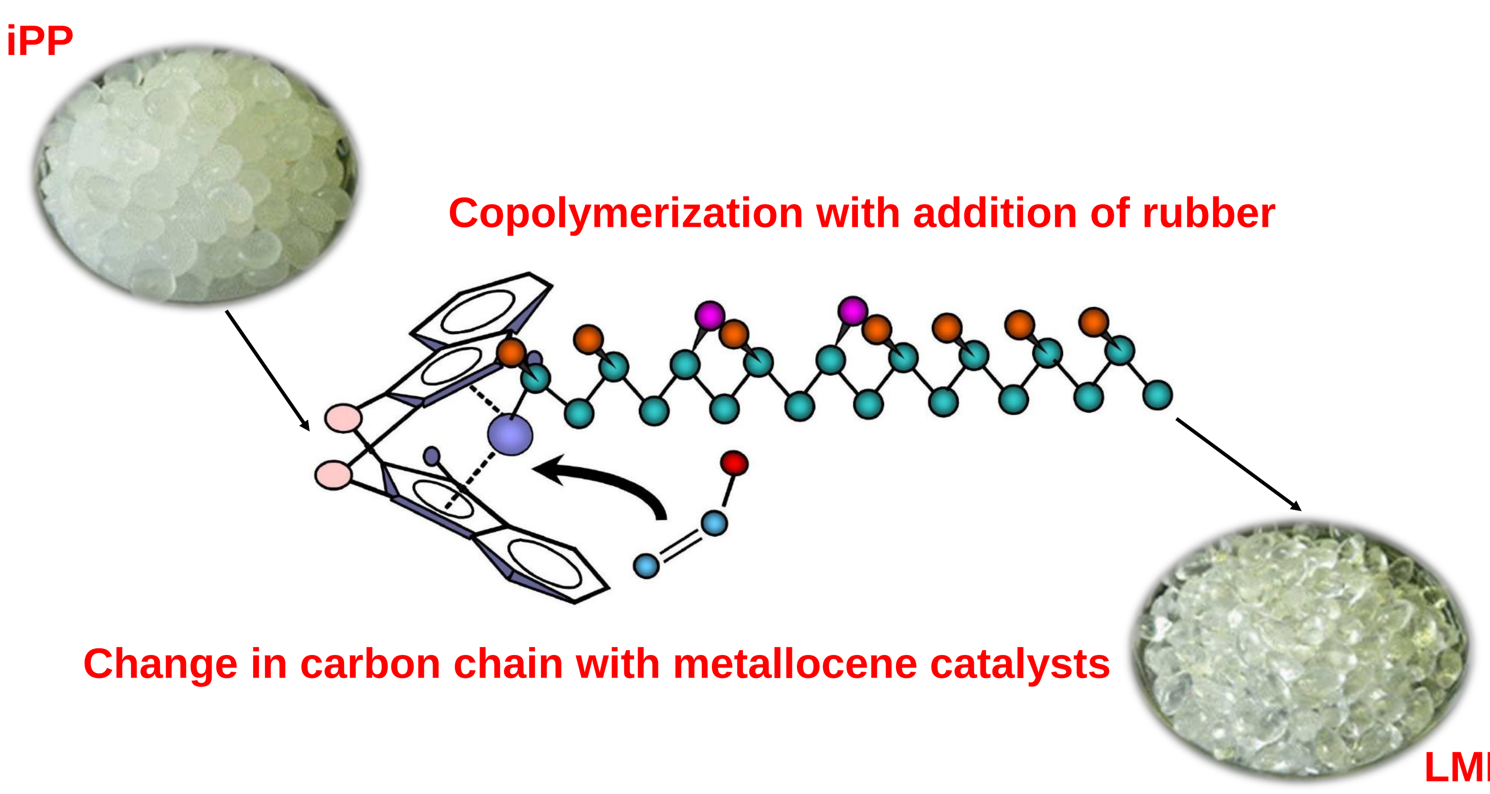
- Dia decrease with LMPP content.
- Smaller the dia, finer and smoother the nonwovens get.



Polarizing Optical Microscope (POM)

- Spherulite growth of iPP, LMPP and their blends via POM at isothermal crystallization temperature (120°C).
- Bright and sharp spherulite are visible for blends, while for LMPP not very clear.
- Smaller and sharper the shperulites, better the crystallization behavior.

Mechanism of LMPP modification [3]



Conclusions

- ➢ iPP/LMPP with good miscibility was achieved, which resulted in finer and compact blends.
- ➢ iPP/LMPP blends with various cohesive points and finer yarns, provided smoother and strong nonwovens.
- ➢ Both strength and toughness of iPP/LMPP spundbond nonwoven fabric improved, showed max at 15-20% of LMPP content.

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SELVLIES PRO

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SelVliesPro – Digitization for the process of carbon fiber recycling – From rCF to organic sheets

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stfi SÄCHSISCHES TEXTIL FORSCHUNGS INSTITUT e.V.

Introduction

The consortium of the SelVliesPro project aims at developing an intelligent plant for processing recycled high-performance fibers into organic sheets and thus increasing the degree of recycling carbon fibers. The process is characterized by the continuous production of a textile material through several successive process steps, which are mutually dependent on each other on process and parameter side.

For this purpose, a technologically self-optimizing and learning control system using constant data logging will be integrated into the plant and a strategy for intelligent maintenance will be developed. Furthermore, the use of context- and role-specific assistance systems on mobile end devices under difficult production conditions is investigated.

The following benefits are supposed to be achieved with these steps:

- Shortening of product development cycles through intelligent process control
- Closing existing gaps in the recycling process for the economical reuse of carbon fibers
- Developing new market segments for organic sheets made from recycled carbon fibers as a basis for lightweight construction applications
- Further developing PPE (Personal Protective Equipment) under the aspects of digitization
- Increasing productivity through smart maintenance strategies

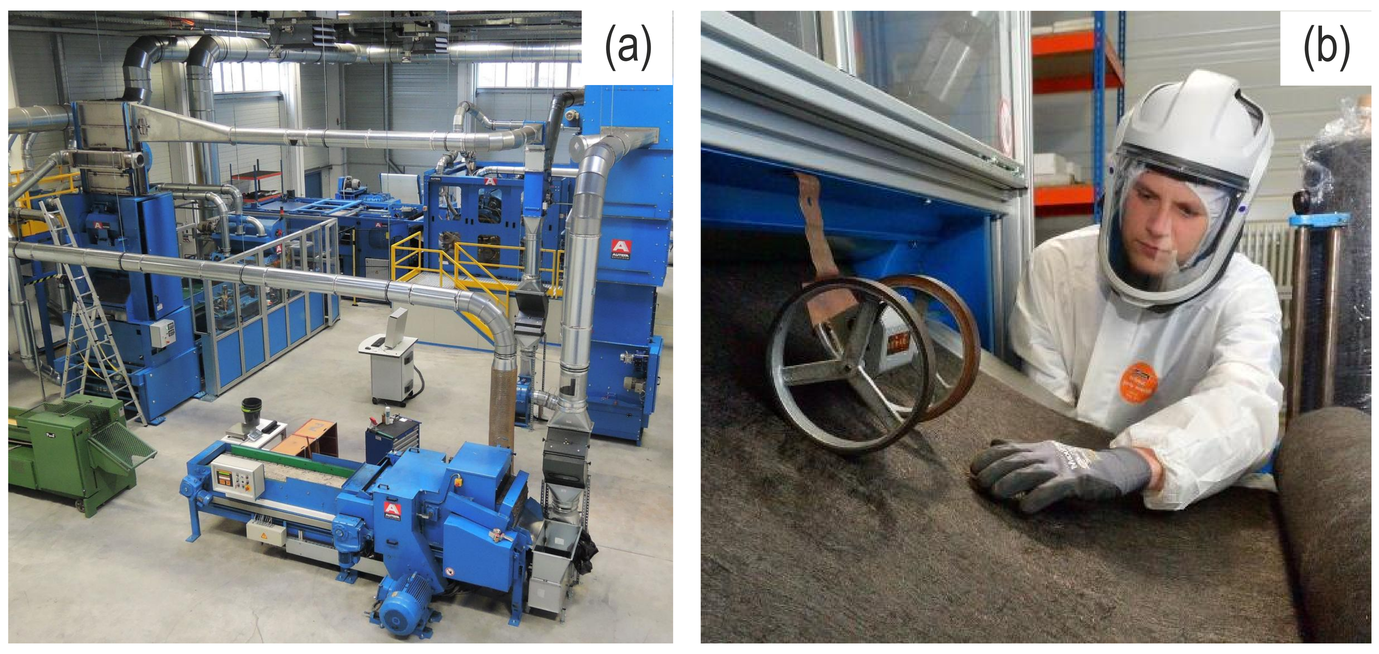

Fig.1: Plant technology for carbon fiber recycling (a) and PPE as protection against carbon fibers (b)

Experimental & Results

Within the frame of the project the complete process ranging from fiber preparation, web formation to entanglement and composite consolidation is considered. The semi-industrial production facility in the Centre for Textile Lightweight Construction at the Saxon Textile Research Institute (Sächsisches Textilforschungsinstitut e.V.) serves as experimental environment. The following technological fields of action are included in the considerations:

Intelligent maintenance

- Development of process models for the implementation of intelligent maintenance applications
- Identification of additional data requirements as well as retrofitting of corresponding hardware (sensors)
- Concept development for the integration of a process control system

Human-machine interaction

- Development of use cases for human-machine interaction, taking into account specific work tasks and work environment
- Creation of a 3D model of the plant for use in an AR application
- Interface integration/interface development with backend/data storage

Fig. 2: 3D model of the plant

Decentralized decision-making through a technologically self-optimizing production line

- Identification of suitable data analysis approaches for maintenance and process control
- Development of procedures for self-learning control systems
- Creation of program sequences for data collection and evaluation

In order to transfer the complex contents of the technological fields of action to industry, a modular teaching and training concept will be developed. With the help of the project, interested companies are able to better understand the digital technologies and approaches in use. The concept is tailored to the needs of the businesses by means of a survey.

Conclusion

During the project following results have been achieved so far

- Creation of the OPC UA interfaces, expansion of the data base by means of energy data acquisition was realized
- Analysis methods for data evaluation were examined and defined
- Software architecture was defined and tested
- Photogrammetry of the plant was carried out and converted into a 3D model
- Survey about the design of the teaching and training concept was carried out

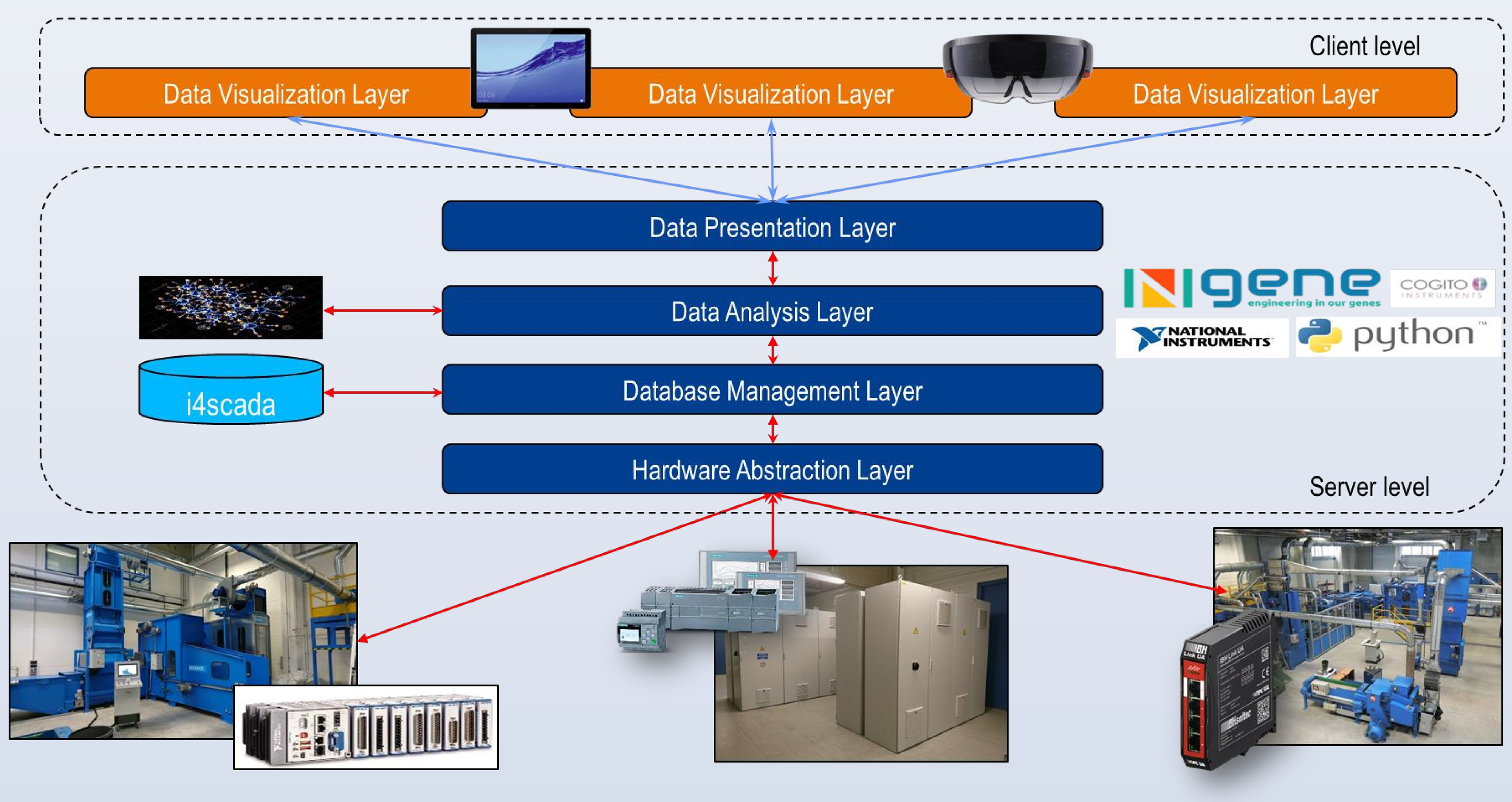

Fig. 3: Software architecture of the process control system

Further steps

- Implementation of the process control system
- Integration of algorithms for maintenance & self-control
- Realization of the AR application
- Development and evaluation of the teaching and training concept

Acknowledgement:

Financial support by the German ministry of education and research (BMBF) within the framewok Entrepreneurial Regions, project futureTEX, no. 03ZZ0627 is gratefully acknowledged.

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Blockchain-based framework for traceability – A case example in nonwoven supply chain

Tarun Kumar Agrawal[1,2], Vijay Kumar[2], Rudrajeet Pal[2]*

ABSTRACT

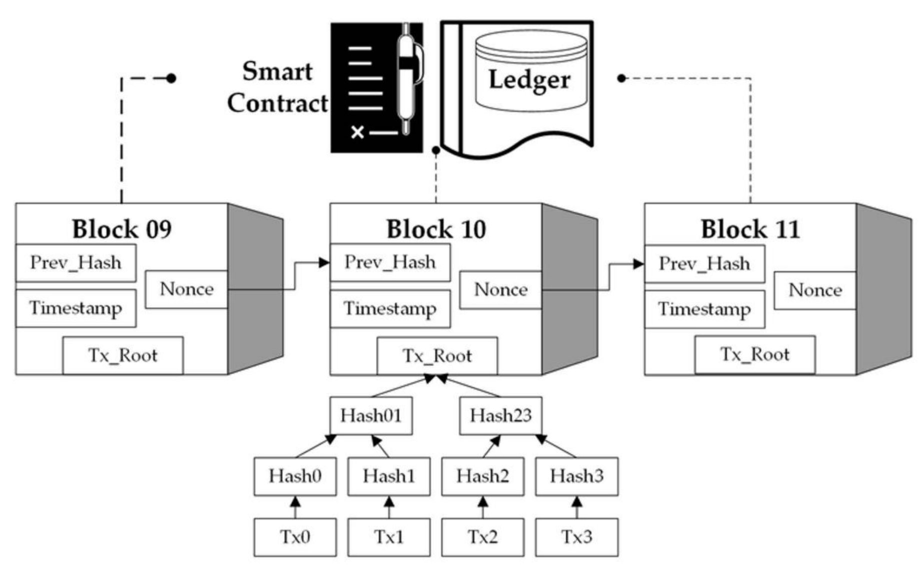
In line with Industry 4.0, this study investigates blockchain technology, which uses a shared and secured data infrastructure to keep track of information about assets and requires no central authority to function. It further proposes a blockchain-based traceability framework that explains nonwoven supply chain partner interaction and network architecture at organizational level and smart contract and transaction validation rules at the operational level. In order to illustrate the application of the framework, the study presents an example of a nonwoven supply chain to track the nonwoven manufacturing and distribution processes. The proposed system can build a technology-based trust among the supply chain actors, where the distributed ledger would be used to store and authenticate of supply chain transactions.

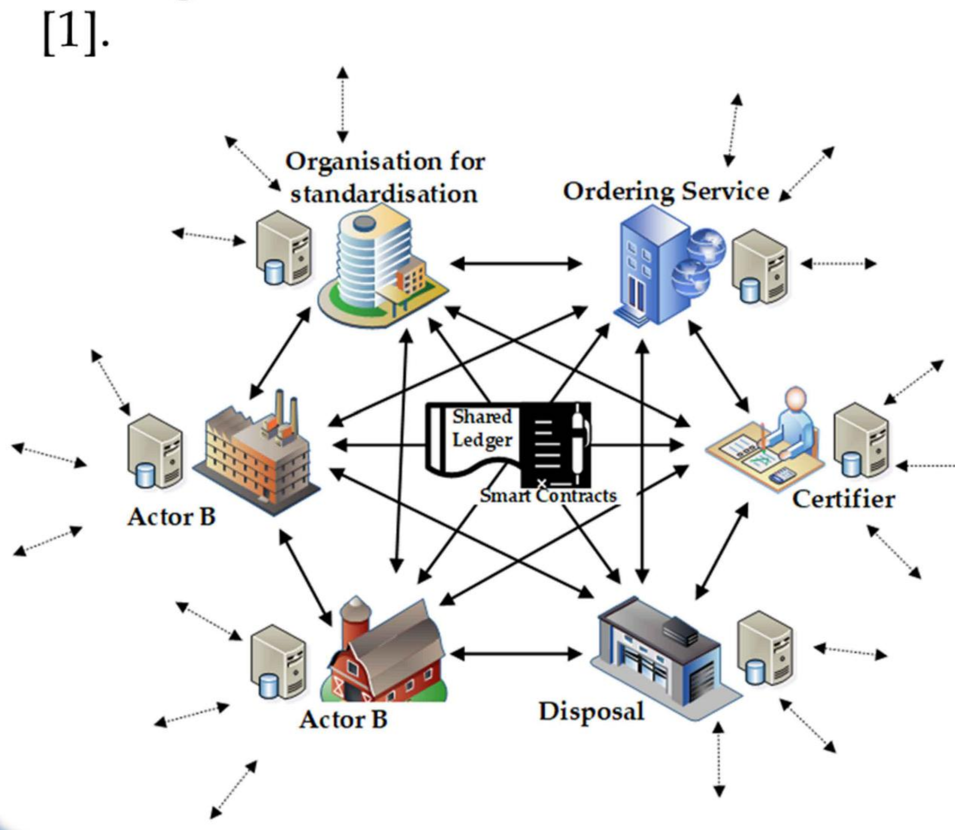
INTRODUCTION

- As defined by ISO traceability is "the ability to identify and trace the history, distribution, location, and application of products, parts, materials, and services. A traceability system records and follows the trail as products, parts, materials, and services come from suppliers and are processed and ultimately distributed as final products and services".
- Supply chain traceability has emerged as a prime requirement for multi-tier supply chains.
- Nonwoven supply chain is one such example that particularly requires traceability implementation due to prevailing problems related to information asymmetry and complex supply chain networks.
- In this direction, the study explores the implementation of traceability (at the information level) in the nonwoven supply chain using blockchain technology using a demonstrative simulation [2].

METHODOLOGY

- "Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible (a house, a car) or intangible (intellectual property, patents). Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved" [1].



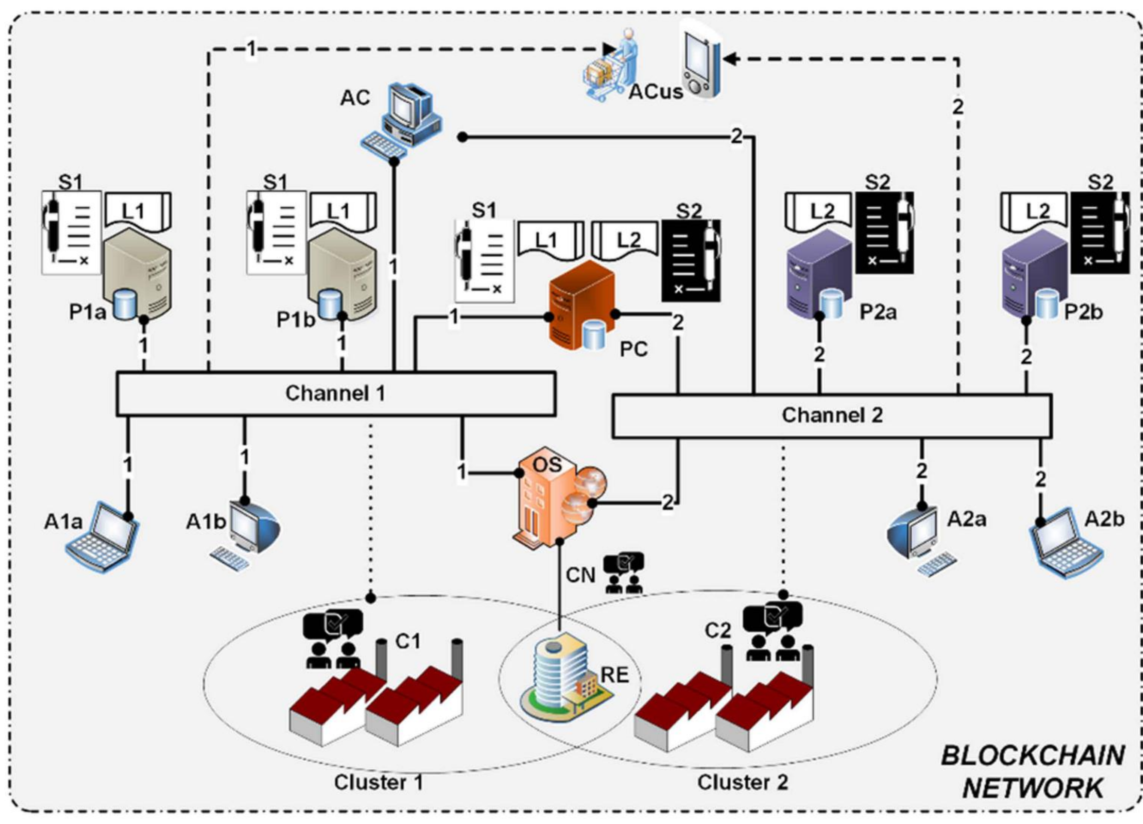


- Smart contract, shared ledger, consensus and permissions are four main pillars of blockchain mechanism. In an idealistic scenario, with blockchain-based traceability system adaptation throughout the supply chains, every individual partner would involve in multiple blockchain networks. Each of this network will have a different set of shared ledger and one or multiple smart contracts [3-4].

CONCLUSIONS AND FUTURE RESEARCH

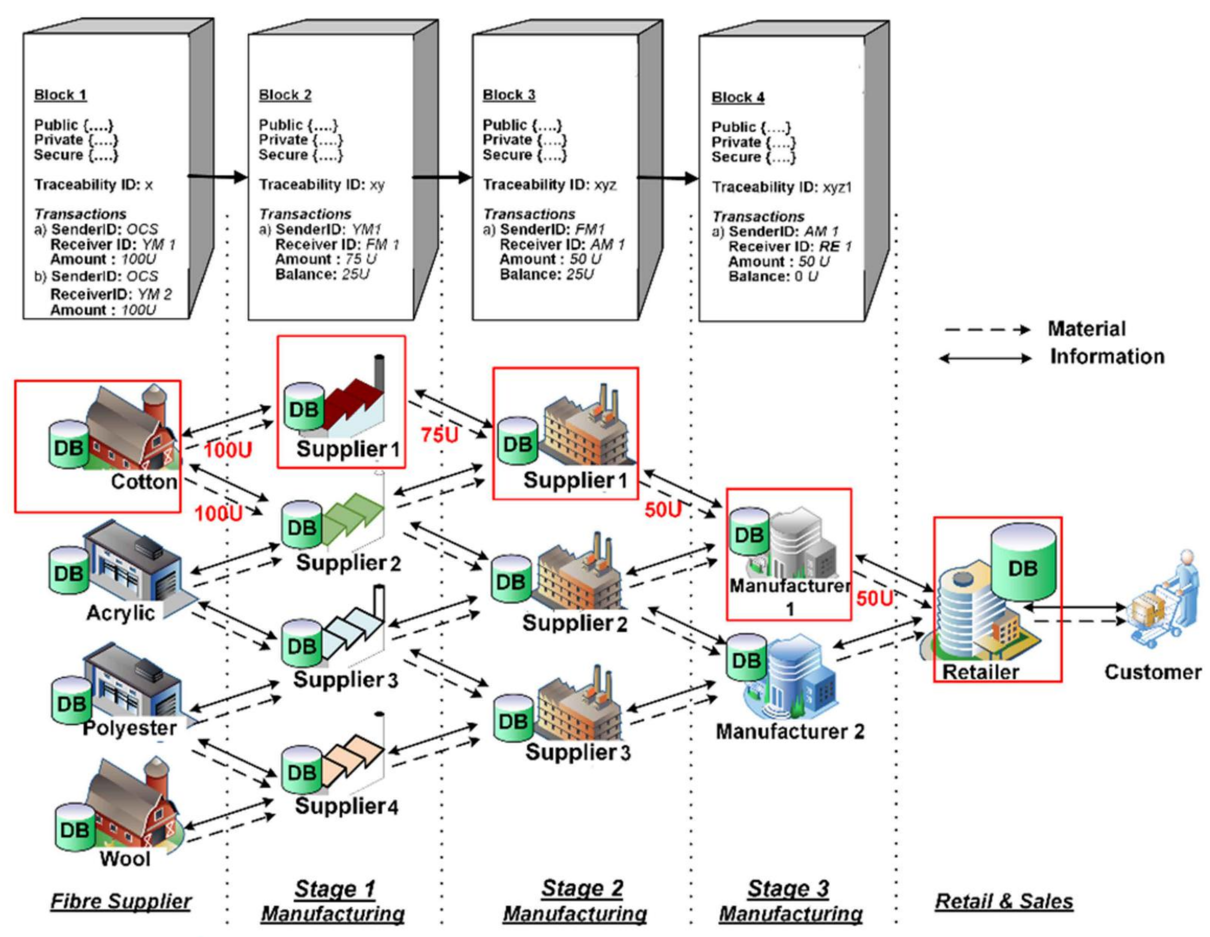
- The study develops and illustrates an example blockchain with mass-balancing based smart contract to authenticate the blockchain transaction and update the shared ledger.
- It provides a critical view on various essential components of blockchain for information/material exchange, supply chain partners' interaction, distributed ledger arrangement, smart contract development and information/material traceability and security
- In future, the blockchain transaction rules and smart contract will be modified to accommodate complex supply chain transactions.

CASE EXAMPLE - NONWOVEN SUPPLY CHAIN

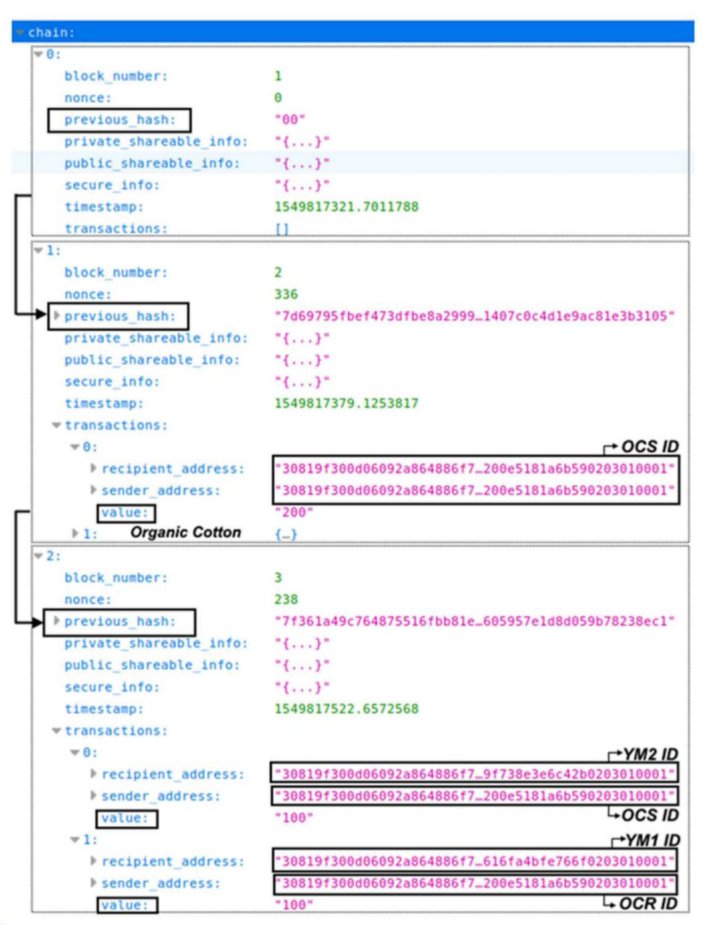


P - Peer System
S - Smart Contract
L - Distributed shared ledger
OS - Ordering service
1 - Related to channel 1
2 - Related to channel 2
A - Application with access to specific blockchain channel
CN - Channel rules (common)
C - Channel rule sepcific for a channel
AC - Application with access to multiple channel
ACus - Application for customer to access blockchain network
PC - Peer System with access to multiple channel

- Simplified representation of the proposed blockchain network for the nonwoven supply chain. It shows a simple network with two channels, each for a particular set (cluster) of supply chain partners including the retailer.



- The example blockchain demonstrates a simple scenario of trading and transfer of cotton from fiber supplier to retailer in sequential order i.e. simulating the material flow as it actually happens in a supply chain.



- A snapshot of the full blockchain that shows transactions and block data as they occur and are recorded in different blocks. Highlighted are the actors involved in the transaction (trading partners), value being traded, previous hash, nonce, timestamps and most importantly how the blocks are linked with the previous and next block forming the chain of transactions

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Effects of Filter Media Structure on Particle Capture and Dust Holding Capacity

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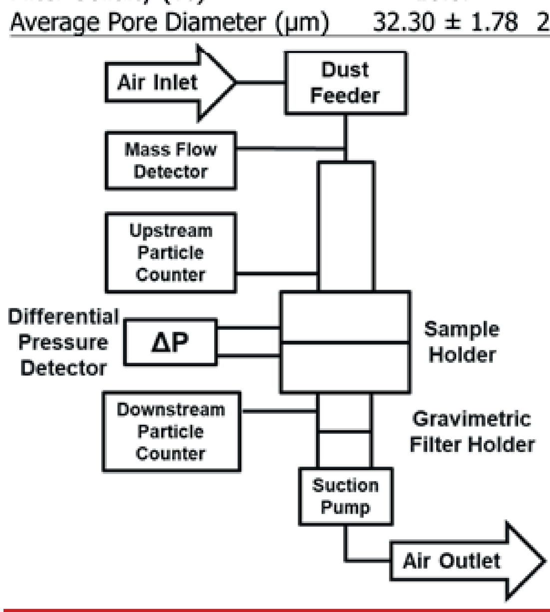
Objectives

Study the effect of **basis weight** of meltblown nonwoven filter media on particle loading behaviors using both experimental and X-ray micro-computed tomographic (XMCT) methods.

- Fabricate polypropylene (PP) meltblown nonwovens with different basis weight.
- Study the particle loading behaviors with experimental measurements.
- Characterize the particle deposition across the filter depth of particle-loaded filter media using XMCT.

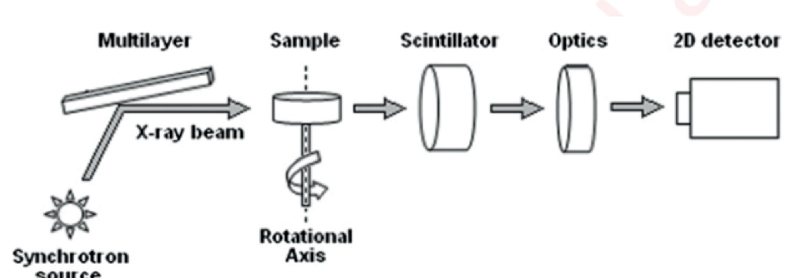
Materials & Methods

	BW-100gsm	BW-150gsm	BW-200gsm
Average Fiber Diameter (μm)	10.86 ± 4.04	10.86 ± 4.04	10.86 ± 4.04
Median Fiber Diameter (μm)	11.06	11.06	11.06
Basis Weight (g/m2)	96.8 ± 3.3	146.2 ± 6.3	194.6 ± 1.5
Filter Thickness (μm)	986.8 ± 13.9	1053.7 ± 19.0	1131.3 ± 20.8
Filter Solidity (%)	10.37	14.67	18.18
Average Pore Diameter (μm)	32.30 ± 1.78	24.84 ± 1.97	18.11 ± 0.23



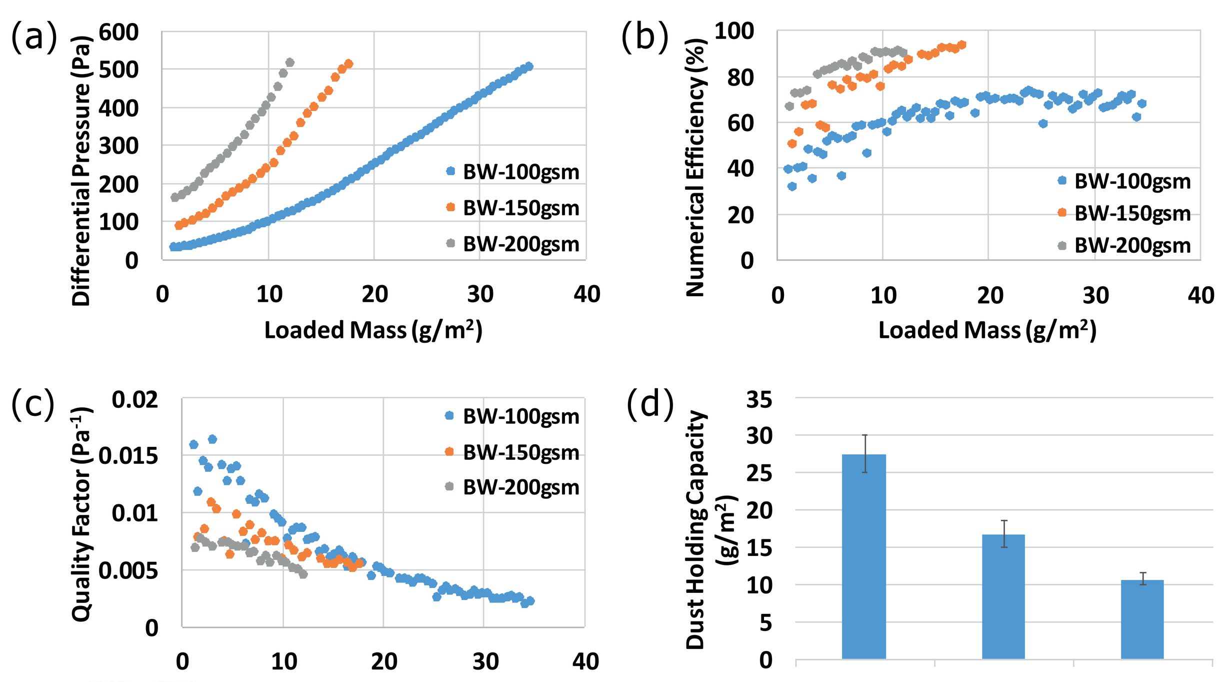
Particle loading testing:
- Palas MFP 3000 (A2 dust, ISO 5011)

3D imaging and structure characterization:
- X-ray micro-computed tomography (Xradia, Zeiss, resolution: 1.00 μm)



Particle Loading Studies

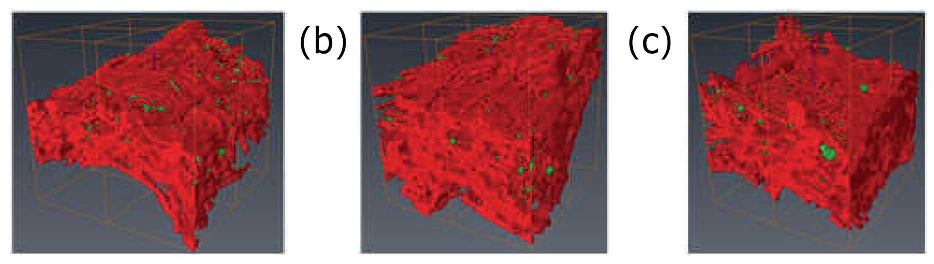
Meltblown filter media were loaded with A2 standard dust particles to study the evolution of filtration properties during the particle loading process.
(a) Differential Pressure vs. Loaded Mass, (b) Numerical Efficiency vs. Loaded Mass,
(c) Quality Factor vs. Loaded Mass, (d) Dust Holding Capacity vs. Loaded Mass.



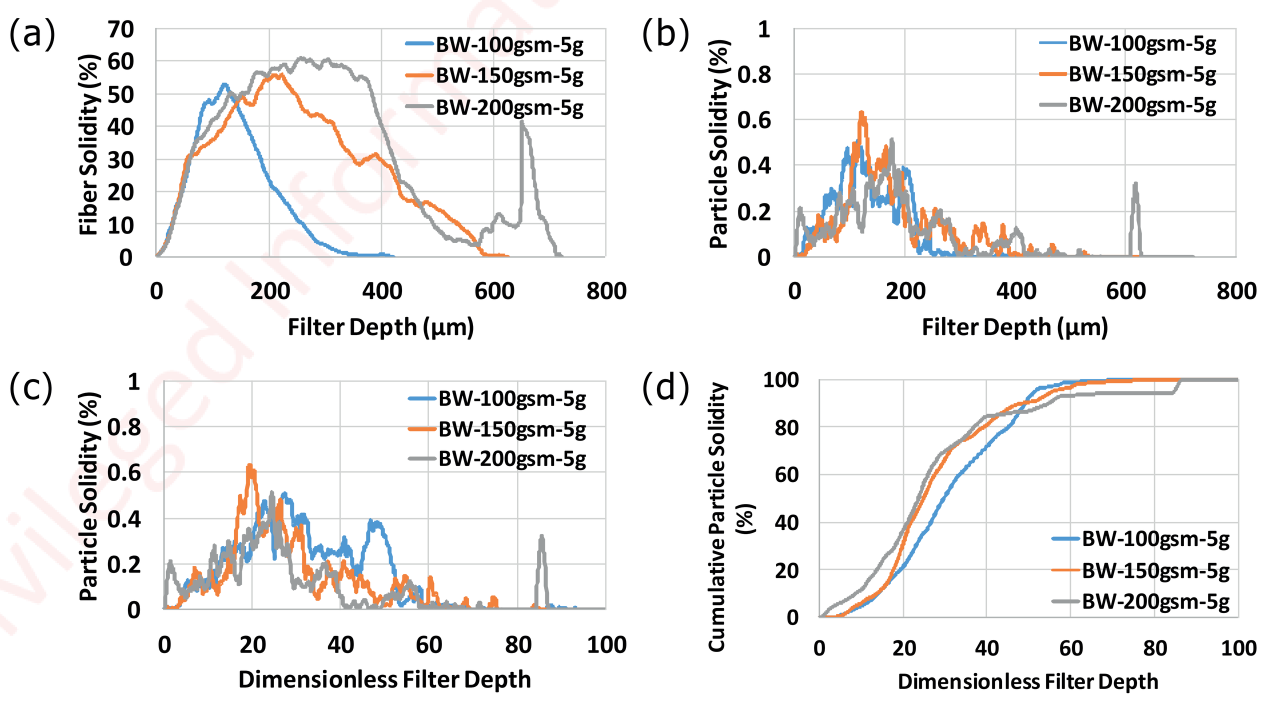
$$QF = \left(\ln\frac{1}{1-\eta}\right)/\Delta p$$

Structure Characterization

Meltblown filter media respectively deposited with 5g dust were scanned by XMCT:
(a) BW-100gsm-5g, (b) BW-150gsm-5g, (c) BW-200gsm-5g



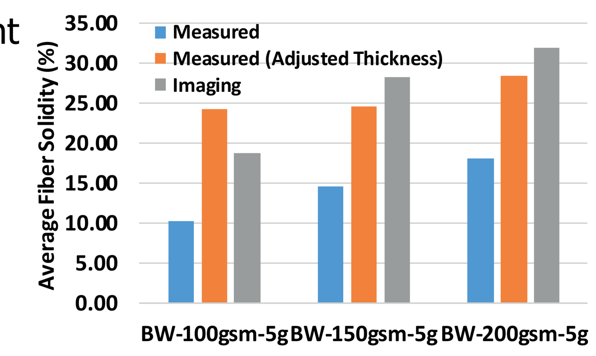
Fiber/particle solidity distribution were obtained from the above XMCT images.
(a) Fiber Solidity Distribution across Filter Depth,
(b) Particle Solidity Distribution across Filter Depth,
(c) Particle Solidity Distribution across Dimensionless Filter Depth,
(d) Accumulative Particle Solidity across Dimensionless Filter Depth.



Fiber solidity obtained from measurement and imaging methods were compared.
- Measured = BW/H/ρ,

where H is the thickness from measurement
- Measured (Adjusted) = BW/H_A/ρ,

where H_A is the thickness from imaging
- Imaging = Derived from 3D imaging



Conclusions

For meltblown nonwoven filter media with compact structures:

- Higher basis weight: faster pressure drop increase, higher filtration efficiency, lower quality factor, and lower dust holding capacity at the end.
- Higher basis weight, higher ratio of particles would be captured by the part from the surface to the same dimensionless filter depth.
- Fiber solidity with a ‘real’ value can be obtained by the 3D XMCT imaging tool.

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