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BOOK OF ABSTRACTS

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CONTENT

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PROGRAMME

September 25, Thursday

08.30-09.30 **Registration**

09.30-10.00 **Opening Speeches**

10.50-11.15 **Coffee Break**

September 26, Friday

15.10-16.10 **Coffee Break**

September 27, Saturday

08.00-18.00 **Social Activities (Optional)**

PLENARY SESSION 1

DEVELOPMENT OF THREE DIMENSIONAL PRESSURE RELIEVING CUSHIONS FOR PREVENTION OF PRESSURE SORES

S.C. Anand[1], **C. Wood**[2], **B. McArdle**[3]
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Polyurethane (PU) foam is commonly used for seating and cushions in many applications varying from car seats, chairs, wheel chairs, sofas, mattresses and furniture. It is well known that PU foam cushions and seats are not breathable and lack thermoplysiological comfort. They are also not washable at high temperatures and are environmentally hazardous both in terms of flammability and recycling.

Warp Knitted Spacer Fabrics are extremely versatile in terms of designing, thickness, comfort, washability, compression and resilience and above all they are extremely efficient in pressure relief. These unique three dimensional (3D) structures can have between 2mm and 65mm thickness with good compression, resilience and breathability. The two independent fabric faces can be knitted into any kind of mesh or solid structures and in order to sustain the space between the two faces, and to obtain the required compression and resilience properties in the thickness direction, monofilament yarns are normally used as the spacer yarn.

The paper discusses the systematic research and development of pressure relieving cushions, by combining a series of three-dimensional warp knitted spacer structures in order to achieve the desirable properties, such as good compression resistance and resilience, reduction of peak pressure and pressure distribution over much larger area of the cushion. The fundamental research work was carried out at the University of Bolton, U.K.

The various innovative and unique features of the Airospring® Cushions are as follows:

1. They are much better at reducing peak pressures under the bottom than PU foam cushions.

2. They distribute the pressure evenly over much larger areas of the cushions or seats than PU foam cushions.
3. They conform to the shape of the body and have sufficient compression resistance to support the person without "Bottoming Out".
4. They provide a well-ventilated, comfortable surface that does not unduly restrict movement.
5. They can be laundered in the washing machine, are non-flammable and can be easily recycled.
6. They are particularly beneficial to the persons who are prone to developing pressure sores, due to prolonged periods of sitting in the wheel chair and other support systems.

Airospring cushions have been covered by a patent application and are being commercially developed and marketed by Baltex Limited, Ilkeston, Derbyshire, United Kingdom.

INNOVATION IN KNITTING TECHNOLOGIES AND APPLICATIONS

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The Institut für Textiltechnik (ITA) belongs to the top 10-institutes of RWTH Aachen University. Its core competencies are the development of textile machinery and components, high performance fibre materials, manufacturing technologies and comprehensive process chains and the development of innovative textile based products in the sectors of mobility, civil engineering and living, energy and health. The essential technology fields of its research are material and energy efficiency, functional integration and integrated production technologies. The institute employs about 90 researchers graduated in the studies of mechanical engineering, business engineering, physics and chemistry. A major field of research at ITA is textile machinery and within this fabric production, in particular knitting.

Textile companies as well as research institutions, in particular those located in Germany, pursue an ongoing advancement and new development of their existing products and processes. Knitting facilities in Germany and Central Europe have recently increased their production of knits for technical application fields. This trend refers to the application of the produced products as well as the used materials. For example knitted fabrics out of common material (Polyester, etc.) are used for technical applications like base yarn materials for composite structures. On the other hand known applications, for instance home textiles made out of new materials like glass yarn, are researched in the field of flame protection.

A trend of the development of knitted structures is the machining of superfine yarns. From this follow further challenges in machine construction. In particular the machine gauge (number of needles per unit of length) needs to be adjusted. Through the realisation of finer machine gauges by attending denser knitted structures, new fields of application are opened. One of these application fields is the filtration technology [1].

Furthermore, an important research field at ITA is the investigation of new, mainly technical yarn materials for knitted fabrics. In comparison to other types of machinery in fabric manufacturing (e.g. weaving, warp knitting) there is a high potential for the investigation of innovative materials using knitting machines. In general, knitting machines require a little amount of yarn material for fabric manufacturing – e.g. using small circular knitting machines there is just a need of one single yarn bobbin. The set up and production times are low, so the mechanical properties of knitted fabrics made out of new material can be determined quickly. That is why knitting machines are often used in prototype production. At ITA, the knitting processability of new yarn material, such as melting polyolefin and glass has already been investigated successfully. One important property of glass fibre material is its flame resistance, so brought into fabric it can be used in automotive interior, living area as well as in garment engineering application [2].

Another focus at ITA lies in the automation of entire textile process chains as well as of single textile manufacturing processes. The circular knitting technology including the integrated electronic needle control provides excellent conditions for automation issues. The electronic needle control enables a high range of pattern creation and changing, so product variations can be performed easily during operation. Additionally, integrated material changing systems increase the possibility of product variation [3]. Further research issues focus on the interconnection and intercommunication of the knitting process with upstream and downstream production steps as well as the integration of these production steps into the knitting process. A topical example in industrial application is the Spin-Knit technology. It has been developed by diverse circular knitting manufacturers and enables the integration of the yarn spinning process into the knitting process. [4]. Furthermore, ITA conducts research in online-production supervision. Production defects can be detected and the machines themselves are able to adapt their production parameters. Comparable approaches in self-optimisation have been recently realised at ITA regarding the weaving process within the scope of the research project „Onloom Imaging“ [5].

Key Words: Yarn material, weft knitting, technical applications, mechanical engineering, automation

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PLENARY SESSION 2

TEXTILES TO BREATHE FREELY- TEXTILE SOLUTIONS FOR RESPIRATORY TISSUE ENGINEERING

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The research area of respiratory tissue engineering is a young discipline, which is aiming to support lung function by innovative living implants. Hereby it addresses the treatment of end-stage lung disease, which is often related to a further injury of the lung tissue by aggressive mechanical ventilation or by the failure of conventional and avital implants e.g. in endobronchial stenting.

The presentation will deal with two innovative concepts of
- a bioartificial lung (EndOxy) and
- a endobronchial stent device (PulmoStent)

Within the 7th FP programme of the EU the ***PulmoStent Project*** is aiming to develop a viable endobronchial stent for the treatment of broncho-tracheal cancer diseases. The concept is based on the combination of stent technologies with the principles of tissue engineering. The PulmoStent is a multi-layered structure based on a textile stent providing a functional respiratory epithelium on the luminal side, which allows the maintenance of the mucociliary function in the stented area, a mechanical separating layer on the external side, enabling a local tumour suppression to avoid stent displacement and restenosis by a growing tumour.

The EndOxy project is aiming to provide a fully implantable lung as a biohybrid system. The aim is to overcome the current limitations of artificial organs, which is based on the unspecific protein binding on foreign body surfaces. The endothelial cell lining on an innovative textile based membrane is therefore a promising solution. Therefore the modification of the current hollow fiber membranes towards a flat sheet membrane with optimal cell adhesion properties is necessary. The combination of spacer fabrics with e-spinning technologies allows the optimization of the flow pattern in the oxygenator device and an optimal cell lining.

The presentation will give an overview about both projects and the current state of the art with specific focus on the textile challenges and current solutions.

COMPUTATIONAL EVALUATION OF HOSPITAL MATTRESSES

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Pressure ulcers are areas of soft tissue breakdown caused by sustained mechanical loading of the skin and underlying tissues and affect the quality of life of many individuals [1]. This condition is often avoidable using pressure ulcer prevention strategies which reduce the magnitude and/or duration of pressure at the interface between the patient and his/her support surface. An ideal support surface (cushion, mattress or overlay) provides pressure redistribution and maintains a healthy skin microenvironment preventing pressure ulcers [2]. Usually these support surfaces can be classified according to their main material to standard foam, alternative foam, gel filled, fluid filled, fibre filled and air filled surfaces [3].

In the literature, two ways to investigate the effectiveness of a support surface dominate. The most common is controlled clinical trial comparing beds, mattresses and overlays, measuring the incidence of new pressure ulcers [3, 4]. The other is the experimental measurement of the pressure on the interface of the body and the support surface. This method has been used by Nicol et al. and a sensor mat consisting of uniformly distributed pressure sensors was developed and used to monitor the performance of different hospital mattresses in four subjects representing extreme body built [5].

The finite element method (FE), used already to investigate sleeping comfort [6] and interface pressure on the heel and the buttock [7, 8], could prove itself useful in this area. In the present paper, the FE method has been used to qualitatively evaluate different 3D textile materials for their use in hospital mattresses. The elastic modulus of different 3D textile materials has been computationally evaluated utilizing the results of a compression test performed on them. Then a FE model consisting of a human body in an exact geometrical representation and a hospital mattress of typical dimensions has been built and meshed in ANSYS Workbech v 14.0. The human body was considered to consist of soft tissue, while for the mattress the elastic moduli of different 3D textiles have been used. Several transient structural analyses have been performed using as load the gravity acting on the human body and restricting the vertical movement of the lower surface of the mattress, simulating the supine body posture. The FE method gives the opportunity to investigate pressure interface, as well as other mechanical quantities, such as deformation or strain energy density that could be proven helpful indices in the future.

Key Words: Pressure ulceration, mattress, finite element analysis, interface pressure

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THE ROLE OF ANTIMICROBIAL IMPREGNATED MATERIALS ON THE HEALTHCARE ASSOCIATED INFECTIONS

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Healthcare associated infections (HAIs), or "nosocomial" and "hospital" infections are the most common complications during health-care delivery worldwide. Each year between 7% to 10% of hospitalized patients are affected by HAIs worldwide and facing to significant morbidity and mortality. The risk of getting HAIs is much higher in patients admitted to intensive care units, transplantation units, oncology units and burn units.

There are many antimicrobial impregnated products available on the market using in health-care practices such as; hospital infection control, invasive and implantable devices and wound care. All of them have different physical properties; such as the level of antimicrobial they release, the duration of effective action and the characteristics of carrier dressings. Ideel antimicrobial dressing should has broad anti-microbial spectrum, rapid and sustained activity, non-irritant and non-toxic to tissue, not inhibited by body fluids, wound exudate and biofilms and cost effective.

As an antimicrobial agent silver has been used since Hippocrates for various purposes. Today nano-silver shows high antibacterial effects against a large number of bacterial species with multiple bactericidal mechanisms. Nano-crystalline silver wound dressings have been used for the treatment of burn and ulcer wounds. In a clinical study with 166 different burn wounds the efficacy of nano-crystalline silver dressings was evaluated. In this study nano-crystalline silver dressings decreased wound healing time by an average of 3.35 days and increased bacterial clearance when compared to conventional silver sulfadiazine dressings. Nano-crystalline silver usage is increasing in health care settings to provide effective treatment for different types of wounds. Chitosan nano-crystalline silver containing dressings as an new fabricated nano-crystalline silver has superior healing rates compared to silver sulfadiazine dressings.

One of the most common HAIs is catheter related bloodstream infection (CRBSI). Patient' own skin flora is the major sources of catheter related blood stream infection In a meta-analysis the effect of anti-infective impregnated dressings on the risk of vascular and epidural catheter bacterial colonization and infection was assessed. The result of meta-analysis showed that chlorhexidine-impregnated dressing reduced significantly both the risk of intravascular catheter or exit-site bacterial colonization [(14.8% versus 26.9%, $P < 0.00001$) (14.3% versus 27.2%, $P < 0.0001$)] and epidural bacterial colonization (3.6% versus 35%, $P = 0.0005$) when compared with placebo. The same results with chlorhexidine-impregnated dressings were also obtained in pediatric patient groups.

In another meta-analysis examining the impact of a chlorhexidine dressing including both a sponge dressing and an integrated dressing revealed that the chlorhexidine-impregnated dressings were more effective than traditional site care for reducing CRBSI in patients admitted to intensive care units (ICUs). Even after careful skin antisepsis and cover the catheter surface by transparent dressing, central venous catheter related blood stream infection can occur due to regrowth of the skin flora and migration of bacteria from the dermis to the epidermis. In a randomized, multicenter trial it is proven that chlorhexidine-impregnated sponges prevented the regrowth of bacteria in the epidermis, and lowered the catheter related infections (0.6 vs. 1.4 per 1.000 catheter-days HR, 0.39; $P= 0.03$) and catheter related blood stream infection (0.4 vs. 1.3 per 1.000 catheter days; HR, 0.24; $P< 0.001$). In recent years chlorhexidine-impregnated gel dressing was developed and has also been shown to decrease the cutaneous flora as in the sponges.

Incorporation of copper (II) into alginate hydrogel dressing showed great antimicrobial activity against *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* (MRSA), *Staphylococcus epidermidis*, *Streptococcus pyogenes* and *Escherichia coli*. This study showed that new antimicrobial dressing is promising and is likely candidate for antibacterial wound dressings.

As a result antimicrobial-impregnated materials have been successively used with and/or in addition to infection control measures to prevent or lower the rate of health care associated infections.

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WOUND DRESSINGS

HONEY-CONTAINING ELECTROSPUN PET WOUND DRESSINGS

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The wound dressing materials produced by electrospinning method have excellent properties when they were compared with the dressings obtained by conventional methods. Nanofibrous wound dressings having small holes and high effective surface area can promote hemostasis phase [1]. In this study, fibrous mats were fabricated via electrospinning from solutions of polyethylene terephthalate (PET), PET/chitosan and PET/honey at different concentrations. The effect of honey and chitosan on electrospinning process was investigated and compared. The resulting fibrous mats were well characterized in view of wettability, water-content, chemistry and also cytotoxicity.

Honey generally is composed of glucose (30%), fructose (40%), sucrose (5%), water (20%), and many other substances, such as amino acids, vitamins, minerals, and enzymes. It has been used in wound care, due to its medicinal properties. It is known that honey can provide a moist healing environment without the risk of bacterial infection. Honey also has an antimicrobial property. Maleki et al. [2] showed that fabrication of the electrospun honey based fibrous matrices could be possible. They examined poly(vinyl alcohol) (PVA)/honey electrospun fibers and obtained uniform, bead-free fibers.

In the presented study, as a potential wound dressing candidates PET, PET/chitosan and PET/honey fibers were electrospun and fibrous matrices were prepared. Smooth and uniform PET/honey fibers were obtained up to 40 wt % honey. In the case of PET/chitosan, while the fibers had a beaded morphology at a low polymer concentration (17% wt), fiber diameter increased and ribbon like/branched fibers observed at a higher polymer concentration (19% wt). The jet stability was improved and processing limitations related to chitosan was eliminated with the addition of honey to the spinning solution during spinning proccess. All fiber mats show good water absorbing capacity when compared typical wound dressing. Basic properties of fibrous mats are presented in Table 1. MTT results demonstrated that electrospun PET, PET/chitosan and PET/honey matrices have no toxic effect on the cells. Besides to these desirable characteristics of PET/honey and PET/chitosan-honey mats their well-known antibacterial properties sourced from the presence of chitosan and/or honey make them good alternatives as wound dressings.

Table 1. Basic properties of fibrous mats (thickness: approx. 140 μm) prepared from different PET, chitosan, and honey compositions at the optimized electrospinning condition (voltage: 24 kV; flow rate: 3.5 mL/h; distance to collector: 30 cm), (Cs: Chitosan, Hny: Honey. Subscripts denote the weight ratio).

Composition of fibers	Fiber diameter (nm)	Matrix porosity (%)	Equilibrium water content (%)	Water contact angle (^{o})
17(PETCs$_{10}$)	565 ± 245	50.5	nd	nd
17(PETCs$_{10}$Hny$_{10}$)	557 ± 217	47.3	nd	nd
17(PETHny$_{10}$)	678 ± 145	49.4	nd	nd
19PET	682 ± 111	47.9	430 ± 20	135.0 ± 1.5
19(PETCs$_{10}$)	1484 ± 389	43.4	426 ± 21	0
19(PETHny$_{10}$)	780 ± 106	44.2	418 ± 27	134.8 ± 1.3
19(PETHny$_{20}$)	755 ± 128	45.4	nd	nd
19(PETHny$_{30}$)	720 ± 130	49.0	nd	nd
19(PETHny$_{40}$)	668 ± 177	49.1	282 ± 9	132.7 ± 2.1

Key Words: Polyethylene terephthalate, chitosan, honey, electrospinning, wound dressing

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HAEMOSTATIC, RESORBABLE TOPICAL AGENT MADE OF THE NATURAL POLYMERS

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The aim of the research is to elaborate technology for manufacture of haemostatic topical agents of fourth generation featuring immediate stop of bleeding from trauma and surgical wounds and guaranteed high degree of safety during application.

The variations of the haemostatic topical agents were designed differing in the form and the formulation of micro- and nanofibryds made of natural polysaccharides.

The presented study covered the selection of the most proper form and the formulation of the haemostatic topical agent based on the usable properties as well as assumed requirements for the clinical use.

The usable parameters were selected taking into the account the results of the risk analysis (acc. EN-ISO 14791 Standard) being one of the aspect of the project activities.

The project will be realized at the Institute of Biopolymers and Chemical Fibres in collaboration with the Institute for Security Technology MORATEX in Lodz, Wroclaw Medical University and the Military Medical Institute in Warsaw (consortium formed units). Industrial partner of the project is MASKPOL.

Key Words: Nanofibrids, microfibryds, topical haemostatic agent, polysaccharides

THE DEVELOPMENT OF BIOPOLYMER-BASED WOUND CONTACT LAYERS

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Medical textiles include all textile products used in healthcare and hygiene applications. The performance and price of these products vary extensively. Among high value and performance critical products, composite materials used in wound care and treatment gets a great deal of attention. Composite materials are formed by combining textiles with film, foam, adhesives and etc. In parallel with continuous improvement in polymer technologies, development of high value added multifunctional new materials for wound care and treatment is extremely important in terms of their favourable contribution to healing process.

The aim of this project is to produce a functional wound contact layer as an alternative to existing products on the market. For this purpose, silk fibroin/chitosan blend films were prepared by dissolving them in formic acid, casting this solution in plastic Petri dishes and leaving them at room temperature for evaporation of solvent. Resulting films were treated with olive leave extract.

Silk fibroin and chitosan are both naturally occurring materials. Silk-fibroin is a fibrillar protein produced by the silk-worm larvae *Bombyx mori.* It is biocompatible and biodegradable, and has good oxygen and water vapor permeability properties and high tensile strength with adequate flexibility [13-16]. Chitosan is a polysaccharide prepared by *N*-deacetylation of chitin obtained from shells of crabs or shrimps. It has unique biological and chemical properties, including biocompatibility, biodegradability, nontoxicity, physiological inertness, antibacterial properties, heavy metal ions chelation, gel forming properties and hydrophilicity, and remarkable affinity to proteins [5-12]. Olive leave extract is one of plant extracts, which have been used traditionally in wound healing treatment for years. It is believed that wound healing effect of olive leave extract is due to oleanolic acid and flavanoids in the extract. In addition, some active compounds in olive leave extract have positive effect on fibroblast, which is necessary for healthy skin and have perfect antioxidant activities particularly in oxidative stress situations.

Antibacterial properties of films were tested using disc diffusion method against *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans*. Figure 1 shows some results.

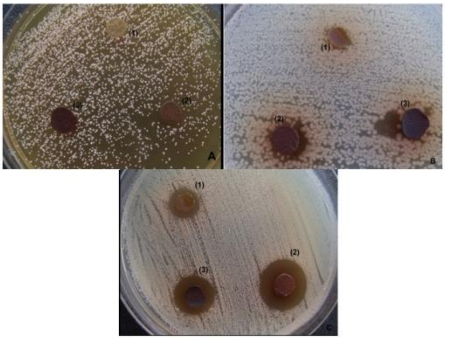

Figure 1. Antimicrobial activities of olive leave extract treated silk fibroin/chitosan films against *Candida albicans* (A), *Escherichia coli* (B) ve *Staphylococcus aureus* (C) (1): %100 SF, (2): 50/50 SF/CHI, (3): 75/25 SF/CHI)

Key Words: Wound dressing, silk fibroin, chitosan, olive leave extract

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APPLICATION OF ANTIBACTERIAL AGENTS TO CARBOXYMETHYLATED GAUZE DRESSING

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Textile materials supply living habitat for proliferation of micro organisms. The micro organisms are not only harmful for human health, they also cause bad smell, undesirable color changes, and strength loses on the textile materials. Antibacterial textiles are a kind of functional textiles and they have been used since the Second World War. The demand for antibacterial textiles has been increasing day by day. [1]

In this paper, antibacterial finishing of carboxymethylated gauze dressing was studied. The latter was used because carboxymethylated cellulose is more hygroscopic than untreated one [2, 3]. The aim of the process is the production of antibacterial medical textiles like wound bandages. After carboxymethylation, antibacterial agents were applied to fabrics in ultrasonic bath. The antibacterial agents were silver nitrate, silver sulfadiazine and zinc oxide. It is known that silver and zinc compounds are strong bactericide, and they have been used in wounds, dermatologic diseases and burn treatments. The usage of these metal ions in medical treatment might be toxic if they are used in excessive concentrations. For this reason acceptable concentration for human health was applied to carboxymethylated gauze dressing.

Antibacterial properties of the treated gauze dressing were determined according to ASTM E-2149. Whiteness (CIE formulae) and yellowness (E313) of the samples were measured by Ultra Scan PRO (Hunterlab). SEM photos were taken at laboratory from University of Maribor from Slovenia.

Table 1. Antibacterial test results of the treated samples

		Zinc oxide + US	Zinc oxide	Silver nitrate + US	Silver nitrate	Silver sulfadiazine + US	Silver sulfadiazine
S. Aureus	Carboxymethylation with US	18,75	79,16	99,99	99,99	99,99	99,99
	Carboxymethylation without US	99,99	52,08	99,99	99,99	93,12	99,99
	Alkali treatment (NaOH) with US	52,08	31,25	99,99	99,99	99,99	99,99
	Alkali treatment (NaOH) without US	43,75	60,41	99,99	99,99	99,99	99,99
E.coli	Carboxymethylation with US	90,00	93,52	99,99	99,99	99,99	99,99
	Carboxymethylation without US	88,73	98,23	99,99	99,99	99,99	99,99
	Alkali treatment (NaOH) with US	99,45	99,99	99,99	99,99	99,99	99,99
	Alkali treatment (NaOH) without US	99,99	99,99	99,99	99,99	99,99	99,99

Consequently, silver compounds were antibacterial against S. aureus and E. coli. But zinc oxide indicated lower antibacterial activity against S. aureus.

Key Words: Carboxymethylation, antibacterial gauze, silver sulfadiazine, silver nitrate, zinc oxide, medical textile

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COMFORT OF MEDICAL TEXTILES

LYCRA® FIBER TYPE T902C- THE IDEAL SOLUTION TO IMPROVE THE COMFORT AND COMPLIANCE OF A MEDICAL COMPRESSION PRODUCTS

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Elastic medical textiles are an important part in the therapy of certain medical indications where compression is the main functionality for healing. Various studies show that especially venous relating diseases are growing towards a widespread disease affecting all age groups. Graduated compression therapy with medical compression stockings is one of the key therapy methods used. To support the acceptance by the customer and thus the therapy success, next to the medical functionality, secondary attributes like easiness to put an elastic medical garment on the body and comfort during moving are essential for the success of these products.

The objective of this presentation is to provide an insight in how different types of Spandex fibers affect the properties of medical compression stockings and how the selection of the spandex can improve the comfort and thus the compliance of a medical compression textile product.

PHYSIOLOICAL STUDIES ON THE IMPACT OF TEXTILES ON HEALTH AND PERCEPTION

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The majority of textile interaction with the human body is by skin contact of clothing: Touching and wearing a fabric create external stimuli, which are perceived by multiple sensors of the skin, either consciously or unconsciously [1]. A variety of (external and internal) factors modulate the perception of external stimuli towards a pleasant or unpleasant sensation. Persons, especially patients suffering from skin diseases or burns, perceive textiles on their skin completely different. We therefore conducted physiological studies with healthy persons and subjects with skin disorders, to address wellbeing and perception of next-to-skin fabrics.

To assess parameters which can influence fabric feel we first assessed textile properties, like water vapour resistance, surface roughness and stiffness of common fibre types and blends. In addition, we measured skin physiological parameters (e.g. TEWL, pH, and hydration) from persons with healthy skin as well as from patients with noncontagious skin diseases (e.g. neurodermatitis or psoriasis). Finally we correlated these sets of data with the dynamic coefficients of friction on either healthy or diseased human skin. Our results showed that the tribological behaviour of a textile on diseased skin completely differs from its tribological behaviour on healthy skin. Hence medical textiles have to be optimized in this respect.

To understand the parameters which influence skin friction in more detail, we ran a pilot study on the impact of textiles on wellbeing using a newly developed technical skin substitute (HUMskin$_{V02}$), a standardized artificial skin, with physiological and morphological skin features. Special attention was given to the tribological parameters (static and dynamic coefficients of friction, COF) of the textile/skin interaction. We demonstrate here, that the closer both COF factors are, the more comfortable a fabric is perceived by test subjects.

Fabric samples were also compared with regard to their mechanical skin irritation potential, again starting with friction measurements on healthy human skin of test persons. On different anatomical skin areas of test persons we evaluated skin reddening, temperature as well as fabric feel and sensation of pain via questionnaires. Taken together, our results showed that a fabrics surface and construction as well as force, application velocity and anatomical application site mainly influence fabric/skin friction values and the perception of wellbeing [2].

To understand the influence of fabric/skin friction on the human brain, we drafted 25 healthy persons for a brain scan study using a 64-channel electro-encephalogram (EEG) to overcome the biases of questionnaires. In contrast to questionnaires, brain scans are strictly objective. For these experiments we developed a device called SOFIA (**S**tandardized **O**perating **F**abr**I**c **A**pplicator). SOFIA allows the application of fabrics with adjustable application pressure/force and velocity on different anatomical skin sites during a real-time measurement of the test persons' electro-encephalogram. In these experiments, the brain scans showed significant differences between a smooth knitted fabric, a common single jersey and a coarse woven fabric both, on the emotional valence (acceptance) and the mental capacity of the test persons. Thus, SOFIA allows the objective measurement of textile perception and the discrimination of the acceptance of textile samples.

The results of this mapping study showed, that fabrics clearly differ in their effect on the perception by and the physiological impact on human skin. These findings are of utmost importance for the development of medical textiles and fabrics in the health care sector. Additionally, clothing and yarn manufacturers as well as manufacturers for work wear benefit from these data.

Key Words: Skin friction, skin irritation, mental performance, textile perception

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THERMO-PHYSIOLOGICAL BEHAVIOR OF SINGLE USE SCRUB SUITS USING A THERMAL MANIKIN

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Scrub suits are known as traditional uniform worn by healthcare staff and, inside the operating room (OR) it´s used under the surgical gown and frequently denominated as "pajamas" that consists of pants and shirt [1]. Scrub suits produced with non-woven fabrics, according with the Association of Operating Room Nurses [2], promote high-level of cleanness and hygiene within the practice setting in the operating room (O.R.). Inside of OR, thermal comfort of medical clothing apparel is also a very important parameter, since the lack of comfort can lead to thermal stress that influence the physic and psychological conditions of the surgeon, as the ability to maintain constant vigilance and concentration of which, the correct surgical procedure is dependent. Thermal comfort of the user of medical apparel depends on thermal insulation and its adjustment to the environmental conditions in the operating room during the surgery, among many other factors like design, size and fabric characteristics. The overly insulating, and very low absorbent, medical clothing apparel result in the increase of skin temperature inducing a higher accumulation of humidity between staff skin and clothing, which can decrease psychophysics conditions of surgeons.

The aim of this study was to evaluate thermal comfort of medical clothing made of non-woven fabric. Twelve types of non-woven single-use scrub suits were tested. The experiments were conducted on a thermal manikin to evaluate the thermal insulation. The test was performed at standard atmosphere according to ISO 139. Heat flux lost was recorded and thermal insulation calculated.

The lower value of heat loss measured was 54.1 W/m^2 and the higher was 83.9 W/m^2 corresponding to a total isolation value of 0.23 m^2. °C/W and 0.14 m^2. °C/W. The higher is the heat loss from the skin to the environment, the lower is the isolation value of the clothing apparel. So, the material that could absorb and conduct heat well, will remove heat from the skin and give the sensation of being a “coolest” garment. The

conducted experiments provided the grounds to conclude that heat loss of thermal manikin using different scrub suits has no significant differences. This can be explained by different designs of scrub suits and it would have an effect on thermal insulation through air space between skin and clothing [3]. The use of thermal manikins helps simulating the thermal insulation and comfort and predicts if a material is going to have a too hot or too cool sensation for its user.

Key Words: Single-use scrub suits, thermal comfort, thermal manikin

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USER EVALUATION OF A NEW GENERATION OF DENTISTS' GARMENT: A PILOT EXPERIMENT

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Introduction: During oral health care, dentists are in contact with numerous potentially infectious germs from patients' saliva and blood: hepatitis B, hepatitis C, HIV, etc. In addition, dentists' apparel used in routine applications should not only be protective but also comfortable and breathable as dentists have to perform many operations and treatments on patients throughout the day with high levels of concentration. However, this type of protective garment has not been studied scientifically nor has been specifically designed to face these risks.

For this reason, we proposed new garment designs featuring both protective parts and a system to control heat accumulation, which is considered to be an important factor in reducing the level of comfort experienced by users [1]. The freedom of movement was also studied to relieve the users of any interference during their work.

Prototypes of the new garment were made and tested with a thermal imaging camera and pressure sensors [2]. The last step of the evaluation of the prototypes was to test them in real conditions. The test took place during routine work done by student dentists at the Dental Clinic of the University Hospitals of Strasbourg (HUS) during July and August 2013.

Methodology: Two types of gown were evaluated: the prototype and a control gown. As the gown used by the clinic is the same as that used by the majority of practitioners, this was chosen as the control gown. As it is very difficult to directly ask the users to compare the gowns without any bias, and to objectively analyse their evaluation based on subjective parameters, we chose to evaluate the level of satisfaction for specific criteria of each garment. To achieve this goal we made a specific survey which is designed to objectively evaluate personal feelings and perceptions of the users. This survey was composed of five different judgment levels combined with open questions. The data were analysed for each garment separately and the results of the satisfaction for the two models were finally compared.

Results: Seven points were evaluated by the survey: the effectiveness of the protection, the comfort of the protective fabric, the comfort at the neck, on the sleeves and with regard to the air regulation system. The evaluation of the thermal comfort and the aesthetics of the garment rounded off the review. The central tendency, dispersion, and H0 were analysed for each of the five dimensions of the satisfaction judgement inquired by the surveys.

Analysis and Conclusion: The results of the new garment showed a level of satisfaction at least equal to or better than the satisfaction experienced with the control gown. The thermal discomfort concerned 33% less users and the sleeve comfort concerned 5 times fewer users with the prototype than with the control garment. The overall architecture of the prototype was validated, but some points can nevertheless be furtherer improved, such as the shape of the neck.

Key Words: Garment, dentists, design, user evaluation, comfort

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TEXTILE IMPLANTS

NEW GENERATION OF YARNS FOR TEXTILE BASED IMPLANTS

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Luxilon Industries NV is an innovative SME located near Antwerp (Belgium), specialized in the production of high-tech filaments. The filaments are used in mainly 3 sectors: sports, medical and technical textiles.

In the medical sector Luxilon manufactures different products such as monofilaments for surgical sutures, hernia mesh, orthopedic surgery etc. A multifilament line was installed for yarns for cardio-vascular prostheses and mesh.

The most used polymers at the moment in the medical textile devices are polypropylene, polyester, polyamide and polyvinylidene fluoride. These materials are all non-absorbable polymers. For some applications these materials are absolutely required, e.g. cardio-vascular textile implants with a long life time. Other implants however, don't need this long life time. In some cases a low or mid-term life time is required, like an implant only developed as a structural support for cell growth. Once the human tissue is regenerated, the implant preferably disappears. This can be done with a second surgery or by absorption of the implant by the body.

In the surgical sutures these absorbable biopolymers are already widespread: polymers like PDO, PLLA, PGA, PCL or compounds of these material.

In the Surgical mesh industry, there is a structural shift ongoing from completely non-absorbable mesh, via semi-absorbable, hybrid structures towards completely absorbable meshes. Compared to the non-absorbable materials, the new absorbable materials have the following benefits: improved biocompatibility, lower rejection and infection, added functions (anti-bacterial, anti-fouling etc.). Due to the absorption, a secondary surgery is avoided, with a serious benefit, as well for the patient as for the health service costs.

On top of the development of the basic polymeric yarns, Luxilon and its partners developed a unique method to apply coatings of biomaterials on yarns and implants to give an extra benefit to polymers: better acceptance of the implant, faster / better healing and lower infection risk.

The development of all these new yarns is a multi-disciplinary cooperation between polymer suppliers, textile companies and medical device manufacturers. With a strong support of RTD centers and Universities, financing governments (EU) and controlling bodies like NAMSA, FDA etc.

Luxilon participates in 3 EU funded projects for medical applications (Green Nano Mesh, Colcomp and ASCaffolds). The aim is to develop a new generation of functionalized textile based implants. Examples of products developed in these projects are anti-bacterial yarns (other than silver technology), protein and poly-saccharide coated yarns for implants and wound care, yarns for scaffolds and stem cell therapy etc.

Each particular goal and results of these projects will be presented during the presentation. The presentation will also show that with a good interaction, understanding and cooperation between research and industry, the EU is still on top for developing new and innovative products.

Key Words: Bio-polymers, textile-based, functionalized implants

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THREE DIMENSIONAL CIRCULAR WOVEN STRUCTURES FOR POSSIBLE ARTIFICIAL ORGAN APPLICATIONS

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The study was on the development of three dimensional (3D) fully-interlaced representative circular woven preform structures for possible degradable scaffold on artificial organ application and to understand the effects of weave pattern and number of layers on 3D circular woven structures. Various 3D circular woven preforms were developed. Data generated from these structures included yarn-to-yarn space, density, yarn angle, yarn length and crimp. Basically, weave pattern and number of layers were considered as processing parameters. 3D plain, twill and satin representative circular woven preform structures were made under these parameters. The data obtained from the developed 3D circular representative preform structures were measured under out-of-loom conditions in the force-free environment.

We found that the yarn-to-yarn spaces in the 3D fully-interlaced structures were high compared to those of the traditional 3D orthogonal woven structures due to the directional interlacement where the directional fiber volume fraction can be affected. It was found that the axial angle (θa) in fabric length, the circumferential angle (θc), and the interlaced radial angle (θri) in fabric circumference were due to the axial-circumferential and axial-radial interlacements. These angles depended on the type of weave pattern, whereas the radial angle (θr) in fabric length mainly depended on take-up rate. It was also observed that the interlacement in 3D circular woven structure caused slight irregular axial and radial densities in fabric circumference. All yarn lengths in the 3D circular woven preform structures depended on the weave pattern and the

number of layers. The interlacement on three yarn sets results in axial crimp, circumferential crimp and the radial crimp. Probably, the unique feature of this research was the radial crimp in the 3D circular woven preform. In addition, it was found that the directional crimps of the 3D fully-interlaced circular woven structures slightly depended on the types of weave pattern and the number of layers.

In light of these findings we plan to conduct future research on 3D fully-interlaced circular woven preform structures using biocompatible and biodegradable fibers for use in possible self-generated artificial organ applications.

Key Words: 3D fully-interlaced preform, 3D plain circular preform, 3D twill circular preform, 3D satin circular preform, radial crimp, artificial organs

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QUALITY IMPROVEMENT AND VIABILITY INCREASE OF DERMAL EQUIVALENTS THROUGH NANOFIBER WEBS

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Tissue engineering is a multidisciplinary field that is rapidly emerging as a promising new approach in the restoration and reconstruction of imperfect tissues. In this approach, scaffolds play a pivotal role in supporting the cells to accommodate and guide their growth into a specific tissue. [1] The treatment of burned patients, or affected by other medical conditions that may require a skin graft, is in a stalemate due to the lack of alternatives for the effective treatment of these kind of lesions. The solution to cover large surfaces in a definitive way passes through the obtaining of a crop of autologous skin of the patient, presenting good results, but at the same time, it is extremely complex to handle by its fragility and the difficulty to attach it on the bed of the wound. The product described consists of a scaffold of biocompatible synthetic nanofibers, cultivated with fibroblasts and keratinocytes extracted from a patient´s healthy skin biopsy. This product is a compound that solves the problems of application of the skin culture, bringing greater manageability, and improving the attachment of the graft, facilitating the anchorage, growth and proliferation of cells in the structure of nanofibers that acts as a scaffold for the improvement of healing. [2, 3] The structure can be functionalized with growth factors, antibiotics or other active principles, to prevent infection and promote regeneration. [4]

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ANTIMICROBIAL FINISHING & STERILIZATION

ANTIBACTERIAL ACTIVITY OF CETYLPYRIDINIUM CHLORIDE TREATED COTTON WOVEN FABRICS

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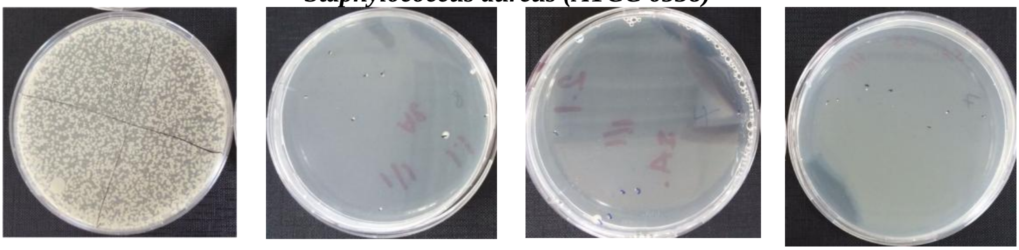
There has been an increasing interest in textiles with antimicrobial properties especially for products made from natural fibers such as cotton and wool. Such fibers provide a suitable media for the proliferation of microorganisms such as pathogenic or odor-generating bacteria and fungi [1, 2]. Antimicrobial functions were imparted to nylon fabrics via chemical finishing with quaternary ammonium salts. Processing parameters such as pH, finishing temperature and time were found to affect the exhaustion of the salts on the fabrics [3]. Quaternary ammonium salt containing monomers were grafted on cotton fabrics through high energy gamma radiation and antibacterial efficacy against various bacteria were obtained on the treated samples [4].

In the current study, a pretreated 100% cotton woven fabric was selected as material. Samples of cotton fabrics were treated with 2%, 4% and 6% wt/vol cetylpyridinium chloride with respect to liquor volume. Fabric samples were agitated for 60 min in a finishing bath with a liquor ratio of 30:1. The finishing temperature was 90°C. The treated samples were rinsed thoroughly in tap water, and allowed to dry in the open air. Antibacterial activity of test samples was determined according to a modified version of ISO 20743:2007 standards entitled as “Textiles-Determination of antibacterial activity of antibacterial finished products”. Two bacteria, one from gram negative (*Klebsiella pneumonia* ATCC 4352) and the other from gram positive (*Staphylococcus aureus* ATCC 6538) were used to test the antibacterial activity. The test samples are shown in Table 1. The antibacterial activity results are provided in Figure 1 and Table 2.

Table 1. Test samples

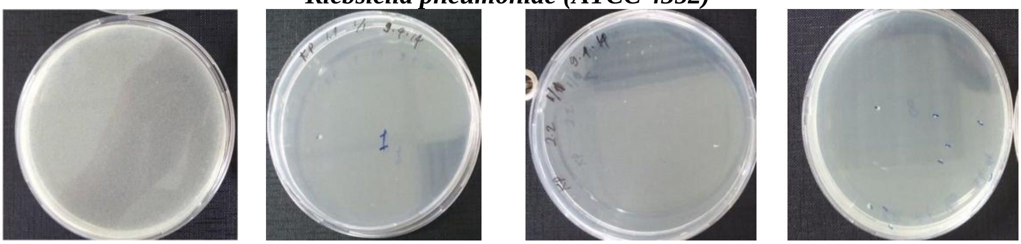
Sample	Cetylpyridinium chloride % (wt/vol)
Control	0
S1	2
S2	4
S3	6

Staphylococcus aureus (ATCC 6538)



(a) (b) (c) (d)

Klebsiella pneumoniae (ATCC 4352)



(e) (f) (g) (h)

Figure 1. Pictures showing bacterial growth on fabric samples for Staphylococcus aureus and Klebsiella pneumoniae (a) control, (b) 2% wt/vol Cetylpyridinium chloride, (c) 4% wt/vol Cetylpyridinium chloride, (d) 6 % wt/vol Cetylpyridinium chloride, (e) control, (f) 2% wt/vol Cetylpyridinium chloride, (g) 4% wt/vol Cetylpyridinium chloride, (h) 6 % wt/vol Cetylpyridinium chloride

Table 2. Reduction in bacterial activity of control and cetylpyridinium chloride containing samples in logarithmic scale

Sample	Staphylococcus aureus	Klebsiella pneumoniae
Control	0	0
S1	4.5	5
S2	5	5
S3	5	4

The control (untreated) samples showed no antibacterial activity. However, the treated S1, S2 and S3 samples were found to display bacterial reduction at 4 logarithmic scale.

Key Words: Woven fabric, cotton, antibacterial activity, quaternary ammonium salts

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TO PRODUCE ANTIBACTERIAL SELF-STERILIZING COTTON SURFACES BY COATING WITH TITANIUM OXIDE

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Nowadays textile materials are specifically treated for some novel applications in order to satisfy growing requirements. In this respect, the use of titanium dioxide (TiO_2) appears to be popular. The coating of titanium dioxide to absorb UV radiation and provide antibacterial barrier [1], to improve stain repellency and self-cleaning characteristics of textile fabrics [2], have been analyzed. TiO_2 particles catalyze the killing of bacteria on illumination by near-UV light. The generation of active free hydroxyl radicals (_OH) by photoexcited TiO_2 particles is probably responsible for the antibacterial activity [3-4]. The antimicrobial effect of TiO_2 photocatalyst on *Escherichia coli* in water and its photocatalytic activity against fungi and bacteria has been demonstrated [5].

Some of the metallic compounds possess antimicrobial property. In this work, Different types of titanium oxide particles deposited on the surface of cotton fabrics using direct coating method. The treated cotton fabrics were characterized by FT-IR and SEM. The effects of the coatings on tensile strength was investigated. The antibacterial activities of the TiO2 fabric composite were tested against Escherichia coli(Gram negative) and Staphylococcus aureus (Gram positive) cultures. A significant bactericidal effect was demonstrated.

In this study, TiO_2 was used in coating bath for antibacterial particle. Titanium dioxide is the most commonly employed of n-type semiconductors, relatively low cost and non-toxicity. Often metal-doped in order to increase the λ radiation adsorption. It is the photocatalyst of choice in organic synthesis for the preparation of self-sterilizing surfaces[6].

Plain woven fabric made of cotton fibre was used in the experimental work. Firstly, activated samples were cut into size 30x30 cm and then weighted. The coating material was prepared by dispersing titanium dioxide particles using a Thermo Scientific Haake Viscotester 6 plus, for 15 minutes at 100rpm. The cotton samples were treated with different concentrations of nano- TiO_2 ranging from 1-5% in a bath by direct coating method. These samples were then dried at 100^0 C for 2 min. and cured at 150^0 C for 2 min.

The antibacterial tests results indicated that treated samples with nano-TiO_2 have an excellent antibacterial activity against both *E. Coli* and *S.aureus* as the reduction of bacteria in cotton fabric as shown in table 1.

Table 1. R% for nano TiO_2 treated samples

TiO_2 (%)	E.coli	S.aureus
Control 1	90.9	88.4
Control 5	94.02	92.35

Key Words: Cotton, Nano-TiO_2 , anti-bacterial **,** surgical aprons

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RELATIONSHIP BETWEEN THE IRRADIATION AND THE FABRIC HAND OF MATERIALS USED FOR NON ACTIVE MEDICAL DEVICES

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According to the Medical Device Directive 93/42/EEC, surgical gowns, drapes and air suits are non active medical devices, whether they are reusable or single-use gowns and drapes.

For gamma and electron beam irradiation, according to the European standard EN 552 "Sterilization of medical devices - Validation and routine control of sterilization by irradiation", the minimum dose is 25 kGy. Since, the recommended irradiation methods for single-use products are the low temperature sterilization, we applied this irradiation on our material.

In this study the use of two other different doses was also studied: 80 kGy, because in an industrial irradiation process (to guarantee the minimum dose of 25 kGy) this dose can be achieved and 160 kGy, a maximum dose to see the behavior of the tested material with a severe dose irradiation.

The development of the objective method of evaluating fabric handle for this type of materials is new and is a challenge, because of the preconceived negative idea that exist about the material perception of nonwoven based surgical gowns versus the reusable classical textile gowns. The material perception can be achieved using the Kawabata devices and measure the mechanical properties that correspond to the fundamental deformation of fabric hand manipulation. The numerical expression of the primary hand (HV) and total hand (THV) is especially important and useful for the trace of the influence of the radiation process over the nonwoven. Table 1 shown the characterization of women's suiting, by mean of the objective method for the nonwoven.

The global analysis permits to conclude that the total hand value (THV) of the nonwoven is very low, indicating great discomfort by wearing it.

The gamma radiation increase the total hand value for 25 kGy (standardized dose) and 80 kGy (in an industrial irradiation process to guarantee the minimum dose of 25 kGy this dose can be achieved).

Table 1. Characterization of fabric hand for the nonwoven (women´s summer suiting)

Hand value (HV)	“Koshi” Stiffness	“Numeri” Smoothness	“Fukurami” Fullness and Softness	Total Hand Value (THV)
Without radiation	9,44	5,46	6,61	0,49
Gamma 25 kGy	9,38	5,85	6,57	0,85
Electron beam 25 kGy	9,56	5,28	6,36	0,38
Gamma 80 kGy	9,23	5,05	6,33	0,72
Electron beam 80 kGy	9,42	5,54	6,58	0,59
Gamma 160 kGy	9,79	3,68	5,41	0,16
Electron beam 160 kGy	9,65	2,42	3,84	0,13

A severe dose irradiation, as we performed with a maximum dose of 160 kGy is harmful for the material for both irradiation methods. So we can indicate that for the user, as a physiological point of view, the gown irradiated after gamma radiation are more comfortable than after electron beam radiation if the irradiation process were performed in a standardized range (minimum dose of 25 kGy and maximum dose of 80 kGy).

Key Words: Fabric hand, irradiation, sterilization, KES-FB, non active medical device

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INFECTION CONTROL & FUNCTIONALIZATION

CLEAN AIR SUITS VS SCRUB SUITS: WHAT ARE THE BENEFITS OF USING THEM FOR INFECTION CONTROL IN HOSPITALS?

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Experts in infection control are often asked about issues related to the use of scrubs and clean air suits in the operating room (OR). So far there is no clear explanation or mandatory obligation why the surgical team has to wear clean air suits or scrub suits in the operating rooms (OR´s) and more importantly, what are the main differences between these two type of clothing. There is a general perception that the two are equal or very similar.

So, what are clean air and scrub suits? Where did the concept and employ originate? Are they necessary from an infection control point of view, are they an useful resources of preventing or controlling transmission of infection?

The clean air suits are considered a Class I medical devices according to the definition and classification rules of the consolidated EU directive 93/42/EC as amended by 2007/47/EC and the scrub suits don´t have any regulation for their use in any hospital area.

Routes of infection are contact or airborne. In the last case, dispersed human skin particles are often carriers of infection. A healthy individual can disperse to the air approximately 5000 bacteria-carrying skin particles per minute during walking and males disperse more than females. The particles are 5 µm to 60 µm in size and the average number of aerobic and anaerobic bacteria carried is estimated to be about 5 per skin particle. The airborne particles contaminate the surgical site directly by sedimentation or indirectly by first setting on instruments or other items that are then brought into contact with the surgical wound. Fabrics with interstices larger than 80 µm do little to prevent the dispersal of skin scales.

This paper seeks to highlight the most relevant information of this products and try to define the benefits of using them for preventing airborne disposal from the surgical staff, reducing the risk of infection.

Several standards were recently revised to an unique standard EN 13795+A1:2013 – and the clean air suits appear, but will emerge soon in an entirely new standard for these types of products: EN 13795-2: 'Clean air suits, used as medical devices for clinical staff – General requirements for manufacturers, processors and products, test methods, performance requirements and performance levels'. This document will supersede the existing standard that nowadays deal with clean air suits.

The clean air suits are used mostly in the Scandinavian countries and are not very spread in other European countries or over the world. As a result, will this norm influence the use of clean air suits or perhaps increase the consumption of this product in Europe, turning it as an obligatory item in the OR such as the surgical gowns and drapes? Will there be any reference regarding the scrub suits?

Key Words: Non active medical devices, clean air suit, scrub suit, normalization

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ENHANCING SURFACE CLEANLINESS AND ANTIMICROBIAL PROTECTION BY ADVANCED NANOCOATING TECHNOLOGY

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Recently, the pathogenic effects of microorganisms lead to a dramatic increase to improve environmental hygiene in healthcare settings and produce antimicrobial materials for medical textiles, surgery equipments and hygiene applications [1]. There are several surveillance protocols and precautions to decrease Staphylococcus aureus and Escherichia coli transmission in public use and common use areas especially in hospitals. At this point, quaternary ammonium compounds are very effective since their target is directly to the microbial membrane and they accumulate in the cell driven by the membrane potential [2, 3]. In the present study, quarternary ammonium compounds are functionalized by alkyl alkoxy silane groups to increase the adhesion of antimicrobial agent on surface. These functionalized quarternary ammonium compounds are applied on the surfaces by sol-gel polymerization. During polymerization, the surface of fibers was positively charged that created an "electromagnetic" attraction between the negative charged microorganisms. This patented compound, branded as Antimic® in the market, is colorless, odourless and non-toxic material that forms nanolayers on the surfaces and its long-term conservation on surfaces inhibits the growth of microorganisms [4].

Antimic® prevents the emergence of antibiotic/antimicrobial resistance and cross-infection due to its permanent coating. Antimic® provides antimicrobial protection against bacteria (Staphylococcus aureus, Escherichia coli, etc.), fungi, yeast, and viruses (H1N1, Influenza A and B, etc.). This technology effectively inhibits the growth of microorganisms on all types of surfaces and thus provides hygienic environment in hospitals and healthcare facilities. The antimicrobial effect of Antimic® is proven on all type sanitary fixtures, from toilet seats, faucets, fittings, soap and paper towel dispensers, door handles and also on different types of cloths. Especially the application of Antimic® during the finishing stage increases the resistance against microorganisms and reduces the contamination. In addition, this material reduces the formation of unpleasant odors in textiles and prevented the mold formation and provided a physical barrier between the skin and cloth. Consequently, this proposed technology minimizes any adverse impacts of pathogens on human health and environment and decreases environmental contamination of high touch surfaces.

Key Words: Quarterner ammonium compounds, sol-gel coating, antimicrobial, textiles, healthcare, hygiene

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FUNCTIONAL NONWOVENS FOR MEDICAL APPLICATIONS

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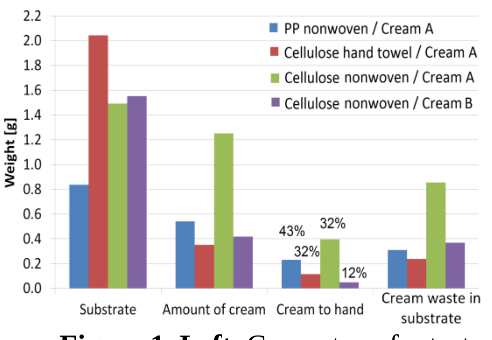
Introduction: Nonwovens are versatile material group suitable for various medical applications including e.g. wound care, tissue engineering, wipes and absorbing materials, operating room textiles, and protective clothing. Properties of nonwoven materials can be adjusted not only by varying materials and production methods, but also functionalization with various surface treatment and coating technologies. Printing methods, for example, can be used in functionalization of selected areas of nonwoven material. The foam coating technology enables application of thin functional coatings. Atomic layer deposition (ALD) and sol-gel techniques can be used to adjust surface properties with inorganic coatings also in nanoscale. In this presentation we will review some examples of nonwovens functionalization's with above mentioned technologies.

Results: We used screen printing method in order to prepare a medical cloth for application medical aids to skin. Various fibrous base materials were screen printed with creams and then cream wiped onto skin. Results of the cream transfer tests are presented in Figure 1 (left). Depending on the base and cream 10% - 40% of cream were transferred onto the hand. The less viscous cream A transferred easier than the more viscous B.



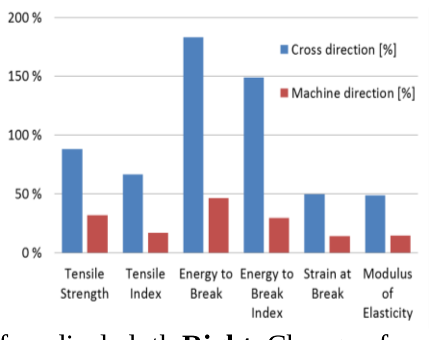


Figure 1. Left. Cream transfer test of medical cloth **Right.** Change of nonwoven tensile properties with foam coating (PVA-NFC-ZnO-TiO_2).

We used foam coating to make functional coating onto cellulosic fibre based nonwoven materials with polyvinyl alcohol (PVA)-nanofibrillated cellulose (NFC)-ZnO/TiO_2 –solution. Coating increased the strength of nonwoven material compared to non-coated material (see Figure 1 right) most likely due to NFC and PVA, while metal oxides made it bacteriostatic.

Surface properties of nonwovens were adjusted by ALD and sol-gel coatings. Hydrophobicity of ALD coated nonwovens depended on the used coating material and coating thickness. For example, while capillary rise of cellulosic nonwoven after 30 s was 80 mm, 5 cycles of TiO_2 reduces it to 50 mm and 25 nm (570 cycles) to 30 mm. Water contact angle (WCA) of cellulose nonwoven was 50° (after 30 s), but 5 cycles of Al_2O_3 increased it to 130° and 25 nm (315 cycles) to 108° even though WCA of Al_2O_3 on flat surface is ~50°. Surface roughness of ALD coating on porous material, thus, also affected the hydrophobicity. Same affect was observed with sol-gel coating trials. Sol-gel coating (ADDSOL) changed polyester nonwoven (WCA ~85°) more hydrophobic (~120°), while superhydrophobicity (~140°) was obtained onto polypropylene (PP) nonwoven base (~115°) using same sol-gel hybrid coating modified with SiO_2 nanoparticle.

Possible Applications: Cream printed cloths can be used for controlled dosage of e.g. medical creams onto the skin if certain area of skin has to bet treated with medical cream without exposure of other parts of the skin. Self-care of skin problems (eczema, fungal infections etc.) as well as cosmetic purposes are relevant options for such cloths. Strengthened bacteriostatic nonwovens can be used e.g. in wound care and bandage applications, and prospective application for metal oxide functionalized textiles include with water, oil and soil repellent and antimicrobial medical textiles.

Key Words: Functional nonwovens, medical cloth, screen printing, foam coating, ALD, sol-gel

NANOFIBRES FOR MEDICAL USE

RELEASE CHARACTERISTICS OF NAPROXEN LOADED POLY(VINYL ALCOHOL) NANOFIBERS CROSSLINKED WITH POLYCARBOXYLIC ACIDS

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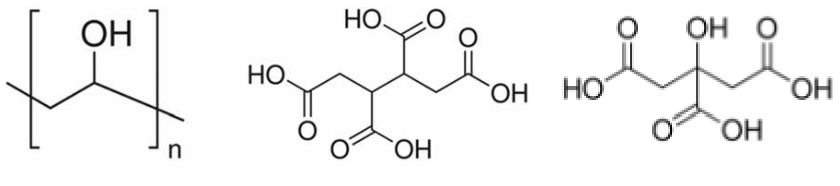
Electrospinning is a promising and emerging method for the production of medical textile materials with controlled release properties. One of the main advantages of the electrospinning process over the conventional film-casting technique is the highly porous structure of electrospun fiber mats which exhibit greater surface area that assumingly could allow drug molecules to diffuse out from the matrix much more conveniently [1]. In terms of material selection, electrospun poly(vinyl alcohol) (PVA) hydrogel nanofibers are believed to be a potential candidate for drug release applications. Poly(vinyl alcohol) (PVA) is a hydrophilic, semi-crystalline polymer with good chemical and thermal stability [2-3]. Electrospun PVA nanofibers have been one of the most extensively studied topics due to its biocompatibility, nontoxicity, hydrophilicity and ease of processability [4-5].

Non-steroidal anti-inflammatory drugs (NSAIDs) are used for controlling pain and inflammation in rheumatic diseases. Naproxen which is one of the most efficient NSAIDs [6-7] was selected as a model drug for this study. The release mechanisms of drug-loaded electrospun PVA nanofibers are based on the diffusion of the drugs through the swollen PVA fibrous matrix and the release due to partial dissolution of the matrix [2-3,8]. Control over the release characteristics of the drugs can be provided through partial crosslinking of the PVA fibrous matrix [8].

Methanol treatment and chemical crosslinking with glutaraldehyde are found to be most applied treatments but they display toxicity problems and thus their potential applications as biomaterials are limited [9-10].

Therefore in this study, polycarboxylic acids; 1,2,3,4 butanetetracarboxylic acid (BTCA) and citric acid (CA) were selected as crosslinking agents (Figure 1.). BTCA and citric acid are low cost, non-toxic alternatives that have been reported to crosslink electrospun PVA hydrogels [9-10]. Another advantage is the miscibility of them with PVA electrospinning solutions, thus they can directly be added into the spinning solutions [9].



PVA BTCA CA

Figure 1. Poly(vinyl alcohol) (PVA), 1,2,3,4 butanetetracarboxylic acid (BTCA) and citric acid (CA)

(a) (b) (c)

Figure 2. Images of the non-crosslinked (a) BTCA (b) and CA (c) crosslinked (PVA) electrospun membranes after immersion in dissolution medium for 24 hours

In this study, the crosslinking of PVA nanofibres with polycarboxylic acids and its effect on the resultant nanofiber morphology, swelling behavior and naproxen release characteristics were investigated. BTCA and CA crosslinked PVA mats showed swelling ratio about 1110% and 1580%, respectively; while swelling of non-crosslinked PVA was about 631% (Figure 2) based on final dry weight. Weight loss of PVA mats were about 44%, 3% and 42% for non-crosslinked and crosslinked with BTCA and CA, respectively. BTCA and CA crosslinked nanofibrous mats showed slower release rates than non-crosslinked mats.

Key Words: Electrospinning, PVA, crosslinking, polycarboxylic acids, naproxen, drug release

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OPTIMIZATION OF STRUCTURAL PARAMETERS OF NANOFIBER SCAFFOLDS FOR MESENCHYMAL STEM CELLS

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Tissue engineering ensures the use of biodegradable porous polymer scaffolds to provide a structural template for cell seeding, and support cells to regenerate new extracellular matrix which has been destroyed by disease or injury without stimulating any immune response [1]. An ideal polymeric scaffold should be biodegradable, biocompatible, mechanically stable, and also should provide cell interactions, cell attachment, proliferation, differentiation, and extracellular matrix (ECM) formation in the implant site [2]. The basic expectation from the scaffold is replacing the natural ECM until host cells can repopulate and reform a new natural matrix [3].

Electrospinning is a simple and versatile method to produce scaffolds having large specific surface area, high porosity, and spatial interconnectivity of nanofibers. It is possible to achieve a web structure composing of nanofibers with ultrafine fiber diameter (less than 50 nm) while maintaining high porosity with this technique. Electrospun mats, which allow well nutrient transport, cell communication, and efficient cellular responses, are ideal mediums due to the structural similarity to the tissue extracellular matrix [4].The fundamental parameters in electrospinning are solution concentration, flow rate, electric field strength, distance between tip and collector, needle tip design, and collector geometry. Fiber diameter, porosity, and structural uniformity can be arranged by changing these parameters [5]. Structure of scaffolds have great effects on shaping cell morphology, guiding cell migration, and affecting cell differentiation.

Native ECM fibers, which have a diameter less than 100 nm, preferably in the range of 10–50 nm, need an appropriate medium having high porosity for cell infiltration and migration [2, 4]. Pore diameter of 10-100 μm is adequate for cell migration of most cell types [5]. Scaffolds should possess sufficient mechanical strength to temporarily withstand functional loading in vivo or cell traction forces in vitro [1]. The elastic modulus is a critical parameter for the cell development.

In this study, Poly(DL-Lactide-co-caprolactone), and Poly(D,L-Lactide-co-glycolide) biodegradable polymers were obtained from Sigma Aldrich. Chloroform was also purchased from Sigma Aldrich which was used as solvent. Human mesenchymal stem cells (hMSC) were obtained from the Lonza. Nanofiber scaffolds were formed via electrospinning method. Scanning electron microscopy (SEM) analyses, and tensile tests were performed to understand the morphological, tensile properties in these nanofiber mediums. We cultured mesenchymal stem cells (hMSC) on nanofiber scaffolds, and compared them with the cells grown on tissue culture plates. The viability and proliferation of the cells was then determined by an MTT assay.

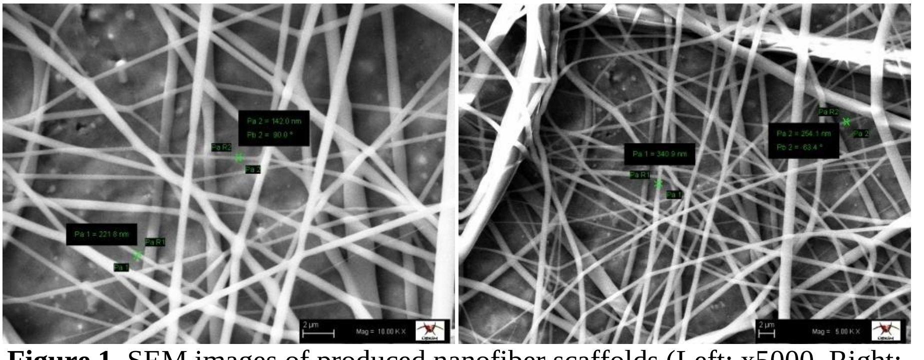

Figure 1. SEM images of produced nanofiber scaffolds (Left: x5000, Right: x10000).

Results showed that, up to 142 nm fiber diameter were obtained in these scaffolds with high porosity, and average fiber diameter was determined as 370 nm (Fig. 1). Tensile strengths of nanofiber scaffold samples were adequate for scaffold applications, and they are suitable for cell culture, proliferation and attachment.

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SMART & FUNCTIONAL MEDICAL TEXTILES

SMART CLOTHING SYSTEM FOR RESPIRATORY MONITORING - WEARABILITY AND USER ACCEPTANCE STUDY

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Long-term respiratory monitoring provides valuable information for clinical and diagnostic treatment. Traditional measures of respiration require a mouthpiece or a mask, neither of which can be used as ubiquitous healthcare equipment. Using a smart clothing system seems to be a better alternative. The use of smart clothing for medical reasons requires an understanding of the users' perspective and a willingness to use the products [1]. Functionality, wearability, and user acceptance are critical issues for the development and eventual commercialization of the smart shirt [2, 3]. In this study, wearability and user acceptance has been examined by two surveys. Survey A was conducted in combination with a scenario technique, which introduced the participants into medical situation in which smart clothing may be used. The questionnaire was delivered to 100 randomly selected people from the internet, and 85 participants (45 women, 33 men; 20–70 years old, average age: 33 years) submitted responses within 2 weeks. After analysis, 63 responses were seen as effective answers. In this survey, gender, age, educational background and occupation were chosen as independent variable, while the pro- and con-arguments of using smart shirts were dependent variables. Survey B has been delivered to a focus group of participants with basic knowledge of smart textiles, mainly, the students and the employees from Textile University. The goal of the focus groups was to gather information of wearability regarding the prototype made by the author. This questionnaire was given to 16 participants (13 women and 3 men) who have seen and/or tested the smart shirt, with the purpose of studying and analysing the wearability of different clothing-based respiratory monitoring systems, including the ordinary respiration belt, and 3 different prototypes (Figure 1).

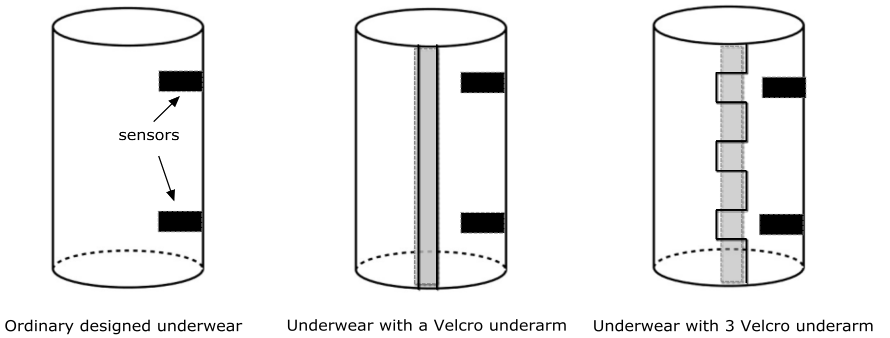

Figure 1. Design of easy wear in prototypes 1, 2, and 3

Survey results has been analysed quantitatively. The results shown that most of the participants indicate that users were more comfortable with the smart clothing system and that most believe that using a smart clothing system will improve both health condition and quality of life.

Key Words: Smart textiles, textile sensors, respiratory measurement, wearability, user acceptance

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A PARAMETRIC STUDY ON THE ENCAPSULATION OF PHOTOCHROMIC DYES FOR ULTRAVIOLET PROTECTION

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Medical textile applications include protective and healthcare textiles that contribute to protection of human health against ultraviolet (UV) radiation, microbes and bacteria, chemical toxins, microbiological poison etc. Among these, protection against UV radiation has become one of the most important issues due to ozone layer depletion and global warming.

Clothing is one of the most important tools for UV protection. UV protection properties of textiles change depend on fiber type [1, 2], structure of fabric [1-3], color [1, 3], finishing process [4, 5] etc. The color of textiles has a significant influence on UV protection properties depending on the wavelength of UV absorption bands of the dyes and dye concentration [6]. Additionally, there exists a special group of dyes that can absorb UV radiation, which is called ‘photochromic dyes’. These dyes change their colorless molecular structure to colored one when irradiated by UV light; the colored structure can then return to the colorless structure, when the irradiation end. In addition, photochromic dyes also have a UV protection function [7] since they absorb UV radiation. However application of photochromic dyes onto textile materials, especially to natural fibers, is problematic because they have neutral molecules with a balance of hydrophilic and hydrophobic character and there is no ionic attraction with the fibres. On the other hand insolubility in water, low heat resistance and poor washing fastness are the other disadvantages. Encapsulation of photochromic dyes is a solution to eliminate all these disadvantages. In this study, solvent evaporation method was used to encapsulate the photochromic dyes and the effects of main encapsulation parameters were discussed. The effect of solvent type (dichloromethane, acetone, ethyl acetate), amplitude rate of sonication (30%, 50%, 70%), stabilizer type (polyvinyl alcohol, tween

20, tween 80) on the morphology and UV protection properties after application onto textiles of the resultant capsules were investigated.

The optimum encapsulation results were obtained when dichloromethane and polyvinyl alcohol were used as solvent and stabilizer, respectively. This result was analogous with the study of Feczko et al. [8] The size of the capsules varied depending on the amplitude rate of sonication and stabilizer type. It was observed that UV protective properties of the fabrics improved with application of photochromic dye capsules.

Key Words: Photochromic dyes; encapsulation; solvent evaporation, ultraviolet protection; textile.

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FACILITATING USER INVOLVEMENT IN TEXTILE DEVELOPMENT

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Three-dimensional (3D) textiles is a category of technical textile that recently have been successfully applied in healthcare, as demonstrated by e.g. advanced wound healing bandages, textile blood vessels, and scaffolds used for growing e.g. [1]. Smart textiles, i.e. textiles based on new “smart” materials and/or textiles used in “smart” applications, have also attracted a huge interest based on the potential seen in healthcare e.g. to monitor (electro) physiological signals using textile electrodes/sensors [2] in order to take full advantage of these new opportunities the textile industry need to find new ways to develop new smart textile based products.

One strong and valuable contribution to the development of new innovative products is to involve users early in the development process.
By including healthcare personnel as users in the development of innovative textile products, directed to the healthcare market completely new solutions or applications may be suggested by the users based on their experiences and what they see is lacking in their everyday work situation.

The approach of the study presented in this paper is to examine how textile *product representations* such as prototypes or material samples for instance, can be used early in the development process to facilitate the communication and collaboration between developers and users. *The aim of this paper* is to highlight how textile product representations can contribute to the communication and understanding within the user and developer and the facilitating roles the product representations might have in the development of new textile based innovations within healthcare.

Method: The innovation process covered in this study lasted for and involved which were studied using a qualitative analysis based on recordings of the dialogue within the team (participating observation).

The focus of the observation was to see how the *product representations*, which were developed between and introduced at the meetings, contributed to the dialogue between the users and developer

Results: The main conclusion is that product representations in support exchange of knowledge and experiences. Five facilitating roles which the product representations play were identified,

- Demonstration - i.e. serve to demonstrate technical solutions.
- Verbalisation - i.e. serve to fill in were words are missing or when terms are not understood.
- Visualisation - i.e. facilitate team members to recall or adapt mental images of the intended future product.
- Stimulation - i.e. inspire team members to generate new ideas or design
- Integration - i.e. unite different perspectives within the development team.

Conclusion: To take full advantage of opportunities made available by recent development in materials and new manufacturing techniques the textile industry need to find new ways to develop new innovative products that fulfil the users' needs.By increasing the awareness on how product representations may facilitate the dialogue between users and developers, the textile industry may based on this research take the step from traditional textile development to a more user-oriented approach where product representations can support real user involvement

Key Words: Product development, smart textile, 3D textile, product representation

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A REVIEW ON THE CLOTHING NEEDS OF THE ELDERLY

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Ageing of world population is one of the most significant demographic facts of the 21st century which is also named as "century of ageing" [1]. In the whole world, people live longer, birth rates decrease and consequently the elderly population increases both numerically and pro rata [2]. The substantial increases in life expectancy at birth achieved over the previous century, combined with medical advances, escalating health and social care costs, and higher expectations for older age, have led to international interest in how to promote a healthier old age [3].

Ageing can be defined as the process of progressive change in the biological, psychological and social structure of individuals [4]. By biologists, ageing is defined as a continuous process that starts at conception and continues until death [5]. Population of people aged 65 and above have exceeded 500 million throughout the world [6] and 2 billion older persons are projected to be alive by 2050 [7].

Individuals experience many changes during ageing process. In this study, changes which are more related to clothing were reviewed. Muscle atrophy is the most recognised symptom of old age. As people grow older, body posture becomes bent forward. Shoulders become more narrow and the pelvis widens [8, 9]. Weight increases, proportion of the body changes and waist thickens [10, 11]. Body height decreases due to shortening of the spine. Additionally, flexion of the spine may cause humps which pull the back of the clothing upwards [12]. These changes require alterations in standart measurements when the elderly are considered.

Ageing increases risk of thermoregulatory dysfunction. There may be deficits in heat production and natural insulation against heat loss which may even cause hypothermia [13, 14]. Dryness, pruritus (itch), wrinkles and becoming thinner are the most common problems of elderly skin [15, 16]. Ageing of skin results in a less effective barrier, delayed wound healing, and greater opportunities for microorganisms to invade [17, 18].

Urinary incontinence, the unintentional loss of urine, is a major problem of the elderly. Urinary incontinence induces skin irritation and infection, pressure ulcers, falling and fractures [19, 20]. Pressure ulcers are areas of localised skin and tissue damage that usually occur over bony points of immobilised people and are caused by continuous or long term pressure, shear or friction forces [21, 22].

Since the elderly live through many changes during ageing process, their clothing needs may differ from the younger and the healthier people. First of all, as growing older, body form and measurements change. Thus, when designing clothes for the elderly, these differences should be taken into consideration besides the standart measurements [23]. Moreover, older people’s mobility is usually limited. For instance, most elderly people cannot hold their hands above their heads. Therefore, a wide armhole can facilitate comfortable movement [8]. Sleeves should be wide enough to ease donning and doffing, and necks are recommended to be round or V-shaped [24].

The design and position of clothing fasteners often lead to a restriction of the functional capacity of the elder. Clothing fasteners should be located in the optimum grip area, easy to understand and identify visually as well as tactually, possible to handle with one hand, not scratch or rub. Additionally, it was found that the front position for the fasteners was superior to a diagonal or lateral position on the chest for the elderly [25]. Furthermore, elastic bands may be used in trousers’ waists as the elderly, especially with dementia, may have diffuculties with fasteners like buttons, hook&eye etc.

A crutch or cane is a common tool of the elder individuals which requires that sleeves and/or openings do not restrict use of equipment nor cause a privacy problem, as a conducted study showed that crutch tends to press the armpit and pushes up the clothing [26].

People with highly sensitive skin should avoid clothing with hard seams [27]. There should not be buttons, snap buttons, stitches etc. on the clothing contacting both the body and the bed in order to avoid pressure ulcers [28].

1 in 3 elderly fall and injure themselves, often leading to hospitalisation, a rapid decline in physical and mental condition and potentially even death. For this reason, some elderly are afraid to venture out of their home for the fear of falling, ironically, staying mobile and active also contributes to healthy ageing. Hence, protective pads for the hips can be used to keep the elderly active [29, 30]. Urinary incontinence issue causes falling and fractures besides skin irritation and other physical and social problems. For urinary incontinence, it is suggested to keep the skin clean and dry. Absorbant pad usage is also recommended [22].

Comfort of the elderly can be provided through the use of materials which are smooth and elastic, porous and allowing changes in temperature and the free flow of air [8]. Cotton or linen clothes and sheets which let the air through are recommended for the elderly [31].

The elderly experience various changes in their bodies such as decrease in physical and mental functions [32], elasticity loss in joints, decline in strength and mass of muscles [33]. These changes make harder to complete daily activities like getting dressed for the elderly and necessitate some requirements from clothes. In this study literature regarding the elderly, a fast growing population group, and the changes they experience regarding ageing process were reviewed and their clothing needs in terms of health were aimed to be revealed.

Key Words: Elderly, ageing, clothing, health, need

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FOOTWEAR

EFFECT OF PRODUCTION PARAMETERS ON PERMEABILITY PROPERTIES OF COMPRESSION STOCKINGS

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Compression has been successfully applied to the management of leg disorders as a treatment since time of Hippocrates [1]. Controlled application of compression effect with specialequipment is the basis factor of compression therapy. Compression therapy is the cornerstone in the treatment of venous diseases [2]. Also it can be implemented as monotherapy or as a short-term treatment in addition to surgery or other operations [3]. Aging population of the developed countries and increasing healthy life expectations of people raise the importance of this treatment.

Compression garments are special garments which apply a certain pressure to the body mainly for medical, sports and body shaping [4]. Compression stockings, which constitute one of the most important groups of compression garments, are engineered to regulate blood flow in venous system. They help the natural pump mechanism of the muscles in the leg to improve circulation. They can be used to prevent as well as treat a number of conditions that affect the circulation in the body. These special stockings are commonly used for venous diseases such as varicose veins, chronical venous insufficiency, venous ulcer, deep vein thrombosis, lymphedema and lipedema.

The most critical success factor of compression stockings is their sustainability. Many parameters such as seasonal temperature changes or difficult daily activities decrease the practicability of the treatment. Because of these situations, patients feel discomfort and the using of compression stockings become a trouble for them during the treatment. Especially thick and tight structures, such as compression stockings at the high pressure levels, are a nightmare for user in a hot summer day. Thus the patients need to use special products which are more breathable and a solution for the sweating problem. As known, textile products that have been engineered to meet particular needs are suitable for any medical and surgical application in which a combination of strength, flexibility and sometimes moisture and air permeability is required [5]. In this study, the effect of some production parameters on air and water vapor permeability of compression stockings were investigated. The samples were manufactured using different elastane yarn counts, elastane feeding tensions and fabric tightnesses. The statistical analysis indicated that all these parameters have significant effects on permeability characteristics of stockings as following:

- Finer elastane yarn count caused to higher permeability values.
- Both of the permeability characteristics affected differently by changing elastane feeding tensions.
- The tightness and permeability values were inversely correlated and the loosest structure had the most permeable surface.

Key Words: Medical textiles, compression therapy, compression stockings, air permeability, water vapor permeability

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A RESEARCH ON ODOUR ABSORBENT NONWOVEN SHOE LININGS

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Shoe lining is the inside material that touches the sides of the foot, the top of the foot, and/or the back of the heel. Linings can be made of a variety of materials.

The main purpose of a lining is to cover the inside seams of a shoe, but linings made of special materials also have comfort features such as additional padding, or the ability to pull moisture away from the foot. [1]

Good footwear lining materials must fundamentally provide optimal temperature regulation. Moisture produced during physical activity must be allowed to escape and be transported away from the foot. In that way heat build-ups and blisters can be prevented. The materials must also be guaranteed to dry quickly after use in order to minimise the waiting time after an adventure. At the same time the surface must feel good to the touch, and it must lay in footwear without creases or folds. [2]

Leather, textile or synthetic materials can be used for footwear lining. A high level of comfort is achieved in footwear based on the combination's multi-faceted characteristics, includinging its ability to dissipate heat and moisture, a high abrasion-resistance and durability, as well as its pleasant hand feel. [2]

Various shoe lining materials are available in the market, such as; tricot fabrics laminated with PU foam, spacer fabrics, canvas, PVC coated fabrics, non woven fabrics and cambrelle with foam lamination.
Non woven linings are extensively demanded by safety footwear and gents footwear. The non woven fabrics used can be felt, dotted or leel grip. [3] Nonwoven shoe linings provide specific functions such as absorbency, liquid repellent, resilience, stretch, softness, strength, flame retardancy, washability, cushioning, filtering, use as a bacterial barrier and sterility. [4]

In this study, polypropylene meltblown nonwovens were produced and printed with zeolite and zeolite/borate mixture to be used as shoe lining materials. Zeolites are microporous, aluminosilicate minerals commonly used as commercial adsorbents and catalysts. [5] Borates are naturally occurring minerals that exist in trace amounts in rock, soil, water and all living things. [6]

1100 MFR polypropylene granulles were processed to form microfibre nonwovens, by using Biax Fiberfilm Meltblown Machine, in Ege University Textile Engineering Department. After that, surface of the produced meltblown nonwovens were treated with zeolite and borate minerals via pigment printing technique to obtain the odour absorbance function. Printing process was performed according to 3 different recipes with different zeolite and zeolite/ borate mixture concentrations and different particle sizes. [7]

Hydrophility, water vapur permeability and subjective odour tests were applied to the materials. Results have shown that change in the particle size and concentration effected the hydrophility and odour absorbence significantly. Higher hydrophility results were obtained with 5 g/kg zeolite concentration when 0,1 mm particle size was used. With 0,020mm particle size, highest hydrophility results were obtained with 10 g/kg zeolite concentration. It was also observed that hydropility stayed in the same level, after a certain zeolite concentration. The best odour absorbtion results were obtained with 15 g/kg zeolite/ borate mixture concentration. [7]

Key Words: Shoe lining,nonwoven, polypropylene, meltblown, zeolite, borate

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THERMOCHROMIC FOOTWEAR FOR DIABETIC FEET

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Foot problems due to diabetes remain the commonest cause of hospital admission in Western countries [1]. Diabetic foot is characterized by a total of different manifestations starting with loss of skin moisture progressing to inflammation and numerous infections, ulceration and destruction of soft tissues and even of the underlying bones and joints. Diabetic foot is closely associated to neurological abnormalities (diabetic neuropathy) and various degrees of peripheral vascular disease of the lower extremities of the patients with diabetes mellitus (DM) (the International Working Group on the Diabetic Foot, 1999) [2]. Additionally to that, the Charcot foot, also referred to as Charcot neuropathic arthropathy, is a severe and potentially limb-threatening condition affecting the foot and ankle of diabetic patients. The pathophysiology of Charcot foot is considered to be multifactorial, while in the vast majority of cases it is secondary to diabetic neuropathy, trauma or bone perturbation [3]. These disorders are accompanied by temperature elevation and edema [2].

Temperature monitoring seems to be a useful tool in identifying these disorders, since temperature difference between corresponding sites of the left and right foot is an early warning sign of foot disease in diabetes [4]. Armstrong et al., [5], performed studies of dermal thermometry suggesting that variations in temperature of foot could be helpful in skin surveillance. In more detail, temperature differences of 2.2 °C between left and right corresponding sites have been observed [5]. Also infrared thermography is regarded as an imaging modality of thermometry [2]. Especially in the case of Charcot foot, physicians using a portable infrared thermometer may document a 2-6 ^{o}C temperature elevation between the affected and the contralateral foot [3].

In the present paper a novel technique for non invasive, continuous and easy to use in home environment temperature measurement based on thermochromic fibres is presented. Thermochromic materials have the property of altering their colour due to temperature change [6]. For the development of such thermochromic fibres Chromicolor PP ® master batch thermochromic material produced by Matsui along with polypropylene (PP) has been used in 30% wt. The mixture has been extruded in a FET extruder and thermochromic multifilament yarn of 150 dtex value has been produced. This yarn combined with conventional yarn has been knitted in the form of a sock as it is presented in Fig. 1(a).

(a)

(b)

Figure 1. (a) Thermochromic footwear and (b) Experimental setup

The measuring accuracy of the sock has been tested in a specifically designed experimental setup simulating a human lower limp, as presented in Fig. 1(b). The results of the experiments were encouraging.

Key Words: Diabetic foot, thermochromic fibres, polypropylene, footwear

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AN INVESTIGATION ABOUT ANTIBACTERIAL SWEAT PADS MODIFIED BY BIOPOLYMERS

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Today, consumers prefer products that improve their life standards and hygienic absorbent products are among the product groups that enable comfort and hygiene. Therefore, hygienic absorbent products have a rapid developing market [1] and many scientists focus on functionalizing of these products; mainly baby diapers, feminine hygiene pads and adult incontinency pads [2,3,4]. As the end-use environment of absorbent hygienic products is suitable for growth of hazardous microorganisms, antibacterial treatments obtained by natural or synthetic materials are commonly preferred for diapers or pads.

In this study, which was carried out within a national project, topsheet layer of a designed foot sweat pad, constituting of polypropylene and polylactic acid (PLA) nonwoven fabrics, was modified by natural based antibacterial materials. Pads were produced in a shape suitable for feet and absorbent and coverstock layers were made of woodpulp/SAP and breathable polyethylene in turn. Antibacterial herbal materials (cinnamaldehyde, phenyl ethyl alcohol, geraniol) which have also natural pleasing fragrances were sprayed by suitable solvents (ethanol) or PLA based biopolymers were prepared by three different chemical methods. In solving method, PLA is solved by the help of PEG 4000 and tetrahydrofuran (THF) as solvent, in cationic monomer activated method with PLA as a monomer, ring opening process occurs with existence of alcohol [5,6,7] and in photo cationic polymerization method, UV light is used for polymerization of PLA [5]. Optimizations about concentrations were carried out and minimum antibacterial herbal material concentrations were determined according to the required antibacterial activity. Antibacterial performance of herbal materials were evaluated with acidic and basic artificial sweat solutions (ISO 3160-2) containing bacteria by the quantitative antibacterial activity method under dynamic contact conditions (ASTM E2149-01) of the herbal materials when directly sprayed on nonwoven fabrics by the solvent ethanol were also

evaluated by qualitative disc diffusion method (SN 195920:1992) before quantitative antibacterial performance tests. pH buffering effects of antibacterial herbal materials were also detected and effects of antibacterial materials on acidic and basic sweat solutions were also investigated. After being sure about antibacterial performances of the herbal materials in direct form or within a biopolymer (minimum 93% of inhibition is detected), performance analyses of the sweat pads having modified topsheet layers were conducted. Effects of topsheet antibacterial treatments on air permeability, absorption capacity, absorption period (drop test) and wetback performances of sweat pads were analyzed.

According to the results, besides a slight decrease about liquid transfer performance of topsheet layers, most of the treated topsheet layers are sufficient for an absorbent hygienic product. Cinnamaldehyde has a good performance about pH buffering of especially basic sweat which is hazardous for the skin. It can be concluded that, natural-based antibacterial materials which has also natural odors and pH buffering effects can be used for disposable hygienic products. Moreover, some of the biopolymers produced within this study can be applied on reusable products such as shoe liners where long-period durability is a concern.

Key Words: Antibacterial sweat pad, natural antibacterials, biopolymer, pH buffering

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MISCELLANEOUS

TENSILE AND KNOT PERFORMANCE OF SILK, POLYPROPYLENE (PP) AND POLYAMID (PA) SUTURES

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Suture is a generic term for all materials used to bring served body tissues together and to hold these tissues in their normal position until healing takes place. The success of a suture is generally linked to its mechanical performance such as tensile and knot strength [1]. Many researchers have evaluated physical and mechanical characteristics, handling characteristics and tissue reaction characteristics properties with different types of suture materials [2-7].

In this study, it is aimed to investigate the mechanical performance (tensile and knot strength) of materials such as silk, PP and PA. The experiments are carried out on the Instron 4301 tensile tester before and after inserting physiologic solution according to ASTM D3217-79 standard under controlled laboratory conditions. Prior the tests, all sutures were conditioned at 21°C and 50 % relative humidity for 24 hours. All tests were repeated ten times. The experiments were carried out in two stages. At the first stage, it is investigated the tensile and knot strength of all sutures before inserting in physiologic solution. For the second stage, the sutures are inserted in physiologic solution for 30 days.

Table 1. Technical properties of the tested sutures

Materials	Silk, PP, PA
Origin	Natural, Synthetic
Type	Non-Absorbable
Structure	Monofilament
Size (USP)	0, 2/0, 8/0
Sterilization	EO (Ethilen oksit)
Physiologic solution	0.9 % NaCl and 0.9 % NaCl-N-200 mg/lt acetyl-p-aminophenol, 1 ml/lt antibiotic

The obtained results showed that the mechanical performances of sutures are affected sutures materials, sutures size, physiologic solutions and knot type.

Key Words: Catgut, suture, knot strength, tensile performance

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DYEING PROPERTIES OF POLY(ETHYLENE TEREPHTHALATE)/ORGANOCLAY FILAMENT YARNS

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Among various kinds of natural and synthetic nanofillers, montmorillonite type of clay has been more widely investigated because of its high aspect ratio, plate morphology, natural abundance, and low cost [1]. Considering the literature, it is obvious that there has been a lack of related studies concerning physical and dyeing properties of PET/clay nanocomposites in filament yarn form for textile applications. To cover partly this deficit, this research was aimed the generation of poly(ethylene terephthalate) (PET)/organoclay nanocomposite filaments by melt-spinning method and investigation of their physical and dyeing properties.

Two montmorillonite types of clay (Resadiye clay (RK), Rockwood clay (RW)) were modified using an intercalating agent synthesized and PET/organoclay (85/15 wt/wt) master batches were pre-pared using a co-rotating intermeshing twin screw extruder. Afterward, nanocomposite filaments containing different amounts of organoclay (0.5–5 wt%) were produced and dyed with two disperse dyes at atmospheric and high temperature dyeing conditions. Addition of the organoclay has led to reduced tenacity values. This effect is more pronounced with increased clay concentration. Apparently, addition of 1 wt% organoclay acted as stress concentrators within the nanocomposite fibers and gave rise to reduced physical properties (Table 1).

Table 1. Physical properties of the neat PET and PET/organoclay nanocomposite filaments

Sample	Tenacity (cN/dtex)	Elongation at break (%)	Boiling shrinkage (%)
Neat PET	2.37 ± 0.14	130.3 ± 1.2	63.3 ± 0.8
PET/RKOC 99.5/0.5	2.19 ± 0.11	131.6 ± 0.8	62.7 ± 1.1
PET/RKOC 99/1	1.85 ± 0.16	140.8 ± 2.1	64.2 ± 0.7
PET/RWOC 99.5/0.5	2.17 ± 0.12	137.1 ± 1.4	64.6 ± 0.9
PET/RWOC 99/1	1.96 ± 0.11	138.1 ± 0.9	64.5 ± 1.2

Independent upon the clay type and the clay concentration used, PET/organoclay nanocomposite filaments exhibited clay domain sizes varying between 1–2 µm and 8–10 µm.

Generally, it can be said that PET nanocomposite yarns containing different amounts of organoclay (either RKOC or RWOC) showed a small decrease in lightness (L*) values especially when dyed at atmospheric (with/without carrier) conditions. Clay incorporation led to reduced mechanical properties, which are in accordance with the XRD results. PET/organoclay nanocomposites showed only intercalated structures (not exfoliated). Morphological and thermal analyses delivered complementary results. Degree of crystallinity of the nanocomposite filaments did not affect the dyeability. Dyeing properties of the PET/organoclay nanocomposite filaments were enhanced due to improvement of the accessibility of PET by clay incorporation for the disperse dye.

Key Words: Nanocomposite, PET, montmorillonite, filament

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POSTER SESSION

THE USE OF REGENERATED CELULOSIC FIBRES FOR NURSING PADS

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Nursing pads are absorbent pads which are used to prevent breast milk leakages following childbirth. This study focus on an alternative absorbent layer for nursing pads produced from needle punched nonwoven machine with three different regenerated cellulosic fibers. The mixture of 50 % bamboo, 50% tencel and 50% viscose fibers with hydrophobic cotton fibers were used as a raw material in the production of non-woven absorbent layer.

The most important features for the nursing pads including absorption capacity, wetback, moisture management and subjective handle properties were examined (Table1).

Table 1. Properties of the nursing pad absorbent layers

Absorbent layers	Top wetting time (sec)	Bottom wetting time (sec)	Top absorption rate (%/sec)	Total absorbency (%)	Wetback (gr)	Subjective handle*
50% Bamboo/ 50 % Cotton	16,97	123,64	24,35	526,12	1,38	1,0
50 % Viscose/ 50 % Cotton	9,45	146,77	45,81	588,40	1,59	2,0
50 % Tencel/ 50 % Cotton	9,10	78,04	55,81	664,71	1,46	2,9

**1 meant hardest and 5 mean softest*

It was revealed that raw material type had an influence on the top wetting time, top absorption rate, total absorbency and handle properties. Tencel pads have the softest handle property with the fastest and the highest liquid absorbency properties among the others. On the other hand wetback property of nursing pad layers did not change according to raw material type.

Key Words: Nursing pad, absorbent layer, nonwoven fabric, bamboo, viscose, tencel

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ANTI-BACTERIAL FUNCTIONAL KNITTED FABRICS ESPECIALLY FOR OVERWEIGHT PEOPLE

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Hygienic textile garments have used from the second World war and nowadays these products draw intense interest because of increasing demands of hygienic garments and social sensitively[1].

During the wearing time the heist and moisture conditions of textile garments occur better conditions for reproducing of micro-organisms between textile fibers. Besides negative influences on human health these micro-organisms cause unpleasant smell on textile structures discoloration, spotting and reduction fabric strength[1].

Anti- bacterial garments have important usage area in technical textiles which have high functional characteristic. These products use effort protecting human health, personal hygiene and comfort, blocking reproducing of bacteria's and fungus, unpleasant smell and contamination by micro-organisms, discoloration and spotting of textile structures.

Anti- bacterial textiles have important advantages for human health but they also carry risk for human and environmental health. In the long term these garments have noteworthy negative influences, such as allergic reactions, negative influences on human flora and toxicity potential for environment.

Cloth comfort is more important especially overweight people. Because of their body structure they make more effort the other people so that a new fabric design and manufacture is an obligation to get better life standards for these people.

The metabolism of overweight people works slowly because of their body structure and they have more adipose tissue than a normal person. These situations cause Obesity. The risk factors of obesity are lower physical activity, food habits, age, educational level, marriage, parity and genetics. The sweat problem of overweight people and this uncomfortable situation as a result of sweating are tried to remove with the methods which will be used in the scope of this study. In this study the functional characteristics such as antibacterial- antifungal effect, spreading good smell, and absorbing unpleasant smell of sweating will be added to knitting fabric with raw material and some finishing processes for moisture management properties.

For this aim, we will use in this study some raw material like Seacell, Milk, Lyocell, Coolmax, coolmax fresh and blend of this yarns. Owing to these yarns, we can produce anti-bacterial, comfortable, high moisture management under-wear products. All of yarn is natural, comfortable, soft and strength[2].

In addition, seacell, milk and soybean fibers are soothes, cares for skin, absorbs moisture, inhibits growth of bacteria, soft and comfortable[5] Thanks to its fibre structure it creates light weaves with a lovely silky look that allow the skin to breathe and humidity to be absorbed, making the skin tender and smooth[5].

And finally, scope of study the moisture management capacity of fabrics will measure. High moisture transmission capable of textile products is also very important to feels dry and comfortable[6].

In this study we will do some anti-bacterial, anti-fungal tests, moisture management test and of course some performance tests to measure effective of fabrics. For example, the assessment of the antimicrobial activity was carried out according to the standard procedure described in the AATCC test method 100-2004[3].

You can see the yarns and tests which will be used in this study in Table 1.

Table 1. Name of yarns and test which will be used for this study

Fabric Quality	Name of Yarn	Anti-bacterial - Anti-fungal			oisture managment and Comfort tes			Fabrics performance tests						Test of garment	
		AATTC 100 Anti-bacterial activity	AATTC 147 Anti-bacterial activity	AATCC 30 Anti-fungal activity	AATCC Test Method 195-2009-Moisture Managment	AATCC Test Method 79	ISO EN 31092-2000 Textiles - Hotplate tests	Rubbıng Fastness	TS EN ISO 12945-2 Martindale – 2000 turn	BS 8479 : 2008-Resistance to Snagging Test	TS EN ISO 13938-2 bursting resistance	ISO 15797 endüstrial laundry	TS ISO EN 12947-4 Martindale-2000 turn	SN V 195651, DIN 10955	Dermatest Skin Friendly Test
Ne 40/1 Sıngle Jersey/ 140 gr/m2	Cotton yarn														
	Lyocell Yarn														
	Milk Yarn														
	Soya Yarn														
	Seacell Yarn														
	Coolmax arn														
	Coolmax Fresh Yarn														
	%50 seacell/ %50 cotton yarn														
Ne 40/1 Rıb/ 180 gr/m2	Cotton yarn														
	Lyocell Yarn														
	Milk Yarn														
	Soya Yarn														
	Seacell Yarn														
	Coolmax arn														
	Coolmax Fresh Yarn														
	%50 seacell/ %50 cotton yarn														

Key Words: Anti-bacterial, anti-fungal, moisture management, underwear, knitted fabric, functional

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WET WIPES INCLUDING NATURAL-BASED CLAYS AND LIQUIDS FOR COSMOTEXTILE APPLICATIONS

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Recently, advancements about life quality standards of people has led to an increase in hygienic personal care product consumption. Disposable wet wipes are among the widely used care products that has an effect on total world fiber consumption. They can be used for many areas including baby wipes, cosmetics, sun care protection, fragrance or antiperspirant applications, famine hygiene, medical or other industrial applications [1]. Besides functional properties (cleaning or applying a specific product), dermatological compatibility, acceptable hand, ability of holding appropriately the liquid component, homogeneous distribution of the impregnated liquid, and transferring items smoothly to the skin in use are the required characteristics of a wet wipe [2,3]. All these features depend on the structural properties of the liquid component used for wetting, the fabric raw material selected and production method used. Wet wipes are commonly produced from synthetic and natural fibers such as polyolefin fibres, viscose, woodpulp and bicomponent materials as nonwoven fabric which are generally moistened with aqueous composition which contains amongst other surfactants, preservatives, scents [4] and natural oils (avocado oil, apricot oil, coconut oil, rose hip oil, soybean oil, etc.) [5]. Wet wipes should be sterile and hygienic by the time it gets into the consumer's hand. Non-woven wipe substrates, once moistened, become an excellent medium for the growth of microorganisms. Therefore, preservation is crucial for wetwipes.

In this study, selected spunlace nonwoven fabrics made of viscose and polyester in different rates were moistened and functionalized with natural liquids (rosewater, etc.) and antibacterial substrate containing clays. Alfa terpineol which has sufficient antibacterial action against 13 different bacteria and 8 different fungi [6,7] was located in micro porous structure of natural clays by caging method and its existence was determined by FTIR analyses. Moreover, rosewater which is the main wetting material is unique for our region and is naturally antiseptic that can keep the moistened wet wipe in a package during its shelf life [8]. The liquid and clay based components of the produced wet wipe are completely natural and no preservative including paraben or alcohol is necessary for the product. The wet wipe was designed as a tool to carry beneficial components to skin by wiping. During usage, antibacterial including clay will stay on skin for a certain period, transferring antibacterial component on skin and cleaning the skin from sebacous secretions and black head spots. Absorption capacities of the nonwoven fabrics were determined and fabrics were moistened by sufficient amount of (30% of the capacity) liquid and clay material. Besides standard mechanical properties in dry and wet forms, wiping performance of different nonwoven fabrics including components having different viscosities were determined by an apparatus simulating wiping of a person. Antibacterial performance of the wet wipe in its final form was determined quantitatively under dynamic contact conditions (ASTM E2149-01). Subjective hand evaluations were carried out to select optimum fabric/liquid component pairs. According to the results, sufficient antibacterial activity was detected for skin during a usage period. Mechanical properties are still sufficient after moistening and components including more than 25% clay minerals are suitable for a functional cosmetic textiles application. And it is thought that natural substrates that are antiseptic can be combined with clays having mineral/antibacterial material exchange capacity for cosmetic wet wipes.

Key Words: Wet wipes, cosmotextiles, natural liquids, clays

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IMPLEMENTATION POSSIBILITIES OF OPEN INNOVATION IN MEDICAL TEXTILES: TURKISH CASE

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The open innovation approach can be considered as antithesis to the traditional, vertical integrated model of research and development where products are developed internally. Socio-economic trends like the growing collaboration between firms and customers, short product life cycles and high market dynamics are the foundation of a new paradigm in innovation management. This approach has become more important and the level of awareness of open innovation in larger companies has dramatically risen in the last years [1].

Open innovation was defined by Chesbrough in 2003 as a combination of internal and external ideas as well as internal and external paths to market to advance their technology [2,3]. The open innovation paradigm can be characterized by its porous innovation process and the strong interaction of the company with its environment. By integrating a large number of individuals into the innovation process, new creativity and know-how are brought into the organization [1].

The open innovation process can take on three different forms; the outside-in process, the inside-out process and the coupled process [2,4].

Nowadays, medical textile, which is a branch of technical textiles, is one of the pioneer and fast growing areas within the textile and clothing sector. Medical textiles consist of all kinds of textile materials which are used in health sector. In this context it involves a large product range from basic products like gauze to complicated products like artificial organs. Developed countries concentrate on smart and innovative medical textiles whereas developing countries focus on basic and standard products. Technical knowledge, cooperation with other disciplines (medicine, electric-electronic engineering and mechanical engineering) and research and development activities are required in order to produce smart and innovative medical textile products. Medical textiles directly affect the human health and life quality. Therefore, its consequences and success are very important. Open innovation is one of the most significant innovation development techniques which can be used for increasing success.

When we look at the Turkish textile and clothing sector, we see that the sector is developed and significant in terms of national economy. However, the sector recently canalizes to technical textiles therefore to smart and innovative products. For this reason, our enterprises mostly produce basic and standard products (gauze, hygienic products, surgery sets (the surgical covers), surgical gowns, orthopedic medical textiles (corset, varsity socks etc.)) in medical textiles which is a branch of technical textiles. Therefore, the research and development activities within medical textiles are recently developing.

Within the scope of our study, we make interviews with two enterprises' owners which operate in medical textiles in İzmir. We see that, the enterprises, which operate in medical textiles, produce basic and standard products and they recently canalize to innovative products. Therefore, the research and development activities within the sector have recently started. In this context, open innovation can be easily and conveniently implemented by our medical textile enterprises with its advantages.

Key Words: Innovation, open innovation, textile and clothing sector, medical textiles

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INVESTIGATION ON MELT SPUN PCU FILAMENTS FOR MEDICAL APPLICATION

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Introduction: Warp knitted structures made out of inelastic materials are used in the therapy of tissue fractures (hernias) in order to reinforce the native tissue [1]. These so called hernia meshes may lead to significant problems in areas of high anatomical mobility. One of the reasons therefore is the very low elastic elongation of all commercially available meshes. For the therapy of hernias in high anatomical mobility areas structures with defined elastic behaviour are required [2]. Warp-knitted structures made from elastic filaments can meet these requirements. The aim of this study was the development of monofilaments with an appropriate elasticity for the usage in elastic mesh implants. For this purpose, the melt spinning process for medical grade Poly(carbonate)urethanes (PCU) was investigated.

Materials and Methods: Soft (shore 93A) and hard (shore 55D) types of PCU were analysed in this study with respect to their processing behaviour and their elastic properties. The melt spinning process was performed on a special single-screw extruder spinning machine by Fourné Polymertechnik GmbH, Germany. Monofilaments with draw ratios of 1 and 3.5 were produced and analysed in cyclic tensile tests with an applied elongation of 60 %.

Results: A stable spinning process for the production of PCU monofilaments could be achieved for a temperature profile from 193°C up to 218 °C. Regarding the cyclic tensile tests it was found that the hard PCU filaments have a lower elastic elongation than the soft PCU filaments. This is due to the higher mobility of the macromolecules of the soft PCU. The draw ratio did not have an effect on the elastic elongation for the soft PCU filaments. The elastic elongation of hard PCU filaments decreased with an increasing draw ratio. This could be caused by the formation of hard and soft domains within the hard PCU filament.

Conclusion: PCU monofilaments were successfully produced using the melt spinning process. Furthermore, filaments with a high elastic elongation rate could be produced out of PCU - shore 93A. An increasing draw ratio results in a decreasing elastic elongation for the hard PCU filaments (shore 55D). PCU filaments show a high potential for the use in elastic mesh implants and will be further investigated regarding their processibility into such meshes.

Key Words: Elastic mesh, poly(carbonate)urethane, melt spinning

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THE AREAS OF USAGE AND PROPERTIES OF LEAD APRONS

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In the medical industry, both health care staff and the patient himself can be easily affected by some tools or machines' rays that are used for treatment. Many of these effects that are encountered very often but the harm that people take appears after a long time caused by the machines that are used in radiation treatments in the radiology department of a hospital. Some of the methods that are in used by radiologists such as X-ray radiography, ultrasound, computed tomography (CT), nuclear medicine, positron emission tomography (PET) and magnetic resonance imaging (MRI) to diagnose or treat diseases. In all departments of each sectors for the terms of security of patients and medical staff, the lead apron, neck protector and glasses must be used and be careful [3]. The inner part of the lead aprons is made from plastic materials containing lead powder. Generally the thickness of this inner lead material is between 0,3mm and 0,5mm. In the production of lead aprons, these inner materials are covered by polyester material [6].

Medical radiological examinations have an indispensable place the treatment of the diseases. However, the negative effects of radiation on living organisms should not be ignored. These effects can vary according to dose of the radiation and exposure time. Maximum allowable dose of radiation that is clarified by International Commission on Radiological Protection (ICRP), the dose of radiation which does not induce any body symptoms and do not generate any effect genetically. The recommendations of ICRP (Table 1); maximum permissible dose of radiation for workers who work in radiational places, should not exceed the limit of 20 mSv which is the average of consecutive five years (maximum 50 mSv in a year), for other members of society in the same conditions the limit should not exceed 1 mSv [1]. Different units can be used in radiation measuring. In determining the effect on living tissue, the most widely used unit is Milisievert -mSv-. This unit is the amount of energy in the body. In a large megalopolis cities, the normal acceptance level of radiation in the air is 0,1 mSv and slightly higher. Another example is while shooting a dental x-ray, the radiation level received is up to 10 mSv.

Table 1. The recommendations of ICRP, maximum permissible dose of radiation* [2]

Dose limit	Occupational	Public
Effective dose	20 mSv per year, averaged over defined period of 5 years†	1 mSv in a year‡
Annual equivalent dose in:§		
lens of the eye**	20 mSv	15 mSv
skin	500 mSv	50 mSv
hands and feet	500 mSv	–

**The limits apply to the sum of the relevant doses from external exposure in the specified period and the 50-year committed dose (to age 70 years for children) from intakes in the same period. †The effective dose should not exceed 50 mSv in any single year. ‡In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over 5 years does not exceed 1 mSv/year. §For other organs, stochastic effects are limiting and hence the dose to these other organs is controlled by the limit on effective dose. **Based on the April 2011 Statement of the ICRP on dose limits for the lens of the eye.*

The lead aprons need to be used in each field if the radiation is in question to protect workers themselves against to radiation.

Production of the Lead Apron: In our country, there are lots of problems about production of the lead aprons. Especially the products that are produced in unlicensed production with poor quality, out of specs and too far from the main goal are to protect people who have to use them. Therefore, these products that protect the human health from serious harm must be manufactured and documented in the companies which are audited according to directives PPE (Personal Protective Equipment) as (89/686/EEC) by Ministry of Labor and Social Security (MOLSS). The audit scope of these products can be checked with the 4 digit ID number (Example CE 0120) of the manufacturer company which put on the products [4].

Use of the Lead Apron: The care and usage control points of the lead aprons which protect humans from the beam are listed below.

- *Visual Check;* There should not be any holes or tears on the lead aprons that protect from the beam.
- *X-ray Check;* These products need to be tested in x-ray and fluoroscopy maximum in each 3 months period.
- *Conservation and Preservation;* These products should be kept in a place which is 10°C-20°C and with special hangers.

- *Cleaning;* These products should be cleaned with a soft swab, warm water and dishwashing detergent.
- *Disinfection;* Disinfectants should not contain alcohol and autoclave should not be used.
- *The Lifetime;* In general, the life of the lead aprons may be extended by following the instructions described above.
- *Destruction;* These products should be destroyed by competent authorities with the framework of local laws.

In this study, as a textile product, the lead aprons types, the places of use and properties, the materials used in production and general manufacturing of these products are considered. Also the points that take into account in audit are examined.

Key Words: Lead apron, textile and clothing industry, radiation protection

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THE PHYSICAL PROPERTIES OF MEDICAL FACE MASKS

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Filtration is the process of increasing fluid purification by separating articles having certain dimensions within air or liquid. Filtration textiles include a wide range of products which can be grouped under industrial, medical and geo-textiles subgroups of technical textiles [1]. In recent years, due to the increasing population and developing technology, air pollution has become a serious problem for living organisms which threatens their health. Quality and purity of indoor and outdoor air have great importance on the health of human beings. To breathe clean air, purified from different types of contaminants, air filtering applications are essential in our daily lives. Hence, measurement of filtration efficiency, concerned standards of efficiency measurement methods have attracted great attention of researchers considering the determination of the quality of filtering processes and providing optimum construction parameters for filtering material [2].

One of the common usage areas of filtration textiles is as face mask. Surgical masks have been in widespread use since the early 1900s to help prevent infection of surgical wounds from staff-generated nasal and oral bacteria. Today surgical masks vary widely in style and intended application and can be found in a broad range of hospital and health care settings [3]. Various types of face masks available to the general public are worn for protection against inhalation of dust, pollutants, allergens, and pathogenic organisms [4].

In order to choose the right mask suitable for the level of filtration required and risk level, ASTM F-2100-11 standard specification for performance of materials used in medical face masks is used. This specification covers testing and requirements for materials used in the construction of medical face masks that are used in providing health care services such as surgery and patient care and provide the classification of medical face mask material performance. Medical face mask material performance is based on testing for bacterial filtration efficiency (BFE), differential pressure, sub-micron particulate filtration efficiency, resistance to penetration by synthetic blood, and flammability. The selection of the appropriate medical face mask must be governed by the potential exposure hazards based on the specific areas of performance associated with class of medical face masks. General use masks provide minimal fluid resistance and are suitable for situations such as in isolation settings and for certain types of patient care. Where procedures involve the generation of sub-micron particles, such as in laser or electrocautery surgery, sub-micron filtering masks are appropriate. Where procedures involve the probability or likely exposure to blood or body fluids, selection of fluid-resistant medical faces masks is suitable. The masks are classified as level 1, level 2 and level 3 based on the barrier performance properties of the materials used in medical face masks, as given in Table 1 [5].

Table 1. Medical face mask material requirements by performance level

Characteristic	Level 1	Level 2	Level 3
Bacterial filtration efficiency, %	≥95	≥98	≥98
Differential pressure, mm H_2O/cm^2	<4.0	<5.0	<5.0
Sub-micron particulate filtration efficiency at 0.1 micron, %	≥95	≥98	≥98
Resistance to penetration by synthetic blood, minimum pressure in mm Hg for pass result	80	120	160
Flame spread	Class 1	Class 1	Class 1

Besides the performance properties of the facial masks, the physical and comfort properties are also important. The breathability, durability, how well it attaches to the face, comfortability of the masks is as important as the performance features.

In this study, some of the physical properties of three different face masks produced from 100% polypropylene fibre were investigated. For this, mass per unit area, air permeability and water vapour permeability of the face masks was measured and the results are given in Table 2. As it can be seen, the facial masks have different permeability values, which can affect the user`s comfort directly.

Table 2. Some of the physical properties of face masks

Product	Mass per unit area (g/m^2)	Air permeability (lt/m^2/s)	Water vapour permeability (mg/cm^2/h)
A	35	2080	46.18
B	43	2060	51.72
C	70	66	16.54

Key Words: Medical mask**,** surgical mask, facial mask, filter

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POLYPROPYLENE/DIATOMITE TEXTILES WITH ENHANCED ABSORBENCY PROPERTY

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Synthetic textile materials with improved absorbency property have always attracted great interest both by academicians and industrialists. Textile surfaces with enhanced absorbent property will be produced by melt spinning technique. In this study, diatomite (D), which is a natural inorganic mineral with inherently high water and oil absorption capacity will be used (see Figure 1 and Table 1). The D will be incorporated into a thermoplastic polymer (PP) and finally, textile surfaces with enhanced absorbency property will be developed. No study has been observed in the literature on the incorporation of diatomite into thermoplastic polymers in melt stage and production of yarn, fabric and/or nonwoven structures thereof and their utilization as a sorbent material.

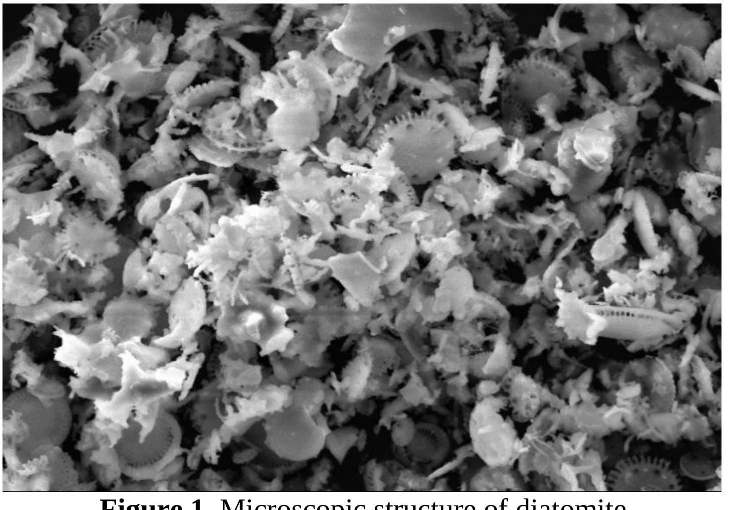

Figure 1. Microscopic structure of diatomite

Table 1. Water absorption of diatomite (D)

Sample	Water absorption (g/g D)
Untreated D	1.13
10 wt.% FC treated D	1.06
10 wt.% SA treated D	1.02

Key Words: Diatomaceous silica; surface modification, polypropylene, water absorbency

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COMPUTATIONAL MODELLING OF PELTIER DEVICES FOR PHYSIOTHERAPY PURPOSES

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For many years water based gel packs have been widely used in medical applications [1, 2]. Their usefulness is quite evident in physiotherapy, as a means of heating or cooling specific parts of the human body [3-5]. However, their applicability is limited by the fact that they have to be pre-cooled or pre-heated before use.

Peltier devices have been long recognized as one of the most reliable solutions considering both heating and cooling applications [6, 7]. In the past they have also been widely employed in medical applications [8-14]. In this work the operation of a Peltier module, incorporated into a cooling/heating system for physiotherapy purposes, has been examined computationally. The finite element model of the proposed system has been constructed using ANSYS® Workbench Software, V. 14.0. Furthermore, the possibility of employing an identical device for energy harvesting purposes, in order to exploit the temperature gradient between the human body and the environment, has been investigated.

Computational analysis indicated that the proposed cooling/heating system can achieve the desirable temperature levels as well as the temperature uniformity required across the surface of the gel pack facing the skin. The power consumption of the module under both cooling and heating operation has been identified. The proposed setup could be integrated into fabrics produced for physiotherapy purposes. Finally, performance analysis of the same thermoelectric device when operating as a power generator pointed out that such an approach could be useful for specific medical wearable applications [15, 16], even with currently available commercial thermoelectric materials.

Key Words: Medical packs, Peltier, computational analysis

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THERMOCHROMIC FIBRES: DESIGN AND IMPLEMENTATION OF MEASUREMENT SYSTEMS

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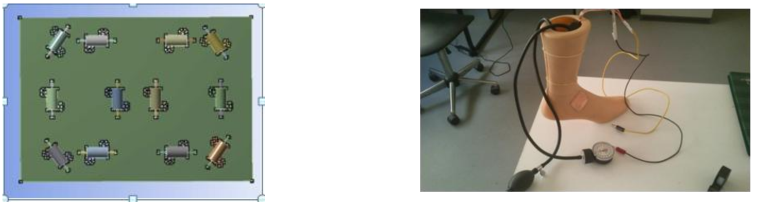
According to the literature, there are two types of thermochromic systems, direct and indirect. Indirect thermochromic systems usually operate in an environmental temperature range [1] while direct thermochromic systems change their colour to a predefined temperature range. In order to embed thermochromic properties in fibres one can either subject them to printing with thermochromic ink or incorporate a thermochromic material to the batch material of the fibre by microencapsulation. In the late 80's and early 90's the company Generra Sportswear, which created T-shirts with numerous options in the colour palette, bought the rights to print cotton fabric with organic thermochromic pigments with negative thermochromism by Japanese chemical company Matsui-Shikiso creating the Hypercolour ® brand [2]. Similarly, based on the idea of the simulation of indigo-faded effect of Jeans, thermochromic pigments have been used in jeans that change their colour at body temperature. Thermochromic pigments containing colour formers have also been incorporated in the past using manmade cellulose fibres at the stage of wet spinning (filament formation) [3]. Also, thermochromic leucodyes were mixed with cellulose in the spinning bath in order to produce thermochromic yarns. Furthermore, thermochromic acrylic yarns have been produced during melt spinning [4].

In all the aforementioned products, the use of thermochromic materials leads to colour changes which occur on them at various temperatures or temperature ranges. If the colour change is predefined and the temperature in which it occurs is priorly know with accuracy these fibres can have great potential for applications in the medical textiles field. As a matter of fact there is a patent for children's clothes with thermochromic effects, provided in the fabric via printing or coating [5], that are able to visualize body temperature [6].

The present work focuses on the design and the implementation of two measurement systems suitable for monitoring the change in the chromic properties of thermochromic fibres and fabrics versus temperature in order to provide a fibre-specific relationship between colour and temperature. The first measurement system provides a uniformly heated surface on which thermochromic fibres or fabrics can be placed, while the second one has the topology of a human limp and is designed for monitoring the effect of local heating of the thermochromic fibre or fabric. In order to implement these measurement systems several design and construction issues have been encountered using proper techniques and tools, such as Finite Element Analysis.



(a) (b)

Figure 1. (a) Final computational model of the aluminum plate and (b) physical model of the human limp

In Figure 1 the final computational model of the first and the physical model of the second measuring system are presented. Polymeric thermochromic fibres have, already, been tested using these measuring systems and the effect of the percentage of thermochromic material in the master batch material versus the start and end temperature of the thermochromic phenomenon has been investigated.

Key Words: Thermochromic fibres, measurement systems, FEM, temperature control

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