The Institute of Textile Science

2023 SYMPOSIUM
ABSTRACTS FOR ORAL PRESENTATIONS

TEMPERATURE - RESPONSIVE SHAPE MEMORY POLYMER FILAMENT INTEGRATED POLYESTER KNITTED FABRIC FEATURING MEMORY BEHAVIOR

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Presentation time: Tuesday March 7 at 11:30 am MT/1:30 pm EST

Recent developments in smart materials motivate researchers to create novel textile products for innovative and functional applications. This study investigates the memory behavior of shape memory filament integrated into a knitted textile structure and advances the knowledge of how it responds within the textile structure. A memory filament and polyester yarn were knitted to produce a shape memory knitted fabric (SMF). Thermo-mechanical tensile test was carried out to quantify the memory behavior of SMF under different thermo-mechanical conditions. The experimental findings demonstrate excellent shape recovery (100%) and shape fixity up to 88% at different strains (20% and 60%) and temperatures (30℃ and 50℃). Experimental results reveal that memory filament behaves differently in a fabric structure than in its pristine condition. The cycle test of SMF indicated complete shape recovery with an increase in shape fixity. So, the utterly recoverable textile structure was achieved after a few initial cycles.

IMPROVEMENT IN IMPACT ENERGY OF 3D WOVEN HONEYCOMB BASED COMPOSITE USING ZNO NANOROD SURFACE FUNCTIONALIZATION

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Presentation time: Tuesday March 7 at 11:45 am MT/1:45 pm EST

Advanced 3D textile architectures provide structural stability and fibre continuity through multiaxial in-plane and out-of-plane fibre orientation. 3D woven honeycomb is an advanced textile structure, and its reinforced composite is a novel approach to attain better structural integrity and energy absorption with lightweight. In this study, ZnO nanorods were grafted throughout the surface of 3D woven honeycomb preform followed by composite conversion to enhance the impact energy of developed composites. ZnO-grafted nanorods enhance fibre-polymer interaction, resulting in a strong adhesive bond. Flatwise and Dynamic impact tests were carried out on treated and untreated honeycomb composites with different honeycomb cell sizes. The result shows that grafted honeycomb-based composite can withstand higher peak loads and absorb more energy than untreated 3D woven honeycomb-based composite. This study offers a novel approach for modifying the fibre-matrix interface of 3D woven honeycomb composites intended for high-impact energy absorption.

THE TEXTILE SENSORS' APPLICATIONS IN CLOGGING DETECTION OF INDUSTRIAL AIR FILTERS

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Presentation time: Tuesday March 7 at 1:00 pm MT/3:00 pm EST

Nowadays, air filter has an important role in public areas such as swimming pools and shopping centers for improving air quality. Clogging is one of the most significant matters of fibrous filters, which industries are trying to solve. Over the years, smart textiles can once again be a suitable solution. In this study, the thermoplastic polyurethane (TPU) membrane was produced by electrospinning. The sensory membrane is strongly air-permeable and SEM pictures show uniform, homogenous, and beads-free nanofibrous membrane with high porosity. The carbon-based ink was printed on the surface of the electrospun TPU membrane using different patterns. Then, the samples were tested in the ventilation tunnel to measure the pressure drop, deformation, and electrical properties under the low air flow of the filter. The sensory membrane can be used as a multidirectional strain sensor needing high sensitivity and air permeability in clogging detection of air filters.

STUDIES OF POLYCYCLIC AROMATIC HYDROCARBON EXPOSURE TO WILDLAND FIREFIGHTERS' PROTECTIVE CLOTHING

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Presentation time: Tuesday March 7 at 1:15 pm MT/3:15 pm EST

In wildland firefighting, polycyclic aromatic hydrocarbon (PAH) is generated through burning of trees, and PAH deposits and/or transmits through fabrics used in wildland firefighters' protective clothing to their bodies. This PAH may cause lung, bladder, and skin cancer to firefighters. This study investigates the impact of fabric structure and surface attributes on deposition/transmission of PAH. To do this, we evaluated the air permeability and determined the surface properties of different types of fire-protective fabrics using Kawabata Evaluation System. To determine the PAH deposition on fabrics, we scientifically simulated the source of PAH generation through burning wood and investigated the amount of PAH deposition on fabrics for a certain duration of exposure. Based on statistical analysis, it was found that fabric structures and surface attributes could significantly affect the deposition of PAH on fabrics. This study could help us understand what kind of fabric will deposit/transmit the least amount of PAH.

ROLL-TO-ROLL ELECTROCHEMICAL FABRICATION OF SILVER/SILVER CHLORIDE YARNS FOR DEVELOPING E-TEXTILE ELECTRODES

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Presentation time: Wednesday March 8 at 1:30 pm MT/3:30 pm EST

This work presents a roll-to-roll electrochemical coating system for producing silver/silver chloride (Ag/AgCl) yarns, applied to developing electrodes for biological signal monitoring. Ag/AgCl is the preferred material for electrodes interfacing the body for biopotential signal monitoring. E-textile Ag/AgCl-coated nylon yarns offer a flexible and breathable alternative to conventional rigid, or flexible film-based Ag/AgCl electrode materials. The developed system allows for controlled process parameters for AgCl deposition on Ag-coated nylon yarns. The electrical, electrochemical, micro- and nanostructure, and crystal structures of the yarns were characterized to obtain and optimize process parameters. The yarns produced were applied to the design of flexible dry electrodes by embroidery stitching. Electrocardiogram signal comparison results demonstrated that the Ag/AgCl e-textile electrodes can collect stable signals and heart rate measurements. The characterization of the continuous yarn coating method, and subsequent application to electrode materials contributes to the development of flexible e-textile-based Ag/AgCl sensor materials.

LAUNDRY PRACTICES AND PROPOSED SUSTAINABLE SOLUTIONS IN THE CANADIAN PRAIRIES

Jackie Fisher*, Dr. Rachel McQueen, and Dr. Sven Anders
Department of Human Ecology, University of Alberta
Presentation time: Wednesday March 8 at 1:45 pm MT/3:45 pm EST

Washing and drying laundry are resource intensive practices. Despite technological improvements in laundry equipment, energy use is still dependent on consumer behaviour. While there is a wealth of studies about laundry practices, there is a noticeable absence in the literature about Canadian laundry behaviour. To address this gap, a survey was conducted to examine Canadians' current laundry practices. This presentation disseminates some of the results on laundry behaviours of 356 respondents living in the Canadian Prairie provinces of Alberta and Saskatchewan. Through addressing this unique population base, the climate and energy sources of Alberta and Saskatchewan, this research begins to explore some of the laundry behaviour nuances and sustainable opportunities in the Canadian Prairies. Canadian Prairie households could modify their laundry behaviour in order to mitigate resource consumption. Therefore, some laundry innovations and proposed solutions will also be covered where environmental savings could be made.

IMPROVED THERMAL INSULATION PERFORMANCE OF COLD-WEATHER PROTECTIVE CLOTHING INCORPORATING BIO-SOURCED MATERIALS

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Presentation time: Wednesday March 8 at 2:00 pm MT/4:00 pm EST

Protective clothing provides thermal comfort and insulation in extreme cold-weather workplaces. However, the development of textile assemblies with high insulating properties incorporating bio-sourced materials is a challenge.
In this project, various proportions and structures of natural fibers and PLA were used to develop and implement natural thermal insulation textile assemblies. Fibers morphology and diameters were evaluated using optical microscopy. Thermal properties of PLA and natural fibers assembly were assessed via DSC. A sweating test-bench, often referred to "skin-model" based on ISO11092 standard, was adopted for the thermal resistance measurements.
It was found that the fiber assembly does not provide good homogeneity, which is necessary for a thermally efficient assembly. On the other hand, the result showed that consolidation temperature used in the assembly manufacturing does not reach the melting point of the PLA. Multi-layer assembly was adopted as a solution to these problems and to improve thermal and mechanical resistance.

WEAR TRIAL ASSESSMENT OF A NEWLY DEVELOPED BRA FITTING METHOD.

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Presentation time: Wednesday March 8 at 2:15 pm MT/4:15 pm EST

Many women experience bra dissatisfaction and frustration. These issues are aggravated in women with significant breast asymmetry, voluminous breast and/or who have undergone breast surgery. Research shows that these issues could potentially be solved by having a custom-made bra. However, the optimization of a custom-made bra is highly dependent on the accuracy of the fitting. With the current fitting techniques, fit is largely dependent on the experience of the fitter, and varies from one fitter to another. Therefore, it is important to establish a method to ensure consistency and accuracy in the fit of bespoke bras. This paper presents the results of a wear trial assessment of a newly developed bra fitting method. It includes a step-by-step procedure involving fitting pre-assembled bra parts directly onto the body. The findings will inform the preparation of a standard operating procedure for bra fitting, and create awareness on the benefits of bespoke bras.

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2023 SYMPOSIUM
ABSTRACTS FOR POSTER PRESENTATIONS

GREEN ELECTROSPUN ULTRAFINE PARTICLES FILTER STRUCTURES FOR CHEMICAL PROTECTIVE CLOTHING.

Adnan Masri*, Ludwig Vinches
Department of occupational health and security, University of Montreal
Presentation time: March 7 and March 8 at 2:00 pm EST
Location: University of Montreal

Ultrafine particles (UFPs) in the workplace present a potential harmful effect on the health of workers. Type 5 chemical protective clothing (CPC) are recommended for skin protection. However, if type 5 CPCs have shown their efficiency against micrometric particles, recent studies highlight a lower efficiency against UFPs. In addition, most of these CPCs contain non-biodegradable thermoplastic polymers and cause serious damage to the environment.
In this regard, my project deals with the development of new green filtration structures by electrospinning that can be applied to CPCs. Electrospinning is a recent technology allowing the design of nonwoven filtering structures based on nanometric-sized fibers. Indeed, recent studies have shown that the integration of nanometric fibers considerably improves the filtration efficiency of its structures. Once the bio-sourced structures are designed, their filtration efficiency will be evaluated using a robust and proven methodology.

ISO 11092 STANDARD: IS A REVIEW NEEDED?

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Presentation time: March 7 and March 8 at 2:00 pm EST
Location: University of Montreal

The ISO 11092 standard uses a bench test named "skin model" to measure the thermal and water-vapor resistances of materials employed in the textile industry. This test simulates the heat and moisture generated by human skin. However, the standard only considers specific environmental conditions, i.e., 20 °C with a relative humidity of 65% and a lateral air speed of 1 m/s, which do not accurately reflect the real conditions of a Canadian winter. A recent study has shown that the thermal insulation of textile assemblies can be significantly impacted by wind speed. Specifically, a loss of 85% of thermal insulation was observed when wind speeds increased from 0 to 4.4 m/s perpendicular to the assemblies, primarily due to compression.
In light of these findings, we recommend that the ISO 11092 standard be adapted to better represent the environmental conditions of a Canadian winter.

DEVELOPMENT AND ASSESSMENT OF N-HALAMINE-BASED SELF-DECONTAMINATING FINISH ON FABRICS USED IN PROTECTIVE CLOTHING

Anita Amir Labonno*[1], René Arredondo[1,2], Jemma Forgie[1], Yongfeng Gao[2], Paulina de la Mata[2], Jane Batcheller[1], James Harynuk[2], Patricia Dolez[1]

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Presentation time: March 7 at 10:00 am MT

Location: University of Alberta

The COVID-19 pandemic has unveiled the unprecedented demand for protective clothing to control the propagation of biological pathogens, especially for frontline workers such as military and medical personnel. Therefore, protective clothing with the surface application of biocide solution could help address this issue. N-halamines are an effective and fast-acting biocide that can be regenerated using a free halogen source. However, the N-halogen bond in N-halamines tends to decompose under UV light. This research focuses on improving the UV stability of the N-halogen bond by adding metal oxide nanoparticles to the N-halamine finish. In addition, two approaches are explored for applying the finish solution on the fabric: the wet route using a solvent and the dry method using powder under heat and pressure. The performance of the fabric after the finish application, including its bactericidal activity, and the effect of simulated use conditions on the self-decontamination efficiency, are assessed.

CONTROLLING THE VARIABILITY IN THE MEASUREMENT OF THE EFFICIENCY OF JOULE HEATING TEXTILES

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Presentation time: March 7 at 10:00 am MT

Location: University of Alberta

The lack of standardized testing methods for Joule heating textiles is a key barrier to their commercial growth. Research has been initiated to fill this gap in terms of efficiency, durability and safety assessment. Getting reproducible heating, i.e, change in temperature over time in response to a given power, is important when characterizing the heating textile efficiency. This communication reports on the effect of different parameters that may lead to irregularities in heating. It was performed with six different types of heating textiles: woven, knitted, inserted, stitched, coated, and nonwoven. The type of tape used to secure the thermocouples on the textile did not have any effect while the location of the thermocouple, the nature of the boundary layers, the presence of air movement, corrosion in the copper power interconnects, and the environmental temperature affected the results. Ultimately, this research will contribute to improving Joule heating textile product's quality.

STUDY OF POLYURETHANE FILMS AS A SACRIFICIAL UV-SENSITIVE LAYER IN A GRAPHENE-BASED END-OF-LIFE SENSOR FOR FIRE-RESISTANT FABRICS

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Presentation time: March 7 at 10:00 am MT
Location: University of Alberta

High-performance fibers used in fire-protective garments age silently when subjected to typical fire-scene conditions. An end-of-life sensor is currently being developed to monitor the fabrics' degradation since there are no non-destructive test techniques available. For the UV-sensitive part of the sensor, a commercially available polyurethane is explored as a sacrificial layer to simulate the degradation of the fabric in response to UV radiation. Upon UV aging, the polymer layer should crack and break, disrupting the graphene track underneath. The loss in conductivity of the conductive track informs the garment user about the fabric's deterioration during service. Mechanical testing of polyurethane film specimens exposed to UV radiation for different durations revealed a reduction in the tensile toughness, which indicates an increased brittleness as the exposure time increases. Adding UV blockers to the polymer could allow us to tune its degradation so that it matches that of the fabrics used for fire-protective clothing.

UV AGING OF FIRE-PROTECTIVE FABRICS

Md. Saiful Hoque *, Patricia I. Dolez
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Presentation time: March 7 at 10:00 am MT
Location: University of Alberta

High-performance fibers such as para-aramid, meta-aramid, polybenzimidazole (PBI), and poly (p-phenylene benzobisoxazole) (PBO) are widely used to manufacture protective clothing for various professionals, including firefighters. These high-performance fibers demonstrate excellent performance when new. However, prolonged exposure to ultraviolet (UV) radiation can have a negative impact on these high-performance fibers. This study subjected three fabrics, which correspond to typical blends used in firefighters' protective suit outer shells, to UV radiation at irradiances between 0.35 W/m2 to 1.35 W/m2 and temperatures between 40°C to 80°C for up to 600 hours. After exposure to UV aging, all three fabrics exhibited a significant loss in tensile strength, even at an irradiance as low as 0.35 W/m2. This reduction in the fabrics' strength can be attributed to fiber breakage due to aging. However, no evidence of chemical changes by FTIR analysis was observed for the UV-aged specimens.

OPTIMIZING THE ELECTROSPINNING PARAMETERS FOR META-ARAMID NANOFIBRES

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Presentation time: March 7 at 10:00 am MT
Location: University of Alberta

Carcinogen exposure among firefighters has led to the desire for a fire-protective clothing to provide a barrier against fire-generated chemicals. The strategy explored here relies on inherently flame-resistant nanofibre webs produced via electrospinning of meta-aramid fibres. Nanofibres offer light weight, high surface area, and improved filtration efficiency when compared to conventional non-woven filters. Production of nanofibre webs was achieved through a needle-based electrospinning process. Meta-aramid fibres were dissolved in N, N-dimethylacetamide to produce the electrospinning solution. Characterization of the nanofibre webs was performed via optical and scanning electron microscopy to assess how parameters associated with the polymer solution, electrospinning parameters, and ambient environment affected the fibre morphology. Optimal nanofibre morphology, diameter, and density in the web were obtained through adjustment of these parameters. These results pave the way to the development of new firefighter protective clothing with improved protection against fire-generated aerosols.

COMFORT PROPERTIES OF A PROPOSED NEW WILDLAND FIREFIGHTERS' SHIRT DESIGN WITH IMPROVED THERMAL PROTECTION

Elena Kosareva*, Jane Batcheller, Stephen Paskaluk
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Presentation time: March 8 at 10:00 am MT
Location: University of Alberta

Every year wildland firefighters prevent wildfires from spreading by performing fatiguing activities while facing hot weather, smoke, and hostile fire conditions. Their personal protective clothing is designed to insulate against high thermal exposure and flame, while still providing ventilation for the evaporation of perspiration to minimize physiological strain. This poster will present a newly developed shirt design to improve thermal protection that incorporates a flame-resistant, lightweight, and porous 3D warp-knitted fabric, and provide the results of testing to investigate the effect of the added material on the comfort properties of the wildland garment, including thermal and evaporative resistance, and air permeability. The results show that the proposed garment design can improve thermal protection without significantly reducing comfort properties.

REVISITING THE MEASUREMENT OF DRY THERMAL EFFUSIVITY OF FABRICS

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Presentation time: March 8 at 10:00 am MT
Location: University of Alberta

Recently, thermal effusivity has garnered increased attention in the textile industry as it can predict the warm/cool touch perception of apparel products. The current study assessed the thermal effusivity of 27 sportswear fabrics using the stacked method (following ASTM D7984-21) and air-hoop method (modified method). The results showed that the pressure range mentioned in ASTM D7984-21 (i.e., 10 to 50 kPa) may compress the fabric, leading to a measurement of a material-based thermal effusivity rather than the fabric's thermal effusivity. A 1 kPa pressure may be more appropriate for the measurement of sportswear fabrics as it does not alter the fabrics' 3D structure. With this value of applied pressure, a good correlation was observed between the results provided by the stacked and air-hoop methods for fabrics with thicknesses equal to or greater than 0.4 mm. This opens the door to simulating garment use more realistically using the air-hoop method.

POLYIMIDE AS SACRIFICIAL POLYMER FOR A MOISTURE-SENSITIVE END-OF-LIFE SENSOR FOR FIRE-PROTECTIVE CLOTHING

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Presentation time: March 8 at 10:00 am MT
Location: University of Alberta

Fire fighters' protective clothing (FFPC) is produced using inherently flame-resistant materials. Over time, the excellent performance of these fibers decreases due to exposure to various conditions, including moisture. Polyimide is a temperature resistant polymer that degrades by hydrolysis when exposed to moisture. It is explored for use in a moisture-sensitive end-of-life sensor to mimic the aging of the high-performance fabrics used in the outer shell of FFPCs. Polyimide film strips were aged in water at different temperatures (70, 80, and 90°C) for up to 56 days. The specimens became brittle and there was a gradual darkening over time. The color change was quantified with a spectrophotometer. It was associated with chemical changes in the polyimide molecule leading to the creation of side groups. As the next step, we are investigating if the aging process creates surface features like cracks in the polyimide film.

OPTIMIZATION OF THE ELECTROSPINNING CONDITIONS OF POLYACRYLONITRILE NANOFIBROUS MEMBRANES EMBEDDED WITH MAGNESIUM OXIDE NANOPARTICLES FOR CHEMICAL AND BIOLOGICAL PROTECTIVE CLOTHING

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Location: University of Alberta

Currently, available solutions for chemical and biological protection include air-permeable membranes combined with a sorptive material and full encapsulation with impermeable materials and sealed clothing constructions. Nanotechnology, with high surface-area-to-volume ratio and low pore size, offers the possibility to increase protection without decreasing comfort. Nanofibrous membranes can be fabricated easily and economically using electrospinning. In addition, some metal oxide nanoparticles (NPs) such as magnesium oxide (MgO) can be embedded in the nanofibers for detoxifying chemical and biological compounds. This study examines the effect of a series of environmental and manufacturing parameters on the morphological aspects of nanofibrous membranes composed of polyacrylonitrile nanofibers embedded with magnesium oxide NPs: relative humidity, voltage, collector distance, solution flow rate, and position and dimension of an auxiliary electrode. This work is part of the Canadian Department of National Defence (DND) IDEaS COMFORTS (Comfort-Optimized Materials For Operational Resilience, Thermal-transport, and Survivability) project.