The Institute of Textile Science

2024 ITS SYMPOSIUM
ABSTRACTS FOR ORAL PRESENTATIONS

EMULSION ELECTROSPUN CROSSLINKED FIBROUS MEMBRANE FOR WATER PURIFICATION

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Presentation time: Tuesday, March 5 at 11:30 am (MT)/1:30 pm (EST)

The industries including food, cosmetics, textile, and refineries are causing a serious concern of water pollution worldwide by discharging huge amount of oily wastewater into mainstream water resources. The purification and the treatment of such wastewater is an urgent need to prevent environmental hazards and human health dangers. The membrane technology has played a pivotal role in encountering oily wastewater. It offers efficient purification, higher flow flux, lower fouling, and versatility in handling wastewater in harsh conditions. Nanofibrous membranes have been found to be of superior performance in treating emulsified oily wastewater because of its microstructure, high surface area to volume ratio and they also provide ease of functionalization.

Crosslinked structures and their products having excellent strength, thermal and/or solvent resistance serve in advanced applications ranging from filtration and composites to biomedical fields. Constructing well-aligned fibrous structures from pre-crosslinked polymers or resins has been a strenuous task as these polymers or resins exhibit the un-processability and restricted solubility in diluents. To fabricate crosslinked fibrous matrices, we identified the need to formulate near gel resin emulsion (nGR) based on crosslinked polystyrene. Electrospinning was employed to produce nanofibers from nGR emulsion without using any toxic organic diluent. Oil-in-water based nGR emulsion was formulated by drop wise mixing the monomeric mixtures of polystyrene into the

continuous phase of emulsion of aqueous polymer solution. The stable emulsion formed by surfactant was subjected to heating for synthesis of nGR within the disperse phase of emulsion.

Upon electrospinning, the uniform and continuous strands of nanofibers were produced through nGR emulsion. The single nanofiber displayed the core-sheath morphology where fibrous core of crosslinked polystyrene was templated within sheath of nanofiber. nGR emulsion and resulting fibres were characterized for its rheological behaviour, disperse phase droplet size measurement, monomer conversion by NMR, mechanical strength, and uniformity of core-sheath components with the variation in nature of surfactant and crosslinking density present in dispersed phase. The core-sheath nanofibers in which crosslinked sheath was super-hydrophilic in nature and core was composed of crosslinked hydrophobic material. As the sheath made of hydrophilic polymer, it created the hydration layer on the surface of membrane when it was submerged in aqueous medium. The hydration layer produced a barrier resisting the oil droplets to penetrate through the membrane thereby exhibiting an excellent underwater oleophobic nature. The membranes showed excellent separation of oil/water and oil-in-water emulsion at more than 99% of separation efficiency. The membranes were analysed for repeated emulsion separation up to 10 cycles without any loss in separation efficiency. Additionally, these matrices demonstrated a high oil adsorption capacity up to 3000%. Different oils were used for oil adsorption experiments to prove the universality of membranes. The membranes have shown promising performance and can be used in catalysis, filtration, and separation sciences effectively.

CHARACTERIZING THE THERMAL PROTECTIVE PERFORMANCE OF TEXTILES UNDER FLAME EXPOSURE WITH VARYING INTENSITIES.

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Presentation time: Tuesday, March 5 at 11:45 am (MT)/1:45 pm (EST)

Introduction

Annually, an estimated 100 firefighters experience fatal injuries, with tens of thousands sustaining nonfatal injuries. Burn injuries constitute a significant portion of fireground injuries, accounting for 7%-8% of the overall injury statistics. Despite utilizing thermal protective clothing, incidents of burn injuries highlight its inadequacies. The suboptimal

performance of such clothing is primarily attributed to the unpredictable nature of hazardous fire incidents encountered by on-duty firefighters. Flame exposure variability arises from factors such as proximity to hazard sources, fuel availability, and other hazard parameters. The air layer between the skin and clothing assumes importance, as motion and posture changes during rescue work can significantly impact the thermal insulation property of protective clothing. Consequently, this study investigates the impact of flame exposures of varying intensities on the Thermal Protective Performance (TPP) of single and multi-layered fabric materials, considering the influence of air-gaps in the fabric system.

Materials and Methods

Specimen samples, including two outer-layers, two moisture-barriers, and two thermal-liners, were selected based on commercial availability. These specimens were organized to form two single-layer and eight multilayer configurations. Assessments of fabric system properties, such as weight, thickness, and air permeability, followed corresponding ASTM standards. The TPP of the fabric systems was evaluated using an ASTM F2700-compliant tester (Figure 1), incorporating only flame heat sources at intensities of 17.5, 35, and 70 kW/m2, representing low, medium, and high intensities. Additionally, three air-gap values (0, 6, and 12 mm) were introduced to assess the impact of post-exposed air-gap distribution on thermal protection performance. Statistical analyses employing descriptive and inferential methods, such as ANOVA and regression analyses, were applied to reveal potential associations among study parameters.

Figure 1 Thermal Protective Performance Tester

Results and Discussion

Observations from the tests are charted in Figure 2. Data revealed a positive correlation between the protective performance and fabric thickness/ weight, attributable to the entrapped air and the extended heat-transfer path to the skin simulant sensor. Heat-flux exhibited a negative association due to higher per-area heat flow. Positive associations between air-gaps and protection performance were identified owing to the insulative properties of the air layers. However, the positive associations were influenced by the

boundary conditions of stagnant air-gaps. Beyond the 6 mm air-gap, a notable increase in thermal protection performance was not evident, attributed to the shift in heat transfer mode to air convection. Statistical analyses revealed a quadratic relation between TPP and the air-gap. Multiple linear and multivariate curvilinear regression models indicated heat-flux, weight, and air-gap as predominant parameters influencing TPP prediction, with fabric weight showing minor effects.

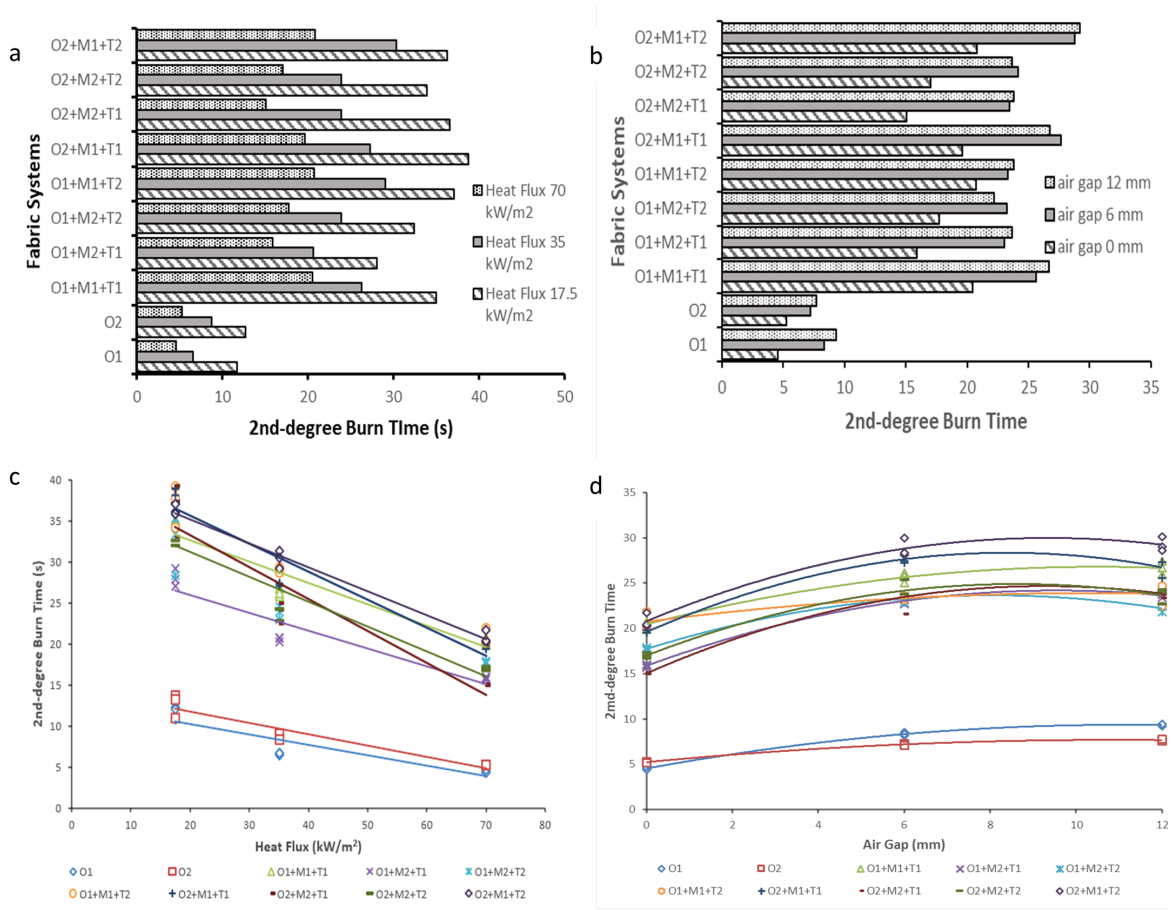

Figure 2 (a) TPP of Different Fabric Systems with No Air-gaps, (b) TPP of Different Fabric Systems with Different Air-Gap Simulations, (c) Effects of Heat-flux on TPP for Different Fabric Arrangements, (d) Effects of Air-Gap.

Conclusion

The study encompassed a broad range of parameters influencing the TPP of clothing. Different fabric arrangements were explored to assess parametric effects under varying flame intensities. This effort aims to enhance predictive TPP modeling for effective material development. Presently, TPP testing is destructive; predictive modeling offers cost-effective estimates for various fabric systems under diverse exposures, informing firefighters about gear limits and potentially preventing burn injuries. Utilizing sensors based on these inferences can act as a safeguard for firefighters.

EVALUATION OF HAPTIC PROPERTIES OF TEXTILE FABRICS BY SYNTOUCH AND CREATION OF AN EXAMPLE BOX

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Presentation time: Tuesday, March 5 at 1:00 pm (MT)/3:00 pm (EST)

Introduction

Tactile perception begins the moment there is physical interaction between the skin and external stimuli. The receptors within the skin can sense mechanical stressors, temperature, and pain, which are sent as electrical signals to the central nervous system and interpreted as part of the sensory system. BioTac SynTouch System is a multimodal tactile sensor, designed to mimic the sensory capabilities of the human finger and evaluate the thermo-haptic properties of a wide range of materials. It can sense the force, temperature, and vibrations generated through interacting with the material, resulting in 15 haptic dimensions related to human touch. The present research explored the thermo-haptic properties of textiles towards the creation of a textile-specific example box for the thermo-haptic dimensions.

Materials and Methods

More than 200 fabric (woven, knitted, multilayered, and nonwoven) samples were collected from Lululemon's internal library and local fabric suppliers. They were selected with varying compositions, manufacturing techniques, coatings, and physical parameters to represent the breadth of fabrics used for numerous applications.

Fabric samples (3×3') were mounted on the magnetic plate of the SynTouch System and tested in the "standard at mid-line" mode, which consists of a series of drag and push maneuvers. Each test generated the numeric values for the 15 dimensions consisting of roughness (macro and micro texture), friction (static and kinetic), adhesion, stiffness (compliance, deformation, damping, relaxation, yielding), and thermal (cooling, persistence) using proprietary scales between 0 (not at all perceivable) to 100 (perceivable).

Results & discussion

In terms of texture, the five texture dimensions describing the roughness, coarseness, texture, and regularity of the fabric surface ranged between 0 and 85. Regarding friction, the sliding resistance and tactile stiction presented a wide span between 16 (slippery) and 100 (resistive), and between 7 (low grip) and 56 (high grip), respectively. The different parameters describing the fabric compliance covered at least one-third of the scale: 0-41 for tactile compliance, 0-67 for yielding, 0-33 for damping, 0-33 for relaxation, and 0-80 for local deformation.

For the last two categories of dimensions, the values given by the more than 200 fabrics tested only covered a narrow range of the perception scale. Values for the adhesive tack ranged between 3 to 9, indicating poor adhesion compared to the different materials intended to be covered by the SynTouch System. In the dry state, for thermal cooling and persistence, all the textiles fell between 3 and 17, and between 0 and 17, respectively. The low thermal conductivity of textile materials is responsible for the low values taken by the thermal dimensions.

Conclusion

The applicability and limits of the Syntouch System for the assessment of the haptic properties of textiles were assessed using 200 fabrics of varying structures, fibre contents, manufacturing techniques, coating, areal densities, and thicknesses. An example box was created using fabrics corresponding to the high, low, and median values of the perception scale for each dimension. The example box will be used to provide anchoring during human testing as well as for education about fabric haptic properties.

CHARACTERIZING OF HEAT TRANSFER PERFORMANCE OF THE CONTAMINATED FLAME-RESISTANT FABRIC: IMPLICATIONS FOR HEALTH AND WELL-BEING OF OIL AND GAS RIG WORKERS

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Presentation time: Tuesday, March 5 at 1:15 pm (MT)/3:15 pm (EST)

Introduction

More than half of the countries of the world are involved in oil and gas production. In this large number of oil and gas fields (OGFs), fire hazard is one of the most common forms of accidents as oil and gas are prone to fire. Skin burns are found one of the most common non-fatal work injuries here. As a result, flame-resistant clothing is a mandatory requirement for this industry's workers. Additionally, this field contains multiple hazardous and flammable oily contaminants such as crude oil and drilling mud. Consequently, the flame-resistant clothing is contaminated with these contaminations which may harm the heat transfer performance of the flame-resistant fabric (FRF). Heat transfer performance (HTP) is a crucial parameter for the FRF to evaluate the protection

performance from heat and flame. Therefore, proper evaluation of the HTP of the oily-contaminated FRF is required to reduce workers' injuries. Hence, the research objective of this research is as below:

• To evaluate and characterize the impacts of contaminations on the HTP of FRF under different fabric parameters, contamination types, and levels.

Materials

Fabrics – Flame-resistant fabrics (Nomex/cotton, Nomex/Kevlar, Kevlar/PBI, FR Cotton) Contaminants – Crude oil and Drilling mud

Methodology

The HTP of FRF has been evaluated and characterized by exposing the fabrics to convective and radiant heat through thermal protective performance testers according to the respective standard. Different quantities of crude oil and drilling mud have been added to the FRF to simulate practical scenarios of worker exposure. The second-degree burn time and peak temperature of the contaminated fabrics during and after the exposure have been collected to understand the HTP. The derived data have been further characterized through the scanning electron microscope (SEM) to understand the contamination's placement in the fabrics. Also, the differential scanning calorimetry (DSC) and cone calorimeter (CC) have been used to understand the heat capacity and heat release rate of the contaminated fabrics respectively to characterize the transmissive and stored heat of the fabric during and after exposure.

Result and Discussion: This study has found a significant level of variation in second-degree burn time and peak temperature, depending on the fabric, type, and level of contamination (Figure 1). The HTP has shown both increases and decreases, which have been characterized and evaluated using findings derived from SEM, CC, and DSC techniques

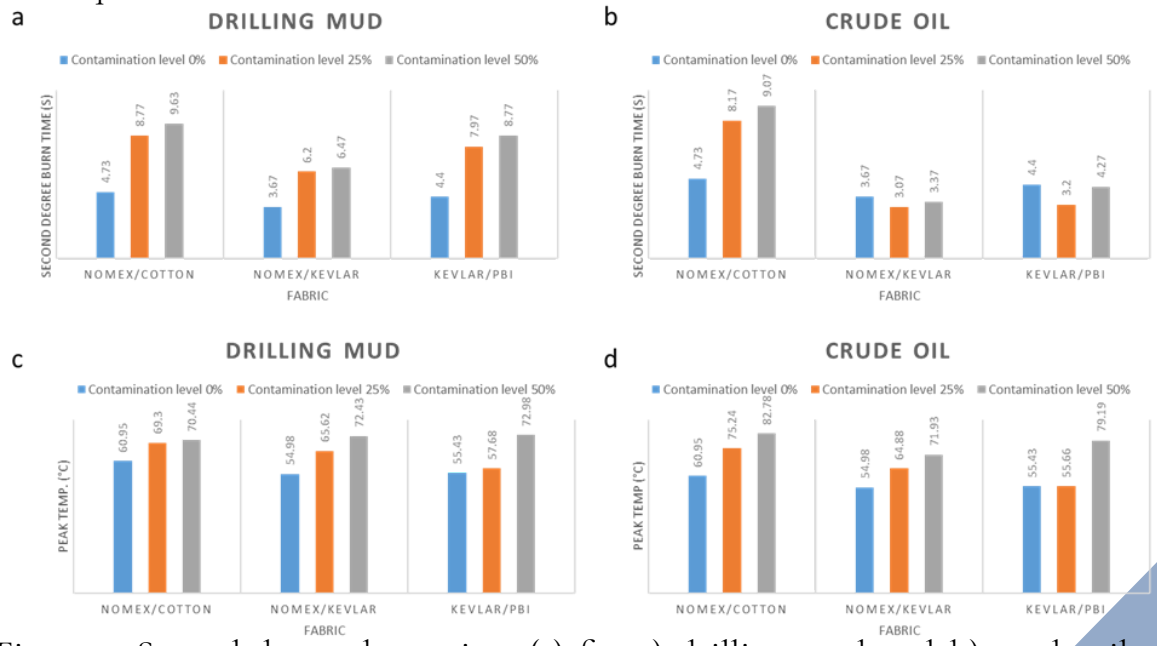

Figure 1: Second-degree burn time (s) for a) drilling mud and b) crude oil, and peak temperature (◦C) for c) drilling mud and d) crude oil-contaminated FRF.

Conclusion

Through the investigation of the impact of oily contaminants on HTP, this study will help to reduce skin burn injuries and fire injuries among the workers of the OGF. In the long run, this study will have a positive impact on the health and well-being of the workers who are working inside the contaminated and hazardous environments, such as the OGF workers.

THERMAL EFFUSIVITY MEASUREMENT OF SPORTWEAR FABRICS IN THE WET STATE: TEST METHOD DEVELOPMENT AND RESULT ANALYSIS

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Presentation time: Wednesday, March 6 at 2:00 pm (MT)/4:00 pm (EST)

Introduction

The study aims to address a critical concern in the sportswear apparel industry related to the thermal touch perception of fabrics, particularly when they are wet. While prior research has assessed wetness perception through wear trials, there exists a significant research gap for the instrumental characterization of the thermal touch perception of fabrics in the wet state. The current study developed a systematic approach to characterize the thermal touch perception of fabrics in terms of thermal effusivity at various water saturation levels. Relationship between the thermal effusivity results obtained for the wet fabrics and the amount of absorbed water, saturation percentage, and physical properties of the fabrics were investigated.

Materials and Methods

A total of 27 sportswear fabrics were used to conduct this study. The structure of these fabrics comprised woven and knit structures. Fiber content included cotton, lyocell (regenerated cellulose), wool, polyester, Coolmax®, elastomultiester polyester, recycled polyester, nylon, X-static®, and elastane fibers. Fabric thickness and mass per unit area varied between 0.083 and 2.19 mm.

Two separate wetting protocols were developed depending on the water saturation percentage. For saturation levels of 25%, 50% and 75%, the fabric specimens were either dipped in water or sprayed with water, and then allowed to dry until they reached the

weight corresponding to the desired level of saturation. The wetting protocol for 100% saturated specimens consisted of seven steps involving repeated fabric dipping, water dripping, and moisture equilibration. The thermal effusivity measurements were conducted using a Modified Transient Plane Source (MTPS) sensor (TCi-3-A, C-Therm Technologies, Canada). The fabric specimens were tested while being secured in the air hoop frame. A 1 kPa contact pressure was maintained between the fabric specimen and the sensor.

Results and Discussion

Results show that the thermal effusivity of fabrics gradually increased with an increase in the water saturation percentage. The rate of increase in thermal effusivity with water saturation was low when the saturation percentage of fabrics was below 75%. On the other hand, the thermal effusivity of fabrics experienced a sharp increase above water saturation of 75%. This shift in behavior was attributed to the formation of a thin layer of water on the fabric surface above 75% saturation. It was also found that the thermal effusivity of fabrics at 100% saturation was related to the amount of water absorbed by the fabric, which was controlled by the fabric thickness. The thermal effusivity of wet fabrics below 75% saturation exhibited a positive correlation with their dry thermal effusivity. Furthermore, for a fixed amount of water added to the fabrics, the thermal effusivity of thin fabrics was found to be greater than that of thick fabrics.

Conclusions

The method developed in this study builds on the ASTM D7984-21 standard test method for the measurement of fabric thermal effusivity in the dry state. It provides a wetting protocol that allows characterizing the thermal effusivity of single layer fabrics in the wet state using the air-hoop frame and a contact pressure of 1 kPa.

INVESTIGATION OF MICROPLASTIC FIBER RELEASE ON HAND-WASHED POLYESTER

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Presentation time: Wednesday, March 6 at 2:15 pm (MT)/4:15 pm (EST)

Introduction

The presence of microplastic fibers (MPF) in our oceanic environments is a major concern requiring the attention of the international community. The spread and potential damage of MPF are increasing due to overconsumption/fast fashion. This investigation focused on textile coatings that can minimize MPF release during the laundering process. This area of research has been undertaken by many labs, but nearly all the laundering is done with the use of a machine. Highlighting the lack of inclusivity in the work being done in material science. Hand-washing was selected because two thirds

of the world does not have access to a laundry machine, and therefore the majority of garment washing is done by hand. Three hand-washing methods were considered. The first method followed a published report from Hanghzou University, while the other two hand-washing techniques were developed based on standard hand-washing practices in East Africa and South Asia. Polyester was the material of focus due to its wide usage, accounting for 60% of the global fiber market and 51% of the fibers in the textile market. Hand-washing was performed using three different levels of water hardness, ensuring an accurate simulation of the conditions of the regions investigated. Moreover, most hand washing is done using the nearest body of water. The hardness of the waters was 0 ppm for deionized water, 130 ± 10 ppm for tap water, and 160 ± 20 ppm for water sourced locally from Lake Ontario. An environmentally friendly polydimethylsiloxane (PDMS) surface coating was applied onto the polyester to minimize the MPF release by reducing inter-fiber friction, based on a previously published technique. The MPFs released were counted with the use of a 55mm diameter nylon mesh filter and Jiusion microscope.

Our investigation indicated that harder water results in a greater release of MPFs per wash regardless of whether that fabric was coated or uncoated. For example, 505 ± 134 MPFs were released per gram of bare polyester hand-washed in deionized water, as compared to 1043 ± 37 MPFs g-1 fabric hand-washed Lake Ontario water, i.e. a 207% increase. When the fabric was treated with the PDMS coating, 165 ± 43, 344 ± 75, and 940 ± 300 MPFs g-1 polyester fabric were released when hand-washed in deionized water, tap water, and Lake Ontario water, respectively. These represent reductions of 92%, 88%, and 77%. Further work will emphasize on the relation between MPF release and water hardness by expanding the range, while investigating different techniques from other regions in the world.

MIND THE GAPS: A COMPREHENSIVE LITERATURE REVIEW OF SURF WETSUITS AND ENSEMBLE ACCESSORIES

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Presentation time: Wednesday, March 6 at 2:30 pm (MT)/4:30 pm (EST)

Introduction

From 2019 to 2020, the core surfing population increased by 34%, leading to an estimated 3.8 million surfers worldwide (Surfonomics, n.d.). Given the growing population and the extreme nature of the sport, it was astounding that there was a lack of textile-based research in surf-specific wetsuit design. Surfing presented a unique challenge for textile innovators, especially those attempting to move away from the harmful chemical processes required to produce neoprene and develop sustainable material alternatives

instead. Surfers were exposed to extreme air and water temperatures, with much of their time spent idle in cold water and wind chill. Also, there was a need for surf wetsuits to have a significant range of motion to paddle effectively and for the flexibility/elasticity of materials to perform once catching a wave. Therefore, this research's purpose was to conduct a comprehensive and systematic literature review of the published literature regarding surf wetsuit design and to acknowledge the gaps for future research.

Methods

The scoping review was built using resources from the Florida State University (FSU) Library System Databases, ResearchGate, and a deep dive into both textiles and sport engineering journals. As of the time of this study, to our knowledge, the only academic institute conducting and publishing surf wetsuit research was California State University San Marcos (CSUSM) in the Surf Research Laboratory.

Results & Discussion

CSUSM has conducted human wear trials in both pool and ocean settings which are the most realistic, however, provide limited opportunity for replication which requires controlled laboratory conditions. This approach alone provides only a limited understanding of the effects of surf wetsuit textile fibers, finishes, and designs on the user. While CSUSM has provided leading research on human physiological performance in various water-based environments while wearing surf wetsuits, there remains a large gap in the literature regarding the thermal comfort and durability of specific wetsuit materials. One methodological tool that has been utilized to assess the thermal comfort of similar sport performance apparel is a sweating thermal manikin such as the one housed in the ThermaNOLE Comfort Lab® at FSU.

Conclusion

The goal of this comprehensive literature review was to create a resource regarding wetsuit material types, performance qualities, previous research, alternative materials, sustainable initiatives, and other innovation in the surf accessory industry (e.g. gloves, boots, helmet/head covering, seaming, zippers, PSI vests, etc.). Ultimately, this work aimed to provide an updated and comprehensive scoping review for future researchers to fill gaps in surf wetsuit research. Future research should continue to explore the properties of neoprene for wetsuit applications and how these properties can be replicated or enhanced in future textile-based design research.

HYDROTHERMAL AGING OF PBO FABRIC – EFFECT OF HYDRO CONDITION AND TEMPERATURE

Rajitha Botheju, Md. Saiful Hoque, and Patricia I. Dolez

Department of Human Ecology, University of Alberta, Canada

Presentation time: Wednesday, March 6 at 2:45 pm (MT)/4:45 pm (EST)

Introduction

The firefighter protective garment is designed to provide the required level of safety to firefighters so that they can perform their duty and come back to safety. Firefighter protective garments are manufactured using high-performance fibers. One of the polymers used to manufacture these fibers is poly(p-phenylene-2,6-benzobisoxazole) (PBO). Even though PBO displays exceptional performance when new, it is as susceptible to aging as other polymers. Hydrothermal aging of PBO has received special attention because the residues of polyphosphoric acid (PPA) that were trapped during the manufacturing process of PBO fibers shown to have a significant impact on their rate of hydrothermal degradation. Hence, PBO fabrics have a higher tendency to degrade under hydrothermal aging conditions.

Materials and Methods

In this study, the effect of different hydrothermal conditions on the residual strength of a 100% PBO fabric (AS regular Zylon, Toyobo) was investigated. Fabric specimens were subjected to two hydro conditions: water immersion and exposure to a 100% relative humidity (RH) atmosphere. The hydrothermal aging treatments were conducted at 21, 60, 80, and 90°C. Aged specimens were collected after 10, 20, 30, 40, and 50 days of aging. Five replicates were produced for each condition. The residual mechanical strength of the revealed specimens was evaluated following the ASTM D 5035 standard test method. The data set was analyzed using IBM SPSS Statistics, version 29.0.1.0 (171).

Results & discussion

This study focused on responding to two research questions. The first question was whether there is any significant impact of the hydro condition (water immersion vs. RH exposure) on the effect of hydrothermal aging on the strength of the PBO fabric. The second question was whether there is any significant impact of the temperature at which the hydrothermal aging is performed. The results showed no significant difference in the force at break of the PBO fabric whether the hydrothermal aging was performed via water immersion or by exposure to a 100% RH atmosphere. The percentage of residual load at the break at 90°C for water immersion and 100% RH were 65% and 57%, respectively. On the other hand, a large effect of the temperature on the reduction in

strength produced by the hydrothermal aging treatment was observed. Surprisingly, thermal aging alone at 90°C was observed to cause a similar decrease in the force at break compared to hydrothermal aging at the same temperature.

Conclusion

The temperature was observed to have a major impact on the effect of hydrothermal aging on the mechanical strength of the PBO fabric. At higher temperatures, the reduction in force at break was higher. There was no significant difference between the two hydro conditions examined in the study. Specimens subjected to 100% RH and water immersion showed a similar behavior. The results obtained shed new light on the hydrothermal aging of PBO fibers in conditions relevant to use in service. They also raise some questions about the behavior of the fiber at low thermal aging conditions that will require further investigation.

The Institute of Textile Science

2024 ITS SYMPOSIUM
ABSTRACTS FOR POSTER PRESENTATIONS

UNDER THE MICROSCOPE: EXPLORING THE USE OF ANTIMICROBIAL TEXTILE FINISHES

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[1]Department of Human Ecology, University of Alberta
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Presentation time: Tuesday, March 5 & Wednesday, March 6 at 10:00 am (MT)
Location: Edmonton

The application of antimicrobial agents has gained popularity in the market due to consumer's attitudes toward hygiene and the increased emphasis on an active lifestyle. For example, antimicrobials have been applied to activewear to help combat odour development. Marketing for antibacterial and odour control clothing can include claims that it does not need to be laundered as frequently as clothing without these specialized treatments. This often translates to claims of the clothing being more sustainable because of the opportunity to reduce water and energy use with less frequent laundering. A range of compounds have been used as antimicrobial agents including triclosan, quaternary ammonium compounds (QACs), metals and metal salts, like silver or copper, zinc pyrithione, and the naturally derived chitosan. As the use of antimicrobial agents in the clothing and textile industry has grown, so have concerns around the potential risks associated with their widespread use. For example, triclosan has been added to the ZDHC Manufacturing Restricted Substances List due to its toxicity and ability to persist in the environment. This review will examine the benefits and drawbacks of adding antibacterial agents to textiles.

DEVELOPMENT OF REGENERATED CELLULOSIC FIBRE FROM HEMP FEEDSTOCK USING AN ECO-FRIENDLY LYOCELL PROCESS FOR SUSTAINABLE TEXTILE MANUFACTURING

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Presentation time: Tuesday, March 5 & Wednesday, March 6 at 10:00 am (MT)
Location: Edmonton

Introduction

This research focuses on developing environmentally friendly regenerated cellulosic fibers using hemp feedstock for sustainable textile manufacturing. With a goal of offering a greener alternative in the textile industry, the study addresses concerns about rising textile consumption by exploring hemp's potential as a sustainable source for cellulosic fibers. The focus is on its minimal environmental impact and suitability for cultivation in Canada. This communication will present the first stage of the study, which involves characterizing different hemp feedstocks to assess the operations needed to make them suitable for the lyocell fiber manufacturing process.

Materials and Methods

Two types of hemp bast fiber samples, one decorticated and the other milled, were analyzed to understand their cellulose composition and evaluate their potential for further processing into regenerated cellulose filament. Moisture content was measured through the Oven Dry test method (ASTM D2654). Ash content was determined following the ASTM E1534 standard test method using a Muffle furnace. Extractives content, including waxes, fats, resins, oils, etc., was determined using the ASTM D1107 standard test method by Soxhlet with a mixture of ethanol and toluene. Metal elemental analysis was carried out using Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES), after microwave digestion. Cellulose, hemicellulose, and lignin levels were determined in both hemp samples by High-Performance Liquid Chromatography (HPLC) following the ASTM E1758 standard test method.

Results

The values measured for the two types of hemp in terms of moisture content were within the targets for dissolving pulp for the lyocell process. On the other hand, the extractives, ash, and metal content were higher than what is recommended for the lyocell process; they can be brought down by chelation as part of the traditional dissolving pulp preparation process to prevent these contaminants from negatively affecting the performance of the fiber produced as well as leading to exothermic runaway reactions of the NMMO (4-methylmorpholine 4-oxide) solvent used in the lyocell process. The cellulose, hemicellulose, and lignin content were within what has been reported in the literature for hemp fibers. The hemicellulose and lignin content can be reduced by washing and bleaching as part of the dissolving pulp preparation process to improve the performance of the regenerated cellulose fiber produced.

Conclusions

In summary, this research explores the production of eco-friendly cellulosic fibers from hemp for sustainable textile manufacturing. Initial findings underscore the potential of hemp feedstocks as environmentally friendly alternatives for the textile industry. These positive findings open the door for further investigation and progress in the next stages of the project, which will involve preparing dissolving pulp from various hemp feedstocks and extruding them to create regenerated cellulose filaments.

PERSONALIZED PROTECTIVE CLOTHING: THE IMPACTS OF ALTERATIONS ON THE SAFETY AND COMFORT OF WOMEN'S FIRE PROTECTIVE CLOTHING

Jemma R. P. Forgie, Patricia I. Dolez

Department of Human Ecology, University of Alberta, Canada

Presentation time: Tuesday, March 5 & Wednesday, March 6 at 10:00 am (MT)
Location: Edmonton

Introduction

Firefighters perform a high-risk job as they encounter thermal, chemical, biological, and physical hazards. To protect these extreme environments, it is critical to wear fire protective clothing (FPC). However, the comfort and protection provided by the FPC depends on adequate fit. For female firefighters, FPC is often poorly fitted, leading to issues with comfort and function. This results in an increased risk of injury for female firefighters compared to male firefighters. To overcome this issue, alterations have been

performed by individuals as a method to improve the fit and function of the turnout gear. However, the impact of these alterations on the overall safety of the turnout gear is unknown. The objective of this project is thus to assess how common alteration techniques performed on FPC impact the safety and comfort of FPC.

Methods

This project will be completed in several phases using a mixed-methods approach. In phase 1, surveys and interviews will be conducted with female firefighters across Alberta to gather information on common fit problems and alterations performed. In phase 2, lab-scale models of identified alterations will be produced using assemblies of the outer shell, moisture barrier, and thermal liner materials. In phase 3, the safety of these material systems will be assessed using relevant textile test methods for physical durability, airgap size, thermal and flame resistance, chemical protection, and resistance to laundering. The comfort of the systems will be assessed using water vapour transmission and evaporative resistance tests, in conjunction with the qualitative data collected during phase 1 of the project. Finally, assessments of the compatibility of this data with computational models in the clothing and textiles field will be used to determine whether a computational model could be suitable in assessing changes in overall garment safety as a result of small-scale alterations.

Conclusion

By understanding how the alterations of FPC can change garment comfort, function, and safety, this project will provide valuable data on how FPC can be improved to serve the needs of female firefighters. This data will provide a cost-effective and efficient alternative to the current custom-fitting process. Although this project focuses on female firefighters, the same methods could be adapted to understand how ill-fitting protective clothing could be improved for a variety of marginalized groups in different fields requiring protective clothing, as it focuses on understanding individualized solutions to systemic issues of garment fit.

MANUFACTURING CELLULOSE PULP FROM COTTON WASTE GARMENTS FOR LYOCELL FIBRE PRODUCTION

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Introduction

This research focuses on recycling used cotton garments to produce regenerated cellulose fibres via the lyocell process. This will not only divert them from landfills but also bring industrial benefits with a local source of regenerated cellulose fibres and environmental sustainability with reduced use of cotton fibres whose cultivation and processing have a large environmental footprint. The primary objective is to develop a comprehensive understanding of the waste cotton characteristics and subsequently manufacture high-quality cellulose pulp as a feedstock for lyocell fibre production. The feasibility of using flame-resistant cotton and blended garments will also be explored.

Methods & Materials

The initial phase involves assessing the suitability of cotton waste for the lyocell process, in particular in terms of the presence of contaminants which would affect the performance of the fibres produced and could catalyze exothermic reactions in n-methylmorpholine-n-oxide (NMMO) used as a solvent in the lyocell process. The properties measured include moisture content (ASTM D2654) and ash content (ASTM E1534). Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) analysis was performed to quantify the metal content in the cotton waste. Soxhlet extraction according to ASTM D1107 provides the ethanol-toluene soluble content, including waxes, fats, resins, oils, as well as tannins. High Performance Liquid Chromatography (HPLC) analysis (ASTM E1758 allows the quantification of carbohydrates, providing the alpha-cellulose, hemicellulose, and lignin content.

Results & Discussion

Characterization was performed on a used, olive-coloured, knitted cotton T-shirt. Moisture content was within the range of what would be desired for dissolving pulp for the lyocell process. Ash content and some metals (e.g. iron, copper, and calcium) in the cotton waste exceeded the levels recommended for dissolving pulp in the lyocell process. The presence of copper was associated with the olive colour of the fabric. These contaminants will be removed as part of the traditional dissolving pulp preparation process, which includes washing, chelation, and bleaching treatments. The results of the measurement of the cellulosic and extractive content are compared with the values reported for similar types of materials in the literature.

Conclusion

The findings reported here are in line with results on similar materials reported in the literature and demonstrate the potential of cotton waste for the sustainable production of regenerated cellulose fibres with the lyocell process. As the next step, cellulose dissolving pulp will be prepared from cotton garment waste. Characterization will be repeated to ensure the proper removal of the contaminants and that the desired cellulose content is maintained. This dissolving pulp will then be turned into lyocell dope

dope using NMMO, from which the lyocell fibre will be extruded. The proposed research aligns with the principles of circular economy, offering a more environmentally friendly alternative to synthetics and viscose fibres. The study's findings will help researchers, industry professionals, and policymakers aiming to promote sustainable practices in textile manufacturing.