ITMC 2019
Conference & Smart Textiles Salon

7th Edition of the International Conference on Intelligent Textiles & Mass Customisation

November 13-15, 2019
Marrakech, Morocco
Palm Plaza Hotel

BOOK OF ABSTRACTS

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7th Edition

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Book of Abstracts

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PREFACE

We are pleased to welcome you to the 7th edition of the International Conference on Intelligent Textiles and Mass Customization-ITMC 2019, which will be held at the historical city of Marrakech (MOROCCO), from the 13th to the 15th of November 2019.

The ITMC 2019 conference is for guests from various industries and disciplines related to the textile industry. Its interdisciplinary approach is the key to maximizing the potential and development of textile materials and tools for various applications. The purpose of the conference is to explore new ideas, effective solutions and collaborative partnerships for business growth by catalyzing the creation of a beneficial synergy between designers, manufacturers, suppliers and end users of all sectors and making full use of this potential. ITMC conference themes are axed on intelligent textiles and mass customization. During the 13th and 14th of November, inspiring speakers from industries, academies, governments and societies will shine the light over new chances and challenges, bringing global statistics and success stories about cutting edge science and technology. The innovation brought to the table of discussion will bloom through cooperation, policy, education and training and rise via an outstanding interaction between speakers and participants, guaranteed through Novel IT tools. On 15th November participants are invited to show their prototypes during the Smart Textiles Salon.

The social program includes a welcome drink on 14th in the evening, guided visits to Marrakech and the conference dinners offering a taste of Moroccan cuisine.

The International Conference on Intelligent Textiles and Mass Customization (ITMC) meets every two years, where the organization rotates among the 5 coordinating countries (Belgium, Canada, France, Japan and Morocco).

On behalf of the Conference organizers, we are honored to welcome all interested business, research institutions and organizations from around the globe to participate in a lively exchange of ideas and experiences featured at the ITMC2019 Conference. We are looking forward to seeing you in Marrakech on the 13th of November 2019!

7th Edition of the International Conference on Intelligent Textiles & Mass Customisation – ITMC 2019
Smart Textiles Salon Vol.7 – STS 2019

13-15 November 2019
Palm Plaza Hotel, Marrakech, Morocco

Scientific Program

Day 0 - Tuesday 12/11/2019

Time	Activity
16:00 - 20:00	Get together party & Registration Palm Plaza Hotel, Marrakech

First day - Wednesday 13/11/2019

Time	Activity
8:30 9:30	Registration
9:30 10:00	Opening ceremony Mr. Mohammed Lahlou, ESITH , Morroco Mrs. Lieva Van Langenhove, University Ghent, Belgium Mr. Vladan Koncar, ENSAIT, France Mr. Jacek Mlynarek, Groupe CTT, Canada Mr. Shigeru Inui & Mr. Shohei Koyama, Shinshu University Japan
Plenary Session - Room A Session chair: Mr. Jacek Mlynarek, Groupe CTT, Canada	
10:00 10:30	Keynote 1 **"E-textiles for medical and industrial applications"** Prof. Vladan Koncar
10:30 11:00	Coffee break + Poster session
11:00 11:30	Keynote 2 **"Complex 3D Woven Textiles : A Sustainable material"** Prof. Bijoya Kumar Behera
11:30 12:00	Keynote 3 **"Hot and Cold 3D Fabric Design"** Mr. Perlinger Eric
12:00 12:30	Projects Session : **Erasmus+ project FOSTEX:** "Fostering innovation in the Jordan and Moroccan textile industry", project number 598347-EPP-1-2018-1-ES-EPPKA2-CBHE-JP Mrs. Mònica Ardanuy **COST Actions:** "CA16227 - Investigation and Mathematical Analysis of Avant-garde Disease Control via Mosquito Nano-Tech-Repellents" Dr. Peyman Ghaffari **Present the BALI Chair** Mr. Pascal Denizart
12:30 14:00	Lunch + Poster session

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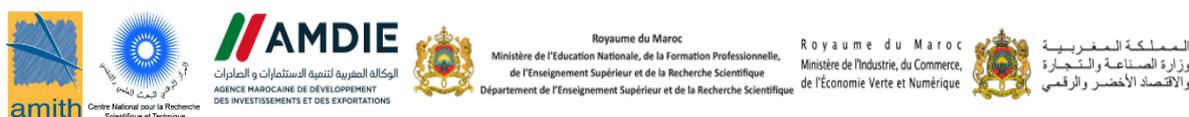
14:00 16:00	Parallel sessions 1			
Session Chairs :	**Intelligent textile 1** **Room A** Mirela Blaga, "Gheorghe Asachi" Technical University of Iasi, Romania Aziz Lallam, ENSISA, France	**Nano technology** **Room B** Francois Boussu, ENSAIT, France Patricia Dolez, University of Alberta, Canada	**Sustainable production / Recycling** **Room C** Ariadna Detrell, AEI TÈXTILS, Spain Cochrane Cedric, ENSAIT, France	**Confort** **Room D** Georgios Priniotakis, Piraeus University of Applied Sciences, Greece Aileni Raluca Maria, Institute for Textiles and Leather, Romania
14:00 14:15	**F44: Use Case of Smart Textiles Bio-Sensors Development and Integration for the Automotive Industry** J. Decaens, O. Vermeersch, D. Lachapelle and P. Forcier CTT Group, Canada	**F28: Synthesis of BaCO3 particles tailored by carboxylated cellulose fibers** A. Jada, S. Ladhari, K. Jradi IS2M-UMR 7361 CNRS - UHA, France Université de Strasbourg, France. University of Quebec at Trois Rivieres, Canada	**F6: Oriented membranes processes for facilitated extraction and recovery of some industrial dyes across polymer inclusion membranes containing Chitin as new extractive agent** Y. Chaouqi, R. Ouchn, M. El Bouchti, O. Cherkaoui, M. Hlaibi Université Hassan II, Morocco REMTEX, ESITH, Morocco	**F21: The effect of moisture on water vapour permeability of men's shirts made of natural fibres and their blends** Lubos Hes, Satyadev Rosunee, Roshan Unmar, Pavel Gebrian Technical University of Liberec, Republic University of Mauritius, Mauritius
14:15 14:30	**F87: Quantification of the silver content of a silver-plated nylon electrode according to the nature of the laundering detergent** Valentin Gaubert, Hayriye Gidik, Nicolas Bodart, Vladan Koncar ENSAIT, France UCLille, HEI - France University of Lille, France Petit Bateau, France	**F35: Polypyrrole coated hematite sand (HS@Ppy) as a new catalyst for degradation of organic dye based on sulfate radicals** Abdellah Ait El Fakir, Zakaria Anfar, Amane Jada, Noureddine El Alem Université Ibn Zohr, Morocco IS2M-UMR 7361 CNRS - UHA, France Université de Strasbourg, Strasbourg, France	**F23: Core-shell particles based on porous carbon@Fe3O4 for efficient removal of dyes from textile effluents** Zakaria Anfar, Abdellah Ait El Fakir, Amane Jada, Noureddine El Alem Ibn Zohr University, Morocco IS2M-UMR 7361 CNRS - UHA, France Université de Strasbourg, France	**F82: A method to reduce the number of sizes in apparel industry** B. Hamad, S. Thomassey and P. Bruniaux ENSAIT, France Univ. Lille Nord de France, France
14:30 14:45	**F8: Novel durable conductive inks & coatings open the door to mass production in smart textiles** Brecht Demedts, Jurgen Mispelon, Daniela Zavec, Milan Baxa, Myriam Vanneste Centexbel, Belgium Titera, Slovenia Vetex, Belgium Applycon, Czech Republic	**F51: A Highly Stretchable Strain Sensor based on Polyolefin Elastomer Nanofiber Membrane** Mufang Li, Kangqi Chang and Dong Wang Wuhan Textile University, China	**F32: A comparative study between tio2 and zno photocatalysis: photocatalytic degradation of textile dye** Meriem Kouhail, Zakia Elahmadi, Abbes Benayada LEC, ESITH, Morocco Mohammed-V University, Morocco	**F99: CALM scale – Assessment of the total comfort of the popular female jeans** Braga. Iara, Abreu. Maria José and Oliveira. Madalena Federal University of Piauí, Brazil University of Minho, Portugal
14:45 15:00	**F144: Effect of the textile substrate in the durability of embroidered textile antennas** Heura Ventura, Laura Gonzalez-Lopez, Monica Ardanuy and Ignacio Gil ESEIAAT - Universitat Politècnica de Catalunya, Spain	**F53: Surface Functionalized PVA-co-PE Nanofibre Membrane for Antibacterial and Bacterial Concentration Detection** Zhentan Lu, Zhenguo Yu and Dong Wang Wuhan Textile University, China. Donghua University, China	**F40: Sustainable wool insulation textile products - an opportunity for entrepreneurial initiatives in Romania** Pyerina C. Ghituleasa, Eftalea Carpus, Angela Dorogan, Cezar Bulacu and Ana Enciu INCDTP, Romania SC MINET SA Company Ramnicu Valcea, Romania ICDCOC Palas Constanta, Romania	**F103 : Comparison and testing of compression stockings for sport activities in the laboratory** Abreu. Maria José, Catarino. André and Enczmann. Franziska University of Minho, Portugal University of Reutlingen, Germany
15:00 15:15	**F45: Design and Development of a piezo-resistive sensor based on**	**F143:The controlled release of silica and phosphates nanoparticles**	**F110: Effect of Through the Thickness Stitching on The Performances of Non**	**F126: Identify the most influential operating parameters affecting**

	PEDOT: PSS applied to Sisal's natural fiber for monitoring of 3D warp Interlock fabric A. Abed, C. Cochrane, F. Boussu, O. Cherkaoui, R. Elmoznine ENSAIT, France REMTEX, ESITH, Morocco Chouaib Doukkali University, Morocco	**coated onto textile by the sol-gel process** Mohamed El Messoudi, Aicha Boukhriss, Omar Cherkaoui, M'hammed El Kouali, Said Gmouh REMTEX, ESITH, Morocco Hassan II University, Morocco	**Woven Textile Wastes at Dry and Composite Scales** Wafa Baccouch, Adel Ghith, Xavier Legrand, Faten Fayala University of Monastir, Tunisia Lille University, France	**stiffness of knitted fabric using fuzzy decision trees** Rania Baghdadi, Hamza Alibi, Faten Fayala, Xianyi Zeng University of Monastir, Tunisia University North Lille of France, France
15:15 15:30	**F129: A new method of measuring the surface roughness of conductive woven fabrics for the integration of organic photovoltaic cells** Hajar Jaouani, Denoun Saifaoui, Mohamed Dalal, Omar Cherkaoui, Dimitra Matsouka, Savvas Vassiliadis University Hassan II, Morocco REMTEX, ESITH, Morocco University of West Attica, Greece	**F150: Microencapsulation for Better Mosquitoes Repellent Efficacy of Cotton Fabrics** A M Grancaric, K Laird, L Botteri, J Shen and K Laatikainen University of Zagreb, Croatia De Montfort University, UK Lappeenranta-Lahti University of Technology LUT, Finland	**F118: Novel water conservation technique and Eco-Dyeing of Wool Fibers using Henna Extract in non-aqueous Medium** Omer Kamal Alebeid Jiping Wang Zhejiang Sci-Tech University, China, University of Engineering Science, China Cleaner Production Institute, Sudan	**F127: Hydrothemal - dewrinkling of textile surfaces** L. Ben Hassine, A. Lallam and D. Ivanov University of Upper Alsace Mulhouse, France
15:30 15:45	**F97: A colorimetric and fluorescent sensor based-azo dye to develop test strip for Cu2+ / CN- detection in aqueous media** S. Fettouche, A. Boukhriss, M. Tahiri, O. Cherkaoui and S.Gmouh REMTEX, ESITH, Morocco, Université Hassan II, Morocco.	**F50: Rheological Properties and Dissolution of cellulose in 3-hexyl-1-methylimidazolium based ionic liquids** Kaoutar Aghmih, Mehdi El Bouchti, Aicha Boukhiss, Mounir El Achaby, Sanaa Majid, Said Gmouh REMTEX, ESITH, Morocco Hassan II University, Morocco Mohamed VI Polytechnic University, Morocco	**F148: Application of natural inorganic adsorbent for removal of cr(vi) ions from textile industry wastewater** Kiril Lisichkov, Hamdije Memedi, Katerina Atkovska, Erhan Mustafa, Stefan Kuvendziev, Flakrim Aliu, Mirko Marinkovski "Ss. Cyriland Methodius" University, Skopje State University of Tetovo, Macedonia	**F128: Using reverse neural networks (ANNi) to predict the structural variables from a fixed value of the crease recovery angle** Hamza Alibi, Rania Baghdadi, Faten Fayala, Abdelmajid Jemni, Xianyi Zeng University of Monastir, Tunisia University North Lille of France, France
15:45 16:00	**F36: Development of a smart piezoelectric textiles by surface modification with coating process based on interfacial interaction on the conformational variationof Poly (vinylidene fluoride) (PVDF) chains.** N. Chakhchaoui, R. Farhan, F. Benkhouya, A. Eddiai, M. Meddad, O. Cherkaoui, Y. Boughaleb, Lieva Van Langenhove Hassan II University, Morocco REMTEX, ESITH, Morocco Mohamed el Bachir el Ibrahimi BBA University, Algeria Ghent University, Belgium	**F54: Application of Fe$_3$O$_4$@polyAcrylate on Cotton fabric by polymer coating** Sara Jamoudi Sbai, Aicha Boukhriss, Mehdi Elbouchti, Omar Cherkaoui ,and Said Gmouh REMTEX, ESITH, Morocco Hassan II University, Morocco	**F41: Mitigation of environmental impact caused by Flame Retardant textile finishing chemicals** Félix-de-Castro, Paula, Boisserée, Nora, De-Vilder, Ine, Detrell, Ariadna, Casamada, Josep LEITAT Technological Center, Spain CENTEXBEL, Belgium. AEI Tèxtils, Spain.	**F151: Comfort-related properties of the seersucker woven fabrics** M. Matusiak Lodz University of Technology, Poland
16:00 16:30	Coffee break			

Second day – Thursday 14/11/2019

Time	Activity
8:30 9:00	Registration
Plenary Session - Room A Session chair: Mr. Vladan Koncar, ENSAIT, France	
9:00 9:30	Keynote 4 **"Digital transformation and open innovation for Railway sector"** Mr. Emmanuel Cox
9:30 10:00	Keynote 5 **"Lithium ion batteries in a fast-changing world"** Mr. Rachid Yazami
10:00 10:30	Keynote 6 **"MASEN Renewable Energy program in Morocco"** Mr. Hicham Bouzekri
10:30 11:00	Coffee break + Poster session
11:00 13:00	**Parallel sessions 2**

	Smart & Functional textiles **Room A** Dominique Adolphe, ENSISA, France Lieva Van Langenhove, Ghent University, Belgium	Supply Chain Management, Logistics and Digital Tools 1 **Room B** Mustapha Hlyal, ESITH, Morocco Elhachemi Nizar, EMI, Morocco	Advanced Manufacturing **Room C** Ana Marija Grancaric, University of Zagreb, Croatia Vladan Koncar, ENSAIT, France	Education & Learning **Room D** Amane Jada, IS2M, France Savvas G. Vassiliadis, Piraeus University of Applied Sciences, Greece
Session Chairs :				
11:00 11:15	**F16: Development of Super-Hydrophobic and Stain Repellent Fabric Finish** Dr. Subhas Ghosh, Roopkatha Pallye Eastern Michigan University, USA	**F4: Use of multicriteria decision analysis methods for the selection of the subcontractors in an apparel supply chain** Mourad Lahdhiri, Mohamed Jmali And Amel Babay University of Monastir, Tunisia	**F7: Verification of fiber diameter and pretreatment method for high signal-to-noise ratio THz spectrum measurement** S. Koyama, R. Tamura and Toru Kurabayashi Shinshu University, Japan Akita University, Japan	**F38: Applications of Smart Textiles in Occupational Health and Safety** Patricia I. Dolez, Justine Decaens, Thibaut Buns, Dominic Lachapelle and Olivier Vermeersch University of Alberta, Canada CTT Group, Canada
11:15 11:30	**F115: Improvement of enzymatic antifelting treatment of Wool Fiber and its effect on the dyeing with juglon of common walnut plant** Younes Chemchame, Hajar Benzbir, Amina Kachachi, El Bouchti Mehdi, and Aboubakr Kharchafi Foundation of Hassan II Mosque, Morocco. REMTEX, ESITH, Morocco	**F9: Study on Classification of Habitat for Cashmere Fiber by Infrared Spectroscopy** First Y. Ikeda, Second S. Koyama, Third H. Ishizawa Shinshu University, Japan.	**F22: Influent product and process parameters on the mechanical behaviour of 3D warp interlock fabrics made with E-glass yarns** A. Kececi, F. Boussu, D. Soulat ENSAIT, France	**F86 : Collection of requirements for teaching in the area of Smart Textiles** Prof. Manuela Bräuning Albstadt - Sigmaringen University, Germany
11:30 11:45	**F80: Smart nanofibrous membrane as chemiluminescence biosensor for hydrogen peroxide determination** Wenwen Wang Wuhan Textile University, China	**F10: Ant colony optimization for the assembly line balancing based on workers' performance** Z. Chourabi, F. Khedher and A. Babay University of Monastir, Tunisia	**F57: Ultrasound Welding Device for Reinforcement of the Invazive Textile Mesh Destined to the Reconstruction of the Thoracic Wall** A.G. Ene, C.Mihai and C.Jipa The Research-Development National Institute for Textile and Leather, Romania	**F130: Application of Make/Use Platform for Sustainable Fashion Design** Anda Ščerbaka Riga Technical university, Latvia
11:45 12:00	**F105: Non-formaldehyde Wrinkle**	**F17: Hybridization of Game Theory and ridesharing to Optimize**	**F58: Innovative Solutions for Increasing the Performance of the**	**F139: A project to improve awareness for**

	Recovery Finish for Cotton and Linen Preeti Arya, Subhas Ghosh Fashion Institute of Technology, USA Eastern Michigan University, USA	**reverse Logistics of healthcare Textiles** Mustapha Ahlaqqach, Jamal Benhra, Salma Mouatassim And Safia Lamrani HASSANII University, Morocco CELOG-ESITH, Morocco	**Cutting Equipment for Textile Subassembly having Variable Geometry** C. Mihai, A.G. Ene and C.Jipa Institute for Textile and Leather, Romania	**cyber security in smart textile applications** Prof. Manuela Bräuning, Tobias Scheible Albstadt-Sigmaringen University, Germany
12:00 12:15	**F112: Knitted Cotton Fabric Strain Sensor by In-situ Polymerization of Pyrrole** G.B.Tseghai, B.Malengier, D.A.Mengistie, K.A.Fante and L.Van Langenhove Ghent University, Belgium Bahir Dar University, Ethiopia Jimma University, Ethiopia	**F67: Theoretical model of green supply chain management** S.Elhidaoui, K.Benhida Université Cadi Ayyad, Morocco	**F77: The investigation of crimp and spinfinish effects on the processing behavior of polyaramide fibers during spinning process** I. Boughamoura, A. Sinoimeri and O. Harzllah Université de Haute-Alsace, France Université de Strasbourg, France	**F30: CONTEXT, a European Network to connect research and innovation efforts on advanced Smart Textiles** Dr. Ariadna Detrell AEI TÈXTILS, Spain
12:15 12:30	**F158: Research regarding electromagnetic shielding achieved by the fabrics support** L Surdu, R M Aileni, R I Radulescu, L Chiriac Institute for Textiles and Leather, Romania	**F69: Integration of Lean management for the growth of Green industry** Kaoutar Jbira, Mustapha Hlyal, Jamila El Alami University Med V, Morocco ESITH, Morocco	**F167: Mathematical and numerical modeling of soiling effects of photovoltaic solar panels on their electrical performance** Marwane Rouway, Zoubair Boulahia and Mourad Nachtane Hassan II University, Morocco ENSTA Bretagne, France REMTEX, ESITH, Morocco	**F145: Review of literature on existing models about the impact of Continuous Training on business performance** Asmaâ Moussaid, Mohamed Tkiouat And Mustapha Hlyal ESITH, CELOG, Morocco EMI, Morocco
12:30 12:45	**F81:The development of a printed, stretchable multi-sensory array for the simultaneous and accurate sensing of differential temperature and strain** Manoj Jose and Wim Deferme Universiteit Hasselt, Belgium IMEC vzw - Division IMO-IMOMEC, Belgium	**F14: Synthesis and application of azo dye on cotton fabric via sol-gel** T Aaboub, A Boukhriss, O Cherkaoui, and S Gmouh REMTEX, ESITH, Morocco. Hassan II University, Morocco.		**F165: Erasmus+ Projects for e-Learning in Engineering Education** M. Blaga, Z Stjepanovič, I R Radulescu, B Malengier, A Dias, P Dufkova Gheorghe Asachi, Technical University, Romania University of Maribor, Slovenia INCDTP, Romania University of Ghent, Belgium University of Minho, Portugal Textile Testing Institute, Czech Republic
12:45 13:00	**F42: Introduction of biochar for the manufacture of flax conductive fabrics** L. Marrot, N. Vellguth, J. Winkelmann, M. Wolf, and D.B. DeVallance Renewable Composites Materials, InnoRenew CoE, Slovenia Wilhelm-Klauditz Institut WKI, Germany			**F62: Adapted sportswear for comfort improvement of elite rowers** S. Vasile, J. Cools and A. De Raeve University College Ghent, Belgium
13:00 14:00	Lunch + Poster session			

14:00 16:00	Parallel sessions 3			
Session Chairs :	**Intelligent textile 2** **Room A** Vincent Nierstrasz, University of Borås, Sweden Bijoya Kumar BEHERA, Indian Institute of Technology, India	**Technical textile** **Room B** Sheilla Atieno Odhiambo, Gent University, Belgium Toshihiro Hirai Shinshu University, Japan	**Mass Customization** **Room C** Vladan Koncar, ENSAIT, France Omar Cherkaoui, ESITH, Morocco	**Supply Chain Management, Logistics and Digital tools2** **Room D** El Hassan Laaziz, ESITH, Morocco Nizar ELHACHEMI, EMI, Morocco
14:00 14:15	**F26: Fiber sensors as the cutting edge material for smart textile –Miniaturization of interrogator and elucidation of blood pressure measurement principle-** S. Koyama and H. Ishizawa Shinshu University, Japan	**F141: Development of 3D warp interlock fabrics based on Moroccan Natural Fibers** Z. Samouh, O. Cherkaoui , D. Soulat, F. Boussu and R. El Moznine Chouaib Doukkali University, Morocco REMTEX, ESITH, Morocco Univ. Lille, France	**F1: Dart creation method in a virtual draping system** Shigeru Inui and Yosuke Horiba Shinshu university, Japan	**F78: Optimization of occupational risks based on multi-criteria decision support methods: case of the textile industry** A. Waguaf, R. Benabbou And J. Benhra ENSEM, MOROCCO
14:15 14:30	**F39: 100% PVDF 3D textiles structures to improve energy harvesting** A. Talbourdet, C. Cochrane, F. Rault, G. Lemort, C. Campagne, and E. Devaux ENSAIT, France	**F74: Sand concrete based on synthetic fiber (polypropylene) for the building sector** H.Suiffi, A.El Maliki, O.Cherkaoui, M.Dalal ENSEM, Morocco REMTEX, ESITH, Morocco	**F33: Value added creation with advanced mass-customized textile labels** M. Barteld, R. Gebhardt, F. Siegel, U. Portsch STFI - Saxon Textile Research Institute, Germany Qualitype GmbH, Germany	**F98: Sustainable Transport in the supply chain using Dijkstra algorithm** Mourad Lahdhiri, Mohamed Jmali And Amel Babay University of Monastir, Tunisia
14:30 14:45	**F63: Development of E-textile electrodes: washability and mechanical stresses** Shahood Uz Zaman , Xuyuan Tao, Cédric Cochrane And Vladan Koncar University of Lille, France ENSAIT, France	**F3: Multifunctional polyester textile coated organophilic graphene nanosheets : synthesis , characterization & application** G.Achagri, Y.essamlali, A.Chakir, M.Zahouily University Hassan II, Casablanca, Morocco MAScIR Foundation, Morocco	**F94: The predictive development of the electroconductive textile using artificial neural network** R. M. Aileni and L. Chiriac Institute for Textiles and Leather, Romania	**F108: A Neural Network based DEA approach for terminal container port: Moroccan Case Study** Mouhsene Fri, Kaoutar Douaioui, Samir Tetouani, Charif Mabrouki and Semma El Alami Hassan 1st University, Morocco CELOG-ESITH, Morocco Mohammed V University, Morocco
14:45 15:00	**F79: Analysis of the power transfer and electrical performances of an embroidered textile loop antenna for near field communication (NFC) applications** Baptiste Garnier, Cédric Cochrane, François Rault, Vladan Koncar, François Dassonville, Philippe Mariage, Savvas Vassiliadis, Nikos Stathopoulos, Stelios Mitilineos ENSAIT, France Univ. Lille, France University of West Attica, Greece	**F168: A facile route for the preparation of hydrophobic and antibacterial pet fabrics using ag-loaded graphene nanocomposite** Boubker Ouadil, Othmane Amadine, Younes Essamlali, Omar Cherkaoui, Mohamed Zahouily REMTEX, ESITH, Morocco. Université Hassan II, Morocco. MAScIR Foundation, VARENA Center, Morocco	**F93: Contribution to the supply chain optimization by predicting demand using neural networks** Abdeslam Mozher, Rajaa Benabbou, Jamal Benhra ENSEM, Morocco	**F119: Empirical assessment of critical success factor of lean and six sigma in the Moroccan context** Raja Elboq, Mustapha Hlyal, Jamila El Alami Mohammed V University, Morocco CELOG, ESITH, Morocco
15:00 15:15	**F113: Preparation and Applications of Fiber Based Moisture Sensitive**	**F48: Mechanical and thermal property evaluation of nonwovens made palm fiber**	**F49: Valorisation of waste feathers: treatments and characterization**	**F121: Physical Internet: success factors by analogy**

	Actuator for energy harvesting and smart controller Wen Wang, Chenxue Xiang and Dong Wang Donghua University, China Wuhan Textile University, China	**reinforced polyester composites** O. Azmami, L. Sajid, S. Gmouh LEC, ESITH, Morocco. Hassan II University of Casablanca, Morocco. Mohammad V University, Morocco	Ouahiba Mrajji, Mohamed El Wazna, Abdeslam El Bouari, Omar Cherkaoui University Hassan II Casablanca, Morocco. REMTEX, ESITH, Morocco	K. Jharni, M. Hlyal and Third J. El Alami Mohammed V University, Morocco CELOG, ESITH; Morocco LASTIMI, High Schcool of Technnology, Morocco
15:15 15:30	**F122: New Textile-Based Hybrid Photovoltaic / Thermal (PV/T) System** Barbara Pause Textile Testing & Innovation, LLC, USA	**F120: Chemical Composition and Mechanical Properties of phosphate Glass Fibers based on naturel phosphate and kaolin clay** O. Jamal Eddine, M. El Bouchti, A. Boukhriss, H. Wakrim, O. Cherkaoui, H. Hannache, And S. Gmouh University Hassan II, Morocco REMTEX, ESITH, Morocco University Mohamed VI Polytechnic, Morocco	**F125: Mass personalization, a key driver for the textile industry 4.0** Pascal Denizart CEO CETI, France	**F147: Sustainable Supply Chain Management: Review of Triggers, Challenges and Conceptual Framework** D. Saidi, J. El Alami And M. Hlyal University Med V, Morocco CELOG, ESITH, Morocco
15:30 15:45	**F131: Investigating the Effect of Air Permeability and Moisture on 2.45GHz Textile Microstrip Antenna Performance** A. Wahab Memon, Patrick Van Torre, B. Malengier and L. Van Langenhove Ghent University, Belgium Mehran University of Engineering & Technology, Pakistan	**F34: Development of nonwoven textile materials based on raw palm fiber** L. Sajid, O. Azmami, Z. Elahmadi, A. Benayada, S. Gmouh LEC, ESITH, Morocco Mohammad V University, Morocco Hassan II University of Casablanca Morocco	**F75: Study of Evaporation Coefficient during Capillary Rise** Sofien Benltoufa, Malika Dimassi, Amal Boughatts Faten Fayala University of Monastir, Tunisia	**F155: Exponential Success through Integrated Supply Chain Optimization, Ecomotional Intelligence and Reputation-based Leadership: Zara Model** N. Berbiche, J. El Alami and M. Hlyal Med V University, Morocco CELOG, ESITH, Morocco
15:45 16:00	**F117: Soft Graphene-Based Antennas for Ultrawideband Wireless Communication** Elif Ozden-Yenigun, Isidoro I. Labiano, Muhammed S. Ergoktas, Anne Toomey, Coskun Kocabas, and Akram Alomainy School of Design, Textiles, Royal College of Art, United Kingdom Queen Mary University of London, UK Materials Engineering University of Manchester, United Kingdom	**F70: Effect of water immersion, laundering, and abrasion on the conductivity of a reduced graphene oxide coating on a meta-aramid fabric** Chungyeon Cho, Anastasia L. Elias, Jane Batcheller, Hyun-Joong Chung and Patricia I. Dolez University of Alberta, Canada University of Alberta, Canada		**F146: The esterification and dyeing properties of raw wool fibers** Fatine Akoh, El Bouchti Mehdi, Omar Cherkaoui, and Mohamed Tahiri Hassan II University, Morocco Remtex, ESITH, Morocco
16:00 16:30	Coffee break			

16:30 18:00	Parallel sessions 4		
Session Chairs :	**Intelligent textile 3** **Room A** Ana Marija Grancaric, University of Zagreb, Croatia Shohei Koyama, Shinshu University Japan	**Technical textile / Nano technology** **Room B** Fernando Batista Nunes Ferreira, University of Minho, Portugal Omar CHERKAOUI, ESITH, Morocco	**Supply Chain Management, Logistics and Digital tools2 / Sustainable production / Recycling** **Room C** Amel Babay, University of Monastir, Tunisia Shigeru Inui, Shinshu University, Japan
16:30 16:45	**F11: Functional Shoe for the Detection of Walking Pattern Anomalies** G.B. Tseghai, B. Malengier, D.A. Mengistie and L. Van Langenhove Ghent University, Belgium Bahir Dar University, Ethiopia Linköping University, Sweden	**F19: Functionalization of textile fabric by the sol gel method using ionic liquids: potential application for oil- water separation.** Aziz Bentis, Aicha Boukhriss, Omar Cherkaoui, Mohamed Zahouily, Bouchaib Manoun, and Said Gmouh Université Hassan II, Morocco. REMTEX, ESITH, Morocco. Université Hassan 1er, Morocco	**F20: HAP functionalization of textile fabrics by coating process** A.Bouasria, A.Boukhriss, S.Saouabi, S.Gmouh, O.Cherkaoui, H.Hannache Hassan II University, Morocco REMTEX, ESITH, Morocco Mohammed V University, Morocco
16:45 17:00	**F157: Dynamic Colour in Textiles: Combination of Thermo, Photo and Hydrochromic Pigments** I. Cabral, A. P. Souto University of Minho, Portugal	**F25: Cobalt Nanoparticles/Cellulose Nanofibers Aerogel Composites: Highly Active and Green Catalyst for Reduction of 4-Nitrophenol in Water** Nouaamane EL Idrissi, Aicha EL Mouden, Hamid Kaddami, Larbi Belachemi Cadi Ayyad University Marrakech, Morocco.	**F169: AI based forecasting in fast fashion industry: a review** El Hassan Laaziz ESITH
17:00 17:15	**F5: Smart Vest to Monitor Continuously Musculoskeletal Disorders** Samir Tetouani; Nora Abia; Omar Cherkaoui REMTEX, ESITH, Morocco	**F133: Influence of gradient of diameter on mass transfer in case of electrospun nano-patches** Tatiana Blazevic, Joséphine Delerue, Ali Akbar Gharehaghaji, Dominique C. Adolphe, Emilie Drean, Laurence Schacher University of Haute-Alsace, France Amirkabir University of Technology, Iran	**F37: Preparation and characterization of a new low-cost polyacrylonitrile adsorbent** Hayat Bouchoum, Mehdi El Bouchti, Amane Jada, Mohamed Tahiri and Omar Cherkaoui REMTEX, ESITH, Morocco. Hassan II University, Morocco Univ Haute Alsace, France Univ Strasbourg, France
17:15 17:30	**F88: Enhanced Piezoelectric Properties of PVdF-HFP/PZT Composites Due to High β-Phase formation in Poly (vinylidene fluoride-co-hexafluoropropylene)** K. Oumghar, N. Chakhchaoui, R. Farhan, A. Eddiai, M. Meddad, O. Cherkaoui, Y. Boughaleb, Lieva Van Langenhove REMTEX, ESITH, Morocco Hassan II University, Morocco Mohamed el Bachir el Ibrahimi BBA University, Algeria Ghent University, Belgium	**F100 : Thermal performance and optimum textile insulation thickness of building walls for energy saving** Mohamed EL Wazna, Ayoub Gounni, Mrajji Ouahiba, Abdeslam EL Bouari, Mustapha EL Alami and Omar Cherkaoui Hassan II University, Morocco REMTEX, ESITH, Morocco	**F31: Valorization of Moroccan Natural Phosphate on the Production of Phosphate Glass Fibers** N.Saloumi, M.El Bouchti, O.Cherkaoui, H.Hannache REMTEX, ESITH, Morocco Hassan II University, Morocco Mohamed VI Polytechnic University, Morocco
17:30 17:45			**F18: Identification of natural indigo precursors by HPLC to confirm natural dyeing** Yosra Raji, Omar Cherkaoui, Souad Zyade REMTEX – ESITH, Morocco Hassan II Casablanca University, Morocco
20:00 23:00	**Gala dinner**		

Third day – Friday 15/11/2019 - Smart Textiles Salon 2019

Time	Activity		
8:30 9:00	Registration		
Plenary Session - Room A Session chair: Mrs. Lieva Van LANGENHOVE			
9:00 9:30	Keynote 7 **"Toward the smart fiber & textile"** Pr. Toshihiro Hirai		
9:30 10:00	Keynote 8 **"Developments in the Belgian Textile Industry"** Mr. Kris Van Peteghem		
10:00 10:30	Keynote 9 **"Smart textiles: technological review and future perspectives"** Prof. Dr. Savvas G. Vassiliadis		
10:30 11:00	Coffee break + Poster session		
11:00 12:30	Prototype oral presentations session		
11:00 11:05	**"Textile-based Strain Sensor to Determine Edema Status"** Granch Berhe Tseghai	11:45 11:50	**"Smart Vest to Monitor Continuously Musculoskeletal Disorders"** Samir Tetouani
11:05 11:10	**"DAid® Pressure Socks System"** Peteris Eizentals	11:50 11:55	**"Heated soft shell jacket with smart embroidery"** Justine Decaens
11:10 11:15	**"Graphene based soft antennas"** Elif Ozden-Yenigun	11:55 12:00	**"Modularity Ichthys"** Galina Mihaleva
11:15 11:20	**"NFC Textile wireless energy and data transfer device"** Baptiste Garnier	12:00 12:05	**"Design of a conductive fabric network using simple coating method"** Boubker Ouadil
11:20 11:25	**"Smart luminous products designed to reduce risks on the way to educational institutions"** Manuela Bräuning	12:05 12:10	**"New smart piezoelectric textiles for ambient mechanical energy harvesting application"** Nabil Chakhchaoui
11:25 11:30	**"Alarmgrid"** Marco Barteld	12:10 12:15	**"Smart Geolocation Textile"** Hajar Jaouani
11:30 11:35	**"Vest for women's"** Mourid Fatima	12:15 12:20	**"Piezoresistive sensor based on natural fiber (Sisal) for monitoring a reinforcement fibrous (UD or 3D fabrics) for composite applications"** Ahmed Abed
11:35 11:40	**"Heating mould with conductive nonwoven for composite applications"** Yohan Gendreau	12:20 12:25	**"Smart Solar Textiles SSOLTEX Of Nanotechnology for Generate Power of Students Hostile at Kafrelsheikh University"** Elsayed Ahmed Elnashar
11:40 11:45	**"Electrokinetic drainage geocomposite for mine tailings dewatering"** Patricia I. Dolez	12:25 12:30	**"Invisible fluorescent ink for textile printing via the sol-gel process"** Aicha Boukhriss
12:30 13:30	Lunch		
13:30 15:00	Prototypes interactive exhibition session		
15:00 15:30	Closing ceremony ITMC2019 ITMC Conference and Smart Textile Salon Awards - Best Oral presentation award - Best Poster presentation award - Best Prototype award		
16:00 18:30	**Visit to the Majorelle Garden**		

Lis of Posters ITMC'2019

	List of Posters ITMC'2019
1	**F66: Influence of Textile Laminates Structure and Properties on Work Shoes Comfortability** A. Gulbiniene, V. Jankauskaite, K. Ancutiene Kaunas University of Technology, Lithuania
2	**F89: Interactive Textile Vestimentary Systems for Wellbeing** Eftalea Cărpuș, Angela Dorogan, Ioana Doretty Cărpuș National R&D Institute for Textile and Leather, (Romania) University, Medicine Faculty (Romania)
3	**F90: The color fastness properties of conductive leather improved by the use of mordants** M. Hylli, A. Shabani, I. Kazani, S.Drushku, G. Guxho PolytechnicUniversity of Tirana, Albania.
4	**F136: Needleless Electrospinning of PAN/SBA-15 for the preparation of Nanofibers Membranes** M. Hassan Rafe, Christelle Delaite, Benedicte Lebeau, Magali Bonne, Elham Mohsenzadeh, Dominique Adolphe Université de Haute Alsace, France Université de Haute Alsace (UHA), France UCL, France
5	**F24: Properties of Moroccan Natural Fiber Reinforced PLA Composites** Z.Samouh, K.Molnar ,O.Cherkaoui and R.El Moznine Chouaib Doukkali University, Morocco REMTEX, ESITH, Morocco Budapest University of Technology and Economics, Hungary MTA–BME Research Group for Composite Science and Technology, Hungary
6	**F149: Wastewater Treatment using Flocculation Method and Water Re-use for Dyeing of Polyester Fibres** Forte Tavčer Petra University of Ljubljana, Slovenia
7	**F161: Physical-mechanical properties of thermal protective fabric subjected to textile care** I Schwarz, S Brnada, A Kiš, S Kovačević University of Zagreb, Faculty of Textile Technology, Department of textile design and management, Prilaz baruna Filipovica 28a, 10000 Zagreb, Croatia Čateks d.d., Quality Control Department, Zrinsko-Frankopanska 25, 40000 Čakovec, Croatia
8	**F104: The new era in Retail: Retail 4.0 centered on the human being and its purchase process** Abreu. Maria José, Fernandes, Andreia Raquel University of Minho, Portugal
9	**F109: The effect of material fusing upon 3D Simulation of garments** E. Strazdiene, K. Lekeckas and V. Bytautaite Vilnius University of Applied Science, Lithuania Kaunas University of Technology, Lithuania
10	**F65: Development of a new polymeric electrolyte for lithium ion battery** Kaoutar Aghmih, Sanaa Majid, Said Gmouh, Aicha Boukhriss , Omar Cherkaoui REMTEX, ESITH, Morocco Hassan II University, Morocco
11	**F68: Preparation and characterization of aerogel/cellulose nanocrystal composite as building thermal insulation material** Mohamed El Wazna, Soumia Boukind, Said Sair, Omar Cherkaoui, Abdeslam El Bouari University Hassan II of Casablanca, Morocco. REMTEX, ESITH, Morocco
12	**F154: Extraction of essential oils with mothproof properties for the treatment of wool** Aicha Hamrani, Omar Cherkaoui REMTEX, ESITH, Morocco.
13	**F156: Textile material for the design of wearable microstrip patch antenna** El Batal Khadija, Eddiai Adil, Meddad Mounir, Cherkaoui Omar And Mazroui M'hammed Hassan II University, Morocco. University of Bordj Bou Arreridj, Algeria. REMTEX, ESITH, Morocco
14	**F166: Thermo physical characterization of sustainable insulation materials made from poultry waste** Ouahiba Mrajji, Mohamed El Wazna, Omar Cherkaoui, Abdeslam El Bouari University Hassan II, Morocco REMTEX, ESITH, Casablanca Morocco
15	**F83: Try before you buy: How augmented reality is inspiring online shoppers** A. Ayouzi , R.Aouaal ESITH, Morocco Hassan 1st university, Morocco
16	**F43: Comfort Evaluation of Close-Fitting Clothing using Virtual Try-on Technology** K. Ancutienė Kaunas University of Technology, Lithuania
17	**F96: Cellulose Aerogels: Synthesis, Characterization and Applications** Ayoub Imgirne, Said Sair, Mohamed El Wazna, Omar Cherkaoui, Abdeslam El Bouari

	University Hassan II of Casablanca, Morocco. REMTEX, ESITH, Morocco
18	**F25: Cobalt Nanoparticles/Cellulose Nanofibers Aerogel Composites: Highly Active and Green Catalyst for Reduction of 4-Nitrophenol in Water** Nouaamane EL Idrissi, Aicha EL Mouden, Hamid Kaddami, Larbi Belachemi Cadi Ayyad University Marrakech, Morocco
19	**F130: Application of Make/Use Platform for Sustainable Fashion Design** Anda Ščerbaka Riga Technical university, Latvia
20	**F159: Thermal resistance of double jersey fabric knitted by different yarn raw material** D Kopitar, Z Pavlovic, Z Skenderi and Z Vrljicak University of Zagreb, Croatia
21	**F14: Synthesis and application of azo dye on cotton fabric via sol-gel** T Aaboub, A Boukhriss, O Cherkaoui, and S Gmouh REMTEX, ESITH, Morocco Hassan II University, Morocco
22	**F19: Functionalization of textile fabric by the sol gel method using ionic liquids: potential application for oil-water separation.** Aziz Bentis, Aicha Boukhriss, Omar Cherkaoui, Mohamed Zahouily, Bouchaib Manoun, and Said Gmouh Université Hassan II, Morocco REMTEX, ESITH, Morocco Université Hassan 1er, Morocco.
23	**F78: Optimization of occupational risks based on multi-criteria decision support methods: case of the textile industry** A. Waguaf, R. Benabbou And J. Benhra ENSEM, MOROCCO
24	**F79: Analysis of the power transfer and electrical performances of an embroidered textile loop antenna for near field communication (NFC) applications** Baptiste Garnier, Cédric Cochrane, François Rault, Vladan Koncar, François Dassonville, Philippe Mariage, Savvas Vassiliadis, Nikos Stathopoulos, Stelios Mitilineos ENSAIT, France Univ. Lille, France University of West Attica, Greece
25	**F86: Collection of requirements for teaching in the area of Smart Textiles** Prof. Manuela Bräuning Albstadt - Sigmaringen University, Germany
26	**F131: Investigating the Effect of Air Permeability and Moisture on 2.45GHz Textile Microstrip Antenna Performance** A. Wahab Memon, Patrick Van Torre, B. Malengier and L. Van Langenhove Ghent University, Belgium Mehran University of Engineering & Technology, Pakistan
27	**F143: The controlled release of silica and phosphates nanoparticles coated onto textile by the sol-gel process** Mohamed El Messoudi, Aicha Boukhriss, Omar Cherkaoui, M'hammed El Kouali, Said Gmouh REMTEX, ESITH, Morocco Hassan II University, Morocco
28	**F144: Effect of the textile substrate in the durability of embroidered textile antennas** Heura Ventura, Laura Gonzalez-Lopez, Monica Ardanuy and Ignacio Gil ESEIAAT - Universitat Politècnica de Catalunya, Spain
29	**F6: Oriented membranes processes for facilitated extraction and recovery of some industrial dyes across polymer inclusion membranes containing Chitin as new extractive agent** Y. Chaouqi, R. Ouchn, M. El Bouchti, O. Cherkaoui, M. Hlaibi Université Hassan II, Morocco REMTEX, ESITH, Morocco
30	**F129: A new method of measuring the surface roughness of conductive woven fabrics for the integration of organic photovoltaic cells** Hajar Jaouani, Denoun Saifaoui, Mohamed Dalal, Omar Cherkaoui, Dimitra Matsouka, Savvas Vassiliadis University Hassan II, ,Morocco REMTEX, ESITH, Morocco University of West Attica, Greece
31	**F18: Identification of natural indigo precursors by HPLC to confirm natural dyeing** Yosra Raji, Omar Cherkaoui, Souad Zyade REMTEX – ESITH, Morocco Hassan II Casablanca University, Morocco
32	**F88: Enhanced Piezoelectric Properties of PVdF-HFP/PZT Composites Due to High β-Phase formation in Poly (vinylidene fluoride-co-hexafluoropropylene)** K. Oumghar, N. Chakhchaoui, R. Farhan, A. Eddiai, M. Meddad, O. Cherkaoui, Y. Boughaleb, Lieva Van Langenhove REMTEX, ESITH, Morocco Hassan II University, Morocco LAS Laboratory of Setif, Mohamed el Bachir el Ibrahimi BBA University, Algeria Ghent University, Belgium
33	**F37: Preparation and characterization of a new low-cost polyacrylonitrile adsorbent** Hayat Bouchoum, Mehdi El Bouchti, Amane Jada, Mohamed Tahiri and Omar Cherkaoui

	REMTEX, ESITH, Morocco. Hassan II University, Morocco Univ Haute Alsace, France Univ Strasbourg, France
34	**F167: Mathematical and numerical modeling of soiling effects of photovoltaic solar panels on their electrical performance** Marwane Rouway, Zoubair Boulahia and Mourad Nachtane Hassan II University, Morocco ENSTA Bretagne, France REMTEX, ESITH, Morocco
35	**F145: Review of literature on existing models about the impact of Continuous Training on business performance** Asmaâ Moussaid, Mohamed Tkiouat And Mustapha Hlyal ESITH, CELOG, Morocco EMI, Morocco
36	**F31: Valorization of Moroccan Natural Phosphate on the Production of Phosphate Glass Fibers** N.Saloumi, M.El Bouchti, O.Cherkaoui, H.Hannache REMTEX, ESITH, Morocco Hassan II University, Morocco Mohamed VI Polytechnic University, Morocco
37	**F147: Sustainable Supply Chain Management: Review of Triggers, Challenges and Conceptual Framework** D. Saidi, J. El Alami And M. Hlyal University Med V, Morocco CELOG, ESITH, Morocco
38	**F54: Application of Fe_3O_4@polyAcrylate on Cotton fabric by polymer coating** Sara Jamoudi Sbai, Aicha Boukhriss, Mehdi Elbouchti , Omar Cherkaoui ,and Said Gmouh REMTEX, ESITH, Morocco Hassan II University, Morocco
39	**F141: Development of 3D warp interlock fabrics based on Moroccan Natural Fibers** Z. Samouh, O. Cherkaoui , D. Soulat, F. Boussu And R. El Moznine Chouaib Doukkali University, Morocco REMTEX, ESITH, Morocco Univ. Lille North of France, France
40	**F69: Integration of Lean management for the growth of Green industry** Kaoutar Jbira, Mustapha Hlyal, Jamila El Alami University Med V, Morocco ESITH, Morocco
41	**F20: HAP functionalization of textile fabrics by coating process** A.Bouasria, A.Boukhriss, S.Saouabi, S.Gmouh, O.Cherkaoui, H.Hannache Hassan II University, Morocco REMTEX, ESITH, Morocco Mohammed V University, Morocco
42	**F97: A colorimetric and fluorescent sensor based-azo dye to develop test strip for Cu2+ / CN- detection in aqueous media** S. Fettouche, A. Boukhriss , M. Tahiri, O. Cherkaoui and S.Gmouh REMTEX, ESITH, Morocco, Université Hassan II, Morocco.
43	**F168: A facile route for the preparation of hydrophobic and antibacterial pet fabrics using ag-loaded graphene nanocomposite** Boubker Ouadil, Othmane Amadine, Younes Essamlali, Omar Cherkaoui, Mohamed Zahouily REMTEX, ESITH, Morocco. Université Hassan II, Morocco. MASciR Foundation, VARENA Center, Morocco
44	**F48: Mechanical and thermal property evaluation of nonwovens made palm fiber reinforced polyester composites** O. Azmami, L. Sajid, S. Gmouh LEC, ESITH, Morocco Hassan II University of Casablanca, Morocco Mohammad V University, Morocco

Introduction of biochar for the manufacture of flax conductive fabrics

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Keywords: Biochar; Conductive fabrics; E-textile; Flax; Renewable

EXTENDED ABSTRACT

1.   Introduction

Electro-conductive textiles or electrically conducting textiles can be used for a wide range of applications. For example, they can be used in electromagnetic shielding, gas sensing, electrostatic dissipation, particle filtration, dust- and germfree clothing, and data transferring products [1]. Different technologies exist to produce electro-conductive textiles. Conductive metallic fibres or metal coated fibres can be incorporated during the weaving or knitting process [2]. However, a major drawback with the use of metallic fibres is a reduction of flexibility in the resulting textile material. Another technology consists of coating textiles with inherently conductive polymers [3]. However, some research suggest that using such polymers results in limited processability and a stiffness inherent to their electrical conductive properties [3]. Carbon-based materials under different forms (e.g., carbon nanotubes, carbon black, graphene, and graphene oxide) have been used as conductive materials for textiles, either as particles or embedded materials in a matrix [4]. However, these types of graphite carbon materials remain an expensive and non-renewable carbon resource.

Biochar is a carbon-based material obtained from the thermal decomposition of organic matter, such as residues and wastes, in the presence of no or little oxygen, at elevated temperatures (e.g., 400–1000 °C). Since the biomass used to produce biochar requires atmospheric CO_2 for growth, biochar can reduce greenhouse gas emissions by fixing a large fraction of carbon. Biochar displays a wide range of properties (electrical conductivity, porosity, thermal stability, activated surface area, and ash content) that can be tailored by the manufacturing process and used as conductive materials within a polymer matrix [5].

Diverse sources of biomass can be used to produce biochar. Of particular interest, hemp is a plant that

grows under various climate and soil conditions. Hemp does not require fertilizer or insecticide products for its cultivation. Available in Europe, dried hemp biomass is estimated to be around 300 000 tons in 2017 [7]. Some research [8] has shown successful results in producing activated carbons to build the electrodes of supercapacitor cells from hemp stem.

In this study, we investigate the electrically conductive potential of biochar to create e-flax fabrics. For this purpose, the study will first focus on production of biochar from hemp. The process parameters will be optimized to obtain biochar with a maximum electrical conductivity. Then we will consider the incorporation of conductive biochar in a fabric coating matrix. Biochar dispersion in the matrix material will be evaluated in respect to biochar content. Additionally, process parameters influential to the coating process will be identified. Finally, we will characterize the electrical and mechanical properties of the developed e-fabrics and perform a comparison with uncoated fabrics.

2.   Material and methods

2.1   Flax fabric substrate
A twill 1/3 flax fabric (440 gsm) that has been manufactured at the Fraunhofer WKI with flax yarns (200 tex) from Linificio (Italy) will be used as the "substrate" material (Figure 1).

Figure 1. Twill 1/3 flax fabric (440 gsm)

2.2   Pyrolysis of hemp
Hemp stem (shivs and fibres) will undergo thermal treatment in a tube furnace. Several process parameters will be studied (particle size, gas environment, pyrolysis rate, heating duration and stages, final pyrolysis temperature). Depending upon the initial testing and electrical conductivity results, some pre-processing steps and/or multi-step carbonization will be carried out.

2.3 Matrix
The epoxy matrix chosen for embedding the biochar is the Greenpoxy 55 from Sicomin (bio-content as high as 55%).

2.4 Introduction of biochar in the matrix and coating of the substrate
The biochar particles will be dispersed in an ultrasonic bath prior to being introduced in the epoxy matrix. The matrix will be homogenized and applied to the substrate with lab scale coating equipment. The coated textile will then be cured according to the epoxy supplier specifications.

2.5 Characterization of electrical and mechanical properties of neat and coated fabrics Electrical properties of the uncoated and coated fabrics will be measured with a Metriso 3000.MK device. Tensile tests will be carried out according to the EN ISO 13934-1 standard using a Zwick Roell Z020 universal test machine.

3. Results and discussion

Carbon content, porosity, and electrical conductivity of the resulting hemp biochar will be evaluated for different pyrolysis processing routes. The biochar with highest electrical conductivity will be selected for substrate coating.

Different biochar ratios will be incorporated in the epoxy matrix to coat the fabrics. Results, in terms of homogeneity of coating on the substrate surface (individualization and distribution of the carbon particles), will be correlated with the electrical and mechanical properties of the e-fabrics. A comparison with the properties of uncoated fabrics (Figure 2) will be performed and the efficiency of the conductive coating will be discussed.
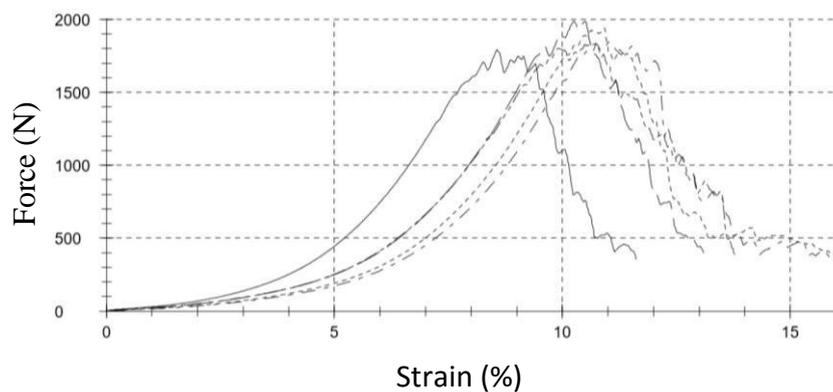

Figure 2. Mechanical response of the uncoated flax fabrics under tension

4. Conclusion

Conductive fabrics developed in this study combine fully renewable flax fabrics with a sustainable source of conductive carbon material. Positive results will promote the further development of solutions for 100% bio-based e-textiles. More efforts remain to be done on the coating, which is only partially bio-based. The envisioned future work after the study will then focus on the development of a coating made of bio-sourced polymers.

References:

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