Tekirdağ Namık Kemal University
Çorlu Engineering Faculty
Textile Engineering Department

ICONTEX 2019

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PROCEEDINGS

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With Our Thanks…

**listed in alphabetical order*

Keynote Speakers

Prof. Dr. **Yaming JIANG**

Tianjin Polytechnic University, School of Textiles, China

Directionally Oriented Knitted Fabric Reinforced Composite Applications

Prof. Dr. **Xungai WANG**

Deakin University, Institute for Frontier Materials, Australia

Recent Research on Fibres and Textiles in Australia

2nd International Congress of Innovative Textiles, ICONTEX2019
Scientific Program

17 APRIL 2019

09:00-10:30	**HALL 2** **OPENING SESSION** Prof. Dr. Fatma Göktepe, Chairperson of Icontex2019 Vehbi Canpolat, Chairman of Textile Finishing Manufacturers Association of Turkey (TTTSD) Adil Nalbant, Chairman of Textile Machinery and Accessories Manufacturers Association (TEMSAD) Ahmet Öksüz, Chairman of İstanbul Textile and Raw Materials Exporters Association (İTHİB) İbrahim Pektaş, Deputy Chairman of Turkish Exporters Assembly (TİM) Prof. Dr. Bülent Eker, Vice-Rector of Tekirdağ Namık Kemal University		
10:30-11:00	**COFFEE BREAK**		
11:00-11:30	**HALL 2** **PLENARY SESSION Prof.Dr. Xungai Wang/ Recent Research on Fibres and Textiles in Australia**		
11:45-13:00	**HALL 1** **Textile Finishing** **Chairman: Assoc. Prof. Dr. A. Pedro SOUTO**	**HALL 2** **Technical Textiles** **Chairman: Prof. Dr. Bülent ÖZİPEK**	**HALL 3** **Yarn Spinning Technologies** **Chairman: Prof. Dr. Suat CANOĞLU**
11:45-12:00	5285-Investigation of Softness Performance of the Vegetable Oil Based Silicone Softeners /Ertuğrul Demir - **Onur Balcı** - Koray Pektaş	5430-Hematite as a Natural Filler in Nonwoven Coatings for Enhanced Sound Insulation Property **/İlhan Özen** - Gamze Okyay - Oğuz Demiryürek	5145-Dual-Core Yarns and Measurement of Twist for Dual-Core Yarns **/Nida Yıldırım** - Gamze Kılıç - Hüseyin Gazi Türksoy
12:00-12:15	5149-Design of a Recipe Using Polyol Based Wicking Agent for Better Wicking Performance of Polyamide 6.6 Seamless Garments **/Berdan Kalav** - Banu Uygun Nergis - Cevza Candan	5250-Effect of Segmentation of the Frequency Range on the Evaluation of Electromagnetic Shielding Effectiveness **/İlkan Özkan** - Abdurrahman Telli	5213-An Investigation on Wickability Properties of Denim Fabrics Made from Microfilament Core-Spun Yarns **/Esin Sarıoğlu** - Osman Babaarslan
12:15-12:30	5292-Steam Application During Laundering for Decreasing Wrinkling of Shirts /Hatice Açıkgöz Tufan - Umut Kıvanç Şahin - **Işıl Uslu Hergenç** - İlkan Erdem	5439-Innovative Laser Technology in Textile Industry: Cutting **/Yordanka P. Angelova**	5350-Influences of Core Draft Ratio on Physical Properties of Dual-Core Slub Yarns /Münevver Ertek Avcı - **Nida Yıldırım** - Hüseyin Gazi Türksoy
12:30-12:45	5227-Investigation of Combustion Characteristics of Fire-Off Treated Co/Pet Fabrics by Cone Calorimeter **/Raziye Atakan** - Gülay Özcan	5157-Compression Stockings with Cotton Components for Long Haul Flights **/Sena Cimilli-Duru** - Banu Uygun Nergis - Cevza Candan	5150-Performance of Denim Fabrics Produced by Using Core-Spun Yarns Containing Nische Elastomeric Filaments /Osman Babaarslan - **Hatice Kübra Kaynak** - F. Beyazgül Doğan - Serhat Karaduman
12:45-13:00	5286-Investigation of the Reusability of the Waste Caustic in the Bleaching Process of the Knitted Fabrics /Yılmaz Yıldız - **Fatoş Ceren Akıncı** - Koray Pektaş - Onur Balcı	5151-Developing Flame Retardant Curtain Fabrics Using Acrylic Coating Material Containing Huntit and Hydro-Magnesite Minerals /Oğuz Demiryürek - **Volkan Karadayı**	
13:00-14:00	**LUNCH**		
14:00-15:00	**HALL 1** **Nanotechnology Applications in Textiles** **Chairman: Prof. Dr. Nihal SARIER**	**HALL 2** **Technical Textiles** **Chairman: Prof. Dr. Özer GÖKTEPE**	**HALL 3** **Knitting & Nonwovens** **Chairman: Prof. Dr. Hale KARAKAŞ**
14:00-14:15	5257-Fabrication and Antibacterial Activity of Composite Peo/Pcl Electrospun Nanofibers **/Zarife Barbak** - Hale Karakaş - Abdülkadir Sezai Saraç - Canan Yağmur Karakaş - Azime Yılmaz	5189-Developing Stone-Wool Panels for Hydroponic Agriculture Applications **/Levent Onal** - Sabri Çamlıca	5147-Abrasion Properties of Warp Knitted Cut-Pile Upholstery Fabrics **/Emel Çinçik** - Selçuk Aslantaş
14:15-14:30	5299-Atmospheric-Pressure Plasma Spray Deposition of Silver/Hmdso Nanocomposite on Polyamide 6,6 with Controllable Antibacterial Activity /A Ribeiro - M Modic - U Cvelar - G Dinescu - B Mitu - A Nikiforov - C Leys - İ Kuchakova - M Vanneste - P Heyse - M Vrieze - A P Souto - **A Zille**	5431-Efficiency of Biodegradable Coated Nonwoven Structure with Controlled Fertilizer Release Property in Lettuce Growth Trials Under Drought Stress **/İlhan Özen** - Gamze Okyay - Abdullah Ulaş	5199-An Inovative Solution Approach for Carpet Pile Pull Out Problem **/Halil İbrahim Çelik** - Özkan Bozoğlan
14:30-14:45	5359-Green Reduction of Graphene Oxide Coated Polyamide Fabric Using Carob Extract **/Nergis Demirel Gültekin** - İsmail Usta - Bahattin Yalçın	5353-Development of Textile Conductive Fabric By Copper Metal Coating Approach for E-Textile Applications **/Zuhaib Hassan** - Ozgur Atalay - Fatma Kalaoglu	5343-Investigation of the Effect of Regional Sap&Pulp Distribution to Diaper Performance **/Ümit Gençtürk**
14:45-15:00	5449-How Nanofiber Alignment Affects Proton Conductivity Of Ionomer Nanofibrous Membranes/ **Aliakbar GHAREHAGHAJI**	5259-Static Electrical Charasteristics of Double Layered Woven Car Seat Fabrics **/Gonca Özçelik** Kayseri - Pelin Gürkan Ünal - Diren Mecit - Faruk Bozdoğan	5233-Structural Properties of Fabrics Made of Metal Yarns **/Nilşen Sünter Eroğlu** - Suat Canoğlu - Sevhan Müge Yükseloğlu
15:00-15:45	**COFFEE BREAK & POSTER SESSION**		
15:45-17:00	**HALL 1** **Textile & Fashion Design and Modelling** **Chairman: Prof. Dr. Ömer Berk BERKALP**	**HALL 2** **Functional & Smart Textiles** **Chairman: Prof. Dr. Xungai WANG**	**HALL 3** **Textile Testing & Quality Control** **Chairman: Prof. Dr. Lubos HES**
15:45-16:00	5260-Evaluation of Project Proposal Performance by Fuzzy Logic in Textile R&D Centers **/Can Ünal** - Ayşegül Kaya	5234-Design and Development of Thermally Enhanced Textile Nanocomposites Incorporated with Phase Change Material Nanowebs /Emel Önder Karaoğlu - **Nihal Sarıer**	5460- Theoratical Study of Tensile Properties of Directionally Oriented Knitted Fabrics/**Yaming Jiang**, He Xiang, Yexiong Qi, Liangsen Liu
16:00-16:15	5358-Modelling of Generation and Dissipation Charges of Static Electricity on Surface of Polymeric Textile Materials /G. Alisoy - F. Göktepe - Ö. Göktepe - **Hafız Alisoy**	5212-Research on Shape Memory Textiles Based on Origami Techniques **/Isabel Cabral** - António Pedro Souto	5202-Image Processing Applications on Yarn Characteristics and Fault Inspection **/Elif Gültekin** - Halil İbrahim Çelik - Lale Canan Dülger - Halil İbrahim Sünbül - Harun Kani
16:15-16:30	5175-Development of Strategies Regarding Circular Economy for Apparel Retailers **/Canan Sarıcam** - Nazan Okur - Eren Eralp - Cem Berke Alpak - Kubra Genc	5139-A New Generation Mattress Ticking: Meditation /Cem Güneşoğlu , **Müjgan Durmuş** ,Ülkü Seyhan, , Gözde Seven, Nurcan Biçer	5258-Performance Charasteristics of Sleeping Bags /Enes Nayman - Nilgün Özdil - **Gonca Özçelik Kayseri** - Gamze Süpüren Mengüç
16:30-16:45	5186-Exploring the Engagement of Consumers With Fashion Brands on Social Media **/Nazan Okur** - Canan Saricam - Akın Yıldırım - Sercan Koçal	5349-Soft Piezoresistive Sensors for Integration into Smart Wearables **/Derya Tama** - Pedro Gomes - Yu Yao - Antonio Pedro Souto - Helder Carvalho	5351-Investigation of the Fibre Loss Effect of Raised 3 Thread Fabric **/Ğassan Asker** - Eray Akkuş - İbrahim Arslan - Murat Sevilmiş - Koray Pektaş - Onur Balcı
16:45-17:00	5266-Fast Fashion and Slow Fashion **/Nazan Kalebek** - Tuğba Ozturk	VII	5268-Dimensional Stability of Woven Terry Towel Fabrics Produced by Hard Core-Spun Yarns /Mehmet Polat - Sıdıka Fidan Polat - **Esin Sarıoğlu** - Hatice Kübra Kaynak - Yasemin Korkmaz

18 APRIL 2019

09:00-09:30	**HALL 2** **PLENARY SESSION Prof.Dr. Yaming Jiang - Directionally Oriented Knitted Fabric Reinforced Composite Applications**		
09:45-11:00	**HALL 1** **Textile Chemistry&Sustainability** **Chairman: Prof. Dr. Habip DAYIOĞLU**	**HALL 2** **Functional & Smart Textiles** **Chairman: Prof. Dr. Yaming JIANG**	**HALL 3** **Weaving** **Chairman: Prof. Dr. Recep EREN**
09:45-10:00	5174-Development of a Sustainable Chemical Management Strategy Through Cleaner Production Techniques in an İntegrated Home Textile Mill /**Ozge Bayraktar** - Emrah Ozturk - Murat Yildirim - Mehmet Kitis	5352-Resistance Variation of Different Substrats Applied Conductive Ink by Screen Print Technique /**Pedro Gomes** - Derya Tama - Hélder Carvalho - António Pedro Souto	5387-Effect of Weaving Pattern and Yarn Density on the Surface Roughness of Woven Fabrics /H. Jaouani - D. Matsouka - **Savvas Vassiliadis** - K.S. Nikas
10:00-10:15	5331-Chemical Recycling of Textile Waste /**Bojana Voncina** - J Valh Volmajer - S Vajnhandl - A Majcen Le Marechal - A P Aneja - A Lobnik	5158-Design of a Plaster Containing Benzoyl Peroxide Loaded Microsponges to Support Acne Treatment /**Nihal Atabay** - Merih Sarışık - Sinem Karavana - Seda Rençber	5344-Physical and Thermal Comfort Properties of Woven Fabrics Produced from Hybrid Yarns /Gözde Ertekin - Mustafa Ertekin - **Arzu Marmaralı**
10:15-10:30	5235-Microfiber Waste Load Analysis in Denim Fabric Laundering Process /**Merve Erkoç** - Gürkan Özkarademir - Osman Babaarslan	5360-A Study on Knitting Performance and Fabric Properties of the Yarns Spun from Nano-Fibers /**Özer Göktepe** - F. Göktepe - S. Şenocak	5188-Utilization of Metallic Fibers in Textiles /**Müslüm Kaplan** - İsmail Borazan - M. Bünyamin Üzümcü
10:30-10:45	5251-Green Synthesis of Reactive Dyes for Inkjet Printing /**Saira Faisal** - Long Lin	5269-Production of Cotton Conductive Fabric by Polymerization of Pyrrole /**Ayse Genc** - Merve Erkoç - Nihan Karakaplan	5325-Development of Woven Fabrics With Electromagnetic Shielding by Quality Function Deployment Application /**Bilge Berkhan Kastacı** - H.Ziya Özek
10:45-11:00	5346-Influence of Chemical Reaction Conditions in P(St-Mma-Aa) Synthesis: Variation in Nanoparticle Size, Color and Deposition Methods /**Rui D.V. Fernandes** - Pedro Gomes - Andrea Zille - António Souto	5184-Modelling and Development of Smart, Solar Powered, Motorized Roller Blinds System Prototype /**Özge Bayraktar** - Hafiz Alisoy - Murat Yildirim	5288-Developing an Electronic Jacquard Sample Weaving Machine /**Müslüm Kaplan** - Deniz Mutlu Ala - Nihat Çelik
11:00-11.30	**COFFEE BREAK & POSTER SESSION**		
11:30-12:45	**HALL 1** **Dyeing** **Chairman: Prof. Dr. A. Merih SARIIŞIK**	**HALL 2** **Technical Textiles** **Chairman: Prof. Dr. Savvas VASSILIADIS**	**HALL 3** **Yarn Spinning Technologies** **Chairman: Prof. Dr. İsmail USTA**
11:30-11:45	5313-Antibacterial Potential Of Cotton Fabrics Dyed With İndigofera Tinctoria-Derived Dye /Diana Santiago - Helena P. Felgueiras - Gabriela Forman - **António P. Souto**	5103-Low Velocity Impact Behaviour of Carbon/Xps Sandwich Composites /Erdem Selver - **Gaye Kaya**	5152-The Production of Bcf Yarn and Machine Carpet from Recycled Polypropylene Yarns /**Şebnem Sözcü** - Cem Güneşoğlu - Mehmet Şakir Erboz - Azize İnce
11:45-12:00	5432-Novel Method for the Bleaching and Brightening of Indigo-Dyed and Sulphured-Dyed Textiles /**Huseyin Akbulut** - Deniz Gunes - Refik Gulbahar	5159-Investigating the Effect of an Antifouling Paint Applied on Polyamide 6.6 Fish Nets /**Korhan Şen** - Levent Çavaş - Ümit Halis Erdoğan	5347-Properties of Drawn Textured Polyester Yarns of Different Cross-Sectional Fibers /**Fatih Ahmet Özat** - Duygu Yılmaz - Mahmut Oğuz Kesimci - Özcan Özdemir
12:00-12:15	5243-Investigation of the Dyeability of Regenerated Cellulosic Fabrics With White Onion Peel in the Presence and Absence of Mordants /Rıza Atav - **Selma Soysal** - Erkan Çağlar - Fatma Yıldız	5183-Effect of Production Parameters on Acoustic and Abrasion Resistance Properties of Needlepunched Nonwovens /**Handan Palak** - Burçak Karagüzel Kayaoğlu	5342-Investigation of Core Covering Performance of Dual-Core Yarns with Image Processing Technique in Terms of Production Parameters /Gamze Kılıç - Bekir Yıldırım - **Sümeyye Üstüntağ** - Hüseyin Gazi Türksoy
12:15-12:30	5246-Determination of the Effect of Knitted Fabric Construction on Color in View of Right-First Time Dyeing /Rıza Atav - **Tuğçe Sena Horasan** - Alpaslan Bilgiç - Orhun Ek	5429-Effect of Plasma Treatment on Glass Fiber /Epoxy Resin Composite /**Aminoddin Haji** - Mohsen Hadizadeh - Elahe Ferasat - Delaram Movaghatian	5198-Investigation of Using New Generation Fibers on Properties of Melange Yarns /**Osman Yayla** - Hadi Samet Mumcu - Eyüp Ali Satıl - Hatice Nida Civan - Serkan Nohut
12:30-12:45	5187-Loop Dimensional Difference/Melange Appearance on Warp Knitted Towel Fabrics /**Tuğçe Töngüç** - Ahmet Ali Dildar - Barış Mancar - Melike Küçüker - Hasan Örtün	5102-Compressive Properties of Z-Fibre Reinforced 3D Composites /**Gaye Kaya** - Constantinos Soutis - Prasad Potluri	5155-Effect of Balloon Length on Yarn Tension Change During Unwinding of Yarns Including Lycra Component /**Özge Çelik** - Recep Eren
12:45-13:45	**LUNCH**		
13:45-14:45	**HALL 1** **Textile Finishing** **Chairman: Prof. Dr. Slah MSAHLI**	**HALL 2** **Ecology&Sustainability** **Chairman: Prof. Dr. Prof. Dr. Aliakbar GHAREHAGHAJI**	**HALL 3** **Textile Testing &Quality Control** **Chairman: Prof. Dr. Arzu MARMARALI**
13:45-14:00	5185-Optimization of Coating Process Parameters for Color Difference After Abrasion of Denim Fabrics by Using Taguchi Method /Hüseyin Gazi Türksoy - **Sümeyye Üstüntağ** - Münevver Ertek Avcı	5327-Ecological Textile Policy /**Habip Dayıoğlu**	5271-The Effect of Heat Transfer Conditions on Thermal Conductivity of Fabrics Determined by Various Testing Instruments /**Lubos Hes** - V. Bajzik - J. Pichova
14:00-14:15	5389-An Alternative Process Development to the Conventional Stone Wash in Net for Denim Garment Production /**Semra Kördüğüm** - E. Oğul - S. Ünlü - O Balcı	5164-Production of a Novel Polyoxometalate-Based Nanomaterials and Their Usage in Purification of Wastewater Containing Textile Dye Effuluents / **İlker Kandemir** - Hazal Oluk - Necip Atar	5210-Seam Slippage Behaviour in Woven Fabrics Obtained from Recycled Cotton Yarns and Blends /**Mihriban Kalkancı**
14:15-14:30	5284-The Improvement of the Fastness of Bifunctional Reactive Dyes Using Natural Bentonites in The Washing Processes /**Dilek Şarapnal** - Fatma Müzeyyen Parladı - Derya Denizhan	5253-A Review on Microplastics and Their Impact on Marine Environment /**Ilkan Erdem** - Banu Uygun Nergis - Seyhan Uygur Onbaşioğlu	5281-A General Overview on the Performance Features of Baby Diapers /**Gonca Özcelik Kayseri** - Esen Özdoğan - Aslı Demir
14:30-14:45	5207-Waterproof Breathable Functional Application for Polyester Fabric /**Erdal Gülcan** - Duygu Yılmaz - Figen Çetinoğlu - Koray Bükülmezer - Burcu Yılmaz Şahinbaşkan		5153-The Failure Mode and Effect Analysis of The Fabric Production in Karadeniz Knitted Fabric Factory /Vedat Özyazgan - Vassilya Uzun - **Mohammed Ahmed Shah**
14:45	**CLOSING CEREMONY** **DEPARTURE FOR BOSPHORUS TOUR & GALA DINNER**		

2nd International Congress of Innovative Textiles, ICONTEX2019
POSTER LIST
17 APRIL 2019 - 15:00 - 15:45 & 18 APRIL 11:00-11:30

P - 01	PRINTED ELECTRONIC GARMENT: CREATING NEW OPPORTUNITIES FOR TEXTILE AND ELECTRONIC INDUSTRIES	**Amine Hadj Taieb** - Slah Msahli - Faouzi Sakly
P - 02	COMPOSITE MATERIAL DESIGN TO BE USED FOR BUILDING ROOF AND SIDE WALLS WHICH OPTIMAL RATE OF WATER VAPOUR PERFORMANCE / MATERIALS THICKNESS	**Utkay Dönmez** - Hacer Nozoğlu - Murathan Sevim - Emrah Kaçmaz
P - 03	AN INNOVATIVE APPROACH WITH DEVELOPMENT OF AN IR REFLECTIVE-COLORED FABRICS FOR ROLLER BLINDS	**Habibe Gülben Selvi** - Murat Yıldırım
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RESISTANCE VARIATION OF CONDUCTIVE INK APPLIED BY SCREEN PRINT TECHNIQUE ON DIFFERENT SUBSTRATES

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Abstract

This work studied the behaviour of two conductive inks, applied by conventional screen print method, on four different textile substrates, 100% cotton, 50% cotton 50% polyester, 100% polyester and 100% polyamide. The inks were also applied on a multifibre fabric. Atmospheric plasma treatment was applied in order to improve the adhesion on the samples [1], and the resistance values were compared with non-treated samples on the different fibres. The values were measured before and after cleaning and washing tests performed to simulate home treatment for garments, in order to predict the behaviour of the inks after the normal usage of the fabrics. Comfort properties like stiffness of the fabrics were also evaluated after 5 and 10 washing cycles.

Key Terms

Conductive ink, Smart garments, Screen print, Washing fastness

1. Introduction

Flexible electronic systems applied in textiles are an interesting method used for monitoring position, posture and activity parameters. It is therefore indispensable to obtain interdependence between electronics and fabrics focused on the flexible compatibility in substrates/electronics [2]. A significant range of studies explore many ways of integrating conductors in textiles. They can be produced by integrating conductive yarns into the structures, dip-coating the fibres, inkjet printing, among others [3-5]. Different applications can be created depending on the final objective of the sensor such as stretch, pressure and impact sensors, textile energy harvesting among others. Systems capable of measuring heart rate or breathing movement, and capable of accumulating energy form the body or the nature energy (sun, rain), can be achieved by these methods [6]. The application of conductive ink by the screen print technique described in this work is intended to evaluate the potential to create electrical circuit networks to be used to carry electrical signals in clothing or technical applications where pressure sensors, previously developed [7] [8], were applied. In order to evaluate the efficiency of the application, Dupont PE 828 and PE 825 inks were applied to different textile substrates, where the values of electrical resistance and flexibility of the material were measured after 5 and 10 standard household washing tests.

2. Experimental

2.1. Materials

Fabrics

Commercial 100% polyester (PES), 100% polyamide (PA), 100% cotton (CO) and 50% cotton (CO) / 50% polyester (PES), fabric with a weight per unit area of 110 g/m^2, were used in this study. The fabrics were washed with 1 g/L of a non-ionic detergent solution at 60ºC during 60 min, in order to eliminate some possible contaminations. Commercial SDCE multifibre DW fabric was also used, a product acquired from SDC enterprises limited.

Conductive inks

Two conductive inks (DuPont PE 825 Silver Composite Conductor and DuPont PE 828 Silver Conductor) were used as conductive material to create the electrical connections. DuPont PE825 Silver Composite Conductor is used to fabricate low-voltage circuitry, on flexible substrates including polyester film, has a curing condition of 120ºC-140ºC, 2-10 minutes. PE825 is a presented as a highly efficient silver-bearing conductor that possesses excellent abrasion resistance, adhesion and print resolution. DuPont PE 828 is a low temperature drying Silver Conductor, designed to maintain low temperature substrate tolerances as this composition can be applied between 60°C-100°C, 10-20 minutes. PE 828 achieve very good physical and electrical properties when dried using low temperatures.

2.2. Procedures

Plasma treatment

The plasma treatment was performed in a semi-industrial prototype machine (Softal GmbH/University of Minho) at room temperature and atmospheric pressure, using a system of metal electrode coated with ceramic and counter electrodes coated with silicone with 50 cm effective width, fixed gap distance at 3 mm and producing a discharge at 10 kV and 40 kHz. A power of 1 kW was applied, with a speed of 4 m/min, each sample passing 5 times per side. The total applied dosage was 5 kW min/m2.

Screen print

The process for the application of the conductive inks was carried out in a Zimmer samples stamping machine using a conventional screen print method, 2 passes were made (one for each side), with maximum magnetic force used. The screen used a 100 thread/cm polyester mesh. Connections of 10 cm length by 0.5 cm width were made (Figure 1). After the ink application the samples were cured at 120°C, during 10 minutes for the PE 825, and 80°C during 20 minutes for the PE 828 ink. The samples were cured in a Memmert laboratory oven.



Figure 11 Conductive sample

Washing test

To assess the resistance to washing, ISO 105-C06 tests were performed in a Roaches washtec-p machine, to determine the resistance to all forms of domestic or commercial

laundering procedures. The samples were washed 10 times each, at a temperature of 40º C during 30 minutes with 10 spheres for a single test.

2.3. Analytical Methods

Stiffness test

To test the influence of the conductive ink on the stiffness of the textile material, a stiffness test was carried out on a Shirley fabric stiffness tester TF113. This test is capable of determine the bending height, flexural rigidity and bending modulus of fabric by simple procedures and calculation. The method complies with ASTM D1388. The test was carried out at 0 washes (0ws), 5 washes (5ws) and 10 washes (10ws).

Resistance test

The electrical resistance values were measured with a Fluke 45 dual display multimeter. The measurements were taken with a distance of 4 cm between the test leads for the 100%CO, 50%CO/50%PES, 100%PES and 100%PA fabrics, and a distance of 1 cm in the multifibre fabric, due to the maximum size of the fibres in the multifibre fabric. The test was carried out at 0ws, 5ws and 10ws.

Microscope analysis

After the washing processes, the conductive track was evaluated using a Leica DM 750 M optical microscope using 5 times magnification, so that it was easier to identify changes in the surface of the applied material, like cracks and wear.

3. Results and Discussion

Stiffness test

After the screen print application of the inks, the fabrics were tested to evaluate the change in flexibility in the fabric, and then compared after 5 and 10 washes (Table I).

Table X Stiffness test

Sample	0ws	5ws	10ws	Sample	0ws	5ws	10ws
PES 825	0.00	3.20	2.50	**PES plasma 825**	0.00	2.90	1.50
PES 828	3.10	2.75	2.70	**PES plama 828**	3.45	2.85	2.15
PA 825	0.00	3.30	3.30	**PA plasma 825**	0.00	2.95	3.00
PA 828	2.55	2.80	3.25	**PA plasma 828**	3.20	2.95	3.30
CO 825	0.00	2.85	2.60	**CO plasma 825**	0.00	3.40	2.65
CO 828	3.45	2.70	2.60	**CO plasma 828**	2.95	2.80	2.50
CO/PES 825	0.00	3.00	2.65	**CO/PES plasma 825**	0.00	3.20	1.95
CO/PES 828	2.95	2.75	2.20	**CO/PES plasma 828**	3.10	2.70	2.50

Samples produced with 825 ink presented a high rigidity after the application and it was not possible to obtain a value on the scale for the pre-wash test (all samples marked as 0), however after the first wash the stiffness value decreased allowing to obtain measurable results. After 5ws the 825 ink still present higher values of stiffness then the 828, after the 10ws the values tend to be similar.

It is possible to confirm a trend of decreasing stiffness throughout the application of the washing for all the samples. Only the PA samples contradict this trend and show a slight increase or maintenance of the values. Application of plasma treatment to the samples results in lower values of rigidity.

Electrical resistance test

Resistance values were measured for each sample, before washing, after 5 and 10 washing cycles, and are compiled in table II. When resistance values were too high to be measured NC (Non-conductive) is reported.

Table XI Resistance value on fabrics, in ohm

Sample	0ws	5ws	10ws	Sample	0ws	5ws	10ws
PES 825	90	126	45	**PES plasma 825**	80	43	NC
PES 828	190	136	NC	**PES plasma 828**	130	186	NC
PA 825	70	NC	NC	**PA plasma 825**	75	NC	NC
PA 828	200	NC	NC	**PA plasma 828**	190	NC	NC
CO 825	90	76	140	**CO plasma 825**	100	105	70
CO 828	80	109	160	**CO plasma 828**	100	160	NC
CO/PES 825	90	160	50	**CO/ plasma PT 825**	100	125	76
CO/PES 828	160	170	NC	**CO/ plasma PT 828**	170	230	NC

After the tests, the 825 ink presented the best results in terms of durability and lower values of resistance. Patterns of behaviour within the different groups of fibres can also be found. PA fabrics lost the conductive propriety after 5 washes due to a weak bonding between the ink and the fibres. PES samples obtained the lowest value in resistance after 10ws for the 825 ink, (PES plasma 825) but had a tendency to break the circuit as shown in figure 2. The samples developed with the 100% CO and the 50% CO/50% PES continued to conduct after 10ws, for the 825 ink. Plasma treatment does not seem to increase adsorption of the inks in the substrates, neither on the resistance values



Figure 12 Cracked sample

Table III and table IV present the results for the multifibre fabric. This samples were measured with a distance of 1 cm. Acetate, Cotton, Polyamide, Polyester, Acrylic and Wool fibres were tested.

Table XII Resistance value on multifibre fabrics Ink 825, in ohm

Ink 825	0ws	5ws	10ws	Ink 825 plasma treatment	0ws	5ws	10ws
Acetate	40	45	75	**Acetate**	40	42	52
Cotton	50	42	50	**Cotton**	55	41	56
Polyamide	60	116	NC	**Polyamide**	70	64	89
Polyester	40	42	38	**Polyester**	40	40	46
Acrylic	50	41	98	**Acrylic**	50	43	100
Wool	50	42	40	**Wool**	45	43	90

Table XIII Resistance value on multifibre fabrics Ink 828, in ohm

Ink 828	0ws	5ws	10ws	Ink 828 plasma treatment	0ws	5ws	10ws
Acetate	40	40	52	**Acetate**	60	52	80
Cotton	50	43	47	**Cotton**	60	51	46
Polyamide	60	49	64	**Polyamide**	80	56	82
Polyester	40	40	42	**Polyester**	50	45	51
Acrylic	40	40	66	**Acrylic**	75	62	80
Wool	40	41	66	**Wool**	50	55	60

The inks showed good results in the capability to withstand the standard household washing tests, and still retains the conductive properties after 10 washes. The 825 ink lost the conductive proprieties in the polyamide non plasma treated.
The thicker structure of the multifibre fabric allowed a better fixation of the paints and at same time reduced the mechanical stress caused by cleaning processes, increasing the resistance to the washes.

Microscope analysis
The samples, depending on the ink used, presented different values of flexibility in the pre-wash fabrics. Microscope images were collected (Figure 3), and it was observed that the PE 825 ink forms a thicker film on the fabric surface contributing to the loss of flexibility of the textile. Plasma treatment increased the penetration capacity of the inks in the CO fabric resulting in an increase in the resistance value of the sample.

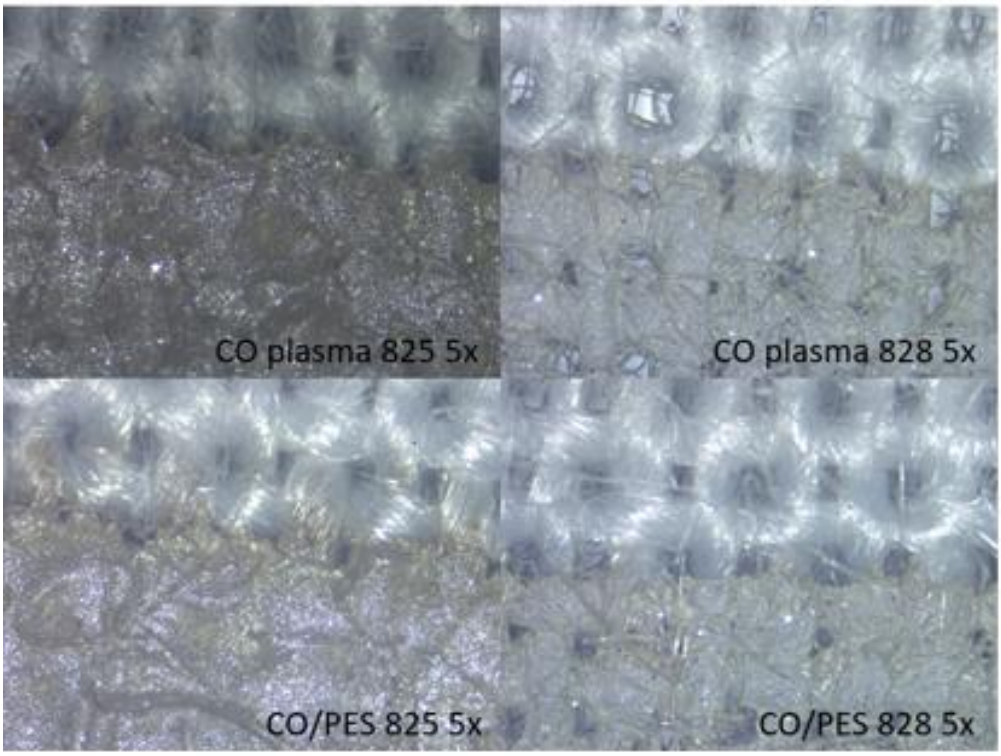


Figure 13 Microscope image of the samples 5x magnified, before wash

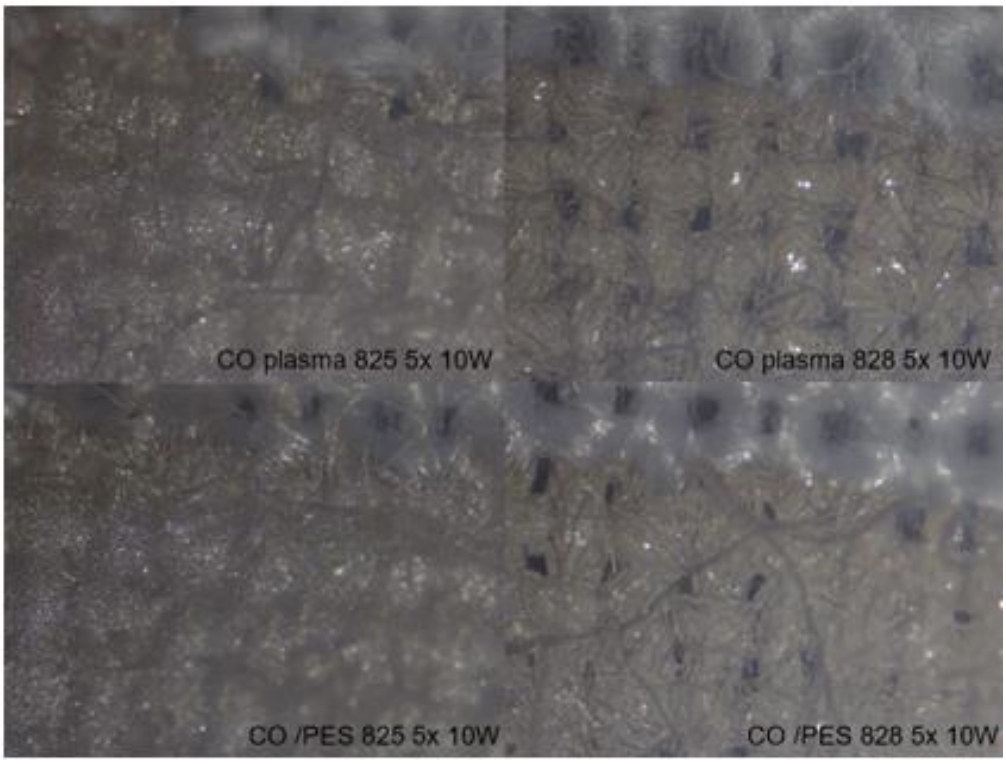


Figure 14 Microscope image of the samples 5x magnified, after 10 washes

After the 10 washes (Figure 4) the samples were re-evaluated, and new images were collected. 825 ink presented still has a high surface coverage where no ink faults are visible in the space between the yarn crossings. In the case of the 828 ink a loss of conductive

material is more visible, only the fibres that make up the fabric are covered. This leads to a smaller area available for electrical condution, increasing the resistance and causing the interruption of the flow when the material is folded.

Despite having a more uniform area coverage, the 825 ink shows greater tendency to form cracks along the connection, as can be observed in Figure 5.

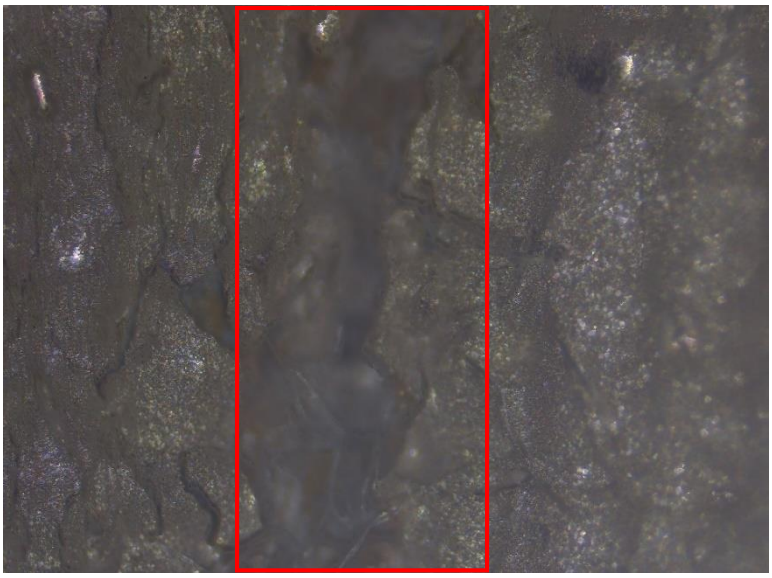


Figure 15 Cracks formation on CO plasma 825 sample 5x magnified

4. Conclusions

This study showed that is possible to use DuPont conductive inks PE 825 and PE 828 to create conductive connections in textile fabric with conventional screen printing.
Cotton fibres presented the best results, the samples developed in the 100% CO and the 50% CO/50% PES continued to work after 10 washes, for the 825 ink. PES samples obtained the lowest value in resistance after 10 washes for the 825 ink but tend to break the circuit because of the formation of cracks in the sample. PA fabrics lost the conductive propriety after 5 washes due to a weak bonding created between the ink and the fibres.
Also, in the test made with the multifibre fabric the samples retain the conductive properties after 10 washes, excluding the PA fibre. The bulkier fabric contributed to greater stamping resistance.
A tendency for stiffness decreases during the application of the washings was observed for all the samples produced, PA fibre excluded.
Application of plasma treatment generates lower values of rigidity in the samples after the washing procedures but does not have a positive effect on conductivity.
After 10 washes the 825 ink presented a high surface coverage, no ink faults are visible in the space between the yarn crossing, whereas in the 828 ink a loss of conductive material is more visible. This means a smaller conductive area, resulting in an increase of electrical resistance.
The 825 ink presented the best results in terms of durability and lower values of resistance in general.

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