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Resources Protection: Towards Replacement of Cotton Fiber with Polyester

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15 August 2022

REPORT ON PHD ACTIVITIES

EDWIN KAMALHA

PhD programme in CHEMICAL ENGINEERING

Cycle: 30

Coordinator: MARCHISIO DANIELE

Supervisor: BONGIOVANNI ROBERTA MARIA

A. Training activities

Most relevant courses and seminars attended

- Catalysts development from fundamentals to application (didattica di eccellenza), 15h, Hard skill, 3
- Color measurement, 20h, Soft skill, 3
- Communication, 5h, Soft skill, 3
- Energy for future factories, 10h, Hard skill, 3
- From science to business: how to get technology out of laboratories and into practical applications, 15h, Hard skill, 3
- Intellectual Property Rights, Technology Transfer and Hi-tech Entrepreneurship (Theoretical course), 30h, Soft skill, 3
- Italian language 1st level, 0h, Hard skill, 3
- Optically excited nanoparticles and their application in nanomedicine (didattica di eccellenza), 12h, Hard skill, 3
- Optimization methods for engineering problems, 30h, Hard skill, 3
- Photocatalysis: Fundamentals and Applications, 30h, Hard skill, 3
- Polymer and radiation, 25h, Hard skill, 3
- Project management, 5h, Soft skill, 3
- Public speaking, 5h, Soft skill, 3
- Public Speaking II, 12h, Soft skill, 3
- Short Course on Enterpreneurship, 7h, Soft skill, 3
- Solid State Chemistry, 30h, Hard skill, 3
- Statistical data processing, 20h, Hard skill, 3
- Surface chemistry, catalysis and catalytic materials (Didattica di eccellenza vp), 30h, Hard skill, 3
- Sustainable engineering, 30h, Hard skill, 3
- Wear of materials, 20h, Hard skill, 3
- Writing Scientific Papers in English, 15h, Soft skill, 3
- X-ray diffraction by materials, 25h, Hard skill, 3
- Characterization of advanced materials, 18h, Hard skill
- Corporate social responsibility, 12h, Soft skill
- Data mining and information, 0h, Soft skill
- Design of nonwovens, 28h, Hard skill
- Fashion marketing and design, 16h, Hard skill
- French Culture, 0h, Soft skill
- Innovation in technical textiles, 30h, Hard skill

- Intensive french for beginners, 0h, Soft skill
- International management, 12h, Soft skill
- Production and performance of technical textiles, 22h, Hard skill
- 'Big Data: Technologies and Applications' (tutorial given in the 12th International FLINS Conference on Uncertainty Modeling in Knowledge Engineering and Decision Making., 5h, Hard skill

Cooperation and/or support to teaching activities at this University (specify the courses and any recognition obtained)

In April-July 2016, I was assigned to work with two Exchange students from ENSAIT, Roubaix, under the guidance of Prof. Roberta Bongiovanni. Our research during their exchange period was successful with help I delivered to them on monomer grafting, moisture management testing, solvent/Soxhlet extraction, air permeability testing and contact angle measurements.

Other activities which may be worth to mention

I have been the Country Representative for Uganda, in the Erasmus MundusStudents and Alumni Association. I participated in two In-country activities sponsored by the European Union. I worked with the EU Delegation in Uganda, and I was a presenter at the 30th Anniversary of Erasmus+ on May 5, 2017, in Uganda. In conjunction with a research team from Europe, on January 30th-31st, 2018, I also organized two outreach seminars to prospective beneficiaries at Kyambogo University in Uganda. These events improved publicity and appreciation of Erasmus Mundus and the EU Education programmes to future beneficiaries.

B. Dissertation

- Title of the dissertation: Resources Protection: Towards Replacement of Cotton with Polyester

Description of the topic researched in the dissertation (maximum 20 lines)

The potential of polyester as a possible substitute to cotton fiber was studied. The global fiber market survey indicates that the future of cotton fiber supply, against the growing demand is unpredictable. Meanwhile, consumer surveys indicate a large preference towards cotton, in many countries. Through available literature, it was also noted that polyester currently dominates the global fiber market share at about 60%, against cotton's share of about 30%, which was about 80% in the 1980's. A further projection is that polyester will peak to about 70% in 2025, against cotton's global share of about 21%. These statistics portray abundance of polyester fiber on a global scale. However, available literature also suggests that polyester has inadequate preference and usage in conventional apparel. Researchers have argued against conventional cotton production, processing and handling; which poses strong bearing on ecological footprints. Moreover, polyester is also well priced compared to cotton. Through experimental studies and consumer surveys, inferior sensory properties, mass and heat transfer properties (moisture and thermal behavior) have largely been argued for the low exclusive use of polyester in apparel. This research explored the sensory and moisture properties of polyester and cotton fabrics. In particular, two studies were carried out; 1) a sensory analysis of cotton and polyester woven fabrics to quantitatively determine and reduce the gap between the two fiber generics. 2) Surface grafting of hydrophilic monomers on polyester woven fabrics to enhance wetting properties.

C. Research activity undertaken throughout the PhD programme

Research activity undertaken

- Lecture: Big Data: Technoloies and Applications' The 12th International FLINS Conference on Uncertainty Modeling in Knowledge Engineering and Decision Making, Conference and lecture attended accounting for 5 European credits, Roubaix, from 24/08/2016 to 26/08/2016
- Workshop "After the PhD? Think about your future", Activity on career development and presentation skills., Archamps, from 15/09/2016 to 16/09/2016

Other activities which may be worth to mention

Description of the specific issues tackled in the research activity

Sensory analysis of cotton and polyester woven fabrics was used to quantitatively determine and reduce the gap between the two fiber generics. The physiochemical characterization of cotton and polyester fabrics was undertaken. Using systematic intelligent computations, the most distinguishing sensory attributes between cotton and polyester woven fabrics were identified. Functionalization of polyester fabrics using caustic treatment and a silicon-based softener was undertaken to enhance the sensory perception. Also, the use of photo-assisted surface grafting on polyester was used to enhance the wetting property of polyester woven fabrics. Moisture behavior was studied with three moisture tests.

Description of most relevant results obtained in the PhD career

The sensory study of polyester and cotton fabrics noted pronounced dissimilarity between fabrics of dissimilar generic (i.e between cotton and polyester). Towards cotton replacement via this sensory approach, the modification of stiffness of polyester woven fabrics has been judiciously suggested. It was also noted that sensory perception can be expressed via vision and touch, and that PET and cotton fabrics can be distinguished by appearance. NaOH and softening treatment of polyester bridged between cotton and polyester woven fabrics studied. NaOH and softening treatment on PET fabrics yield fabrics perceived *soft*, *smooth*, *less crisp*, and *less stiff* compared to untreated polyester fabrics. Caustic soda-treatment on polyester fabrics enhances the air permeability and hydrophilicity, although it induces loss in weight— accompanied with loss in abrasion resistance and bursting strength. Caustic soda-treated polyester fabrics become hydrophobic and less air-permeable when treated with a silicon based softener. It is deduced that characterization by human perception can play a vital role in human centered production and processing of fabrics. The sensory study of knitted fabrics indicates that fiber content, the fabric structure and physical properties influence the sensory perception of knitted fabrics. Perceived sensory attributes of knitted fabrics were found to mostly correlate with the stitch density and thickness. The sensory perception of knitted fabrics was noted to be distinct from that of woven fabrics. Towards the replacement of cotton fiber with polyester, the modification (increase) in the stiffness or drape of PET knitted fabrics has been suggested. Comparing sensory analysis and objective measurements, it was deduced that human perception cannot be directly represented by instrumental measurements. The profiling of fabrics indicates that conventional PET fabrics can be distinguished from conventional cotton fabrics using selected subjective and objective attributes. The potential of PEGDA and METAC monomers for a hydrophilic function in conventional textiles utilizing UV grafting was demonstrated. Water contact angle (WCA) measurements and dynamic moisture management tests (MMT) indicate that PEGDA and METAC induce complete wetting of PET at concentrations 0.1-5% (v:v). The grafted PET fabrics remain hydrophilic following testing using washing and rubbing fastness tests. Colorimetric measurements (K/S and CIELAB/CH) and color fastness tests on dyed PET fabrics suggest that both monomers significantly improve the dyeing efficacy of PET. Meanwhile, the hand and appearance of grafted PET fabrics remained largely unchanged, following drycleaning and laundering tests. It is suggested that PEGDA and METAC generate hydrophilic radicals/groups on PET; the macroradicals are in a form of vinyl structures which form short chain grafts and demonstrate hydrophilic function at the tested concentrations. Physiochemical and performance studies indicate that, with controlled processing

parameters, optimal products with enhanced moisture management and improved sensory perception can be obtained.

D. Publications

�2016, 4.1 Contributo in Atti di convegno, CLASSIFICATION AND MEASURE OF QUANTITATIVE DIFFERENCE BETWEEN POLYESTER AND COTTON FABRICS BASED ON SENSORY ANALYSIS, Kamalha, Edwin; Koehl, Ludovic; Campagne, Christine, International Fuzzy Logic and Intelligent Technologies in Nuclear Science Conference

�2016, 1.1 Articolo in rivista, Fuzzy classification of young women's lower body based on anthropometric measurement, Liu, Kaixuan; Wang, Jianping; Tao, Xuyuan; Zeng, Xianyi; Bruniaux, Pascal; Kamalha, Edwin

�2016, 1.1 Articolo in rivista, Optimization design of cycling clothesâ patterns based on digital clothing pressures, Liu, Kaixuan; Kamalha, Edwin; Wang, Jianping; Agrawal, Tarun-Kumar

�2017, 1.1 Articolo in rivista, Clustering and Classification of Cotton Lint Using Principle Component Analysis, Agglomerative Hierarchical Clustering, and K-Means Clustering, Kamalha, Edwin; Kiberu, Jovan; Nibikora, Ildephonse; Mwasiagi, Josphat Igadwa; Omollo, Edison

�2017, 1.1 Articolo in rivista, A mixed human body modeling method based on 3D body scanning for clothing industry, Liu, Kaixuan; Wang, Jianping; Zhu, Chun; Kamalha, Edwin; Hong, Yan; Zhang, Junjie; Dong, Min

�2017, 1.1 Articolo in rivista, Construction of a prediction model for body dimensions used in garment pattern making based on anthropometric data learning, Liu, Kaixuan; Wang, Jianping; Kamalha, Edwin; Li, Victoria; Zeng, Xianyi

�2017, 4.1 Contributo in Atti di convegno, UV assisted radical graft polymerization on poly-(ethylene terephthalate) for hydrophilic functionality, Kamalha, Edwin; Ferri, Ada; Periolatto, Monica; Peila, Roberta; Bongiovanni, Roberta, 2017 American Association of Textile Chemists and Colorists International Conference, AATCC 2017

�2017, 1.1 Articolo in rivista, Fit evaluation of virtual garment try-on by learning from digital pressure data, Liu, Kaixuan; Zeng, Xianyi; Bruniaux, Pascal; Wang, Jianping; Kamalha, Edwin; Tao, Xuyuan

�2018, 1.1 Articolo in rivista, Parametric design of garment flat based on body dimension, Liu, Kaixuan; Zeng, Xianyi; Wang, Jianping; Tao, Xuyuan; Xu, Jun; Jiang, Xiaowen; Ren, Jun; Kamalha, Edwin; Agrawal, Tarun-Kumar; Bruniaux, Pascal

E. Prizes and Awards

Other prizes and awards which may be worth to mention

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