MEHRAN UNIVERSITY
OF ENGINEERING & TECHNOLOGY
JAMSHORO, PAKISTAN

Department of
Textile Engineering

Textile 20 NEXUS 21

An International Conference to Mobilize Industry-Academia Connectivity

CONFERENCE PROCEEDINGS

09-10 JUNE 2021

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Editors

Dr. Awais Khatri
Dr. Shamshad Ali
Dr. Iftikhar Ali Sahito

Conference Proceedings of Textile Nexus 2021

An International Conference to Mobilize Industry-Academia Connectivity

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Editors
Dr. Awais Khatri
Dr. Shamshad Ali
Dr. Iftikhar Ali Sahito

Mehran University of Engineering and Technology
Jamshoro Sindh Pakistan

2021

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PREFACE

We are delighted to present to you the conference proceedings of the Textile Nexus 2021, An International Conference to Mobilize Industry-Academia Connectivity. Textile Nexus 2021 is held on 09-10 June 2021 at Mehran University of Engineering and Technology (MUET), Jamshoro Sindh Pakistan.

Textile Nexus 2021 was organized by the Department of Textile Engineering, MUET Jamshoro Sindh Pakistan. The aim is to provide an opportunity to strengthen the university-academia working relationship as well as addressing the challenges of the textile sector of Pakistan. It attracts the academicians, professionals, industrialists, faculty members, and graduate students from various institutions.

Textile Industry is the most important sector of Pakistan in terms of exports value and employment. Textile Nexus 2021 serves as a significant platform for the audience (participants and readers) to share, discuss and explore the recent developments in textile sector worldwide, the need to cope with the challenges and opportunities available in the post Covid-19 pandemic era and the ways to strengthen the industry-academia connectivity.

Textile Nexus 2021 has been successful in getting response from public and private sectors, universities, research organizations, stake holders, and industries in the field of Textile Engineering and Technology. Eleven renowned international academicians and eleven national industry experts confirmed their invited talks. The conference also attracted original research works, and eleven of them were accepted for presentation at the event and publication in this proceedings.

Editors thank the university management, organizing team, editorial board, event partners (Soorty Enterprises Pvt. Ltd. and WWF-Pakistan), supporting staff and students to make Textile Nexus 2021 a very successful event including publication of this proceedings. Special thanks are reserved for the invited speakers and contributors.

Editors
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FOREWORD

I am highly encouraged to learn that the Department of Textile Engineering of this university has organized Textile Nexus 2021 and is bringing this proceedings book which is the outcome of a true collaborative exchange of knowledge, practices and experience between industry and academia stakeholders of the textile sector in the post Covid-19 era. This is an appreciable effort made by the organizers and the editors of Textile Nexus 2021.

Prof. Dr. Muhammad Aslam Uqaili
Vice Chancellor
Mehran University of Engineering and Technology

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12:10 – 12:30 pm *+ 5 min QandA*	Prof. Zhaoling Li, College of Textiles, Donghua University CHINA	Flexible pressure sensor and electronic skin constructed with fibrous materials
12:35 – 12:55 pm *+ 5 min QandA*	Christian Schimper, Managing Director, Acticell Technology Solutions AUSTRIA	Modern chemicals support technologies of the future
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Moderator: Dr. Samander Ali Malik

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9:20 – 9:35 am *+ 5 min QandA*	Mr. S. Qutaba Bin Tariq, Ph.D. Scholar Department of Textile Engineering, Balochistan University of Information Technology	A study on green composite made from waste sugarcane bagasse fiber

	Engineering and Management Sciences QUETTA	
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10:20 – 10:35 am *+ 5 min QandA*	Ms. Adeela Nasreen, Research Scholar National Textile University FAISALABAD	Development and Characterization of Thermoplastic Composites Using Novel Commingled Weaving Technique
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12:40 – 12:55 pm *+ 5 min QandA*	Mr. Faraz Khan Mahar Center of Excellence in Nanotechnology and Materials, MUET JAMSHORO	Fabrication of Bio-Polymeric Nanofibers incorporated Natural Drugs Honey and Aloe-Vera for Wound Dressing Application
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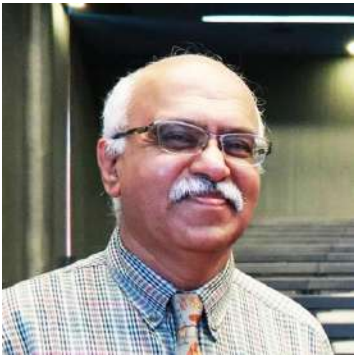
INVITED SPEAKERS (INTERNATIONAL ACADEMICIANS AND PRACTITIONERS)

ID: TN_2021_IA_1

Circular economy in textile sector for achieving SDGs: climate action, nature action, and pollution and chemical action



Dr. Mushtaq Ahmed Memon
Regional Coordinator for Resource Efficiency and SWITCH-Asia RPAC Project Manager
United Nations Environment Programme, Regional Office for Asia and the Pacific
BANGKOK
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Abstract

Increasing consumption, manufacture and use of textile products affect the global climate, the quality of ecosystems and human health, through their high use of energy, chemicals, land, and water High social risks despite the much-needed employment and essential human services it provides High use of energy and/or natural resources: extensive use of chemicals in cotton cultivation and wet textile processing particularly impacts on human health and ecosystems Priority actions are 1) the need for stronger governance to drive the change; 2) the need for collaboration and financing to implement solutions; and 3) the need to change consumption habits.

ID: TN_2021_IA_2

Smart textiles and their applications

Prof. Sung Hoon Jeong
Management Vice President
Department of Organic and
Nano Engineering
Hanyang University
SOUTH KOREA

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Abstract

Smart textiles are becoming more integrated with smart materials and new textile systems that beyond the traditional and current textile industry. Smart textiles are intelligent textile system that can sense and react to environmental stimuli, which may be thermal, mechanical, chemical, optical, biological and electrical amongst others. The scope of this presentation is focused on from smart materials to smart textiles that are classified according to their main fields of application. The objective is to present the latest commercial products together with basic concepts related to the past, present and future applications.

ID: TN_2021_IA_3

Smart textiles: from idea to market

Prof. Lieva Van Langenhove
Department of Textiles
Ghent University
BELGIUM

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Abstract
Smart textiles have been around for more than 25 years now. In spite of huge research investments, commercial successes are still limited. The presentation gives an overview of developments and applications. It highlights challenges and solutions.

ID: TN_2021_IA_4

Intelligent fibers, based on modified cellulosic fibers/textiles with a tuneable slow-release effect

Prof. Thomas Rosenau
University of Natural Resources and Life Sciences
AUSTRIA

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Abstract
The problem of excess and uncontrolled drug release is a common. The modification of cellulose for slow release of active species is one of the ways to control release of active substances. The slow release of drug can be achieved by matrix structures with covalently bonded modified cellulose. Herein, novel trifunctional triazines for the modification of cellulosic material were prepared from cheap chloride. The two stage fixation was performed. In the first stage OH group was covalently bonded with cellulose and in second stage a drug carrier was formed. However, the compounds employ a cellulose-reactive anchor group for fixation, an active substance showing slow release properties, and a reactivity tuner to facilitate release control. According to this study, humidity acts as an external trigger to facilitate the slow-release. While the release-compounds are completely stable under dry conditions, the active substances are released simply by surrounding moisture. The reactivity tuner controls the rate of the release by choosing an appropriate tuner. The concentration maximum can be set anytime between minutes and several weeks. The release kinetics depends mainly on the structure of reactivity tuner and active substance, but only insignificantly on the type of the cellulosic carrier matrix. Thus, matrix carriers with variant drug release can be formed by selecting specific cellulosic matrix. Apart from the inherent limitation to phenolic and carboxylic active substances, the approach is quite general as the active substances may encompass wide ranges of compounds and applications. The product can be used in cosmetics, paper, towel and disposable products. The yield is a cheap and relatively available as modified drug carriers.

ID: TN_2021_IA_5

Smart micro-nano fibrous materials for ultrahigh moisture and thermal management textiles

Prof. Xianfeng Wang
State Key Laboratory
for Modification of Chemical Fibers and Polymer Materials
College of Textiles, Donghua University
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Abstract
Growing need for the directional moisture transport technology has driven scientists into developing new materials and techniques for various applications, from clean water collection from fog to designing functional textiles for comfortable apparels. Moisture transport behavior is of critical significance for regulating the comfort characteristics of textiles, more specifically apparels that are designed for sportswear or workwear. Moisture transport and heat dissipation are the two major performance-regulating factors of comfortable textiles. It is worth noting that rapid water transport relies on abundantly interconnected capillary pores, while sufficient heat dissipation requires a dense structure, indicating the conflict between water transport and heat dissipation. Therefore, combining these two opposite functions of extracting excessive sweat and eliminating the heat stress within the functional textile represents an urgent technological challenge.

This presentation summarizes our current research activities to respond this challenge by developing promising functional nanofibrous materials. Practical application performance of these fibrous materials/membranes for effective moisture and thermal management are systematically introduced.

ID: TN_2021_IA_6

Development of nanofiber based protective materials for antiviral and antibacterial performance

Prof. Kai Wei
National Engineering Laboratory for Modern Silk, College of Textile and Clothing Engineering,
Soochow University
CHINA

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Abstract
The recent outbreak of a coronavirus disease (COVID-19) has posed a great threat to public health and financial system. Most current masks used to prevent the spread of COVID-19 are typically absence of antiviral and antibacterial properties. Multilevel structured nanofiber filter can provide high interception of fine particles and low pressure drop. Meanwhile we designed a novel composite nanofiber filter having antiviral activity for H1N1 virus. To examine the potential of electrospun nanofibrous webs as barriers to liquid penetration in protective clothing systems for medical workers, layered fabric systems with electrospun polyurethane fiber web layered on spunbonded nonwoven were developed. Effects of electrospun web density on air permeability and water vapor transmission were assessed as indications of thermal comfort performance. Penetration testing showed that a very thin layer of electrospun polyurethane web significantly improved barrier performance. Air permeability decreased with increasing electrospun web area density, but was still higher than most of protective clothing materials currently available. Hence, nanofiber based protective materials have a great potential applications for public health and medical protections.

ID: TN_2021_IA_7

Study on interaction mechanism between geo-textiles and optical fiber sensors

Prof. Cheng-Yu Hong
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CHINA

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Abstract
Optical fiber sensors and geotextiles are popular textile based structures/sensors widely applied in various fields. In this presentation, a brief introduction of typical optical fiber sensor technologies including fiber Bragg grating (FBG), Brillouin Optical Frequency-Domain Analysis (BOFDA) and typical geotextile structures are conducted. Applications of optical fiber sensors in some special fields such as mechanical performance monitoring of geogrids embedded inside slope models and internal strain/temperature monitoring of manufactured prototypes within additive manufacturing process are investigated. Typical pressure sensors manufactured using additive manufacturing technologies is examined to valid their measurement performance. It is found that optical fiber sensors fabricated using both additive manufacturing and BOFDA technologies can be used for the measurement stress/strain measurement. These sensors are characterized by the advantages of immunity to electromagnetic interference, small size, high accuracy, ease of design, ease of customization, low cost, etc.

ID: TN_2021_IA_8

Flexible pressure sensor and electronic skin constructed with fibrous materials

Prof. Zhaoling Li
State Key Laboratory for Modification of Chemical Fibers and Polymer Materials
College of Textiles, Donghua University
CHINA

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Abstract

Flexible pressure sensor and electronic skin are of great significance in discriminating various pressure changes and reproducing comprehensive capabilities of biological skin, which demonstrate wide practicability in many emerging fields. Currently, the majority of reported pressure sensor and electronic skin are made from airtight elastic rubbers or dense films serving as electrodes, substrates, and working layers. Ever though these mechanically stable materials perform outstanding flexibility and high stretchability, they are not permeable to air or water vapors, making them impractical to be widely used on human body, since they may cause human skin discomfort and even induce inflammation and itching, especially after wearing for a long time. Exploration of comfortable and breathable constructing materials with excellent sensing capabilities becomes a desired solution to enable the continuous operation of wearable devices.

In this presentation, I summarize our current research activities to respond these challenges by developing promising functional nanofibrous materials. Practical application performance of these nanofibrous materials in the areas of flexible pressure sensor and electronic skin for physiological monitoring and tactile sensing is systematically introduced.

ID: TN_2021_IA_9

Modern chemicals support technologies of the future

Mr. Christian Schimper
Managing Director, Acticell GmbH, Vienna, AUSTRIA

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Abstract

Acticell is a research company that develops innovative solutions for new trends in the textile industry. Acticell is specialized in the field of cellulose chemistry, especially in the textile industry. Acticell know-how can replace the environmentally harmful potassium permanganate in bleaching of jeans and offers solutions for new technologies like laser and ozone. Beginning of the year 2021 the new ATMOSPHERIC process was launched by Jeanologia, which uses an Acticell product to replace stonewash by ozone. Worldwide leading jeans labels already rely on production processes with Acticell technology.

ID: TN_2021_IA_10

Construction and application of the textile-based regeneration scaffold

Prof. Lu Wang
Key Laboratory of Textile Science and Technology of Ministry of Education
College of Textiles, Donghua University
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Abstract
This presentation focus on the textile-based scaffold in the fields of tissue induced regeneration. Textile materials can be matched to the natural tissue in terms of morphology, scale, and viscos-elastic mechanical characteristics by adjusting the structural parameters. Fibers assembly formed a uniform and controllable space grid structures, which provided space for the transportation of nutrients, gas, wastes of cells, and could induce functional tissue regeneration. There are several basic properties of those scaffolds (e.g., composition, topographical substrates, mechanical stimulation, 3D microenvironments), which is closely associated with cell behaviors (e.g., cell adhesion, spreading, proliferation, cell alignment, and the differentiation) and tissue/organ functions. For example, aligned fibers enable to induce cellular and ECM alignment, which is consistent with the topography of ligaments. This presentation discussed textile induced regeneration mainly from two levels. Firstly, summarize the factors of the textile-based scaffold that may influence cell behaviors and tissue regeneration. Then, illustrate scaffolds with different textile technology may proper for preparing which kind of tissue, such as blood vessel, tendon, bone et al. The discussion of challenged and perspective on the development of textile-based tissue-engineered has significance guiding researchers who want work with textiles and providing a perspective from human tissue structure.

ID: TN_2021_IA_11

Virucidal effect against coronavirus SARS-CoV-2 of a silver nanocluster/silica composite sputtered coating on textiles

Prof. Monica Ferraris,
Dr. Cristina Balagna and Dr. Sergio Perero

Politecnico di Torino
Department of Applied Science and Technology, ITALY

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Abstract

During the current pandemic of COVID-19 caused by the new Coronavirus SARS-CoV-2, the confinement measures slowed down the contagion, but did not completely avoid the disease diffusion for health workers, patients and the remaining population. The individual protection equipment (e.g. facial masks), filters for air conditioning systems and common textiles do not possess an intrinsic antimicrobial/virucidal action and they are susceptible to microbial/viral colonization. An efficient antimicrobial/virucidal technology suitable to be applied on textiles is crucial for maintaining a safe environment and protecting people, in particular when lockdown is eased. This talk reports about the virucidal effect, preliminary verified towards Coronavirus SARS-CoV-2, of a silver nanocluster/silica composite sputtered coating, directly applicable on a FFP3 mask.

INVITED SPEAKERS (NATIONAL INDUSTRY EXPERTS)

ID: TN_2021_NIE_1

Role of industry-academia-government collaborations for the growth of textile sector of Pakistan

Dr. Tauqeer Tariq
Chairman
Quetta Textile Mills Ltd.
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Abstract
Textile Industries are the largest profit making industries in Pakistan. But, certain reasons such as not engaging the qualified youth and academia, and lack of in-country innovation, RandD and technological development leading to new ideas and research-based practical solutions, have slowed the industry growth. For example, during the current pandemic of COVID-19, which is almost a year old now, the textile sector of Pakistan is unable to develop proper SOPs for its operation. Organization have developed their own individual practices; however, a joint venture should be made instead involving the stakeholders of industries, academia and government. Many industries became non-operational due to the lack of healthy collaborations. And, the business which is lost due to that has created and may bring a huge socio-economic loss to the country. Therefore, textile industries must move forward with innovation based developments through healthy collaborations and should expand their businesses to the other high value markets and global needs such as medical, health and hospital supplies.

ID: TN_2021_NIE_2

Nut bolts of an innovation economy

Mr. Imtiaz Rastgar
Chairman
Rastgar Group of Companies
ISLAMABAD Pakistan

imtiaz@rastgar.com

Abstract

Every university has a discernible, unique business / technology / skills / ecosystem around it. Recognition and mapping of such ecosystem to bridge knowledge and do-how gaps can create wealth for the clusters around the university while helping sustainability of the university and genuinely growing its knowledge pool for advancement of faculty members, self-employment of new graduates, etc. Being deeply involved with the HEC Pakistan and several universities at the highest level and more than half a century of business life, Mr. Rastgar brings some unusual perspectives as a thought leader. Academia can benefit from his thought for creating its future strategies in a world where formal education is under challenge from informal, democratized, education channels.

ID: TN_2021_NIE_3

Textile sector challenges and sustainable solutions

Mr. Sohail Ali Naqvi
Sr. Manager
Fresh Water Program
WWF-Pakistan (Event Partner)
LAHORE Punjab Pakistan

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Abstract

Textile sector serve as the backbone our country's economy, accounting for 63 percent of exports and contributes about 9% of our GDP. It employs moreover 40% of the country's entire industrial workers. The energy crisis is the main issue in Pakistan but it has severely affected our textile sector. A part from raw material, this sector solely depends on energy and water for the efficient production.

Globally, the concept of circular economy and green supply chain is gaining attention to replicate this concept in Pakistan, World Wide Fund for Nature (WWF-Pakistan) in collaboration with International Labor Organization (ILO) is implementing a European Union funded project, entitled 'International Labor and Environmental Standards Application in Pakistan's SMEs (ILES)'. The project adopts a two-pronged approach by targeting improvement in environmental governance and compliance in the leather and textile sector of Pakistan for leveraging the economic benefits of the European Union's Generalized Scheme of Preferences (GSP+).

ID: TN_2021_NIE_4

Entrepreneurial growth of the industry and role of universities

Dr. Athar Osama
CEO
Pakistan Innovation Foundation,
and Former Member SandT
Planning Commission
ISLAMABAD Pakistan

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Abstract

Innovation and entrepreneurship are the backbone of global prosperity. Countries (and industries) that have developed rather than declined the world over are the ones that have reinvented themselves through creative deployment of new knowledge (research) and technology (innovation). Pakistan is no exception. Pakistan will be able to build a solid track record of continued economic growth and development if, and only if, it is able to use new knowledge and technology to enhance the value and competitiveness of its products and export globally. Corporate / Industrial sector as well as Universities play a critical role in the creation and diffusion of this new knowledge and technology. However, these processes are not very well developed and quite misunderstood in Pakistan. This talk describes this, often misunderstood, landscape and present a model of university commercialization and faculty entrepreneurship that has the potential to succeed and help create and spread the economic benefits of innovation and entrepreneurship within the textile sector and beyond.

ID: TN_2021_NIE_5

Innovation in performance textiles as a post-covid trends opportunity for Pakistan textile industry

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Abstract
Pakistan's textile industry has strived a lot in the last months due to Covid-19 and it is well-established that proper representations of performance textiles and innovative solutions are more effective than abstract concepts. The aim of this presentation is to talk about the innovation and product researches, production viability, branding and marketing and provide integrated solutions and opportunities. Main focus is on introducing durable fabrics, cut resistant and UV resistant materials, specialty chemicals and membranes and armoring, highlighting moisture management, strength and other specialized features.

ID: TN_2021_NIE_6

Combined heat and power (CHP) applications in textile industry

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Abstract

The talk provides an overview of the evolution of Combined Heat and Power (CHP) methods as well as their application in the energy system. A CHP requires a significant investment, but it has an immense potential for energy savings, which ultimately reduces operational costs. It is critical to understand that several factors must be combined in order for a CHP plant to be successful. The very first step is to conduct a thorough examination of estimated load profiles and thermal-to-electric ratios. Following that, detailed engineering should be pursued to investigate the applicability of various types of energy efficient technologies and system sizing. Other important considerations when designing a CHP system include system reliability, economic analysis for CAPEX and ROI (return on investment), and protection from volatile fuel pricing.

ID: TN_2021_NIE_7

Relationship between textile sustainability and testing

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Abstract

Sustainability compliances have become a real challenge for the textile industry and businesses. For which testing plays a key role in the whole process and the system. This talk covers the relationship between Textile Sustainability, QA/QC, ZDHC/RSL Testing and Environmental Testing. The presentation would cover tips to integrate the supply chain, product development and production as per global compliance requirements highlighting critical control points which are often missed by factories which result in surprises.

ID: TN_2021_NIE_8

Challenges faced by denim textile industries in the post Covid scenario

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Abstract

The talk covers how the international market has changed after Covid-19, and what challenges as well as opportunities it has provided to the denim and the textile industry of Pakistan. Global competitions is becoming tougher due to factors such as sustainability, the ever changing fashion trends and requirements of customers have been the key factors. The talk emphasizes why is research and development the only way to moving forward, and what role collaborations can play in it. It also covers highlights on current trends of the denim business and future of denim industry of Pakistan.

ID: TN_2021_NIE_9

Challenges and opportunities for textile industry in post covid-19 era

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Abstract
Covid-19 pandemic has been an unprecedented public health crisis that has exerted an external shock on the global economy. Despite this, the textile and apparel industry could be a key engine for growth and employment in certain developing countries particularly Pakistan. Countries building back after covid-19 should not ignore the textile and apparel industry. It is considered a starter sector in the road to industrialization. The global textiles and apparel industry market has a retail market value of $ 1.9 trillion in 2019 and is projected to reach $ 3.3 trillion in 2030 growing at a compound annual growth rate of 3.5% according to a study conducted by Boston consulting group. This talk focuses to assess the impact of this out break and how it has severely affected the micro, small and medium sized enterprises (MSMEs), their challenges and ways to survive and revive from this crisis and how this situation can become an opportunity for Pakistan to change textile business dynamics in country.

ID: TN_2021_NIE_10

Current challenges for the growth of textile industry and business

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Abstract

Indigenous development has been lacking in the country. And, import of raw materials leads to loss of businesses due to increased costs. For example, Pakistan's textile industry has been based and developed mainly on cotton as a raw material. However, the quality of cotton in Pakistan has deteriorated over time due to poor qualities of indigenous seed and inappropriate cultivation practices. This talk emphasis that indigenous research and development should be focused at the local challenges such as shortage of inland good quality cotton and import of other raw materials. Such development is possible if universities perform the research activities in collaboration if the industry to solve local challenges and the Government should also support such projects through funding and developing suitable policies and legislations.

ID: TN_2021_NIE_11

Challenges in towels industry especially in the post covid-19 era

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Abstract

As the Covid-19 era emerged, the fashion and retail brands started closing that resulted closure of textile industry around the world. The world realized to survive with Covid-19 smartly and some country like Pakistan started production in difficult times. Due to extended lock downs in some competitor countries, the orders shifted to Pakistan and so the towel industry receive good attention. This talk comprises of discussion on challenges in Towels Industry especially in the post Covid-19 era and benefit from the opportunity.

RESEARCH PAPERS / ABSTRACTS

Paper ID: TN_2021_RP_1

Screen printing of electrospun nanofibers membrane with PDA polymer

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Abstract. The use of Electrospun Nanofiber Mats (ENMs) for functional and aesthetic purposes has been discovered in recent times. Herein, the preparation of print paste formulation containing the PDA (Polydiacetylene) polymer has been investigated for the first time. Screen printing method was employed to apply the prepared print paste on cellulose ENMs, and the process parameters were optimized. Electrospinning method was used to fabricate cellulose acetate ENM followed by its deacetylation with caustic soda to prepare CEL ENMs. Distinct blue color was developed with 254 nm UV-irradiation of printed CEL ENMs. We achieved good color strength (*K/S*=3.1) on printed ENMs.

Keywords: Electrospun nanofiber mats; print paste; PDA polymer; screen printing method; cellulose; electrospinning method

1. Introduction

Electrospun nanofibers mats (ENMs) have attained significant importance because of the unique properties at nanoscale. Currently, electrospinning is the major technique used for the production of electrospun nanofibers membrane [1, 2]. The dyeability of ENMs obtained profound interest in recent times [3]. To date, various dyeing methods have been reported on CEL ENs [4].

The dyed ENs have one color and lacks the presence of multiple colors and/or design. Therefore, one study has been undertaken in which reactive dye was applied with screen printing method on ENs [5] that explored the potential of creating color-pattern on ENs mainly for aesthetics. In this study, an attempt has been made to print the CEL ENs with PDA polymer for the very first time. Flat screen printing method was chosen due to its simplicity, low cost and quick applications on the fiber surface [6, 7]. Various parameters were optimized to obtain PDA-pattern/design on CEL ENs.

2. Materials and methods

2.1 Materials

Cellulose acetate (CA) was acquired from the Aldrich Chemical Company (USA) with molecular weight = 30 kDa and 39.8% acetyl content. 10, 12-pentacosadiynoic acid (PCDA) was received from Sigma Aldrich. Printofix CA Liq (thickening agent), Sodium alginate (thickening agent), Helizarin 77N binder and Liquor ammonia were provided by Archroma Pakistan Limited. For all the experiments deionized water was used.

2.2 Screen printing of CEL ENMs For preparing stock paste of 100 g, deionized water (97.8 ml), printofix CA Liq (1.8%) and liquor ammonia (4 g/kg) were used. The resultant mixture was mixed and homogenized by stirring it for 30 min at room temperature.

Printing screen was made up with polyester fabric with mesh size of 120. For printing, the CEL ENMs were placed on the printing machine and print paste was applied with 1 stroke of metallic rod using controlled pressure of 34 Pa and print speed of 3.95 (m/s). Each printed sample was dried at 70ºC for 360 sec followed by fixation in oven dryer.

The PCDA-printed CEL ENMs were exposed to 254 nm UV-irradiation to produce PDA polymer-printed CEL ENMs. The effect of PCDA concentrations (150 mg, 200 mg, 250 mg, 300 mg, 350 mg), fixation temperatures (100ºC, 110 ºC, 120 ºC, 130 ºC, 140ºC), and fixation time (45 sec, 60 sec, 75 sec, 90 sec, 105 sec) was observed.

2.3 Determination of Color strength (*K/S*) of printed samples

The PDA polymer-printed samples were pre-conditioned for one hour before testing. Measurement of *K/S* with Kubelka-Munk equation (eq. 1) and CIE $L*$ (lightness/darkness) $a*$ (redder/greener) $b*$ (blueness, yellowness) $C*$ (chroma) and h^o (hue angle) coordinates were done on spectrophotometer (X-Rite CE-7000A) with aperture size (9 mm), D65 illuminant and 10^o standard observer, UV and specular component included on the maximum absorption peak.

$$K/S = \frac{(1-R)^2}{2R} \quad (1)$$

3. Results and discussion

3.1 Effect of PCDA concentration on *K/S* and CIE *L*a*b** values

Figure 1 portrays that *K/S* of the prints enhanced gradually with an increase in the PCDA concentrations up to 350 mg, indicating good color build up after 254nm UV induced polymerization on CEL ENMs for 2 min. The maximum *K/S* of the prints obtained was 3.0828 at 350 mg PCDA concentration. Therefore, further experiments were performed at PCDA concentration of 350 mg [8].

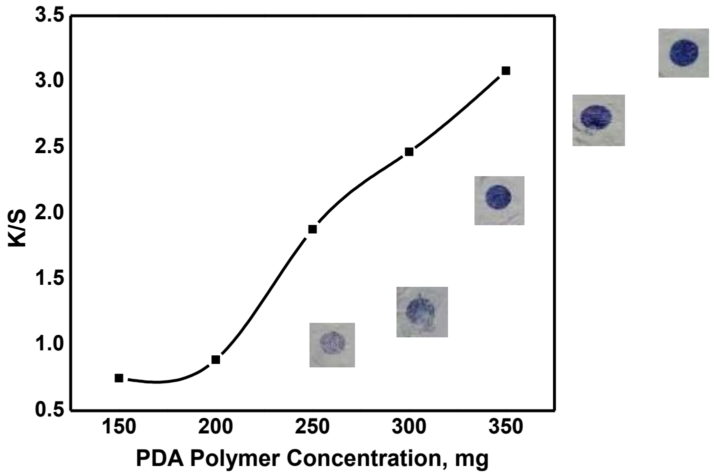

Fig. 1: Effect of PCDA concentration on *K/S* of printed CEL ENMs

The colorimetric values of the PDA polymer-prints have been given in Table 1. It can be observed that with the increased concentrations of PCDA up to 350 mg, the lightness values (L^*) have decreased indicating that the printed webs got darker. With increasing PCDA concentration, the PDA polymer-printed ENMs are moving towards redder region (positive a^*). Likewise, negative b^* designated for blueness. Hence, the obtained results indicate the blue tone of PDA polymer-prints; this can be proved by hue angle h^o that shows all values within the bluer region.

Table 1: Effect of PCDA concentration on colorimetric values of printed CEL ENMs

PCDA conc. mg	L^*	a^*	b^*	C^*	h^o
150	66.67	0.17	-13.91	13.91	270.68
200	63.17	1.46	-13.88	13.95	275.99
250	50.87	5.24	-16.43	17.24	287.70
300	47.19	7.11	-15.48	17.04	294.67
350	44.04	8.19	-17.14	19.00	295.53

3.2 Effect of Fixation temperature and time on *K/S*

Figure 2 depicts that *K/S* of the PDA-polymer prints improved noticeably as the fixation temperature increased from 100°C to 120°C. This may possibly be due to the reasons that PCDA molecules did not agglomerate together, released from thickener film and attached to the CEL ENM, as well as enhanced binder film formation [9].

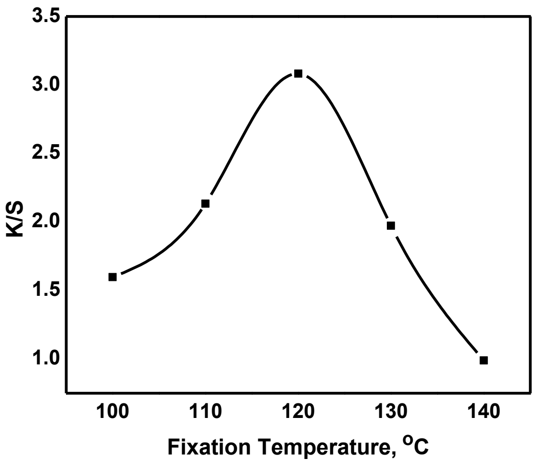

Fig. 2: Effect of fixation temperature on *K/S* of PDA polymer-printed CEL ENMs

However, further increase in the fixation temperature to 130-140°C have caused decline in *K/S* of the PDA-polymer prints of CEL ENMs as shown in Figure 2. It has been reported previously that substantial amount of intermolecular link were formed of PDA film at 120°C. But, increasing temperature to 120-140°C destroyed the formed links [10]. In addition, high fixation temperature caused change in the thickener structure that may have hindered the release of PCDA molecules onto the CEL ENM. Also, required binder film properties were not achieved to hold the PCDA molecules on the surface of CEL ENM. The maximum *K/S* of the PDA-polymer print was 3.0 at 120°C fixation temperature. Therefore, further experiments were done at fixation temperature of 120°C.

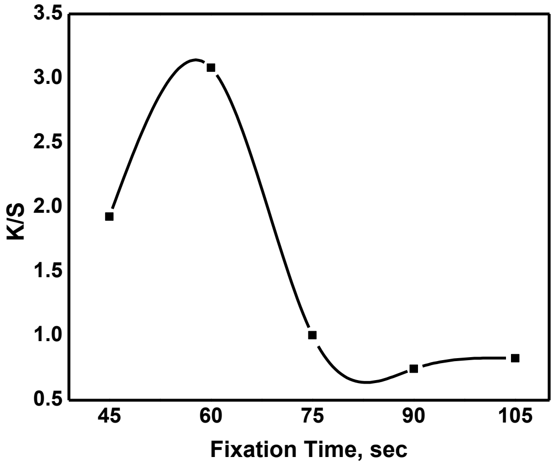

Fig. 3: Effect of fixation time on *K/S* of PDA polymer-printed CEL ENMs

Figure 3. Demonstrates the influence of fixation time on printed ENs with PDA polymer. It can be seen that *K/S* of the PDA-polymer prints increased by the rise in fixation time from 45 to 60 sec (Fig. 3). The maximum *K/S* achieved was 3.0 (Fig 3). However, further increase in fixation time showed substantial fall in *K/S* of CEL ENM that may be due to longer exposure of heat resulting into the deformation in PDA polymer chain structure. Hence, an optimum fixation time of 60 sec was chosen for further experiments.

4. Conclusions

Print paste formulation containing the PCDA was successfully printed on CEL ENMs by screen printing method for the first time. Formation of PDA polymer in the CEL ENM was achieved by 254 nm UV-irradiation for 120 sec. Moreover, *K/S* of the prints was gradually improved with a simultaneous rise in the PCDA concentrations. The maximum *K/S* acquired was 3.1 at 350 mg PCDA concentration. The optimized screen printing parameters were found to be: fixation temperature- 120°C, fixation time- 60 sec and 254 nm UV-irradiation for 180 sec.

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Paper ID: TN_2021_RP_2

Sustainable reactive dyeing process for readymade garments

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Abstratct. This present study concerns with the exhaust process of cotton garments using organic salt GLDA-Na_4 (glutamic acid diacetic acid, tetra sodium salt expressed as GLDA-Na_4) as an exhausting and fixing agent, used as a replacement to inorganic chemicals. The reactive dye, (CI Reactive black 5), at 1% shade, was selected for dyeing of cotton garments. The dyeing results were assessed on the basis of color strength (*K/S) and* dye fixation *(%F)*. The colorfastness to light, rubbing and washing of dyed cotton garments, obtained by using GLDA-Na_4 were good and were approximately same as obtained by using inorganic salt and alkali. The reduction content of total dissolved solids and replacement of salt, results the less polluted dyeing effluent which is environmentally sustainable.

Keywords: Exhaust reactive dyeing; exhaustion and fixation; cotton garments; organic biodegradable compound; color strength (*K/S*)*;* dye fixation (*%F*)

1. Introduction

At present, the reactive dyes are used as the largest dye group for dyeing cotton. They are anionic and have a wide colour range from bright shades to pale/dark shades for cellulosic, amide and protein fibres [1]. They form covalent bonds with the substrate either by substitution (tri-azinyl ring system) or addition mechanism (vinyl sulphone) [2]. The colorfastness properties of reactive dyes are excellent owing to their strong dye-fibre interaction except for washing fastness due to their hydrolytic property [3].

Batchwise reactive dyeing is completed in two stages i.e. Dye exhaustion with an electrolyte and fixation with strong alkali [4]. Intensive research has been donein order to eliminate or minimize the use of inorganic salts [5]. The use of organic compounds can be effective replacement to inorganic alkalis and electrolytes [6, 7]. The use of polycarboxylic acid salts instead of sodium chloride (NaCl) in reactive dyeing has resulted into higher exhaustion and dye fixation (*%F*). In a previous report, Trisodium NTA (Trisodium nitrilo triacetate) was used as an alkali and electrolyte simultaneously in pad steam dyeing of cotton. It has demonstrated a potential advantage of reduction in the amount of TDS of dyeing wastewater [8]. Furthermore, tri-reactive dye range claims to reduce energy consumption and water considerably at lower temperatures [9].

In this research work, reactive dyeing of readymade cotton garments pieces with biodegradable organic salt was studied. For comparison, cotton garments pieces were also dyed with inorganic chemicals. We found equivalent colour strength (*K/S*) and *%F* of reactive dyes with biodegradable organic salt.

2. Experimental

2.1 Materials

In this research work, 100% cotton readymade garment (half-bleached, ready-to-dye pant) was used. It was received from Lucky Textile Mills Limited, having CIE whiteness index of 49.1. The pant was cut into fabric pieces to perform laboratory experiments. The dye (CI Reactive Black 5), Drimagen E-4R (levelling agent) and Ladipur RSK (detergent)were provided by Archroma Pakistan. The alkaline biodegradable organic compound, GLDA-Na_4 (glutamic acid diacetic acid, tetra sodium salt) was provided by AzkoNobel Pakistan. Sodium chloride (NaCl) and sodium carbonate (Na_2CO_3) were of analytical grades.

2.2 Method

2.2.1 Batchwise cotton garment dyeing using NaCl and Na_2CO_3 and Using GLDA-Na_4

Specimen, cut from the pant was used for exhaust dyeing process with reactive dye. At the exhaustion stage of dyeing, specimen was treated with NaCl and then 1% CI Reactive Black 5 (o.m.f) was added in the dye bath. At the fixation stage of dyeing, Na_2CO_3 was added in the dye bath. After that thetemperature was increased-- for fixation of dyes. The sequence of washing-off procedure was: cold rinse, hot rinse, hot rinse with Ladipur RSK and cold rinse till dye desorption was stopped. In the end, the samples were dried at ambient temperature.

Same procedure was followed for exhaust dyeing process with organic salt GLDA-Na_4 , however organic salt was used for exhaustion and fixation. All the experiments were performed on Rapid HT dyeing machine.

2.3 Measurements

2.3.1 Color yield (K/S) and dye fixation (%F)

The *K/S* and *%F* of dyed garment samples were measured on Datacolor SF650 reflectance spectrometer (USA) at the maximum absorption peak with Kubelka-Munk equation (eq. 1) as reported previously [10].

$$K/S = \frac{(1-R)^2}{2R} \tag{1}$$

where *R* is reflectance value of dyed garment sample at maximum absorption peak, *K* is coefficient of absorption and *S* is coefficient of scattering.

%F was calculated by assessing the *K/S* of dyed samples before soaping and after soaping using the following equation (eq. 2).

$$\%F = \frac{K/S\ after\ soaping}{K/S\ before\ soaping} \times 100 \tag{2}$$

2.3.2 Colorfastness properties

The dyed samples were assessed for the colorfastness to washing (ISO 105 C02), colorfastness to rubbing (ISO 105 X12) and colorfastness to light (BS 1006: 1990 UK-TN).

2.3.3 Effluent testing

By using digital pH meter (HACH sension 3), pH of dyeing effluent was tested, Digital TDS meter (Seven Compact, Mettler Toledo) was used for measuring Total Dissolved Solid contents of dyeing effluent.

3. Results and Discussions

3.1 Effect of concentration of NaCl and Na_2CO_3 in batchwise garment dyeing

Figure 1a shows that the maximum *K/S* - 16.65 and *%F* - 90.78 was obtained at 40 g/L concentration of NaCl. Then, decrease in *K/S* and *%F* was observed. This is due to the reason that by adding an electrolyte in dye bath, degree of aggregation of dye molecules has increased [11] that may have caused less dye exhaustion thereby leading to reduced *%F*. Figure 1b demonstrates that the maximum *K/S* - 14.93 was obtained at 20 g/L concentration of Na_2CO_3. Under alkaline pH, reactive dyes can also react with hydroxyl ions in dye bath which produces non-reactive hydrolyzed dyes. Therefore, at the expense of dye-fibre reaction resulting into *%F*, excess amount of alkali (Na_2CO_3) can cause dye hydrolysis [8].

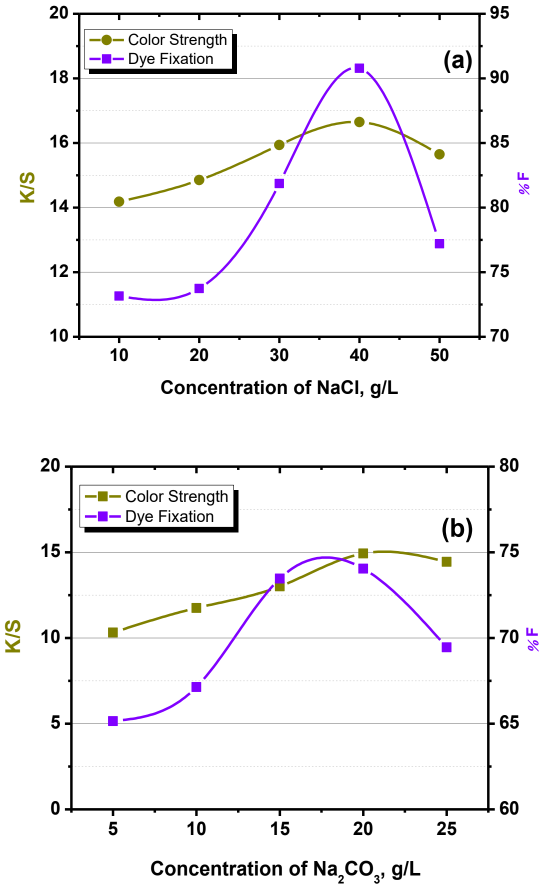

Fig 1: Effect of concentration of *(a)* NaCl and *(b)* Na_2CO_3 on *K/S* and *%F*

3.2 Effect of Fixation Temperature and Time in batchwise garment dyeing

Figure 2a shows that the maximum *K/S* - 24.88 and *%F* - 81.57 was obtained at 55ºC. Further increase in the fixation temperature gradually decreased the *K/S* and *%F*. It is due to the decreased dye substantivity towards the substrate [12, 13]. Therefore, low *%F* was experienced at higher temperature [12].

Figure 2b demonstrates that the maximum *K/S* of 24.88 and *%F* of 92.73 were obtained at 5 min. Then, gradual decrease in *K/S* and *%F* was obtained by further increasing the fixation time. This is because of the prolonged contact of dyes into the dye bath conditions (temperature and pH), which leads to decrease in *K/S* and *%F* [14].

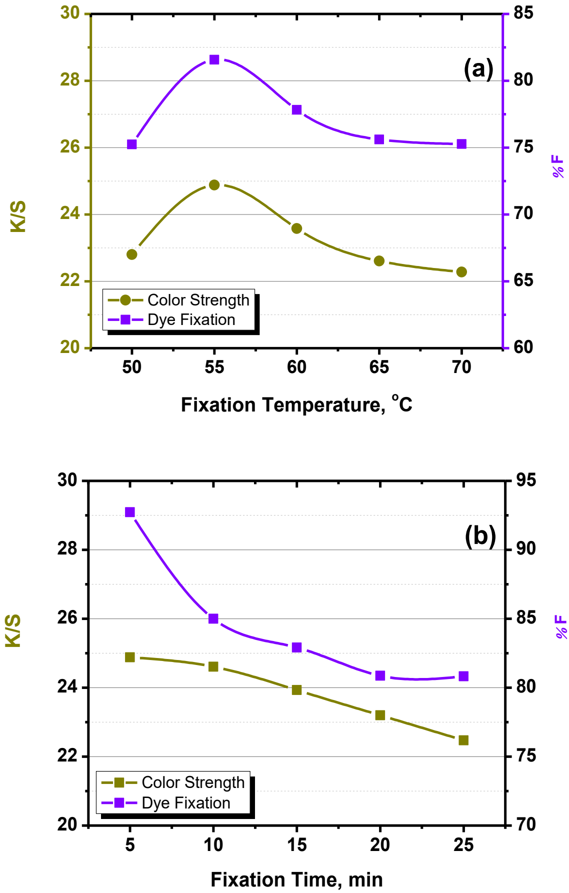

Fig 2: Effect of *(a)* Fixation Temperature and *(b)* Fixation Time on *K/S* and *%F*

3.3 Effect of Fixation Temperature and Time using GLDA-Na_4 in batchwise garment dyeing

Figure 3a shows that the maximum *K/S* - 24.6 and *%F* - 87.73 was obtained at 65ºC. This proves that GLDA-Na_4 acts as both exausting agent and fixing agent for CI Reactive Black 5. Moreover, gradual decline in *K/S* and *%F* was observed with increasing temperature following the mechanism stated previously (Figure 2a). Figure 3b demonstrates that the maximum K/S= 26.06 and % F= 88.63 was obtained at 10 min. Then, gradual decrease in K/S and %F was seen with increasing fixation time. It was due to the due to the mechanism described previously (Figure 3b). Hence, highest K/S and %F achieved of dyed sample with GLDA-Na_4 is higher than in comparison to the optimized dyed sample with NaCl and Na_2CO_3 (Figure 3).

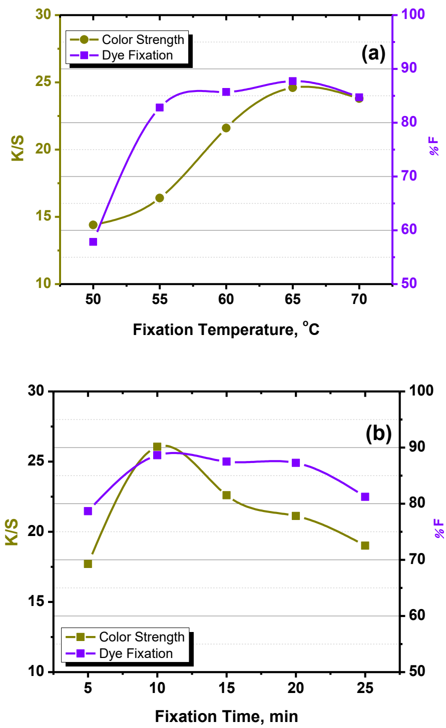

Fig 3: Effect of (a) Fixation Temperature and (b) Fixation Time of GLDA-Na_4 on *K/S* and *%F*

3.4 Colorfastness properties

As shown in Table 1, the colourfastness results to washing, dry and wet rubbing fastness of the dyed garment pieces using inorganic chemicals (NaCl and Na_2CO_3) and GLDA-Na_4 and were the same.Also, the results for colorfastness to light were found good with no significant change in color for both dyeing methods.

Table 1: Colorfastness to washing, light and rubbing results

Dyeing with	Change in color	Washing Fastness						Light Fastness	Rubbing Fastness	
		Staining on Multifiber						Blue wool reference	Dry	Wet
		CT	**CO**	**PA**	**PES**	**PAN**	**WO**			
NaCl and Na_2CO_3	5	5	4/5	5	5	5	5	5	4/5	4
GLDA-Na_4	5	5	4/5	5	5	5	5	5	4/5	4

* CT-Cellulose Accetate, CO- Cotton, PA- Polyamide, PES- Polyester, PAN-Acrylic, WO- Wool

3.5 pH and TDS of dyeing effluent

Table 2 shows the pH and TDS contents of the dyeing effluent samples. The results showed that a considerable decrease in TDS contents was observed for the effluent of the dyebath containing GLDA-Na4 (166% less TDS content) in comparison to the effluent of the dyebath containing inorganic chemicals.

Table 2: pH, TDS and COD values of dyeing effluent

Dyeing with	pH	TDS (mg/L)
NaCl and Na_2CO_3	11.8	34,050
GLDA-Na_4	10.8	12,810

4. Conclusion

The reactive dyeing process using GLDA-Na_4 has been developed by batchwise method for readymade cotton garments. Improved *K/S* and *% F* with equivalent colorfastness properties and less TDS were achieved in the developed garment dyeing process. The findings suggest that there is a great potential of the use of GLDA-Na_4 in the reactive dyeing of readymade garments by batchwise method.

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Density optimization of stainless steel and cotton composite fabric as transparent and conductive substrate for dye sensitized solar cell

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Abstract: The present DSSCs are based on (ITO/FTO) glass electrodes, which are not only costly but difficult in transportation, as well as are stiff and heavy. Textile based electrodes have lately received great interest as wearable energy sources due to their lightweight, flexibility and economic efficiency paired with the simplicity of manufacturing. In this method we have produced a flexible and conducive textile fabric that is easy to bend and at the same time electrically conductive with a certain amount of transparency. With a total of 89 warp and 180 picks/inch, simple stainless steel (SS) fabric demonstrated maximum electrical conductivity of 0.0145 Ω/sq with 35% transparency. The highest transparency in (SS weft) fabric was achieved 74 %. We believe that our suggested textile electrodes can be employed in flexible dye sensitized solar cells in the near future.

Keywords: Stainless steel; dye sensitized solar cell; composite fabric; conductive fabric; conductivity

1. Introduction

The minimal production cost and relatively high energy conversion efficiency of the Dye-sensitized Solar Cells (DSSCs) even under dim lighting have gained considerable interest. DSSCs are believed to be an appropriate solar system for urban such as building-integrated photovoltaic (BIPV) and electronically integrated photovoltaic applications (EIPV) [1-3] .

The study of lightweight and flexible solar cells is essential, due to many advantages for transport and photovoltaic energy system equipment. New designs and applications are feasible to provide mobile power for laptop computers, mobile phones, watches, etc. In addition, the replacement of a stiff substrate with a flexible material enables the manufacture of a low-cost roll-to-roll bulk production. The use of flexible equipment technologies to solar cells (DSCs) is thus of the utmost significance and is a possible cost-effective solar generation system [4-6].

Although several papers showed that flexible and bendable photoelectrodes with TCO-coated polymer substrates or metal meshes, few have till now exhibited highly bendable DSSCs [7-10]. In this study, we have proposed highly bendable textile- based electrodes, utilizing a very simple hand loom weaving machine. We have developed flexible and electrically conductive composite fabric using stainless steel (SS) wires with the cotton fabric to use this substrate in the solar cell application. In addition, it is possible to control the textile structure, size and quantity and change the electrode or spacer materials by replacing the thread. Hence, the textile based DSSC could be applied to a wide range of electrochemical devices.

2. Materials and methods

2.1. Materials

A 0.07 mm-diameter stainless steel (SS) wires purchased from Noman traders (Pakistan) and 100 % cotton yarn of 20 Tex prepared in the yarn manufacturing lab (Textile Engineering, MUET Jamshoro). A simple handloom was utilized for the weaving process. Before weaving, the stainless steel (SS) wires were rinsed with acetone, ethanol, and DI water by sonication and dried.

2.2. Methods

Different fabrics were prepared, including the ones in which cotton was used in the weft in the other one cotton was used in the warp.

(a) Stainless steel both in warp and weft

For the preparation of plain fabric, we use hand loom. First performed sarning and made 6 sq. inch fabric, used total 89 warp yarns and vary the weft density. The number of different density fabrics are summarized in the following Table 1.

Table 1. Different stainless steel (SS) fabrics with varying weft density

S. No.	Code	Density
1	SS1	180 picks/inch
2	SS2	160 picks/inch
3	SS3	140 picks/inch
4	SS4	120 picks/inch
5	SS5	100 picks/inch

After formation of different fabrics, the transparency and electrical conductivity was tested which will be discussed in the next section.

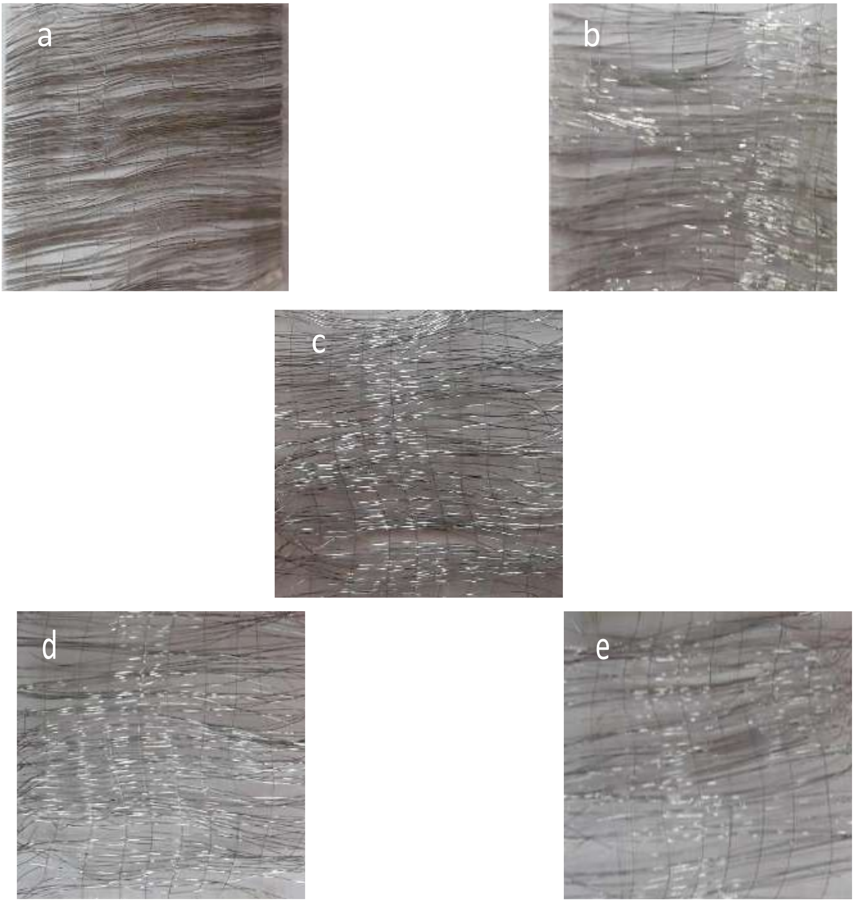

Figure 1. Stainless steel wire woven transparent and conductive electrode with different densities (a) 180 picks/ inch (b) 160 picks/inch (c) 140 picks/inch (d) 120 picks/inch

(b) Stainless steel in warp and cotton yarn in weft

In this type of fabric substrate, we made 6 sq inch fabric by using total 89 stainless steel wires in warp and cotton yarn in weft with 11 picks/inch.

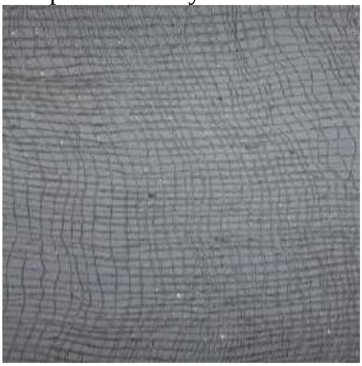

Figure 2. Fabric with stainless steel wires only in warp

(c) Stainless steel in weft and cotton yarn in warp

In this experiment we made the same 6 sq inch fabric by using total 89 cotton yarns in warp and stainless steel wires in weft with 15 picks/inch. After fabric formation we performed the transparency and electrical conductivity test, and the results are discussed in result and discussion section.

Figure 3. Fabric with stainless steel wires only in weft

3. Results and discussion

In order to make a transparent and electrically conductive fabric transparency of the developed fabric and as well as electrical conductivity was required to be tested. The transmittance spectra are measured using the UV-Vis spectrophotometer and the electrical conductivity was measured using a four-probe resistivity/conductivity meter.

3.1. Transmittance of stainless-steel fabric

Following are the results of transmittance % measure on UV-Vis spectrophotometer to quantify the allowance of sunlight which could pass through the conductive fabric. This measurement will help us to optimize the transparency and electrical conductivity. The following graphs belong to five different densities of weft yarns including 100 picks/inch, 120 picks/inch, 140 picks/inch, 160 picks/inch and 180 picks/inch.

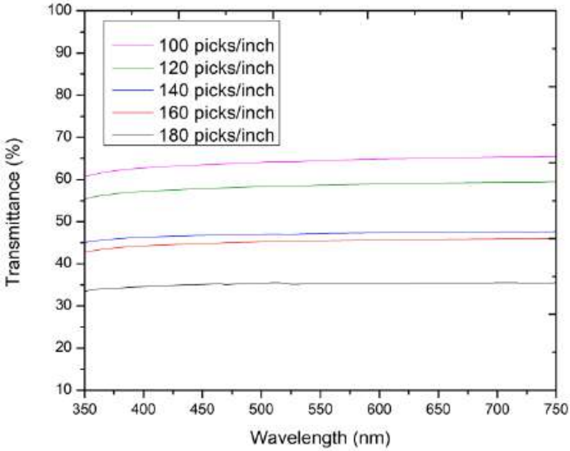

Figure 4. Transmittance of different densities of Stainless-Steel made fabric

The Fig. 4 shows a direct comparison of the different densities of stainless-steel wires used in the experiment. It can be seen that with the increase in the density from 100 picks per inch to 180 picks per inch, the transparency is inversely proportional. As we are increasing the fabric density the transparency is decreasing. At 100 picks per inch the transmittance percentage is around 60 % which reduced to around 34 % at 180 picks per inch. The conventional FTO glass used in the DSSC gives around 95 % transmittance, in such case a higher transmittance is desired, but it may be achieved at the cost of electrical conductivity. In the following section we have made comparison of electrical resistance values and in that section, we may be able to directly optimize the transparency and conductivity.

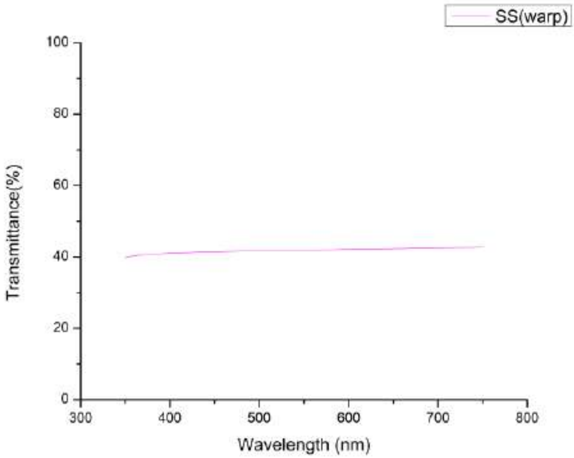

Figure 5. Transmittance of SS warp

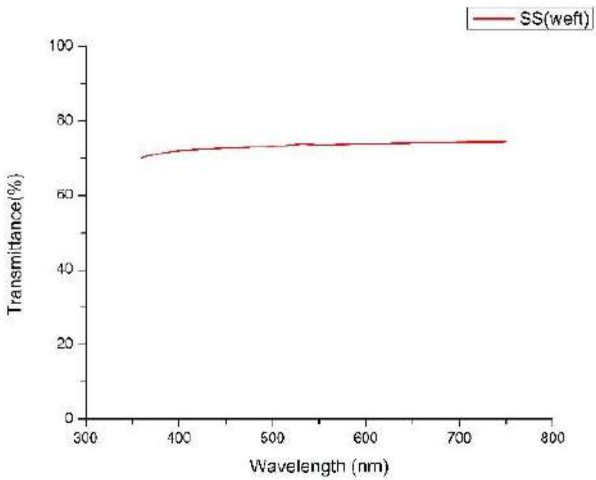

Figure 6. Transmittance of SS weft

We can see in the Fig. 5 and Fig. 6 that the stainless steel wire used in the warp direction only gave lower transmittance values because of higher density of wires in the warp direction. The transmittance % is found to be around 40 %. On the other hand, when the SS wires were only used in the weft direction the transmittance % value is much higher and close to 70 % because there is a smaller number of wefts used as wires in the fabric. Hence, we can optimize the density of SS fabric both in warp and weft directions to prepare a conductive a transparent fabric

3.2. Conductivity or electrical resistance test

Following are the results of electrical conductivity measured using a four-probe resistivity/conductivity meter and the earlier measure transmittance %. The results are summarized in the following Table 2.

Table 2. Different stainless steel (SS) fabrics with varying electrical resistance and transmittance

S. No.	Material	Electrical Resistance (ΩSq^{-1})	Transmittance (%)
1.	SS1	0.0145	35
2.	SS2	0.132	46
3.	SS3	16.8	47
4.	SS4	48.0	65
5.	SS5	42.8	60
6.	SS warp	468.7	42
7.	SS weft	706.9	74

4. Conclusions

The pure stainless steel made fabric showed better electrical conductivity of 0.0145 ohms.sq^{-1} as compared to the maximum 706.9 ohms.sq^{-1} of the composite of stainless steel and cotton. On the other hand, the conventional FTO glass which is used in the dye sensitized solar cells has the electrical resistance of 10 to 12 ohms.sq^{-1}. The transparency of the blended fabric was 74 % compared to the pure stainless steel fabric which was found as low as 35 % only, which may not be suitable for the photoanode material for the dye sensitized solar cell. As per the requirement of transparent and conductive fabric to be used as photoanode in solar cells, the optimum transparency may be above 50 %.

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Application of copper nanocluster for acid red dye removal via precipitation method

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Abstract
The present study deals with the removal of acid red via precipitation method by using polyethyleneimine capped copper nanoclusters (PEI-CuNCs), which were synthesized by the one-step chemical method**.** Currently, the application of nanocluster is used for detection and sensing purposes in the field of the medical and environmental fields. However, still nanocluster is not used for the removal of dye via adsorption or precipitation. In this study application of copper nanocluster has been used for removal of acid dye**.** Effective operational parameters including pH, PEI-CuNCs dosage, dye concentration, and contact time. The maximum removal capacity has been achieved 10000 mg/g, which is the highest achieved removal capacity than any other adsorbent up to date. The maximum removal percentage of acid red to be achieved is 97% under optimum variants including pH 9, dosage 70 µL, time 6 hours, and initial dye concentration 50-250 mg/L. The copper nanoclusters were characterized by transmission electron microscopy (TEM), dye, and sludge by Fourier transform infrared spectroscopy (FT-IR), and the dye removal percentage was determined by UV-vis spectrophotometer. Isotherm models reveal that the Langmuir model better fitted with removal result (R2 = 0.996 for different initial dye concentrations).

Keywords: Copper nanoclusters; acid red; precipitation; azo dye; dye removal

1. Introduction
Environmental cleanup is mainly focused on the removal of contaminants from polluted industrial wastewater, which destroys the ecosystem**.** In particular, the textile industry includes many types of processing steps including pretreatment,

dyeing, printing, and finishing [1]. Textile dyes are responsible to contribute to the mutagenicity of representative environmental samples [2]**.** Dye effluent is toxic, carcinogenic, and reduces the penetration of sunlight, which retard photosynthetic activity and inhibits the growth of biota [3].

There are three types of dyes concerning charges**,** anionic (direct, acid, and reactive dyes), cationic (basic dyes), and non-ionic (disperse dyes). Among this category anionic dyes are commonly used worldwide [4]**.** The charge of anionic dye becomes negative in aqueous solution because of the sulphonate (SO3) groups present in the structure of dye molecules. In acid dye, azo bonds (R-N=N-R2) are present within the chemical structure of dye and mostly belong to azo and anthraquinone groups. Removal of azo dye is generally difficult due to its high solubility in nature [5]. Due to their synthetic origin, the complex structure also makes them difficult to be biodegraded hence making them difficult to treat [6].

Therefore, this type of dye effluent is one of the most important threatening factors in environmental and human health [7,8]. There are numbers of method used for treatment of textile effluents, including the application of photodecomposition [9], electrolysis [10, 11], adsorption [12–20], oxidation [20], biodegradation [21], combined sonochemical and adsorption [22], coagulation-flocculation [23, 24], etc.

The removal of dye through the adsorption process is relatively expensive, because the regeneration is expensive due to rapid saturation and clogging of the reactors and economically non-viable for certain industries specially textile, paper, and pulp. However, the precipitation method is technologically simple, efficient, and inexpensive and also has significant reduction in chemical oxygen demand [25].

In this study, polyethyleneimine capped copper nanoclusters (PEI-CuNCs) were used to remove the acid red dye using precipitation method. Currently, nanoclusters have been used for detection and sensing purposes in the field of environment and medical, however still nanoclusters have not been used for removal of dye via precipitation or adsorption method. Recently ultra-small fluorescence metal nanoclusters (NCs) have attracted great attention due to their unique electrical, optical and physical properties in nanoclusters, possessing metal atoms in a run of few to hundred [26–27].

2. Experimental

2.1 Materials

Acid red was purchased from Archroma, Pakistan Ltd. Polyethyleneimine (PEI, 1.8K) from (Shanghal Aladdin Biochemical Technology CO., Ltd. Shanghai, China), Copper Sulphate pentahydrate ($CuSO_4.5H_2O$, 99%) from (Searle Company Limited, Karachi, Pakistan), Acetic acid (HCOOH 99%) and Sodium Hydroxide (NaOH 99%) from Sigma Aldrich (St. Louis, MO, USA) and Ascorbic acid from Merck (Kenil Worth, NJ).

2.2 Preparation of PEI-capped copper nanocluster

In this process polyethyleneimine (PEI) was used as a capping agent and ascorbic acid as reducing agent. All chemicals were added step wise, initially 0.625% (wt) of PEI and 0.1 M ($CuSO_4.5H_2O$) stock solution were prepared. Adding prepared copper sulphate pentahydrate 40 to 10 mL 0.625% (wt) PEI stock solution and the solution was continuously stirred for 2 h. Finally, few drops of acetic acid were added to adjust the pH to 5, and lastly 30 µL of 0.1 M AA was added to the solution, and continuous stirred for 2 days.

2.3 Characterization

The diameter of Copper nanocluster was characterized by Transmission electron microscopy (TEM) using Tecnai G2F30 instrument. The UV-Vis spectrophotometer was used to obtain the spectra of PEI-CuNCs solution under the wavelength of 200-600 nm. The dye removal percentage was determined using UV-vis Spectrophotometer under wavelength of 400-750 nm.

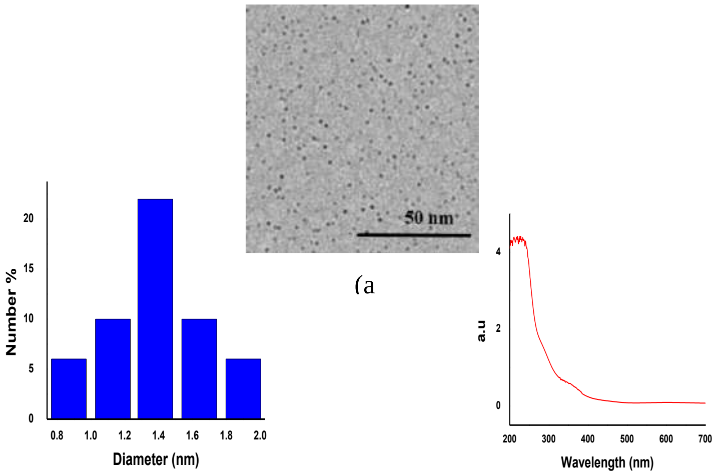
2.4 Precipitation method

The effect of different parameters was investigated under the batch-wise process. For each experiment 10 ml dye effluent were taken and added neat solution under continuous stirring for 3 minutes at 500 rpm. The concentration of dye used was in the range of 50-450 mg/L. Acetic acid and sodium hydroxide were used to adjust the pH in the range of 3-12. The time required for removal of dye was (0.75-6 hours). The concentration of diluted PEI-CuNCs was 6600 ppm, because minor quantity of PEI-CuNCs was used in each experiment. Different amounts of dosage (10- 70 µL) were added in dye effluent.

3. Results and Discussion

3.1 TEM investigation

The TEM image of PEI-CuNCs displays the diameter in Figure 1 a, b. The diameter of copper nanocluster was measured by using image software; diameters achieved were within the range of 0.8-2 nm, as shown in Figure 1 (b). The maximum number of nanoclusters was achieved to be 1.4 nm. The shape of synthesized PEI-CuNCs in spherical form was observed in the TEM image of PEI-CuNCs. These results demonstrated PEI-CuNCs were successfully prepared. Due to small surface area of the PEI-Capped copper nanocluster is increased, which indicate more dye molecules interact with nanocluster, as a result, dye removal is increased. The UV-vis spectra of PEI-CuNCs are shown in Figure 1 (c). The absorption peak of PEI-CuNCs solution was achieved at 245 nm, there is no absorption band found in a range of 560-600 nm, which indicates nanoparticles were not formed.



(b (c

Fig 1. Characterization of PEI-Capped copper Nanoclusters. (a) TEM image of PEI-CuNCs. (b) The diameter statics of PEI-CuNCs.

3.2 Precipitation Studies

3.2.1 Effect of pH

The pH of the dye bath solution plays a great role in dye removal efficiency. The pH of solution was adjusted from 3 to 12, concentration 150 mg/L, and dosage 60 µL. As shown in Figure 2 (a), (c), the removal increased from acidic to basic. The maximum and minimum dye removal achieved were 97% at pH 9 and 12 % at pH 3 respectively. At basic pH, more negatives sites electrostatic attraction creates between dye molecules and PEI-CuNCs, as a result, dye removal was increased and vice versa in acidic pH. As shown in Figure 2 (b), the UV-Vis absorption peaks decline as the removal percentage increased toward basic pH.

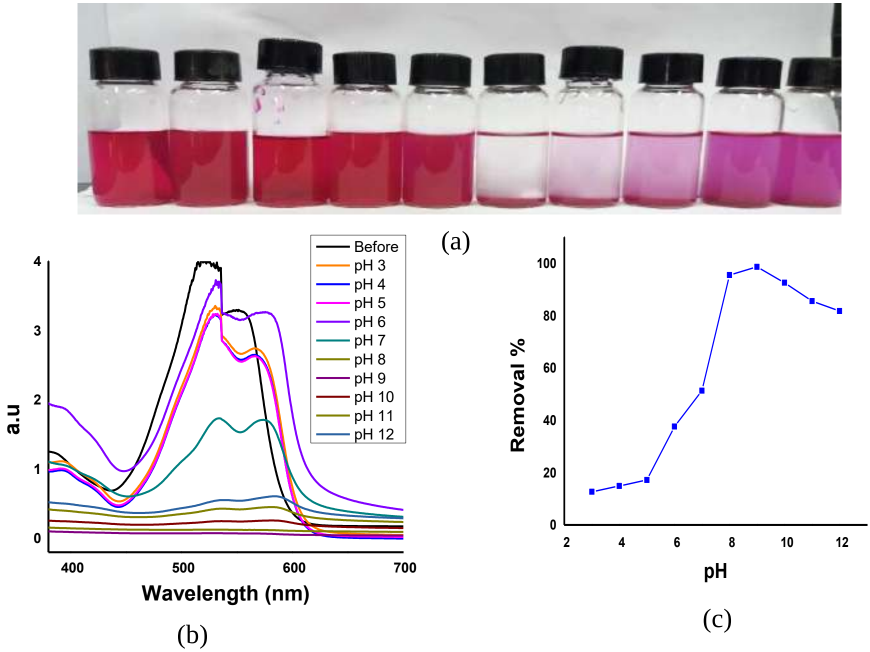
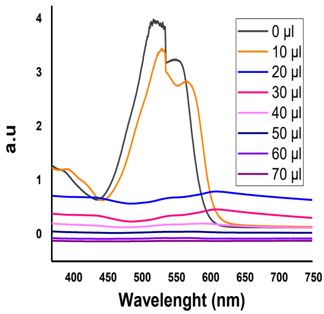


Fig 2. (a) effect on dye removal at different pH, pH increase left to Right. (b) UV-vis spectra at different pH. (c) dye removal percentage at different pH

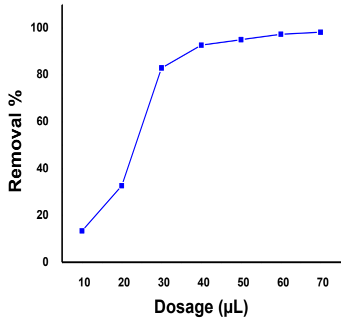
3.2.2 Effect on PEI-CuNCs Dosage

The effect of dosage (10 to 70 µL) was also investigated. The dye removal increased as the dosage of PEI-CuNCs was increased, the dosage increase from left to right, as shown in Figure 3 (a). The maximum removal was achieved (97%) which was found at 70 µL shown in Figure 3 (c). Increasing dosage to more than 70 µL does not create a significant effect of dye removal, because nanoclusters were not used to make any attraction with dye molecules due to unavailability of dye molecules and also it increases the overall cost of the process. A diluted form of PEI-CuNCs was used in each experiment to obtain accurate results. The Concentration of diluted PEI-CuNCs was 6600 ppm. As shown in Figure 3 (c), The UV peaks decline by increasing dosage. It is observed that high dye removal was obtained at a low dosage (70 µL), indicating that the high surface area of PEI-CuNCs plays great role in this regard.

(a)



(b)



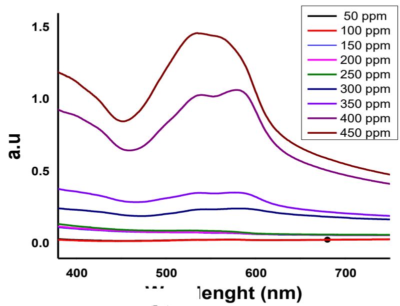
(c)

Fig.3. (a) Image of dye removal at different amount of dosage, Dosage increase left to right. (b) UV-vis spectra at different dosage. (c) dye removal percentage at different dosage

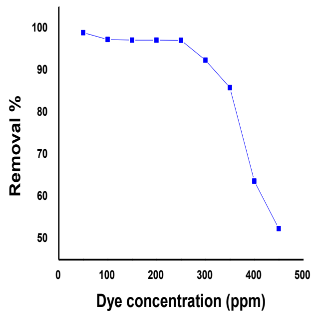
3.2.3 Effect of Dye concentration

In this experiment the pH of the solution was adjusted to 9, optimized in the previous experiment as shown in Figure 2 (c). The dosage of the PEI-CuNCs used was 70 µL, optimized in the previous experiment as shown in Figure 3 (c). The dye removal decreases as the concentration of the dye bath increase shown in Figure 4 (a), (c). More than 95% dye removal was achieved up to dye concentration range 50-250 mg/L as shown in Figure 4 (c). Dye removal percentage was decreased after increase in concertation of dye up to 250 mg/L. As shown in Figure 4 (b), the peaks of UV-Vis spectra increased as the concentration of the dye bath increased. It is observed from the UV-vis spectra graph that the efficiency of dye removal was achieved more than 95% at 250 mg/L concentration, by using optimized pH and Dosage.

(a)



(b)

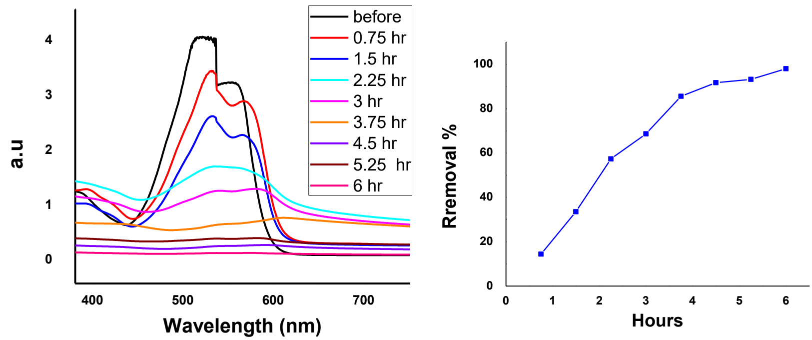


(c)

Fig.4. (a) Image, dye removal at different dye concentration, dye concentration increase left to right. (b) UV-vis spectra at different concentration. (c) dye removal % at differ dye concentration

3.2.4 Effect of Time

There is a directly proportional relationship between time and dye removal. PH, dosage, and dye concentration were optimized in the previous experiment as shown in Figure 2 (c), 3 (c), and 4 (c) respectively. The dye removal was observed at the different intervals (0.75-6 hr), the maximum removal was obtained 97 % in 6 hr as shown in Fig. 5 (b). As the PEI-CuNCs solute was added to the dye bath solution, immediately precipitant was formed, and the solution became cloudy or dispersed. The precipitant was settled down under the gravitational force at the bottom over time. As Shown in Figure 5 (a), the Peaks of UV-vis spectra decline with the passage of time.



(a) (b)

Fig.5. (a) UV-vis spectra of dye bath at different interval.
(b) dye removal percentage at differ interval

4. Isotherm model

The equilibrium adsorption data of acid red onto the PEI-CuNCs were analyzed using Langmuir and Freundlich models. As given in Table 1, on analyzing the experiment data, the (R2) value of Langmuir was achieved 0.9921, which is greater than the Freundlich isotherm model. It demonstrates the adsorption of acid red dye onto the PEI-CuNCs follows Langmuir isotherm model. It also demonstrates that dye removal occurs as the monolayer dyes adsorbed onto the homogenous adsorbed surface. The maximum adsorption capacity was found to be qmax: 9,560 mg/g, by using Langmuir isotherm which was the highest up to date. Langmuir isotherm is represented by the following equation (1).

$$\frac{\mathrm{Ce}}{Qe} = \frac{1}{\mathrm{bqmax}} + \frac{Ce}{qmax} \qquad (1)$$

where Ce is the concentration of dye solution (mg/l) at equilibrium. The q_{max} adsorption capacity (mg/g) and b are related to the energy of adsorption (L/m).The Freundlich constant Kf (Adsorption capacity) and n (intensity of adsorption) were calculated from the following equation no 4.

$$\mathrm{LogCe} = \mathrm{LogKf} + \frac{1}{n}\,\mathrm{LogCe} \qquad (2)$$

As in Table 1, the maximum adsorption capacity was obtained to be Kf: 3875.5 mg/g by utilizing the Freundlich isotherm model. The value of "n" was found 0.7631, which indicates that the adsorption sites maximum adsorption sites were similar, the adsorption sites variation are less.

Table 1. Study on adsorption isotherm of acid red

Langmuir	Freundlich
R^2= 0.9921	R^2= 0.9546
q_{max}= 9,560 mg/g	n= 0.7631
b=0.21	K_f= 3875.5 mg/g

5. Conclusion

The Polyethyleneimine capped copper nanocluster (PEI-CuNCs) was used for removal of acid red via precipitation method, which was synthesized by simple one-step chemical method. The maximum dye removal was found to be 97 % by using optimized parameters pH 9, dye concentration 50-250 ppm, dosage 70 µL, and contact time 6 hours. The dye removal capacity was obtained to be qmax: 10000 mg/L, which is the highest capacity. This method of preparation is also economical and simple, which does not require any capital investment like reactors, energy consumable equipment, and large infrastructure. The efficient removal occurs at pH 9, which is near to neutral water; as a result less supplementary chemicals are required for the process. The adsorption process was found to be fit best into the Langmuir isotherm model.

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Investigation of antibacterial activity of Aloe-Vera, neem extract and AgCl on cotton fabric

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Abstract
Harmful bacteria are ubiquitous which cause several diseases. Natural antibacterial agents such as, Aloe-Vera and Neem are active agents in resisting or killing the bacteria. Present study tends to investigate the antibacterial activity of Neem and Aloe-Vera extracts with added AgCl on Cotton fabric by pad dry cure (PDC) technique. AgCl is a well-known antibacterial agent and the purpose of using AgCl is to enhance antibacterial activity of treated textiles. It is observed that both natural antibacterial agents provided considerable antibacterial activity against E. Coli and S. Aureus bacteria. Moreover, antibacterial activity was further enhanced by incorporating AgCl in to the recipe. Besides that it was also observed that Neem reduces fabric whiteness index.

Keywords: Natural antibacterial agents; antibacterial activity; cotton fabric; whiteness index

1. Introduction
Due to the rising demand for clean and hygienic textile fabrics, this leads to the development of antibacterial textile fabric [1]. Conditions such as temperature, humidity and perspiration activate the growth of bacteria on fabric, and causes infections [2]. Bacteria are microscopic organism, usually single cell. Bacteria and germs are found everywhere and can be injurious because they tend to cause infections. Antibacterial activity can be defined as anything that destroys bacteria or suppresses their growth or their ability to reproduce, by attacking on the shell of bacteria (outer membrane). Bacteria are microscopic organisms, usually single cell; they can be dangerous or unsafe when they cause infections. Bacteria and germs are found everywhere such as

hospitals, homes, offices, and atmosphere. The most synthetic fibers are more resistant to attack because they are highly hydrophobic, more than natural fibers by microorganisms [2]. Several types of antibacterial fabrics can be made directly from specialty fibers like collagen, alginate, chitosan etc. or by treating conventional fibers (cotton, polyester, nylon, etc.) by antibacterial agents. Due to improvement of the principles, ethics of human lifestyle has given people a greater appreciation for the comfort, health and hygiene of clothing and upholstery [3]. Many commercial antibacterial agents in the marketplace are synthetic or artificial and may not be biologically, ecologically pleasant; they are expensive and not preferable for human skin.

The bio-functionalization of textile fibers by using natural products has become increasingly important as they produce safe, nonviolent, non-toxic, skin-friendly and ecologically bioactive textile goods. These antibacterial agents are mainly found from different natural and effective plants [4]. Over the years researchers are working on to get the antibacterial activity form the natural present agents such as herbal, animal, plants etc. among all these agents include a larger section of plant extracts [5]. Due to the nature of the environment, skin, safety, including polysaccharides and their derivatives, the application of natural antibacterial agents has received significant attention in the field of medicinal and textiles clothing [6], so which could be applicable use for home textile and apparel purpose also. Researchers have studied the antibacterial activity of Neem and Aloe-Vera extracts and found that they have considerable effectiveness against gram positive, gram negative bacteria and pathogens and antibacterial activity decreases with repeated laundering. This suggests that AgCl, which is commercially available durable antibacterial agent if added with plant extracts will provide better and durable antibacterial activity [6], [7].

This study aimed to develop environmentally sustainable antimicrobial textiles with numerous advantages based on biodegradable, environmentally friendly natural agents such as Aloe-Vera and Neem with lower concentration of AgCl to improve antibacterial activity and better physical properties.

2. Material and methods

2.1 Material

Bleached cotton plain woven fabric having 60 ends/picks per inch density and 20 Ne count were kindly supplied by Popular Textile Mills Pvt. Ltd. Karachi Pakistan. The GSM of the fabric was 122.6.

2.2 Antibacterial agents

Three different antibacterial agents, including, Aloe-Vera, Neem, and AgCl were used in this research. Aloe-Vera and neem leaves were collected from local vicinity of Hyderabad, whereas silver chloride (AgCl) commercially available in the market was purchased from the RUCO-BAC company.

2.3 Methods

Firstly, Aloe-Vera gel and Neem leaf *(Azadirachta indica)* extracts were prepared by following [8], [9] and then applied on fabric by pad-dry-cure method. Antibacterial activity of Aloe-Vera, Neem and AgCl against bacteria Escherichia-coli and Staphylococcus-aureus was assessed by using the test method AATCC 147 and fabric whiteness index was measured using spectrophotometer by following ASTM E313-20. The recipes of treating cotton fabric with Aloe vera, Neem extract and AgCl are given in Table 1 and Table 2 in results and discussion section.

3. Results and discussion

3.1 Antibacterial activity

After the application of antibacterial finish by Pad Dry and Cure method on to the cotton fabric, the treated fabric was tested for antibacterial activity against E. coli and S. aureus bacteria using AATCC-147 method. AATCC 147 (Agar diffusion test method) is qualitative test method to analyze bacteria resistance and its growth on the fabric.

3.1.1 Antibacterial activity of AgCl, Aloe-Vera, and Neem on pure Cotton against gram negative (Escherichia coli) bacteria

It is evident from Table 1 and Fig. 1 that 100 % cotton fabric; when treated with higher concentration of Aloe-Vera 30 g/l yields good antibacterial activity of a 2.5 mm clear zone of inhibition against Escherichia-coli; whereas, as the concentration decreases zone of inhabitation and at 10 g/l there is no clear zone, but there is no bacterial growth on the specimen. Moreover, zone of inhabitation of samples treated with Neem extract is smaller as compared to Aloe-Vera, and there is no bacterial growth on to the fabric sample. It is observed that fabric treated with 5 g/l of AgCl resulted with 5 mm clear zone of inhibition. Furthermore, a small amount 2 g/l of AgCl with Aloe-Vera and Neem hybrid recipe provides better antibacterial activity against E. coli on cotton fabric with a clear zone of inhibition of 3 mm. It is evident that Aloe-

Vera gel and Neem extracts provide considerable antibacterial activity that can be enhanced by using AgCl.

Table 1: Antibacterial activity of Aloe vera, Neem extracts and AgCl against gram negative (E. coli) bacteria

Sample ID	Aloe-Vera % (w/v)	Neem (g/100ml)	AgCl (g/l)	Zone in mm along with piece of fabric diameter	Width of clear zone in mm	Bacterial growth
1	30	0	0	21	2.5	No
2	20	0	0	18	1	No
3	10	0	0	17	0.5	No
4	0	20	0	17	0.5	No
5	0	10	0	16	0	No
6	15	15	0	18	1	No
7	0	0	5	26	5	No
8	10	10	2	19	1.5	No
9	20	20	2	22	3	No

Figure 1: (a) - treated with AV, NE and AgCl, (b) - treated with NE, (c) - treated with AV and (d) - treated with AV, and NE

3.1.2 Antibacterial activity of AgCl, Neem and Aloe-Vera on cotton fabric against Gram positive (staphylococcus aureus) bacteria

It is evident from Table 2 and Figure 2 that Aloe-Vera and Neem leaf extracts are sufficiently effective against the growth of gram positive (S. aureus) bacteria. Higher zone of inhibition of 24 mm (4 mm clear zone) is achieved at 30 g/l concentration of Aloe-Vera, and it is decreased to 18 mm at 10 g/l concentration.

Neem extracts are less effective as compared to Aloe-Vera; the highest rating 18 mm zone of inhibition achieved at 20 g/100 ml with 1 mm clear zone. All of these samples indicate no bacterial growth. Moreover, antibacterial activity can be further enhanced by adding 2-5 g/l of silver chloride (AgCl) that is commercially available with different trade names. By adding AgCl with Aloe-Vera and Neem extracts zone of inhibition can be increased to 24 mm with 20 gram of Aloe-Vera and Neem extract as given in Table 2.

Table 2: Antibacterial activity of Aloe-Vera, Neem extracts and AgCl against gram positive (S. aureus) bacteria

Sample ID	Aloe-Vera % (w/v)	Neem (g/100ml)	AgCl (g/l)	Zone in mm along with piece of fabric diameter	Width of clear zone in mm	Bacterial growth
1	30	0	0	24	4	No
2	20	0	0	22	3	No
3	10	0	0	18	1	No
4	0	20	0	18	1	No
5	0	10	0	17	0.5	No
6	15	15	0	20	2	No
7	0	0	5	26	5	No
8	10	10	2	20	2	No
9	20	20	2	24	4	No

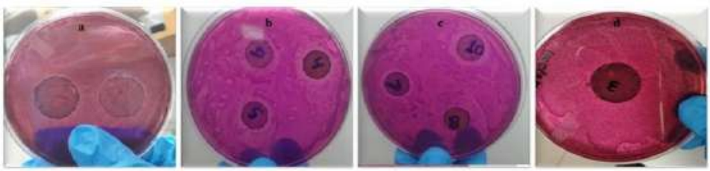

Figure 2: a - treated with AV, NE, b - treated with AV, NE and Agcl, c - treated with AV, and NE and d - treated with AV+ NR

3.2 Assessment of fabric whiteness index on Cotton and PC blended fabric

Fabric whiteness is very important to be assessed after application of antibacterial agents, because some agents reduce whiteness. For whiteness testing, we followed the standard of ASTM E313-20 and whiteness index was measured with Spectrophotometer. It was observed that samples treated with Neem turned fabric green, thus such treated fabrics are only suitable where green shade is needed such as in hospitals. Moreover, the fabrics treated with Aloe-Vera and AgCl have shown minor change in the Whiteness Index as compare to untreated sample as stated in Table 3.

In addition to this, the samples treated with hybrid recipe of Aloe vera + Neem, Neem + Binder, Neem + AgCl have shown drastic reduction in whiteness index as compare to control sample. This tendency is generally attributed to Neem, which made fabric green causing reduction in whiteness index.

Table 3: Assessment of fabric whiteness index

S. No.	Type of fabric	Sample description	WI – ASTM E313
1	Cotton	Untreated	57.83
2	Cotton	(13) AgCl	49.54
3	Cotton	(1) Av	37.29
4	Cotton	(3) Ne	2.53
5	Cotton	(25) Av + Ne + B	4.73
6	Cotton	(15) Av + Ne + AgCl	12.82
7	Cotton	(32) Av + Ne + AgCl + B	5.54

4. Conclusion

This research was conducted to investigate the use of natural antibacterial agents such as, Aloe-Vera, Neem, and AgCl, against E-coli and S. aureus bacteria using pad-dry-cure technique. Antibacterial activity of aloe vera, neem extracts and AgCl was evaluated using disk diffusion method. It is inferred from results that Aloe- vera when applied alone provided good inhibition zone with higher concentration of 30 g/l (w/v), i.e.,21-24 mm zone of inhibition (2.5-4 mm clear zone of inhibition) against E. coli and S. aureus, and even it inhibited bacterial growth at 10 g/l. Furthermore, Neem extracts also provide considerable bacterial inhibition 18 mm zone (1 mm clear zone). Antibacterial activity of these natural agents was further enhanced with addition of 2 g/l of AgCl with Aloe-Vera and Neem extracts to 22- and 24-mm zone of inhibition against E. coli and S. aureus bacteria, respectively. Moreover, whiteness index was slightly affected by AgCl and Aloe-Vera, whereas, Neem extracts drastically reduced whiteness index as compared to control sample.

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Fabrication of co-electro spun poly (4-methyl-1-pentene)/Cellulose nanofibers (PMP/CEL) with enhanced mechanical properties

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Abstract

Co-electrospinning with a mixture of poly 4-methyl-1-pentene (PMP) and cellulose acetate (CA) polymers were used to create PMP/CEL nanofibers, and treated with NaOH. The procedure causes PMP to be neutralized and CA to be deacetylated, resulting in the conversion of CA to cellulose (CEL). The treated nanofibers maintained the fiber morphology. The nanofibers were prepared with different blending compositions such as 1:0, 1:1, 1:2, 2:1, 0:1. The nanofibers were further characterized by FTIR, SEM, XRD analysis. The FTIR results confirm the removal of acetate groups and formation of hydroxyl groups. SEM images showed the smooth morphology of nanofibers before and after deacetylation. The XRD analysis presented the crystallinity of nanofibers. In addition, the combination of PMP and CEL enhanced the mechanical properties of the resultant nanofibers approximately up to 18.9 MPa in Young's modulus and 48 % in elongation at break. Therefore, this nanofibers-based membrane with reasonable mechanical strength can be used for wastewater treatment.

Keywords: Cellulose nanofibers; co-electrospinning; PMP nanofibers; mechanical strength

1. Introduction

Electro spun nanofibers and their composites have shown tremendous success in a variety of fields. [1-3], such as biomedical [4, 5], batteries [6, 7], filters [8, 9], conductive materials [8], and electronics devices [9], owing to their high surface-to-volume ratio, increased porosity, reduced interstitial space, and superior nanofiber connection [10]. Due to the process's simplicity and adaptability [11] and the creation of fibres with dimensions ranging from submicron to nanoscale [12], electro spinning as a nanofiber manufacturing technology has significant benefits over other fibre spinning approaches. The development of coaxial electro spinning dry and wet electrospinning, as well as advancements in the design of different collector systems, [13], which are essential parameters that determine the mechanical properties of nanofibers, increased its versatility. PMP is a polymorphic polyolefin with great optical transparency due to equal densities in the crystalline (0.813 g/cm^3) and amorphous (0.830 g/cm^3) zones, outstanding dielectric characteristics, strong chemical resistance, and high gas permeability [14]. Many applications, such as water filtration webs, biosensor strips, and tissue engineering implants, require not only a high degree of absorbency and wicking rate to convey liquor without obstruction, but also some strength to withstand stress. Co-electrospinning of these two fibers may result in a solid fibrous web with increased wicking rate. Because electrospinning cellulose straight into nanofibers is challenging, cellulose acetate, a unique organic ester, is frequently employed as a precursor to create cellulose nanofibers [15]. Because cellulose acetate lacks wettability due to the presence of an acetyl group in its chemical structure, these acetyl groups are removed through deacetylation. Deacetylation is a typical method of converting cellulose acetate into regenerated cellulose by treating it in aqueous NaOH or EtOH solution to improve wicking ability [16]. Here, we have fabricated the co-electrospun nanofibers of PMP/CELL with enhanced mechanical strength. The prepared nanofibers could be utilized in many applications where high strength is required such wastewater treatment and technical textile purposes.

2. Experimental

2.1 Materials

Sigma Aldrich provided Poly (4-methyl-1-pentene), Cellulose acetate polymer, cyclohexane, acetone, and dimethyl form amide (DMF), which were all employed exactly as directed. PMP was dissolved in a mixture of cyclohexane, acetone, and DMF at facultative mixing ratios at 70 °C for 12 hours with the use of a magnetic stirrer until a homogenous solution was formed. The resulting solution was utilized for electrospinning after cooling to 30 °C, then CA was dissolved in a mix solution of acetone and DMF, which was mixed using a magnetic stirrer at room temperature for 8 hours.

2.2 Preparation of the Co, electro spun PMP/CEL

The co-electrospinning process was used to make PMP/Cell nanofibers. The PMP polymer solution was made by dissolving 12% PMP in DMF, and the cellulose acetate polymer solution was made by mixing 12 percent cellulose acetate with 1:2 (DMF:acetone). The solution was agitated for 5 hours at 40°C. The prepared solution was directly electrospun at an applied voltage of 12 kV and the distance from collector to tip was set to 14 cm. The PMP and CA were co-electrospun with ratio of 1:0, 1:1, 2:1, 1:2, and 0:1. The electrospun nanofibrous web was peeled out and dried at room temperature for 24 hours.

2.3 Deacetylation of nanofibers

The electrospun nanofibers were treated with NaOH in order to deacetylate CA to CEL. Nanofibers containing CA with the composition of 1:1, 2:1, 1:2 and 0:1 were deacetylated, which converted cellulose acetate into cellulose. The deacetylation was carried by following the previously reported method [17]. Briefly, an aqueous solution of 0.05 M NaOH was prepared by dissolving 2 grams NaOH in 500 mL DI water. The nanofibers were dipped in the prepared solution for 48 hours, and subsequently washed with DI water and dried at room temperature.

2.4 Characterization

Scanning electronic microscopy (SEM) was used to examine the fiber morphology using a JEOL JSM-5800LV machine with a 15 kV acceleration voltage. The fiber sizes of the varied concentration nanofibrous mats were evaluated using the image visualization software ImageJ, and the chemical structure of treated and untreated webs was examined using FTIR spectroscopy (IR Prestige-21 by Shimadzu, Japan). The crystallinity of treated and untreated nanofiber webs was investigated using XRD.

2.5 Mechanical test

The prepared nanofibers with different composition were examined for tensile strength. The process of tensile strength measurement of nanofibers was carried out by following [18]. Mechanical testing was carried out on a universal testing machine (Titan Tensile Universal Tester, Company Ltd., Japan) with a 120 N load cell and a 5 mm/min stretching rate. A rotary cutter was used to cut dog-bone-shaped specimens with a length of 20 cm and a width of 10 mm. The tensile stress–strain curves of the specimens were processed using the machine-recorded data. The tensile strains were calculated by dividing the crosshead displacements by the gauge length at the start (20 mm). The Young's modulus was calculated by using equation (1).

$$E = \frac{F \times L}{A \times \Delta L} \tag{1}$$

3. Results and discussion

3.1 Physical morphology

The physical morphology of nanofibers was found to be smooth before and after the treatment with caustic. The SEM images of nanofibers are presented in Figures 1(a-b) and Figures 2(a-c), and the diameter distribution graphs are presented in Figures 1(c-d) and Figures 2 (d-f). The diameter of nanofibers was measured by using image J software. The calculated diameter of nanofibers was found to be in the range from 200 – 1200 nm. The diameter of CA nanofibers increased when blended with PMP nanofibers. It was found that after the deacetylation of CA, the diameter of CA and PMP/CA nanofibers were decreased. The decrement of diameter is due to deacetylation of cellulose acetate, in which acetyl groups are removed which reduces the average diameter of nanofibers.

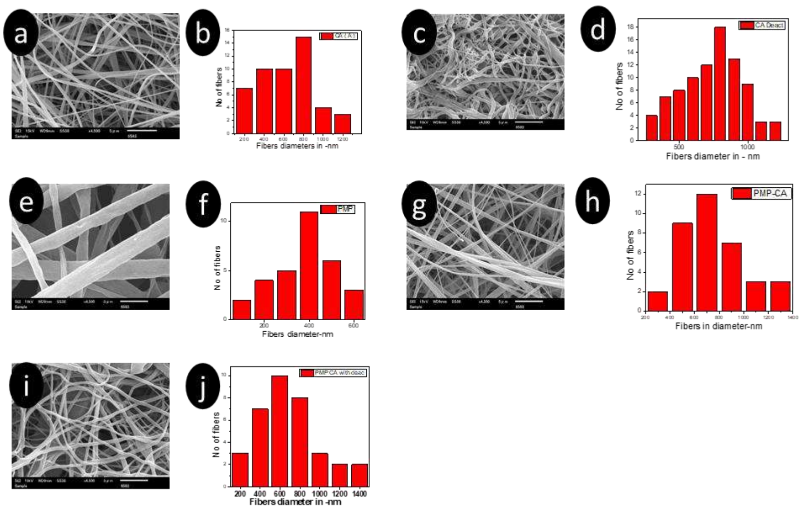

Fig. 1 SEM images and diameter distribution of (a and b) CA (c and d) CA-deacetylated, (e and f) PMP, (g and h) PMP-CA (i and j) PMP/CA-deacetylated nanofibers

3.2 FTIR spectra and XRD analysis

FTIR results presented in Fig. 2(a) reveal that the FTIR spectra of CA nanofibers observed the peaks at 1800, 1340, and 1250 cm^{-1} corresponding to the C-O, C-CH3, and C-O-C bands respectively. After the deacetylation process, the peaks disappeared, which indicates the removal of acetyl groups. On contrary a peak at 3500 corresponding to O-H increased significantly [17]. The corresponding peaks of PMP nanofibers are at 3400, 2900, and 1100 cm^{-1} corresponding to OH, C-C, and C=O groups respectively. The PMP/Cell blended nanofibers showed two major peaks at 2900 and 1750 cm^{-1} which corresponds to OH and C-O bands. The blended nanofibers showed that the peak at 1800 cm^{-1} had disappeared which confirm the deacetylation of cellulose acetate. Figure 2(b) presents the XRD analysis of all samples, and the results showed crystalline band at 15 ϴ for all compositions of nanofibers. It was observed that, when nanofibers were deacetylated with NaOH, it did not show any difference in intensity of band. So, it could be concluded that after treatment of nanofibers, the crystallinity of nanofibers remained the same.

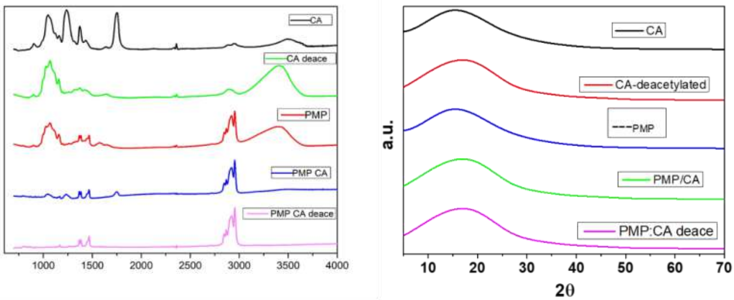

Fig. 2 (a) FTIR spectra and (b) XRD analysis of CA, CA-deacetylated, PMP, PMP/CA, and PMP/CA-deacetylated nanofibers

3.3 Mechanical test

The tensile strength and young's modulus results of all the nanofibers are presented in Figure 3. It was found that the tensile strength of CA nanofibers was greater than deacetylated CA, the strength may be reduced due to removal of acetyl groups and formation of nanopores in CA. In comparison to PMP nanofibers, the tensile strength of CA is lower than PMP nanofibers. When the blend of PMP/CA was prepared it showed the improved tensile strength than the pure PMP and pure CA nanofibers. The young's modulus of blend was 18.9 MPa and elongation was 48%, which is much suitable for the wastewater treatment applications and other medical applications.

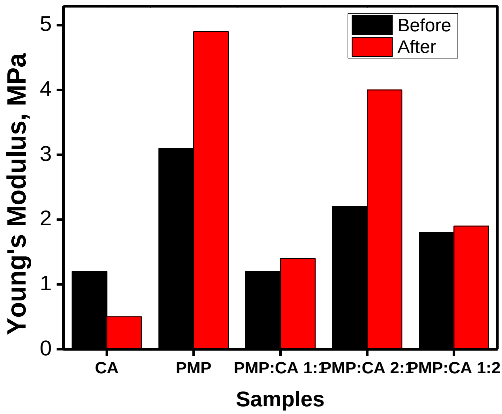

Fig. 3 Young's modulus before and after deacetylation of nanofibers

4. Conclusion

The present study has been carried out to prepare the PMP/CEL nanofibers with enhanced mechanical strength. The nanofibers were fabricated using electrospinning technique with different ratios of polymers such as 1:0, 1:1, 2:1, 1:2 and 0:1. The prepared nanofibers were characterized by SEM, FTIR, and XRD analysis. The FTIR results confirmed the deacetylation of cellulose acetate to cellulose. Further, the tensile strength results showed that the nanofibers exhibit higher tensile strength when blended using ratio 2:1. The maximum tensile strength of 18.9MPa was achieved for blend of 2:1 and elongation strength as 48 %. The prepared blend of PMP/CEL nanofibers could be suggested for the wastewater treatment with nanofibers. The improved tensile strength is more favorable for water treatment purposes.

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Copper and cotton composite fabric for transparent and conductive woven structure for dye sensitized solar cell

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Abstract
Textile fabric-based electrodes have received considerable attention as wearable source of energy because of their lightweight, flexibility and cost efficiency, along with the simplicity of manufacturing and transportation. The current dye sensitized solar cells (DSSCs) are composed of glass electrode, they are not only expensive, but also rigid, brittle, and difficult to transport. In this research we have developed a flexible and electrically conductive textile woven fabric which is easily bendable and at the same time electrically conductive with a certain amount of transparency. The developed copper fabric C3 with 180 picks/inch shows maximum electrical conductivity of 8.48 $\Omega.Sq^{-1}$ with 44 % of transparency. We observed that the developed fabric can be utilized to prepare low cost, flexible, and conductive DSSCs.

Key words: Fabric; transparent; conductive; dye sensitized solar cells

1. Introduction

The solar energy is principal and unlimited source of renewable energy [1]. Solar energy is economical and reliable form of clean energy [2]. Among all solar energy applications, the photovoltaic (PV) type of cell is the most suitable approach for converting solar energy directly into electrical energy. The energy that we receive from the sun in the form of solar energy is an encouraging replacement of fossil fuels because it is renewable and friendly to environment as well as it is available in abundance [3]. Today, dye sensitive solar cell (DSSC) is a promising renewable energy as a potential option for traditional silicon-based solar cell, which has attracted special attention among researchers due to its low cost, high conversion efficiency and ease of use [4-6].

For DSSCs electrodes basically (fluorine tin oxide) FTO glass is used. Therefore, FTO glass is also an expensive part in DSSC. The estimation of conductive glass cost is about 30% of the total of DSSC materials cost [7]. In addition, the hard, brittle, and heavy-duty feature will cause transportation problems for FTO based DSSCs. However, the charges are lower of such flexible substrates as compared to the price of FTO glass. Fabrics are porous and flexible materials that are made up of fibers by pressing or weaving them. This thing enhances its properties like light mass, tensile strength, and flexibility. Natural cellulose or Cotton is one of the most common material due to its ease of processing, relative cheapness, and good mechanical properties.[8].

There has been a fresh interest in flexible solar cells based on traditional materials, such as those related to paper, fibers, and textiles. Flexible solar cells would be adaptable to various surface forms and are light in weight [9]. The high cost, brittleness, and inadequate processing of ITO and FTO films have prompted a quest for alternatives [10, 11] Copper is available 1000 times abundance as compared to indium or silver, and 100 times less expensive [12].

Films of water-coated copper nanowire (CuNWs) might thus constitute a cheap option for usage as a transparent electrode to silver nanowires (AgNWs) or ITOs [11]. Successful conductive yarn integration results in dependable conductive traces on the cloth that help to sustain conductivity. Weaving process is the most popular and easiest approach to incorporate conductive yarn into the textile [13].

In this study, we have used a weaving technique to create feasible textile-based flexible, transparent, and conductive electrodes. Variation of weave parameters such as density and material, results in a flexible and conductive electrode. Using the findings of electrical resistance and transmittance measurements, the performance of conductive fabrics was examined.

2. Materials and methods

2.1 Materials

In this research we have used Copper wires with 26 gauge purchased from Noman traders Pakistan, used as a conductive material for electrodes, cotton yarns with count of 20 tex. Sulfuric acid has been used for removal of copper coating to make it conductive; it was purchased from Merk Company.

2.2 Characterizations

The transmittance spectra were measured using the UV-Vis spectrophotometer. Electrical conductivity measured using a four-probe resistivity/conductivity meter.

2.3 Copper wire coating removal

The copper wires were enameled with nonconductive material and to remove the nonconductive coating, the copper was treated with sulfuric acid. The copper wire was dipped in sulfuric acid for 10 min, and after removal of coating the copper was washed with water then used for electrically conductive fabric formation.

2.4 Preparation of fabric through copper wires

The copper wires were used in three types of fabric for conductive and transparent composite fabric. The wires were used in both warp and weft (C), only warp (Cwarp) and only weft (Cweft).

2.4.1 Copper wires both in warp and weft

For the preparation of plain-woven fabric, hand loom was used, which had 2 heald frames having 320 heald wires, and reed having 177 dents. First perform sarning in which yarns pass through heald wires and reed dent. In this experiment, copper wires were used in both weft and warp direction to make six-inch square fabric. There were 35 warp yarns and vary the weft density as shown in the Table1. After formation of different fabrics, the transparency and electrical Conductivity was test as shown in Figure 1.

Table 1: Different weft densities of copper wire fabric

S. No.	Code	Density
1.	C1	8 Picks/inch
2.	C2	13 Picks/inch
3.	C3	18 Picks/inch

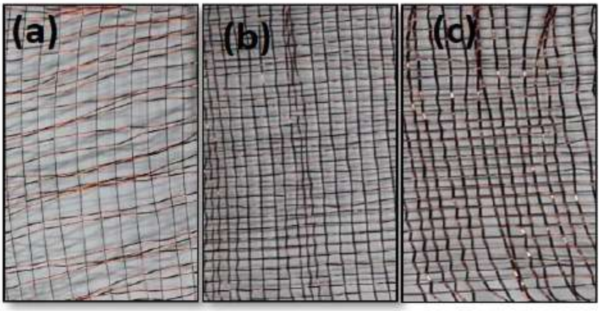

Fig. 1: Copper wire woven transparent and conductive electrode with different densities (a) 8 picks/ inch (b) 13 picks/inch (c) 18 picks/inch.

2.4.2 Copper wires in warp and cotton yarn in weft

In this type of fabric (Figure 2), we were use copper wires in warp direction and cotton yarns in weft direction (Cwarp) to made six-inch square composite fabric. There were 35 warp yarns and cotton yarns in weft with 10 picks/inch.

Fig. 2: Fabric with copper wires only in warp

2.4.3 Copper wires in weft and cotton yarn in warp

In this type of fabric (Figure 3), copper wires were used in weft direction and cotton yarns in warp direction (Cweft) to make six-inch square composite fabric. There were 35 cotton yarn in warp and copper wires in weft with 15 picks/inch.

Fig. 3: Fabric with copper wires only in weft

3. Results and discussion

In order to make a transparent and electrically conductive fabric, it was required to optimize the transparency of the developed fabric followed by its electrical conductivity and to optimize it. In the following section, the transmittance spectra of all the fabrics used in the project has been provided. The transmittance spectra were measured using the UV vis spectrophotometer.

3.1 Transmittance of Copper fabric

Following are the results of transmittance % measurement on UV vis spectrophotometer to quantify the allowance of sunlight which could pass through the conductive fabric. The following graphs belong to three different densities of the copper wires in the weft, which are C1=8 picks/inch, C2 = 13 picks/inch and C3=18 picks/inch. However, the total number of copper wires in the warp was 35.

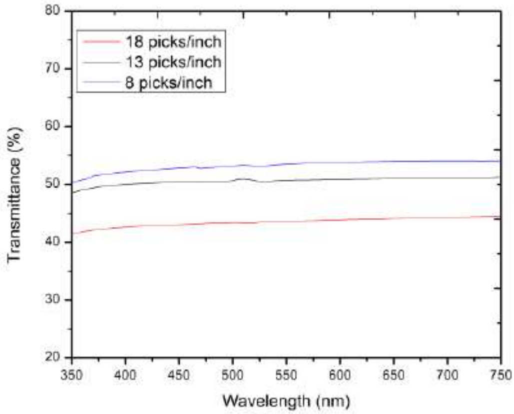

Fig. 4: Comparison of different densities of copper wire for transmittance

In Figure 4, the transmittance decreased with increasing the density of copper wire. At 8 picks/inch the transmittance was found to be close to 50 % and it decreased to around 42 % when the density was increased to 18 picks/inch. Thus, we can say that a lower density of warp and weft wires is good for improved transmittance of the fabric. However, we can only achieve it at the cost of electrical conductivity. The conventional FTO glass used in the DSSC gives around 95 % transmittance, in such case a higher transmittance is desired, but it may be achieved at the cost of electrical conductivity. In the following section, electrical resistance values were compared and in that section, it might be possible to directly optimize the transparency and conductivity.

The following are the results of copper wire either used only in warp or weft directions.

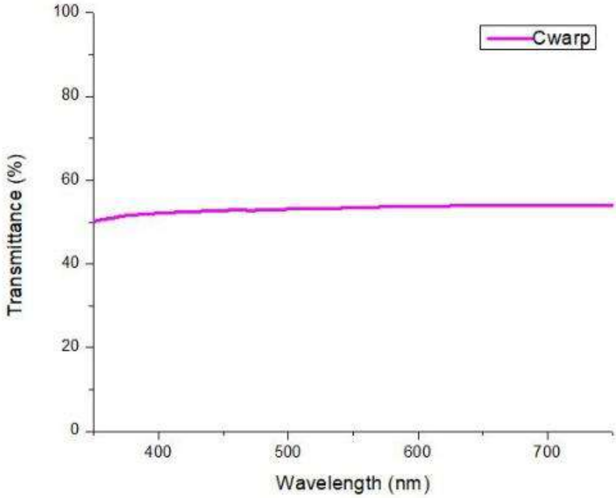

Figure 5: Transmittance of C warp

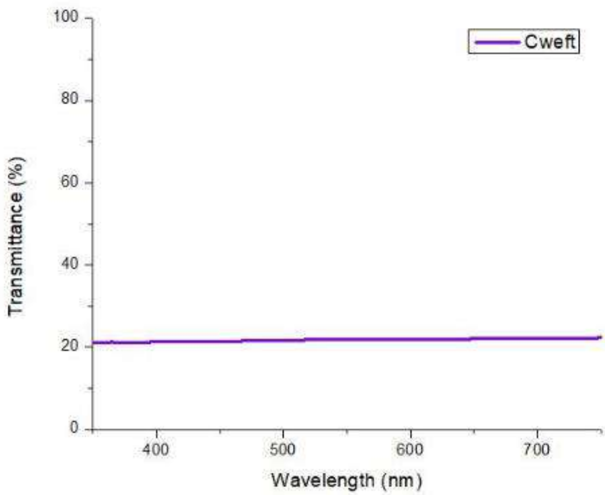

Figure 6: Transmittance of C weft

Due to lower density in the warp direction, the fabric using the copper wires only in warp showed transmittance of 50 %, whereas when copper wire was used in the weft direction, it lowered to only 21 % due to higher number of wires on the weft direction.

3.2 Conductivity or electrical resistance test

Following are the results of electrical conductivity measured using a four-probe resistivity/conductivity meter and the earlier measure transmittance %. The results are summarized in the following Table 2.

Table 2. Electrical resistance and transmittance % of different fabrics developed in the research

S. No.	Material	Electrical Resistance ($\Omega.Sq^{-1}$)	Transmittance (%)
1.	C1	11.8	58
2.	C2	10.0	51
3.	C3	8.48	44
4.	C warp	42.48	54
5.	C weft	92.8	22

4. Conclusions

The results of five different samples of copper wire with different densities have been shown above. It can be seen from the table 2 that the fabric prepared with the copper wire density of 8 picks/inch showed better transparency as may be required by the solar cell for electrodes. The transparency of these fabric ranges from 22 % to 58 % where above 45 % may be utilized to prepare solar cell. On the other hand, the electrical resistance values ranged between 8.0 to 92.8 $\Omega.Sq^{-1}$, which may be further tuned by carrying more experiments on the optimized density. However, such low metallic electrical resistance may be utilized to prepare low cost transparent and conductive solar cells.

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A study on green composite made from waste sugarcane bagasse fiber

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Abstract

This paper presents the preparation and analysis of mechanical properties of textile composite prepared by sugarcane waste (Bagasse fiber). Fiber reinforced composites (FRC) are famous for their strength and lightweight properties that makes them suitable for many industrial applications. In Pakistan wastage of sugarcane, commonly known as Bagasse is widely available after processing and extracting sugar juice. Utilizing the waste of sugarcane into useful products has immense potential to be used in many applications. In this study epoxy resin has been used to prepare composite along with glyceryl, which gives good binding with bagasse fiber. The composite made from these waste materials can be used as a substitute of plywood and particle board. Mostly the furniture is made from wood or derivatives of tree wood such as plywood or particleboard. Advances in composite manufacturing technology helps to get better adhesive properties between fibers and matrix. The bagasse fiber composite shows the better flexural or bending performance, tested against the same sample of plywood of same thickness and length.

Keywords: Sugarcane waste; Bagasse fiber; green composite technology; three-point bending test

1. Introduction

Composites are fabricated by joining two key substrates to get enhanced properties of resulted product as compared to their individual properties [1]. Keeping in mind the requirements for environmental protection, making green materials having ecofriendly characteristics are technically and economically feasible. The combination of biodegradable fibers with natural resins are fundamental to produce green composite materials. The overdependence on petroleum products such as synthetic polymers and resins has consistently increased. Therefore, the researchers are now focusing more on green materials such as cellulose. To replace manmade fibers, cellulosic fibers can be converted in micro and nano scale to achieve the similar properties. Natural fiber reinforce composites are increasingly used due to their cost effectiveness, low density, biodegradability and its ecological nature [2]. Most of the sugarcane waste formed after extraction of sugar, which is mostly wasted. Agricultural residue waste also contains wheat husk, rice husk, hemp fiber and shells from the numerous dry fruits [3]. Recent research focuses on the advancement on the cellulosic fibers waste. That includes the preparation technology/ degumming of agriculture and composites manufacturing [4]. To make natural fiber composites economically feasible and improving the strength many research works has been reported till now [5].

Since the last decade, strong emphasis on environmental awareness attention has been brought in the development of new environmentally friendly composite materials [6]. Therefore, research studies on natural fibers, such as banana fiber, raw silk, hemp, jute, sisal, pineapple leaf, wood and even bamboo fiber, has attracted attention of researchers in the field of material science and engineering. Utilizing these fibers with natural biodegradable and bioresorbable polymers results in the development of new classes of materials and products in some well-developed countries, where environmental awareness is of a great concern [7].

There are several advantages and disadvantages of green composites consisting of natural fiber over conventional glass fibers; such as low density, high specific strength, stiffness, and their biodegradability for their application to composite materials. However, the poor interfacial adhesion between the natural fibers and the matrix polymer is a key issue to be considered in order to increase the properties of green composites. The fiber-matrix adhesion is a critically important factor in a fiber-reinforced polymer composite system to improve the properties and performances of composites. From the above background, the research and development of biomass materials is getting attention. Especially, plant-based natural fibers such as flax, ramie, banana and hemp are expected as an alternative material of synthetic fibers [7].

Cellulose is the main constituent of bagasse fiber. Cellulose is a natural linear polymer with 2000 to 3000 units of monomers in polymer chains. It has a specific gravity of about 1.55. Regardless of the source the cellulose is highly crystalline. Bagasse fiber has a diameter of 10-34 (μm) and length of

0.8-2.8 (mm). Also, in plant fibers, cellulose is the main constituent followed by hemi-celluloses and lignin. Cellulose acts as reinforcement for lignin, hemi cellulose and Pectin. [9] chemical composition is shown in Table 1.

Textile composite of cellulosic fiber (Bagasse) shows the versatile features such as to bear the different loads and stresses much better than ordinary plywood products. These all properties enhance the market demand and viability of textile green composite of (Bagasse) as compare to Plywood furniture [4][10][11].

This research focuses on bagasse fiber to be used as a potential replacement as furniture. Since Pakistan is an agricultural country and bagasse waste could be used to make a textile fiber reinforced polymer matrix composites for commercial use.

2. Research methodology

In this research, bagasse fiber is used as reinforced material for preparation of green composite along with following material and equipment. Poly-functional resin (ethylene oxide), polyamine hardener and cobalt were used. A mold, dry oven and digital balance and microscope were used for experiments. The SHIMADZU UH-500KNI Universal Testing Machine model 2012 has been used to analyze the green composites results with the load cell of 500KN. After preparation of composite, different properties like strength, and flexural proprieties were evaluated.

2.1 Bagasse Fiber

Bagasse fiber is a leftover waste obtained after extraction of juice from sugarcane. After liquor extraction in a sugar mill, fiber was dried for 72 h at 80°C. Then the bagasse fiber was chopped and sieved by sizes. The chemical composition of fiber varies from location to location, variety, and mode of bowing and harvesting. Table 1 shows details of a typical cellulosic bagasse fiber chemical composition. The bagasse fibers were carefully examined under microscopic as shows at Figure 1.


Fig. 1. Microscopic view of bagasse fibers (left), Washing with NaOH (Right)

Table 1. Bagasse Fiber Composition

Component	Percentage
Cellulose	45-55 %
Hemicellulose	20- 25 %
Lignin	18-24 %
Ash	1-4%
Waxes	<1 %

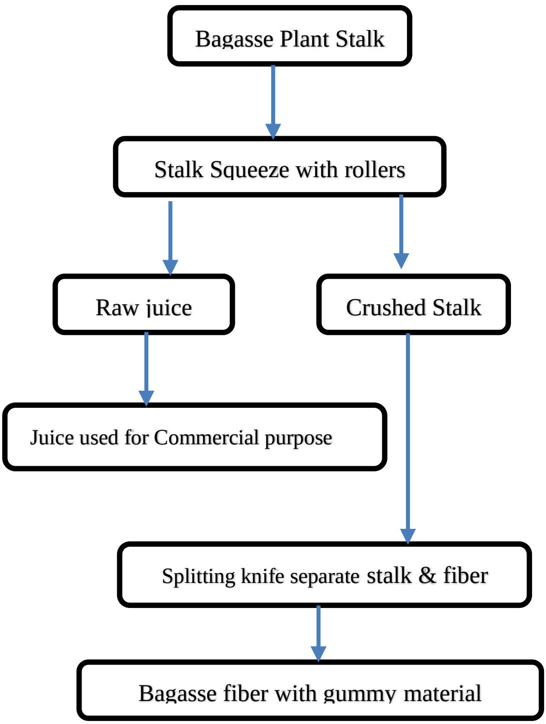

Fig. 2. Schematic flow chart for Extraction of Bagasse fiber from Stalk

As shown in Figure 2, bagasse stalks approximately 30 cm long were feed into a set of rollers, where the juice is extracted and the crushed stalk is separated. The inner roller is equipped with blades, while the outer roller has spikes in order to guide the piece through this station. The removed pith falls through a chute, is fed onto conveyor, and, in commercial processes, the rind piece enters the next station, which removes the outer wax layer. To extract the fibers from the rind, sodium hydroxide (NaOH) solution of 1 normality was used at 120ºC.

2.2 Resin of Poly functional Amines and Hardener

In a composite, epoxy resin contributes in strength, durability and chemical resistance. They offer high performance at elevated temperatures, with hot/wet service temperatures up to 121°C. Poly functional epoxies come in liquid, solid and semisolid forms. They can be cure by reaction with amines or anhydrides. Poly functional epoxies do not cure with a catalyst, like polyester resins. A curing agent can be used also called hardener. Both hardener and the base resin takes part in a co-reaction as an “addition reaction,” according to a fixed ratio. Thus, in order to ensure a complete reaction, it is important to use the correct mix ratio of resin to hardener. To get best properties of composite the resin should be fully cured. For our bagasse composite preparation we have used ethylene oxide, which is an organic compound with the formula C_2H_4O.

2.3 Mold

In molding, the composite gets its shape. Inside a mold, the reinforcement and matrix constituents are mixed and compressed. Although the process and conditions, temperature and time has to be set according to the polymer substrate and matrix. The molding activity has a cure reaction that will be a substitute by providing the supplementary heat or chemical reactivity such as organic peroxide. For many molding techniques, mostly it is suitable to refer it as "lower" mold and as an "upper" mold part.

2.4. Composite Technology

The bagasse-resin composites were fabricated as per following method. The mold was heated to 160°C for 15 min. After the temperature reached 158–162°C, the materials were pressed and held at 10 MPa for 10 min. Epoxy resin, hardener and Cobalt from local market has been used. In composite the fibers were distributed uniformly to achieve uniform results. Finally, the samples were cured for 10 minutes at 120 c in dry oven.

2.5 Preparation of Composite Layers

For the preparation of epoxy resin, following recipe has been calculated by weight and then poured into a glass beaker. The hardener is then added by weight and mixed with epoxy resin. Cobalt was also mixed with epoxy resin and hardener solution. The solution was then mixed uniformly. The following is the details of weight of each component.

Weight of Cellulosic fiber =28 gm
Weight of resin =280 gm
Weight of Hardener =7gm
Weight of Cobalt =5gm
Ratio of bagasse fiber: Resin, 1:10

3. Results and discussion

Before making the composite, the extracted fibers were carefully examined under microscope as shown in Figure 1. The tensile strength of fibers was measured on UTM Model XHL-02 from Jinan XingHua Instruments Co. as shown in Figure 2. Span length and a crosshead speed were set at 15 mm and 1 mm/min. As the load increases from 0 to 6 N, the fibers showed steady elongation. When the load reached 19.5 N, the fibers showed maximum resistance. After that the loads started to drop and gradually reached back to initial position (Figure 3).

Fig. 3. Tensile strength: Testing setup for bagasse fibers.

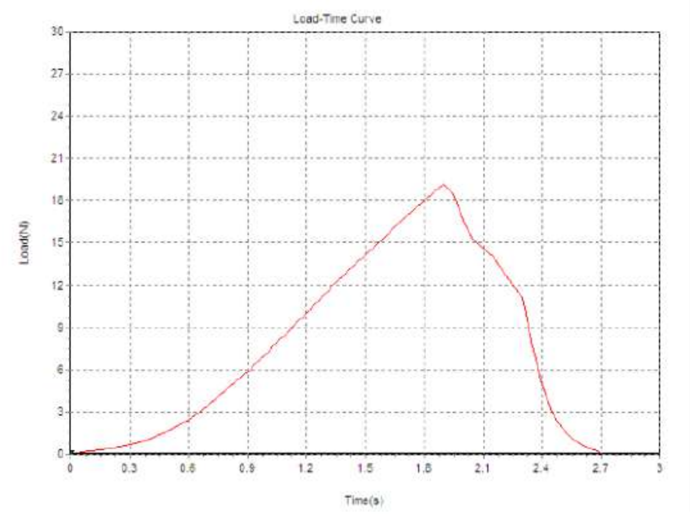

Figure 4. Strength of bagasse fiber

After preparing composite with bagasse fiber, the flexural testing has been performed following ISO 178 using a three-point bending method. Five specimens for each composite material has been prepared. The dimension of the specimen was 30 X 15 X 1.8–1.9 mm. To avoid the effect of temperature, all tests were performed at room temperature of 26°C. Span length and a crosshead speed were 18 mm and 1 mm/min as shown in figure 4. The load-displacement curve was analyzed to calculate flexural modulus and strength of composite and ply wood samples.

After testing both samples of bagasse fiber and plywood samples on same dimensions, the results are presented in Figures 5 and 6. Result shows that maximum bending strength of Bagasse fiber composite is around 390 N achieved around 9.64 % strain. For plywood samples maximum bending strength of Bagasse fiber composite was around 375 N achieved around 7.3 % strain.

Figure 5: Flexural strength Testing setup

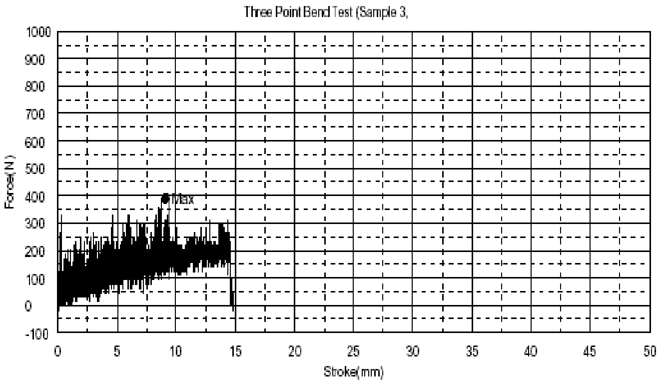

Fig. 6. Strength of bagasse composite

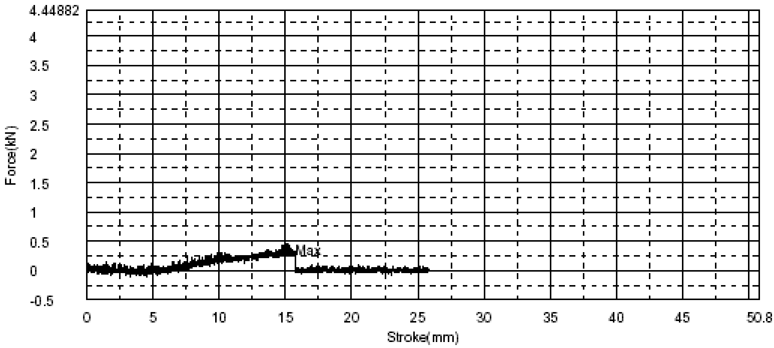

Fig. 7**:** Strength of plywood

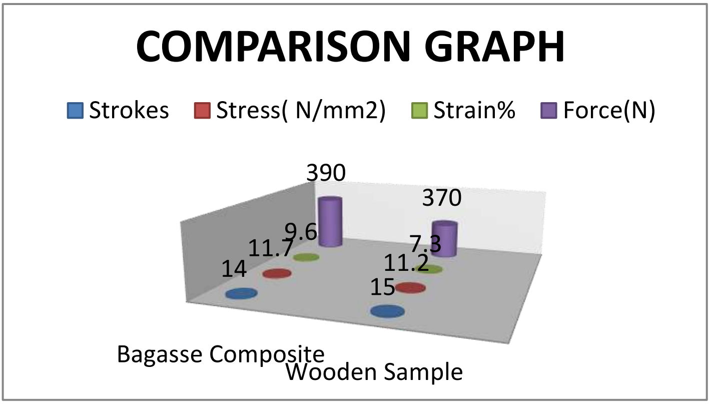

Fig. 8: Comparison of Bagasse fiber and plywood samples

In Figure 7, result shows the better performance of bagasse fiber green composite on basis of bending test as compare to plywood sample. In bending test, we have notice that strain % of bagasse fiber green composite is also batter then plywood sample. Whereas, plywood has shown less strain% as compare to bagasse fiber composite and at half stresses the structure start showing the cracks on surface. Result has also proved that Bagasse fiber composite has better force resistant as compare to plywood and high bending strength which is a requirement for furniture making.

4. Conclusion

With recently generated environmental awareness, the need to develop recyclable and environmentally sustainable composite materials has been increased. Natural fibers with natural resins are both recyclable and biodegradable composite materials. In this work composites were made from wastage of bagasse fiber with combined epoxy resin manufactured by mold technique. Bagasse is re-used and re-cycled fiber widely available in Pakistan. Reuse of bagasse fiber helps to reduce the environmental pollution. Bagasse green composite can be used as a substitute of plywood furniture. Plywood material is also quite expensive and it needs lot of energy and man power to prepare. Bagasse green composite shows good bending strength against plywood sample with same thickness and length. Bagasse fiber and epoxy resin green composite shows good potential against plywood substrate to be used in furniture industry.

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Abstract ID: TN_2021_AB_1

Fabrication of electrospun silk nanofibers and reassembled into ultralight 3D structured silk nanofiber

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Abstract
Although many studies have already been carried out on conventional 2D electrospinning for various applications but recently 3D structured electropsun materials have gained much attention due to their light weight and increased micro porosity. Herein, silk nanofibers have been fabricated via electrospinning and then reassembled into 3D structured using freeze drying method. Field emission scanning electronic microscopic (FE-SEM) images confirmed the smooth and bead free morphology of silk nanofibers with an average fiber diameter of 200nm. After several mechanical interactions during reassembling fibers like high-speed homogenizing and freeze drying, the nanofibers successfully retained their nanofibrous morphology. FE-SEM images revealed clear increased micro porosity in reassembled 3D silk nanofibers. Furthermore, the FTIR results confirmed the chemical composition of silk nanofibers before and after 3D silk nanofibers morphology. The average density of 3D silk nanofibers was decreased due to increased air gaps present in 3D silk nanofibers, thus resulting in ultra-light weight 3-D structured silk nanofibers. Thus, the suggested ulta light weigh nanofibers have potential applications in various fields including continuous filtration.

Keywords: Electrospinning; silk nanofibers; 3D structure; ultralight materials; aerogels

Abstract ID: TN_2021_AB_2

Fabrication of bio-polymeric nanofibers incorporated natural drugs honey and Aloe-Vera for wound dressing application

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Abstract
In this study, nanofibrous webs were produced from aqueous solution of zein polymer incorporated natural drugs; Honey and Aloe-Vera as wound healing materials via electrospinning. In this study, honey and Aloe-Vera were selected as healing materials whereas zein polymer was selected for its good drug delivery system. The electrospinning was performed at different polymer to drug ratios. The loading capacity of each drug was achieved to be 25% for Honey and 30 % for Aloe-Vera. The release profile of both the drugs was studied within 30 minutes. Further the release profiles were analyzed by Korsmeyer-Peppas and Higuchi's models. The release of both the drugs was smooth. The surface morphology of the resultant nanofibrous webs were characterized by FTIR and FESEM; which confirmed the fabrication of uniform and smooth nanofibers were produced at optimized parameters. The fabricated nanofibrous webs possessed anti-inflammatory, anti-microbial and anti-biotic properties due to natural drugs which could increase the healing rate.

Keywords: Honey and Aloe-Vera; natural drugs; zein nanofibers; drug delivery

Abstract ID: TN_2021_AB_3

Development and characterization of thermoplastic composites using novel commingled weaving technique

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Abstract
Thermoplastic composites offer several advantages over thermoset composites including ultimate shelf life, reshaping etc. However, the thermoplastic composites exhibit lower mechanical properties and higher melt viscosity, thus resulting in complex manufacturing processes and complicated infusion to the reinforcements. To overcome these issues, intermediate mixing of reinforcement and thermoplastic materials is adopted in this study. The reinforcement and the thermoplastic yarns were woven together into a comingled structure. The stacking of comingled woven layers was subjected to heat and pressure to produce the thermoplastic composite. The quantity of thermoplastic yarns in a woven structure was optimized to achieve higher fiber volume fraction with improved impregnation. Using the similar technique, Kevlar/PP and Kevlar/Nylon thermoplastic composites were developed. For mechanical resistance, the composites were tested for tensile strength and impact strength. Morphological characterization revealed that the impregnation of reinforcement was improved using this technique. The Kevlar/PP displayed improved tensile and impact behavior as compared to Kevlar/Nylon thermoplastic composite.

Keywords: Thermoplastic matrix; commingling; three dimensional woven fabric; composites

About the Event

Textile Nexus 2021 is a disruptive two-day international conference in the region curated by the Department of Textile Engineering of the Mehran University of Engineering and Technology Pakistan with an audience of textile industry professionals, academicians, and students. It is aimed to provide a hybrid platform (online and physical) to mobilize industry-academia connectivity for sustainable growth of the textile sector in the post Covid-19 era.

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