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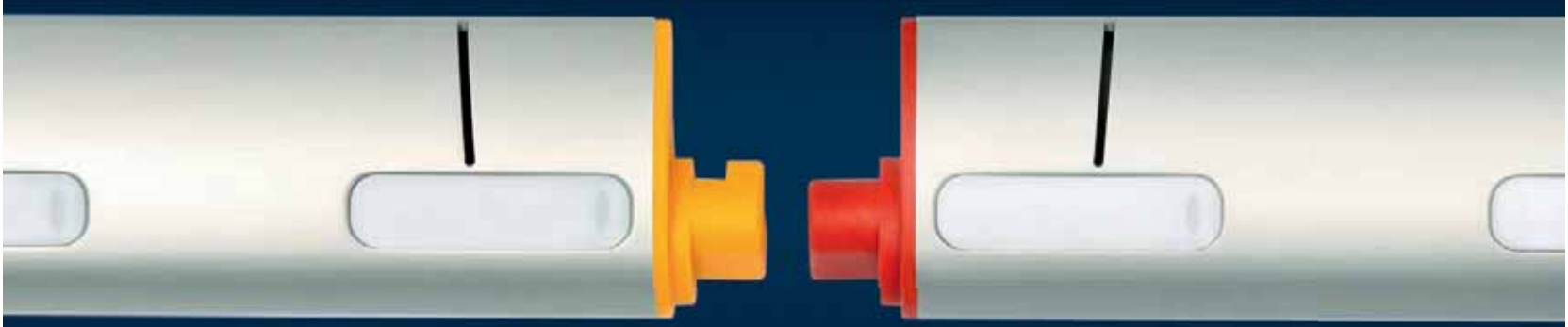

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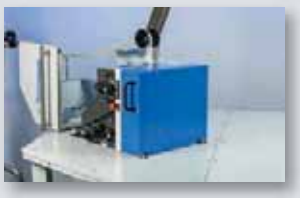

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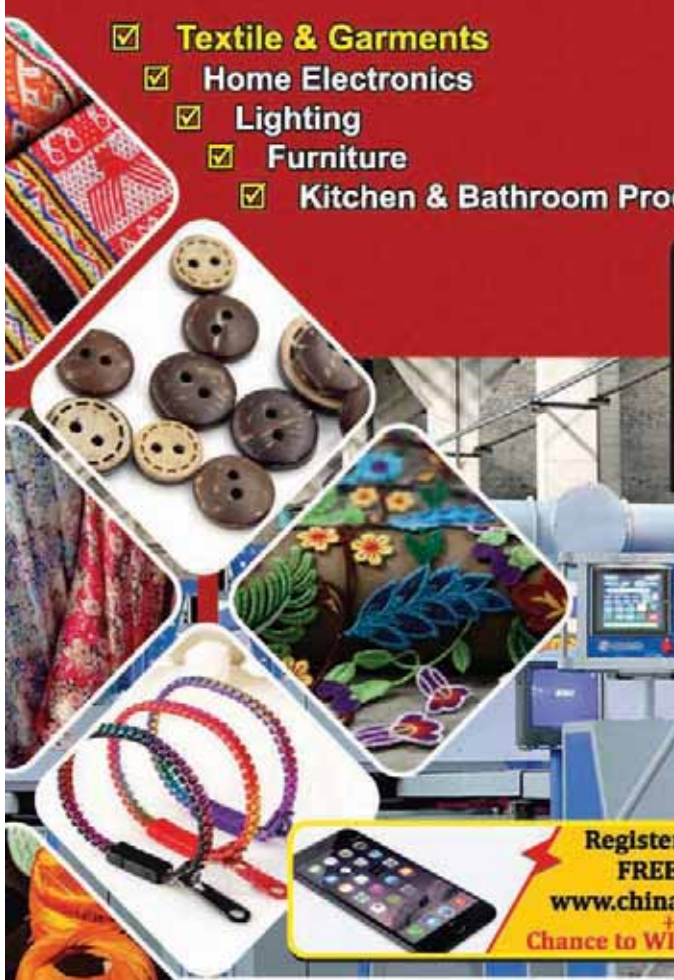

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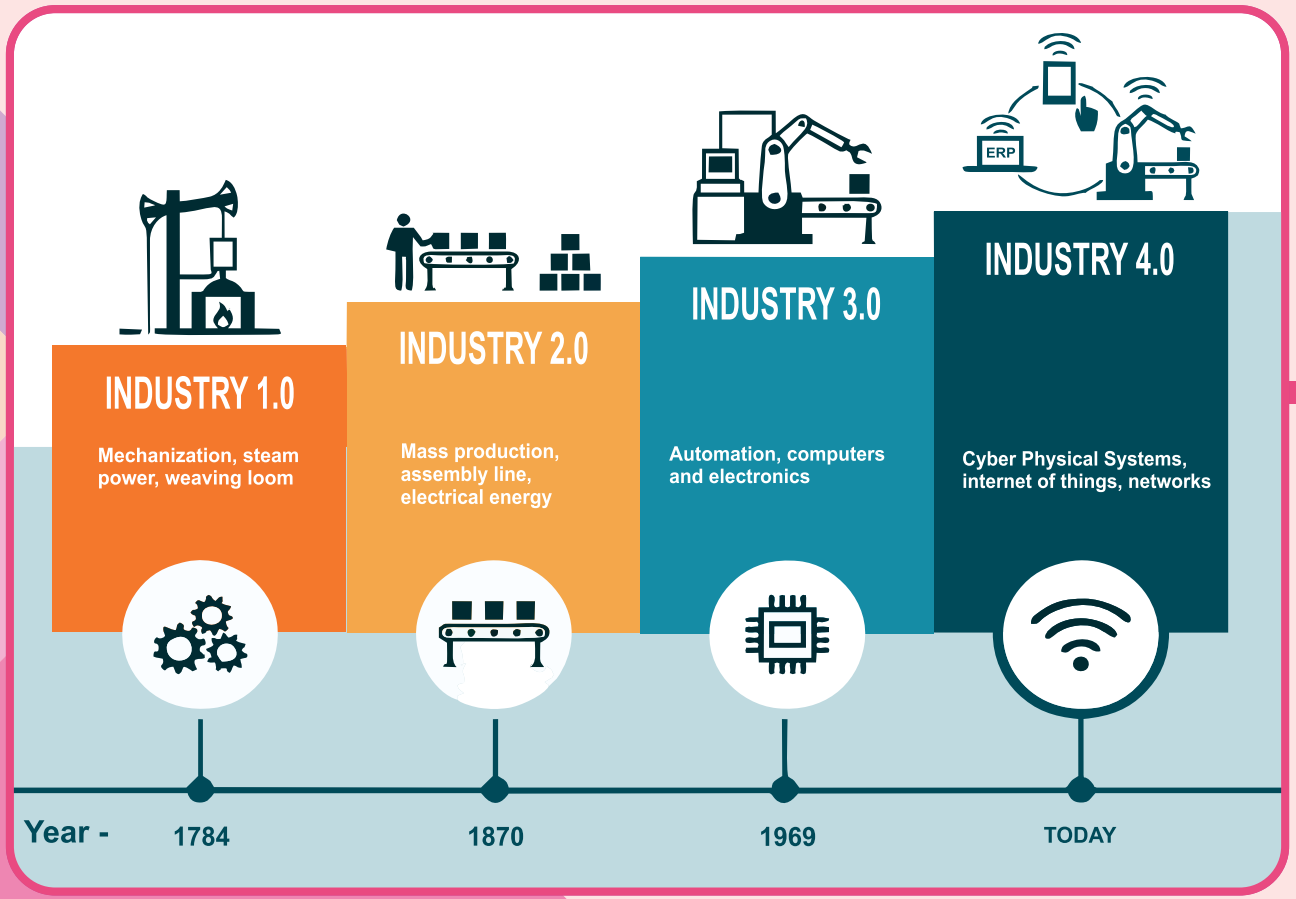
What is Textile 4.0, and how it is applicable to textile industry globally and to India?



The Textile Association (India), Mumbai Unit to organize International Conference on Textile 4.0

The Mumbai unit of The Textile Association (India) is organizing an international conference 'Textile 4.0: Global & Indian Perspective' on March 22-23, 2018, at Hotel The Lalit, Mumbai. The two-day conference will attract mill owners, top textile professionals, experts and textile technologists from India and across the globe, who will deliberate on what is Textile 4.0, how it would impact the textile industry in India and across the globe and what would be benefits to the Textile industry.

The world is on the threshold of a new industrial revolution Industry 4.0 characterized by artificial intelligence, Internet of Things, next-generation robotics, 3D printing, wearables and gentle engineering, nanotechnology, advanced materials, biotechnology among others. Industry 4.0, the future of manufacturing technologies, is increasingly becoming an important trend for automation and data exchange. This enhanced technology, digital systems, and automated processes will make it optimum for manufacturing quality products. Industry 4.0 includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing, which creates a 'smart factory'.

Textile 4.0 is an interpretation and application of Industry Revolution 4.0 in the textiles technology and textile manufacturing sectors across the supply chain in spinning, weaving, finishing, and garmenting. The conference aims to educate stakeholders on how industry 4.0 is shaping up and transforming the global textile business. It will bring together textile manufacturers in all sectors i.e. textile machinery manufacturers, textile technology, solution providers and all stakeholders across the supply chain. Discussions will revolve around major challenges that textile businesses are facing in today's digital marketplace and identify practical steps, which companies can take to digitalize their value chain.

The Textile Association (India), Mumbai Unit is the first to organize such a conference in India/Asia which will help the industry to gear up for Textile 4.0. The Textile Association (India), Mumbai unit is the largest unit of the Association with around 4,000 members. The unit has a reputation of organizing events of topical interest both at national and global level.

The Focus

The conference would focus on concerns like:

- What would be the new avatar of textiles; textile technology and textile manufacturing?
- What would be the practical influence on technology and manufacturing across industry sectors in fiber & spinning, weaving, textile processing (dyeing and finishing) and apparel manufacturing?
- How should textile manufacturing companies engage in this new trend?
- What impact will it have throughout the textile value chain for productivity, quality, and efficiency?
- What does the future hold for textile business commercially through investments and profitability?
- How would the western technology phenomenon be translated into global production centers in Asian/Indian industry?

Speakers & Panelists

The conference will be addressed by international experts on the subject, and mill owners as user perspective renowned experts from across the world and India who are experts in technology.

The conference is expected to be attended by 500 quality participants.

For more details please contact:

Mumbai Unit

The Textile Association (India)

Mumbai Unit

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Face2Face - Interview with Mr. Anjani Prasad

Mr. Anjani Prasad
Managing Director& Head Brand Performance
Textile Specialties -India, Nepal&Srilanka
ARCHROMA India Pvt. Ltd.

Mr. Anjani Prasad holds a B.Sc (Tech) and M.Sc (Tech) in Textile Chemistry from UICT (formerly known as UDCT and now ICT). He started his career in production with Century Mills, where he developed a new process for dyeing with Aniline Black Dyeing, for which he received two patents. He moved to Clarient (India) Ltd. In 1991 as Technical Executive and progressively rose to become Country Head of Textile, Leather, Emulsion and Paper Division in 2006 having turnover of Rs. 500 crores.

In 2010, Mr. Prasad was given a dual responsibility of Country Head - Textile Business and Head - Asia Pacific - NWC. He was seconded to Clariant International in 2011, first at Switzerland and then at Singapore, where he handled Global SCM projects, managed capital and cash flow for the business, aligned the Apparel and Interior in Marketing and worked on sustainability projects. Since 2012, Mr. Prasad is Global Head of New Business and handles innovation with focus on open innovation, asset light options and new business development. Presently, Mr. Prasad is a Managing Director in Archroma India Pvt. Ltd.

Mr. Anjani Prasad is a Chartered Colorists and Fellow of the Society of Dyes and Colorists and a Trustee of SDC India. He published more than 100 articles and presented more than 100 papers in major seminars and conferences in India and abroad. He is also a member of the Bureau of Indian Standards, The Textile Association (India) and FAITMA.

Speaking with Publisher & Correspondent of TAI - Mr. J.B. Soma, Mr. Anjani Prasad, shares the latest developments and innovations at his company.

Q. Give us a brief background of Archroma.

A. Archroma is a global color and specialty chemicals company headquartered in Reinach near Basel, Switzerland. We operates with 3,000 employees over 35 countries and with 24 production sites. Our three businesses - Brand & Performance Textile Specialties, Packaging & Paper Specialties, and Coatings, Adhesives & Sealants - deliver specialized performance and color solutions to meet customers' needs in their local markets, touchingand coloring people's lives every day, everywhere.

Archroma was formed in October 2013 from the textile, paper and emulsions businesses of Clariant, itself a 1995 spin off from Sandoz, a chemical company which was established in Basel in 1886. In 1997, Clariant acquired the specialty chemicals business of Hoechst, a German chemical company. Through this direct lineage, Archroma has knowledge and experience of chemistry and industry spanning more than 130 years.

Since then, Archroma has been growing organically and with its first acquisitions: 75% of M. Dohmen SA, a company specializing in textile dyes and chemicals for the automotive, carpet and apparel sectors; and the global textile chemicals business of BASF acquired in July 2015.

Q. What are your major products in market?

A. As already mentioned that we have three businesses,

- Brand & Performance Textile Specialties: We offer special chemicals for the pretreatment, dyeing, printing and finishing of textiles, from fiber to finish with. Our product packages enhance the properties of apparel and other textiles in applications as diverse as high fashion, home textiles and special technical textiles.
- Packaging & Paper Specialties: We provide expertise in the management of whiteness, coloration, special coatings and strength for all kinds of packaging, paper and tissue.
- Coating, Adhesives & Sealants: Archroma'sMowilith® emulsions offer solutions for the paints, adhesives, construction, textile and paper industries.

We also serve adjacent markets such as leather, wood, personal care, homecare, or water treatment and many more.

Q. Which are your most developed markets and which markets are coming up in a big way?

A. Archroma is present in key developed market like China, India, Bangladesh, Pakistan, Turkey, most of the European markets and also in Mexico and Brazil.

Asia is playing a dominant role in the textile value chain, and fast growing markets such as Bangladesh, Vietnam or Myanmar offer excellent growth opportunities. At the same time, we see markets like Turkey, North Africa or Central America growing and playing an important role to shorten the supply time to the major markets in Europe and America. Europe, is now also from a textile manufacturers market perspective stabilizing after challenging years, and we see segments such as automotive - and technical textiles in general - offer interesting growth opportunities in the years to come.

Q. Can you let us know about your expansion and acquisition plans?

A. we have plans to expand in all key areas for our future growth, and we look at potential acquisitions based on synergy and benefits they can offer for our customers and markets. This is exactly what led us to the acquisition of M. Dohmen and the BASF textile chemicals Business.

Q. Denim dyeing is no longer restricted to just a few selected colours nowadays. What are the latest trends in denim dyeing?

A. For us at Archroma, denim dyeing goes far beyond indigo. We continuously challenge the status quo in the deep belief that we can make our industry sustainable. It's our nature.

In fact, one of our most remarked innovation is our award-winning ADVANCED DENIM, an eco-advanced dyeing technology based on sulphur dyes. The main advantage of coloring denim with sulphur dyes is that we are not limited to blue shades. And we do not limit ourselves to color, we create packages combining colors, auxiliaries and finishes for denim colors and effects with a strong focus on resource savings:

- The ADVANCED DENIM technology, based on our unique Diresul® RDT Blue specialties - allows up to 92% savings in water, 87% in cotton waste and 30% energy compared to convention process;
- Our pre-reduced Denisol™ Indigo 30 is made in a "zero water discharge" production facility;
- Our exclusive Diresul® bright ocean blue colors allow for expanded color inspiration;
- Our Optisul® C dyes, ideally suited for chinos, allow substantial water savings during the dyeing process;

Q. Can you let us know about the latest technological innovations taking place in Archroma?

A. We invest in innovation because we believe that innovation is one of the most efficient drive for more sustainability in textile manufacturing. We are looking for sustainable solutions to address the major problems of our industry, namely waste of resources, pollution and last not least end-consumer safety.

Archroma's most recent and remarked innovations are: Smartrepel® a non-fluorine-based water repellent finish with high wash durability for cotton, synthetic fibers and their blends or EarthColors by Archroma, a range of "biosynthetic" dyes for cotton and cellulose-based fabrics that are made from waste left over by the agricultural and pharmaceutical industry after extraction such as almond shells, saw palmetto, or rosemary leaves. The latest in NFC technology on product hangtags enable transparency and traceability through the supply chain to consumers.

The EarthColors range is making quite an impact on the market. It recently won the Gold Winner at the OutDoor Industry Award 2017, Sustainable innovations Category, and we see more and more brands adopting it as part of their own efforts to use more sustainable ingredients, such as Patagonia or Kathmandu.

Q. Sustainability has always remained high on agenda. Can you share with us some insights about sustainability in your organization?

A. We at Archroma are not just saying that sustainability is important - It's our nature.

First, we strive for continual improvement in processes, saving natural resources and limiting emissions. In late 2013, for instance, we opened the SET facility in Jamshoro, Pakistan, what we believe is the first sustainable effluent treatment facility for a textile operational site. With an investment of 371 million PKR, the facility not only supported the substantial recovery of 80 percent of water but also allowed effluent treatment based on zero liquid discharge.

Second, as a responsible player in our industries, Archroma's purpose is to create chemical technologies that minimize environmental impact at all stages in a product's life cycle, particularly helping to lower natural resource usage at our customers, the textile mills.

The result are the previously mentioned ADVANCED DENIM, Smartrepel®, or EarthColors by Archroma.

Another example is Foron® Rapid Dyeing, a process for the ultimate dyeing of polyester and elastane blends. It reduces the number of water processing steps both in the pre- and post-treatment stages of dyeing and allows for the dyeing of polyester at lower temperatures, which protects the elastane performance, and in shorter times than 'standard' disperse dyes. This results in less impact on the environment with savings on water, energy, and higher productivity levels, all combine to reduce costs while ensuring the high performance required for active sportswear.

Third, it is essential that we break the perception that more sustainable equates to more expensive. Archroma has thus developed an online tool that can digitize mills current process and then can accurately calculate the reduction in resource utilization and also the direct impact on cost, of adopting Archroma's signature processes. The online tool takes our ONE WAY pioneering sustainability service, introduced back in 2012, to a whole new level. The new ONE WAY online platform will launched very soon.

Q. How do you see the Indian textile industry evolve in terms of technology by 2020?

A. The latest innovations in technology are towards sustainability. Textile manufacturers are looking for ways to reduce water consumption, because water is clearly a huge concern for the processing industry where many of the state governments have made zero discharge mandatory. Textile manufacturers are searching for processes which consume less water and allow more bio-elimination because BOD, COD controls the bio elimination and biodegradable products would be of interest. The latest Archroma technologies, supported by our ONE WAY sustainability service, aim at helping our customers select solutions for lower liquor ratio, energy consumption and higher productivity.

We also see Ink Jet picking up slowly in India but development in terms of machineries are still required. That is where our Inkpresso® system comes to the rescue. This is a revolutionary concept, where inks are developed on site at the customer end in the machine. In normal systems, there are different inks to be developed for different print-heads. Inkpresso® allows for a single system to cater to different heads. Furthermore it also allows customization in terms of colors and viscosity of the inks. The total carbon footprint of the

system is also much lesser since transportation is reduced significantly. We are already seeing a lot of enthusiasm for it in India.

Q. Which are your major markets for textile chemical product?

A. The major markets are:

- Apparel -Includes clothing of all types and fashions
- Home textiles -Such as towels, drapes, linens, and furniture fabrics
- Technical textiles including nonwovens -for applications including medical, construction, industrial, carpet, automotive and sports
- Carpet - Includes indoor and outdoor floor coverings
- Transportation - Fabrics in hard-wearing transport applications (planes, buses and trains)

Q. What percentage of processing units in India have incorporated sustainable operations and waste water treatments?

A. Most of the units are connected with CETP plants many markets like Ludhiana and Surat still to undergo this changes. Overall say about 40% of the market is well controlled but 60% have to get reorganized. Small units are there and the capex for waste water treatment is high so they would more or less relocate in to areas where Government already builds up CETP Plants.

Q. Do you have any tie-up with Chinese company or any other countries to boost your company?

A. We have been present in China for a long time, with our own organization and production. We have therefore been able to build a well-established business there.

Q. How is the Environmental Impact & Key Statistics of your products & technology?

A. We have implemented sustainability targets in both our sales & marketing, and manufacturing objectives, so sustainability is clearly a focus for everyone at Archroma.

Q. How do you commercialized your product & technology with a sustainable position in the global market?

A. WithArchroma's constant flow of innovations that bring ever more safety and sustainability both in products and application processes, we are in the position to offer our customers the possibility to adopt more sustainable technologies in their own production and portfolio. And with ONE WAY pioneering sustainability service, we can help them substantiate and market the benefits and added value of doing so.

Q. How do you see your market segment growing in the next 5-10 years both locally and internationally?

A. Key market segments will definitely grow, apparel and home textiles, and also denim and fashion. Technical textiles have still lot of scope to grow, as the per capita consumption is low in India and China at the moment. Once this increases, then the market will increase too.

Q. What are the effects of Digitalization?

A. It is helping us to have better communication both in terms of information sharing, business ecommerce model in dyes & chemicals. It has become easier for the customer to place order in the online portal and also easily trackable of entire supply chain management.

Archroma was actually one of the pioneers of digitalization - in the area of color management. For the past 17 years, Archroma has been offering its color management services using web-based tools for the formulation, standardization and management of custom colors along the entire textile supply chain. We recognized back in 2000 that fashion designers, brands, retailers and their suppliers were all facing challenges, ranging from global sourcing to ambitious deadlines. Since then, our specialists helps them to achieve accurate colors, and accelerate their time to market with color management services, unique software tools and support systems. We recently made a new remarked introduction with the Color Atlas by Archroma®, a color library 4,320 color swatches, available in six volumes and online. Color Atlas even allows users to capture an image using a smartphone, and identify the closest Color Atlas shades with the possibility to purchase a color sample instantly.

DISCLAIMER : All views and opinions expressed in this column are solely of the interviewee, and they do not reflect in any way the opinion of The Textile Association (India).

Face2Face - Interview with Ms. Maria Avery

Maria Avery
Secretary General
CEMATEX

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Miss Maria Avery is the Secretary General of CEMATEX. Born in Newcastle upon Tyne, UK, Miss Avery holds a university degree in Spanish, Portuguese and French and a postgraduate diploma in Business Studies.

She spent 19 years with Bonas Machine Company, manufacturer of electronic Jacquard machines for the weaving industry (now part of the Van de Wiele Group). As its Marketing Manager, she was responsible for Bonas' participation in over 60 textile machinery exhibitions worldwide (including five ITMA shows between 1983 and 1999). During this time she was a member of the British Textile Machinery Association's Exhibitions Committee, and was Chairman of the Committee from 1996 to 1999.

In January 2000 Maria joined the National Exhibition Centre (NEC) as Exhibition Director to head up the organization of ITMA 2003 in Birmingham. She then spent a year establishing a textile machinery event in Dubai, following which she joined CEMATEX (ComitéEuropéen des Constructeurs de Machines Textiles) as ITMA Manager and was appointed Secretary General in July 2005. CEMATEX is the owner of the ITMA and ITMA ASIA series of exhibitions.

Q. Please take us through ITMA journey and your involvement in the exhibition.

A. The first ITMA exhibition was held in 1951. Since its launch, the exhibition has been held successfully across various European cities every four years.

Throughout its history, ITMA has been constantly evolving in orderto stay relevant to the needs of the textile and garment manufacturing industry. It has been expanding its exhibit profile and now it includes 19 product sectors, ranging from spinning to garment finishing and even raw materials and fabrics.

With the emergence of Asia as the largest producer of textiles and garments, a landmark decision was made by CEMATEX in 1999 to launch an Asian version of ITMA. ITMA ASIA caters to the growing needs of Asian textile manufacturers and the first exhibition was held in Singapore in 2001. In response to market demands, ITMA ASIA shifted to China in 2008. This led to the launch of a combined show with Chinese partners - ITMA ASIA + CITME. The show is held biennially in Shanghai with the next edition scheduled to be held in 2018.

To make it more convenient for buyers to source machinery and raw materials under one roof, ITMA's exhibit profile expanded to include fibres and yarns in 2011, and fabrics in 2015.At ITMA 2019, visitors will also be able to exploreleasing and financing services.

As CEMATEX is the owner of ITMA and ITMA branded exhibitions, in my capacity as its Secretary General, I am involved in the strategic development of the ITMA brand, venue selection of each new edition, and ensuring the quality and delivery of each exhibition in order to maintain ITMA's reputation as the world's largest and most established textile and garment technology showcase.

Q.The first ITMA exhibition was launched by CEMATEX in 1951. It has taken place in various European cities with great success every four years, sowhich are the most successful ones of the lot?

A. ITMA exhibitions have grown from strength to strength since their launch. Each edition of the exhibitionhas achieved remarkable milestones, thanks to the support of our exhibitors, sponsors, visitors, supporting associations, media partners and many more who contribute to the exhibition's success.

In terms of turnout, the ITMA exhibition held in Milan in 2015 broke all previous records. It featured exhibits from the entire textile and garment making value chain, including raw materials, and drew the participation of almost 1,700 exhibitors from 46 countries and visitorship of almost 123,000 from 147 countries.

Q. How you could maintain the strong reputation as a world class trade exhibition?

A. ITMA's value proposition includes strict admission criteria of exhibitors, and live machinery demonstrations have helped attract high quality exhibitors and visitors to every edition. Its established set of rules and regulations have helped to maintain the quality of the showcase. As it is only held every four years, exhibitors use it to launch their latest innovations. This makes it an exciting, trendsetting showcase that the industry looks forward to.

Q. What is the size of the global machinery market?

A. According to the latest market report by Technavio, the global textile machinery market isestimated to be valued at US$22.9 billion with an impressive13.8% forecasted annual growth in demand up to 2020.

Q. From which geographies is the demand the most for which machines?

A. In terms of market share and rate of growth, Asia continues to take the lead in the global textile and apparel machinery industry with spinning, weaving and garment making machinesin popular demand. Lately, there is also a strong interest in digital printing as it is more eco-friendly and cost-efficient.

Q. What are the latest innovations that these machines offer?

A. Most textile and garment making solutions are trending towards sustainable innovation. The new machines incorporate eco-friendly features that use less water and energy. The digitization of manufacturing processes has spawned innovations that offer greater automation through more sophisticated artificially intelligent systems and robotics technology. Many of these new innovations which will be unveiled at ITMA 2019.

Q. Any plans to set up ITMA exhibition in other parts of the world, especially in India?

A. There are many domestic exhibitions catering to local market demands in various textile and garment making countries around the world. As an industry leading showcase, ITMA only admits original equipment manufacturers to exhibit, and features live machinery demonstrations. Hence, we do not wish to overtax the resources of machinery sellers and buyers by having too many exhibitions.

Currently, the ITMA and ITMA ASIA exhibitions serve the needs of our exhibitors and visitors worldwide. These are sufficient to support the marketing efforts of our exhibitors, and the sourcing needs of major brands and textile and garment makers. However, we willcontinue to monitor the marketsand can amend our future strategy as relevant.

Q. How do you see your market segment growing in the next 5-10 years both locally and internationally?

A. We shall continue to develop ITMA and make it a relevant and industry leading exhibition that offers an integrated, end-to-end solutions showcase to the entire textile and garmentmaking industry.

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Editorial

FOOD, CLOTHING, SHELTER & ANTIMICROBIAL PROPERTIES!

Towards the end of the year, which marks the beginning of winters, all we need to do is stay abode. Not everyone still is fortunate enough in the whole world to have a roof to protect himself from the chilling months of November and December. Food, clothing and shelter as we all know are the three basic needs of a man perhaps due to the dependence of health on it. Apart from being the basic needs, these three things have one more thing in common which holds utmost importance at any point of time, i.e. its resistance to microorganisms. Be it food, or clothing or shelter, microorganisms can attack anywhere thus threatening the health and environmental hygiene. Micro-organisms exists in single cell form or in colonies, and are not visible to the naked eye. Microorganisms poses danger for both living as well as non-living matters.

As, we are advancing in the 21st century, there are widespread movements for the awareness of health and hygiene. Even the current government had launched Swachh Bharat Abhiyan.
"A clean India would be the best tribute India could pay to Mahatma Gandhi on his 150 birth anniversary in 2019," said Shri Narendra Modi as he launched the Swachh Bharat Mission at Rajpath in New Delhi. The main aim is to eradicate open defecation by 2019 in India.
The question lies here is, are we giving enough attention to the hygienic conditions in and around us and our surroundings??? Are we really taking efforts to keep our surroundings clean and maintain our personal hygiene??? It's not a question of today, it's been put forth on our minds since the very beginning. The least a man can do is keep a personal check on cleanliness all around, and to begin with personal cleanliness. You must be thinking, why am I writing all about cleanliness and personal hygiene and how it is related to textiles. Although we know but we fail to realize that 90% of the material around us is made of fibres; be it your curtains, upholstery, bedsheets, towels, garments - work wear, daily wear, lingerie, sportswear, footwear, etc., even the seats in our car. All these not only act as a carrier of microorganisms but are themselves good media for their growth. Loathsome smell from the garments, staining and degradation of textiles are some of the detrimental effects of bad microbes.

Textiles has innumerable uses be it for clothing, agro-textiles, medical textiles, upholstery, automobile industry and so on. In all of these sectors, resistance to microbes is essential in some way or the other. Thus, it's not just the healthcare industry which needs anti-microbial textiles but the use in other industries too, is endless. Hence, they're treated with agents which

exhibit anti-microbial properties thus protecting the fabric/garment from the attack of microorganisms. Depending on the end use the durability of the finish is important.

This finishing has been known since decades, but have bloomed and gained popularity in recent years as the population is becoming health conscious. Antimicrobial finishing is classified according to the functional behavior. The first one is, Leaching type (Conventional antimicrobials). Conventional antimicrobials diffuses from the garment forming a sphere of activity. Any microbe coming in contact with the sphere are destroyed. These antimicrobials leave the textile and chemically enter or react with the microorganisms acting as poison. The second one is, Non-Leaching type of antimicrobials are bound to the garment and do not migrate off but destroy the bacteria coming in contact with the surface of garment. The chemical is attached to the substrate either by chemical bonding or by polymerizing, forming a layer on the surface of treated fabric. The chemical acts on the cell membrane of the microbes, thus the finishing be remains effective for substantial length of time.

In this issue, along with the texnote series of Graphene- A wonder material, we are bringing up two interesting papers describingthe different routes through which the anti-microbial properties for natural as well as synthetics is achieved, to have an in-depth knowledge of anti-microbial finishing.

Prof. (Dr.) R. V. Adivarekar,
***JTA*, Editor**

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Indian Handmade Carpet- A Millennium Floor Covering

Himansu Shekhar Mohapatra* & Rajesh Kumar Verma
Indian Institute of Carpet Technology

Abstract
In the area of floor covering, carpets are very popular due to its comfort, thermal and resilience properties. Carpets are classified into two groups namely handmade carpets and machine made carpets.Handmade carpets are manufactured in three different ways i.e. knotted, flat weave and tufting. The manufacturing techniques of hand knotted carpets have not changed greatly over centuries because it consists of independent knots and a complex mechanism to tie these knots. There are no machines that can create knots in the same way as human fingers do. A handmade carpet consists of two parts, the first one is the carpet backing manufactured by warp and weft threads and the second one is the carpet pile formed by knotting threads. Turkish and Persian knots are extensively used in handmade carpet sector.In this paper, an attempt has been made to understand the various knots and constructional techniques for Indian woolen handmade carpets through survey in the most famous zone of India.

KeyWords
floor covering, carpet, handmade, knots, Indian woolen

1. Introduction

Carpet is having a use-surface composed of textile material. Here use-surface means that part of a textile floor covering directly exposed to traffic.Indian handmade carpet industry is rural based cottage industry employing over 2 million rural workers. The handmade carpet industry is spread over some specific belts in India such as Mirzapur, Bhadohi and Agra in Uttar Pradesh, Jaipur in Rajasthan, Kashmir valley, Gwalior in Madhya Pradesh and Panipat in Haryana. The Bhadohi-Mirzapur belt in the state of Uttar Pradesh produces maximum number of carpets in India with respect to designs and quality. "Handmade carpets of Bhadohi" have been granted the Geographical Indication (G. I.) in 2011 [1]. The benefit of G. I. registration includes prevention of unauthorized use of G. I. products by third parties [1,2]. Hence, it will boost the exports and bring economic prosperity to producers. Indian carpet is an export oriented item and above 90% of its production being exported [2,3]. Handmade carpet manufacturing is a long process right from the stage carpets design is conceived till the time the carpet finds its place at the buyers. Lots of thought, patience, labour, money and infrastructure are involved in the entire process. The knowledge of handmade carpets constructional parameters is necessary in order to raise customer confidence in the value of such high priced products. It has been reported that the constructional parameters have great influence on the properties of carpet performance [3,4]. However; there is not any literature about the constructional parameters of handmade carpets. Thus, the present study was designed to generate data of handmade carpet constructional parameters from various carpet manufacturers of Bhadohi-Mirzapur belt through survey.

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2. Handmade Carpets

Generally carpets are categorized into two group sdepending on their manufacturingprocess like handmade and machine-made carpets. Handmade carpets are made in three different ways i.e. hand knotting, hand tufting and loom made carpets.The principles of operations for manufacturing of hand knotted carpets are as follows

2.1. Pre-warping operations principle

In the first step, cotton yarns in hank form are converted into a ball shape for easy warping. This is done with the help of iron wheel with stand, which revolves smoothly around its axis. After that two iron rods (traditionally called "Ramba") are fixed into ground using iron hammer. The distance between rods is equal to the carpet size plus allowances for fringes and unutilized wrappings on to the upper beam [4-7].

2.2. Warping on rods

In this operation, warp is brought from one rod to other. At the end of this operation all the warp yarns will be on the rod [6].

2.3. Post warping operations principle

The warps which are laid on the thick iron rod are transferred to a thin steel rod. After transferring the warp into thin steel rod it is folded and carried to the loom for mounting [8].

2.4. On loom operations principle

Two steel rods along with warp yarns are fixed on to the hook provided in the upper and lower beam of the carpet loom. After that warps are set at equal distance as per the required quality. Then healds are prepared for each warp thread. After that warps are tied onto cylindrical wooden stick traditionally called "Gulla" and this Gulla is attached to another stick traditionally called "Kamana" [9,10].

2.5. Principle ofCarpet weaving preparatory on loom

Shedding of warp yarns is achieved with the wooden stick "Kamana". A support for the pile yarns is achieved by inserting cotton yarns in the weft direction. It is a process of putting a base to the carpet, traditionally known as "Khati-Chunan" [10,11].

2.6. Basic operations principle of knotting on loom

The pile yarns are introduced into the carpet by means of tying the knot. Knotting is done on the basis of design, which is available in the graph paper. All the required yarns in different colours are hanging in the top portion of carpet loom [11]. After tying each knot weavers cut the pile yarn with a knife. There is necessity of weft yarn insertion to keep the knotted pile intact and fixed. In this regard, thin weft (traditionally called "lachchi") and thick weft (traditionally called "tharri") are added in two lines after a line of pile knotting. Thick weft is added in the same position of pile knotting and thin weft is added after changing the shed [12,13].

2.7. Measurement and control of pile height, knot density, waste dimension etc.

The pile height in knotted carpets is controlled by the weaver using a pile height gauge to check the required pile height during knotting the initial lines. Once this is set, they simply weave the carpet following the previous height level [13]. The knot density is as per the quality required and is already taken care of while making the warp. However, this only deals with the horizontal knot setting; the vertical knot setting is done with the help of a beater [14].

2.8. Principle of Binding and inspection

The lengthwise sides of the carpet are bound on the loom itself. The widthwise sides have fringes which are later finished by knotting the warps [14].

2.9. Delooming principle of carpet of carpet

Once the knotting process is over, khatichunan is again constructed. After that carpet is separated from the loom by cutting the warp sheet widthwise. Now the carpet is ready for the subsequent operations [15].

2.10. Principle of carpet washing Carpet Washing

Carpet washing takes place on a washing platform, which is an often a cemented area with a water tank attached to it [15,16]. There are three types of washing. Normal Washing, which requires heavy rubbing, uses chemicals such as bleaching powder, caustic soda, acetic acid and softening paste. Herbal washing uses different natural products like henna and ritha. Antique washing, which gives a particular shine to the carpet, uses strong chemicals and heavy rubbing [17].

2.11. Principle of finishing Finishing

Handmade carpets invariably undergo several finishing sequences which includes singeing and shearing, stretching, sorting, clipping, carving and embossing, binding, colour cut, back cleaning, repairing, fringe netting, edge binding etc., to give an enhanced aesthetic appeal of the handmade carpets before it is ready for packing [17].

2.12. Principle of Carpet Knots

A hand knotted carpet consists of two parts: the first is the carpet backing formed by vertical and horizontal threads known as 'warps' and 'wefts'; the second is the pile of the carpet made by knotting threads [18,19]. The texture ofhand knotted carpets is formed from independent knots. It has been reported that Turkish or Ghiordes knot, Persian or Sehna knot and Tibetan knot are used in hand knotted carpet industry [20].Among all; Persian Knot is extensively used in handmade carpet sector.

2.12.1 Turkish Knot mechanism

This is a symmetrical type of double knot, also called a Ghiordes. (Fig. 2.12.1). Here the pile thread forms a loop around two warps, and both ends of the pile thread come out between both warps [4,21]. There is another type called the Jufti knot. It can be symmetrical or

asymmetrical and the difference is that it is formed over four warps.

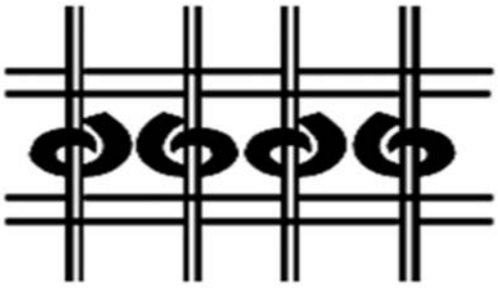

Figure 2.12.1: Turkish Knot

(a) Tied with the warp on one level and two weft threads between each row of knots.
(b) Tied with the warp on two levels, knots inclined to the left.
(c) Tied with the warp on two levels, knots inclined to the right.

2.12.2 Persian Knot mechanism

This is an asymmetrical single knot, also called a Sehna knot or Farsibaff. (Fig. 2.12.2). Here the thread forms only one loop around one of the two warps, so the pile threads vary in protruding between the adjacent warps [4, 5, 22].

Figure 2.12.2: Persian Knot

(a) Left-hand knot: warp on one level: one thread between each row.
(b) Right-hand knot: warp on one level: two weft threads between each row.
(c) Right-hand knot: warp on two levels: three weft threads between each row.

2.12.3 Tibetan Knot mechanism

This uses a different approach (Fig. 2.12.3). A temporary rod, which establishes the length of pile, is put in front of the warp. A continuous yarn is looped around two warps and then once around the rod. Once the row is finished, the loops are cut to form the knot [4,23] .

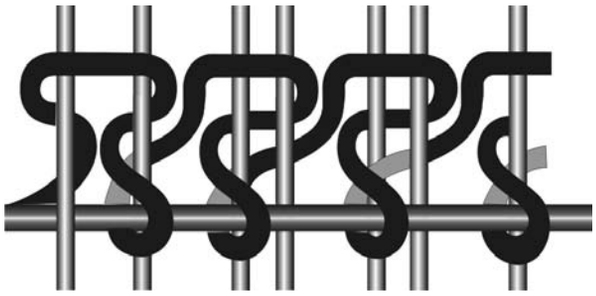

Figure2.12.3: Tibetan Knot

3. Principle and Mechanism of Looms for Manufacturing of Hand Knotted Carpets

Hand looms for hand knotted carpet manufacture may be either horizontal or vertical. Nomads usually use horizontal looms, having components pegged to any convenient patch of ground. Only relatively small rugs can be made on such looms, the length being restricted by the reach of the weaver in fig. 3.1 [6, 24].

The upright loom used domestically and in workshops consists of two posts supporting horizontal rollers. The upper roller holds warps which are stretched between it and the lower roller. Often, the warp is inclined from the vertical. As the carpet is formed, it is taken up on the lower roller and warp is let off from the upper beam.In factory operations, the warp may be fixed and the loom is tall to accommodate the full size of a large carpet. In such cases, several weavers may operate together on the same carpet and they move from the base of the loom to work on simple gantries as the carpet [7, 25].

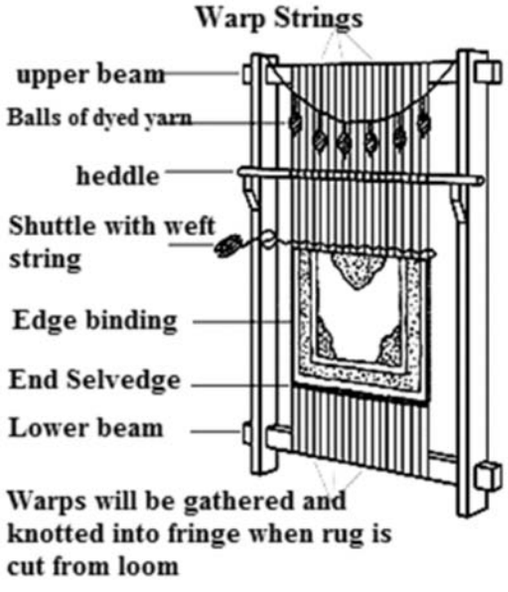

Figure 3.1: Upright loom for manufacturing of hand knotted carpet.

4. Principle and Mechanism of Looms forHand tufted Carpets

The sequences of operations for manufacturing of hand tufted carpets are as follows:

4.1. Framingof primaryfabric

When the primary fabric is stretched on the loom it has to be stretche dtightly. The cloths hould be stable inorder to with stand the for ceof the tufting gun.The cloth should be straight and the nailsof the loom should penetrate the cloth in a straight row [24, 25].

4.2. Analysis of various backing fabric including yarn used for tufting

The process of analysis and inspection of raw material ispossible only through a well-equipped lab, whereall the technical parameter scan be compared with the specific requirements [25].

4.3. Maintenance of tuftinggun

The reare mainly two types of tufting guns: manual gunan delectric gun.

The maintenance of the manual gun is simple and involves mainly the scissors and the pile height setting. The maintenance of the electric gun is complex and requires a qualified personal for the job [26, 27].

4.4. Tracingoverprimaryfabricfordesign

The design is traced in the tracing paper and the n all the lines are punctured with the help of needles. After this, the trace paper is aligned properly with the loom and the design is traced on the primary cloth with the help of a coloured solution which creates the impression of the design on the cloth. Make sure that the solution does not smudge [27, 28].

4.5. Tufting over primary fabric

The tufting process is an art and has to be carried out by trained artisans. They have to make sure that the shots per square in charecons is tent and the design is properly tufted [27].

5. Loom made Carpets (broad loom technique and mechanism)

The sequences of operations for manufacturing of loom made carpets are as follows

5.1. Warping outside the loom

Warp preparation for base and pile: Be aming-the warping of abroad loom carpet is done on a beam which is detach able from the loom. The warp is 100% cotton. The cotton is first sorted out properly and transferred on to bobbins, and then the bobbins are fixed on a stand which transfers the cotton to a large wheel. Setting the range of the warp: once this is done the warp is finally transferred to the beam and the beam is placed behind the pile beam on the loom [28].

5.2. Beam setting on the loom

The loom has three be a ms, one for the warp, one for the pile and the last beam is for the woven carpet. The warp beam and the pile beam are placed at the back of the loom and the carpet beam is placed at the front side. The warp beam is a lwaysplaced behind the pile beam [28].

5.3. Weft preparation

The weft of the broad loom carpet is either cotton or jute. A shuttle is used for putting weft between two knots [3].

5.4. Design setting

The design in broad loom is set with the help of the pile beam and some times an additional beam [4].

5.5. Weaving in broad loom

The weaving in broadloom is done in a cross weaving manner and iron rods are used to set the pile height. If we want to have a cutpile weaving the n we have to cut the pile covering the rods with the help of a blade. If we want loop pile, then the rods are simply pulled out from the sides [29].

5.6. Take-up of a bric and doting of desired length of woven carpet

Dismantling of carpet from the loom is done following standard practice. Chemical processing,backing(optional), finishing, inspection and mending of defects, etc., are also applicable [29].

6. Carpet backing for hand-tufted/hand-loom carpet

Carpet backing is very much essential for the application point of view and durability. Some latest techniques have been discussed below for the better understanding of readers:

6.1. Analysis of latex and/or adhesive material

This operation includes the identification of the type of latex to beused. There are two types of latex used in the formulation in which synthetic latexand/ or natural latex and chalk powder constitute major components (~400gms/m^2 and ~1500gms/m^2 respectively) to make overall addition to the extent of around 2200 gms/

m^2 using various ingredients as per option which includes Glaubersalt, zinc oxide, titaniumoxide, Nonex S.P/Emolvan T, liquid ammonia, Dispersol F(ICI)/ Bilaux T (BASF), sodium silicate, sodium hexameta phosphate, car boxy methylcellulose (CMC), sulphur [29, 30].

6.2. Analysis of backing fabrics

This operation includes the identification of the type of secondary backing to be used in the carpet while latexing. It is a mesh with approx. 2±3 mm squares which allow the latex to penetrate the mesh and reach the tufts. There are different types of secondary backing: (1)100% cottonmesh, (2)100% P Pmesh and (3) cotton-PP mix. The role of the secondary backing is to provide body and dimensional stability to the carpet [30,31].

6.3. Application of latex

A tufted carpet is tightened on a frame or on the ground, and then the design and size of the carpet is set with the help of hand tools. There upon the mesh is applied in the back side of the carpet and finally the latex is applied. The application of latex can be of various types such as hand application (with the help of as preader), spraying and roller application [30, 31].

6.4. Measurement and monitoring of drying and adhesion

The drying of carpets is generally in sun light; this is the most cost-effective method of drying. Apart from this, latexed carpets are also dried in drying chamber sandroller ovens. The latex should be properly dried before removing the carpet from the frame, otherwise the carpet will tend to lose its shape and it may develop mildew (fungus) [7, 24, 30].

6.5. Setting of backingprocess

Process control with respect to delaminating and tuft withdrawal force to ensure proper binding of the tuft. An optimum level of latex is mixed with fillers and tuft with drawal force is tested with the help of proper equipment or in labs to make sure that the bonding is right [29,30].

6.6. Inspection and mending of the defects

Before the carpet is processed for finishing, it is inspected for various qualities such as weight, pileheight, density, design execution, size and surface. Any defect found is mended by simply pulling out the tufts of the defective are and re-tufting that area in the correct manner [31].

7. Conclusions

Handmade carpet manufacturing process, principle, mechanism and various constructional parameters have been discussed extensively in this paper. The handmade carpet segment has immense scope of standardizing the product quality. The wear life of handmade carpets depends mainly on its manufacturing technique, material and construction parameters. Unique knotting techniques and scientific backing systems have also been discussed in this paper clearly which may play an important role for the readers and new generation youth to develop innovative research and development idea in the future.

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Eco-friendly Herbal Dyeing for Wellness Properties on Linen Fabric

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Abstract
A number of researchers are attempting natural dyeing and studying their inherent properties on different fabric. This paper discusses dye extraction from natural sources such as madder, sappanwood and marigold flower and its application on linen fabric. Alum, ferrous sulphate and harda (myrobalan) were used as mordants. Dyeing on linen fabric with mordants showed a substantial increase in colour depth (in terms of K/S value). Optimal results were achieved for dyeing at 90°C for 60 min at 30 % concentration of the dye on the weight of fabric using pre and post mordanted dyeing techniques. Treated fabrics showed good to very good wash, light and rubbing fastness properties with mordanted and dyed linen fabric. Also, use of bio-mordants like harda in dyeing showed very good results and it can also be employed instead of metal mordants for making natural dyeing more eco-friendly.

Keywords
Linen, Herbal dyeing, mordants, Fastness.

1. Introduction

Now a day's linen fabric is increase in demand and it has fascinated textile market even more than cotton fabric due to its several useful characteristics. Linen fibres have a characteristic silky lustre, much more pronounced than that of untreated cotton. The natural look, cool hand and textured appearance give it a unique quality. Linen fibres have about the same amount of hygroscopic moisture as cotton, ranges between 6-8 %. Linen fabrics, unless beetle-finished, absorb moisture quickly and dry faster than cotton. Linen fibres have a poor affinity for dyes due to the hard, non-porous surface of the fibre and its natural gum content (pectin) which does not allow even penetration of the dyestuff. However, favorable chemical reactions can be carried out for removing the pectin by a strong bleaching process, but this may also affect the durability of the linen fabric [1].

Madder is a long-lived perennial of the family Rubiaceae, the same family as coffee. The madder plants sprout in early April and grow to 60 to 100 cm high. Rubia is a genus of the madder family Rubiaceae, which found in Africa, temperate Asia and America. The genus and its best-known species are also known as Madder, RubiaTinctorum (Common Madder), Rubiaperegrina (Wild Madder), and Rubiacordifolia (Munjeet or Indian Madder). Alizarin (1,2-Dihydroxy-anthraquinone) is the most important colouring agent present in small quantity in stems along with Purpurin, Rubiadin and Munjistin as major components [Fig.1 (a)] [2]. The root of madder is used as raw material for making natural dye from it which is natural renewable source.

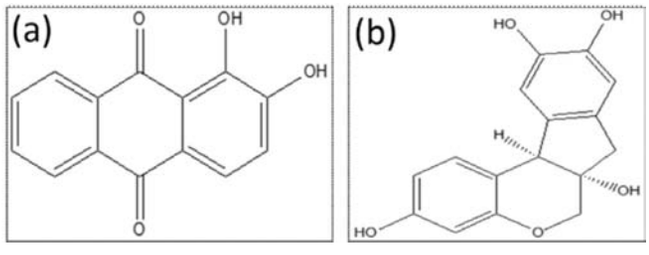

Figure 1.1: Chemical Structure of (a) Alizarin and (b) Brazilin.

Caesalpiniasappan is also known as Indian redwood. Under natural conditions,Caesalpiniasappan grows mostly in hilly areas with clayey soil and calcareous rock at low and medium altitudes. It is found in the region from central and southern India through Myanmar and Thailand to Peninsular Malaysia and to Indo-China and southern China. The main component of dye in the heartwood of Caesalpiniasappan is Brazilin [Figure 1.1 (b)]. Other components are protosappanins, sappanchalcone and haematoxylum.

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Brazilin is a weakly coloured product, which easily oxidizes to give the deep red pigment brazilin, natural red number 24 and dye number 75280 of Colour Index [3-4].

Sappan is a small thorny spreading tree, grows up to 10 m in height and the wood reaches 15-30 cm in diameter. Sappan is cultivated as a horticultural plant for its large compound leaves and bright yellow flowers. It grows well in all kinds of soil and its lush growth is attained in red soil. It withstands any amount of drought and defoliates through only for a short period of 10-15 days. The important part of this plant is the heartwood that contains water-soluble dyes such as brazilian, protosappanins, sappanchalcone and haematoxylin. Brazilian on oxidation yields a red dye called brazilein, the most valuable dye used in colouring leather, silk, cotton, wool, fibres of different kinds, batik, calico printing, furniture, floors, feather, medicines and several handicrafts. Sappan yields different shades of red with or without mordant. The wood is used in carpentry [5].

Marigold flower (Tageteserecta L.), a major source of carotenoids and Lutin, is grown as a cut flower and in addition being grown for its medicinal values. Marigold flowers, which are yellow to orange-red in colour, are a rich source of lutein, a carotenoid pigment. Nowadays, Lutein is becoming an increasingly popular active ingredient used in the food industry and textile coloration. This pigment has acquired greater significance because of its excellent colour value. Although marigold flower extract has been used in veterinary feeds, the potential use of marigold as a natural textile colorant has not been exploited to its full extent. This is due to the lack of information on its safety, stability, and compatibility in textile coloration. In this study, an experiment was conducted to study the use of an extract isolated from marigold as a natural dye. The dye potential of the extract was evaluated by dyeing, using the flower on 100 % linen fabric.

Texttreasure

Science and Technology revolutionize our lives, but Memory, Tradition and Myth frame our response

- Arthur M. Schlesinger

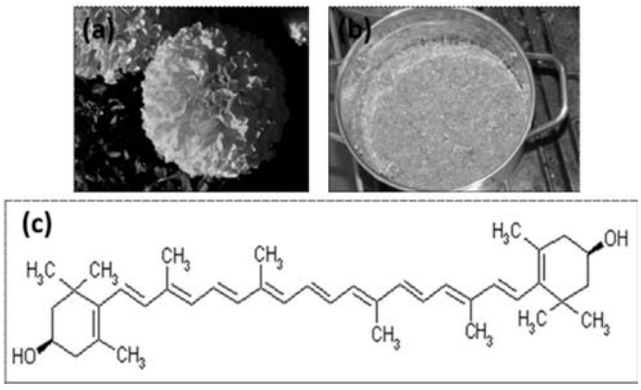

Figure 1. 2: (a) Marigold flower, (b) pulverized marigold and (c) structure of lutein

As per the requirement of sustainability parameters, natural products are being used by many researchers for dyeing and functional finishing giving value-added textile materials. A lot of plant sources like tamarind seed coat, flower waste from the temple, Emblica Officinalis G. fruit (amla), Sterculia foetida fruit shell extract, coconut shell extract, Gulmohar stem shell extract etc. have been utilized for natural dyeing [1, 6-16]. Natural products derived from plants do not affect the ecological balance as the residual material is biodegradable, thus a good alternative for maintenance of the ecosystem.

In the present workLinen fabrics were dyed with different natural dyes in the absence and presence of mordant such as ferrous sulphate, alum and harda for pre-mordanting and post-mordanting techniques. The purpose of this work is to study the behavior of different dyes without and with mordants on cotton fabric. This paper discusses the comparison between the depth of dyes without and with mordants by evaluating K/S values and also their fastness properties.

2. Material and Methods

2.1.Material used for experimental work

The ready for dyeing (RFD) plain woven linen fabric (124 GSM) was supplied by Piyush Syndicate, Mumbai, India. Madder, Sappanwood and Marigold dyes were established from Adiv Pure Nature Products Private Limited. Alum, harda (myrobalan) and ferroussulphate, (laboratory grade) mordants were used.

2.2. Extraction of natural dyesand mordants

The 5 % stock solution was prepared by boiling 5 gm of dry powder in 100 ml of water for 60 minutes. The refluxing technique was used to get the coloured solution. The extract was cooled for some time and then

filtered with anylon cloth. This extracted dye was then centrifuged using REMI R-4C machine for 25 min at 4000 rpm to get undissolved particles to be settled. The supernatant solution was used for dyeing in laboratory rota dyer machine (R. B. electronic and engineering Pvt. Ltd., India). The 5 % stock solution of mordant was used for this work.

2.3. Dyeing Procedure

Three different mordants were used for dyeing as both pre-mordanting and post-mordanting agents. The mordanting and dyeing was carried out in a laboratory rota dyer machine with programmable time and temperature control. The required amount of dye was taken according to the dyeing shade for 10% and 30% respectively on the weight of thefabric. Around neutral pH and material to liquor ratio of 1:30 were maintained and dyeing was carried out at 90ºC for 60 min in rota dyer.

2.4. Evaluation of dyeing

Evaluation of dyeingwas done by determination of K/S and L*, a*, b*, C*, H* values using Spectra Scan 5100+ computer colour matching system. The relative colour strength (in terms of K/S value) of the flower extract dyed cotton fabrics was measured using the Kubelka-Munk equation:

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

where 'K' is the absorption coefficient and 'S' is the scattering coefficient and 'R' is the reflectance of the dyed fabric at the wavelength of maximum absorption.

2.5. Fastness Properties

The dyed samples were subjected to washing fastness test using ISO 105 C-10: 2006 method. Similarly, light fastness and rubbing fastness of the above samples were also assessed according to ISO 105-B02:2013 and ISO 105-X 12:2002 methods, respectively.

3. Results and Discussions

3.1. Dyeing of Linen Fabric using Madder

It was observed that K/S values increased with the increase in concentration of dye in case of dyeing without mordant. The pre-mordanting and post-mordanting on fabric enhanced the values of K/S with an increase in (%) shade (refer Table 3.1). It is so observed due to the formation of the complex between

Table 3.1: K/S values and colourcoordinatesof madder dyed linen using mordants

Mordants Used	% Shade	L*	a*	b*	C*	H*	K/S
Without Mordant	10	66.34	13.05	1.77	13.17	7.73	0.57
	30	65.39	12.58	0.74	12.60	3.37	1.00
	50	64.22	10.76	1.07	10.81	5.69	1.53
	100	64.22	11.07	0.67	11.09	3.46	1.70
Alum Pre-Mordant	10	68.47	13.55	10.55	17.18	37.90	0.66
	30	67.90	16.14	9.22	18.59	29.71	1.00
Alum Post-Mordant	10	65.68	15.10	-0.20	15.11	359.24	0.32
	30	66.07	17.70	2.23	17.84	7.19	0.93
$FeSO_4$ Pre-Mordant	10	66.92	6.67	11.65	13.42	60.19	0.83
	30	65.08	4.95	8.65	9.96	60.20	0.87
$FeSO_4$ Post-Mordant	10	65.59	5.15	10.33	11.54	63.48	0.75
	30	63.61	4.75	4.80	6.75	45.30	1.36
Harda Pre-Mordant	10	64.39	6.45	7.24	9.70	48.29	0.46
	30	64.41	6.96	6.61	9.60	43.50	0.65
Harda Post-Mordant	10	64.17	3.71	10.28	10.93	70.12	0.37
	30	65.85	7.25	10.12	12.45	54.34	0.58

Note: L*: lightness (0 = black, 100 = white); a*: red-green co-ordinates (+ve = red, - ve = green); b*: yellow-blue co-ordinates (positive values = yellow, negative values = blue; C* = chroma (+ve = brighter, -ve = duller); H*= hue.

mordants and dye. Fixation of dye in fabric improved to some extent when mordants were used. Hence, an increased amount of colourant may be getting fixed on linen fabric. The colouration of linen fabric reflected in enhancing K/S values for pre mordanting with three different mordants varied in following order: Alum > $FeSO_4$>Harda> without mordanting. Also, in the case of post-mordantinglinen dyed with $FeSO_4$ mordant showed maximum K/S value. This order of K/S values for post mordanting with three different mordants was as follows:$FeSO_4$> Alum >Harda> without mordanting.

3.2 Fastness Properties of madder dyed cotton using mordants

The fastness ratings of linen fabric dyed without mordant and dyed with three different mordants are presented in Table 3.2.These results indicate that the washing fastness of the linen fabrics dyed with madder dye was good to very good (3-4 to 4-5). It is observed that after washing there was a change in tone of the samples. This might be due to decomposition of the dye itself or breaking of bonds between mordant-dye or dye-fibre. The light fastness was of the grade good to excellent (5-7) for without and with mordants.The colour fastness to rubbing was found to be in the range of 4 to 5 i.e. very good to excellent, with the linen fabric dyed without or with mordants. This may be due to more compact and complex structure formed by dye with a mordant, which increases the affinity of the dye molecules towards substrate during pre-mordanting and post-mordanting techniques.

3.3. Dyeing of Linen Fabric using Sappanwood

It was observed that K/S values of Sappanwood dyed linen fabric increased with the increase in concentration in case of dyeing without mordant (refer Table 3.3). The pre-mordanting and post-mordanting on fabric enhanced the values of K/S with an increase in (%) shade. The colouration of linen fabric reflected in enhancing K/S values for pre mordanting with three different mordants varied in following order: $FeSO_4$>Harda> Alum > without mordanting. Also, in the case of post-mordanting of linen dyed with $FeSO_4$ mordant, it showed maximum K/S value.The order of K/S values for post mordanting with three different mordants was as follows: $FeSO_4$ >Harda> without mordanting> Alum.

Table 3.2:Fastness properties of madder dyed linen using mordants

Mordants used	% Shade	Wash Fastness	Light Fastness	Rubbing Fastness	
				Dry	Wet
Without Mordant	10	3-4	4-5	5	5
	30	3-4	5	5	5
	50	3	6	5	5
	100	3	6	5	5
Alum Pre-mordant	10	3-4	5	5	5
	30	3	6	5	4-5
Alum Post-mordant	10	4	5	5	5
	30	4	6	4-5	4-5
$FeSO_4$ Pre-mordant	10	4	6	4-5	4-5
	30	4	6	4-5	4
$FeSO_4$ Post-mordant	10	4-5	6-7	5	4-5
	30	4-5	7	5	4-5
Harda Pre-mordant	10	4	6	5	5
	30	3-4	6	4-5	4-5
Harda Post-mordant	10	4	7	5	5
	30	4	7	5	4-5

Table 3.3:K/S values and colourcoordinatesof Sappanwood dyed linen using mordants

Mordants used	% Shade	L*	a*	b*	C*	H*	K/S
Without mordant	10	65.57	8.36	5.10	9.79	31.36	0.52
	30	66.09	8.50	5.92	10.36	34.84	0.99
	50	67.58	9.89	8.84	13.27	41.76	2.04
	100	67.55	11.59	9.73	15.13	40.00	2.70
Alum Pre-mordant	10	63.37	20.04	4.76	20.59	13.35	0.79
	30	63.36	22.47	6.19	23.31	15.39	2.15
Alum Post-mordant	10	65.95	6.90	4.75	8.37	34.52	0.23
	30	66.74	10.26	6.81	12.31	33.56	0.61
$FeSO_4$ Pre-mordant	10	62.19	5.42	-0.01	5.42	359.85	3.36
	30	61.51	5.48	-1.69	5.73	342.88	5.30
$FeSO_4$ Post-mordant	10	67.13	3.43	8.89	9.53	68.88	1.26
	30	64.06	4.23	3.77	5.67	41.65	1.68
Harda Pre-mordant	10	73.70	3.54	14.86	15.28	76.59	1.19
	30	76.78	5.16	17.43	18.17	73.49	2.29
Harda Post-mordant	10	67.79	1.21	11.25	11.31	83.83	0.48
	30	69.95	2.92	12.19	12.53	76.49	0.77

Note: L*: lightness (0 = black, 100 = white); a*: red-green co-ordinates (+ve = red, - ve = green); b*: yellow-blue co-ordinates (positive values = yellow, negative values = blue; C* = chroma (+ve = brighter, -ve = duller); H*= hue.

3.4 Fastness Properties of Sappanwood dyed cotton using mordants

The fastness ratings of linen fabric dyed without mordant and dyed with three different mordantsare presented in Table 3. 4.These results indicate that the washing fastness of the linen fabrics dyed with sappanwood dye were average to very good (2-3 to 4). It is observed that after washing there was a change in colour of the samples which might be due to decomposition of the dye itself or breaking of bonds between mordant-dye or dye-fibre. The light fastness was of the grade good to excellent (5-7) for without mordants and with selective three mordants.The colour fastness to rubbing was found to be in the range of 4 to 5 i.e. good to excellentwith the linen fabric dyed with mordants. This may be due to more compact and complex structure formed by dye with a mordant, which increases the affinity of the dye molecules towards substrate during pre-mordanting and post-mordanting techniques.

Table 3.4:Fastness properties of Sappanwood dyed linen using mordants

Mordants used	% Shade	Wash Fastness	Light Fastness	Rubbing Fastness	
				Dry	Wet
Without Mordant	10	2-3	6	5	5
	30	2-3	6	5	5
	50	2-3	7	5	5
	100	2-3	7	5	5
Alum Pre-mordant	10	3	4-5	5	5
	30	3	5	5	4-5
Alum Post-mordant	10	3-4	4-5	5	5
	30	3-4	5	5	5
$FeSO_4$ Pre-mordant	10	3-4	5	5	4-5
	30	3-4	6-7	4-5	4
$FeSO_4$ Post-mordant	10	4	5	5	4-5
	30	4	6	5	4-5
Harda Pre-mordant	10	2-3	5-6	5	5
	30	2-3	6	5	5
Harda Post-mordant	10	3	6-7	5	5
	30	3-4	6-7	5	4-5

3.5. Dyeing of Linen Fabric using Marigold

It was observed that K/S values of marigold dyed linen fabric increased with the increase in concentration in case of dyeing without mordant (refer Table 3.5). The pre-mordanting and post-mordanting on fabric enhanced the values of K/S with an increase in (%) shade.The colouration of linen fabric reflected in enhancing K/S values for pre-mordanting with three different mordants varied in following order: Alum >Harda> FeSO4>without mordanting. Also, in the case of post-mordanted with FeSO4 dyed linen showed maximum K/S value. This order of K/S values for post mordanting with three different mordants was as follows: $FeSO_4$>Alum>Harda> without mordanting.

Table 3.5:K/S values and colourcoordinates of marigold dyed linen using mordants

Mordants used	% Shade	L*	a*	b*	C*	H*	K/S
Without Mordant	10	67.55	-0.12	12.60	12.60	90.58	1.18
	30	72.29	-0.97	15.31	15.34	93.66	2.44
	50	75.39	-1.80	16.06	16.16	96.41	4.12
	100	77.91	-2.68	16.10	16.32	99.50	8.04
Alum Pre-Mordant	10	78.31	-1.37	25.20	25.24	93.15	4.23
	30	82.93	-2.35	28.91	29.00	94.68	9.31
Alum Post-Mordant	10	68.06	-1.81	16.00	16.10	96.49	0.64
	30	73.79	-0.10	22.21	22.21	90.29	2.79
$FeSO_4$ Pre-Mordant	10	60.94	1.24	10.01	10.08	82.93	1.77
	30	61.63	-0.17	9.96	9.96	91.04	3.23
$FeSO_4$ Post-Mordant	10	60.88	0.34	10.02	10.03	88.04	2.92
	30	60.07	-0.31	9.60	9.61	91.86	8.14
Harda Pre-Mordant	10	71.56	-1.68	11.88	12.00	98.08	2.05
	30	78.68	-2.64	15.20	15.43	99.87	4.33
Harda Post-Mordant	10	70.27	-1.11	12.36	12.41	95.15	1.12
	30	74.10	-1.53	14.12	14.20	96.23	2.16

Note: L*: lightness (0 = black, 100 = white); a*: red-green co-ordinates (+ve = red, - ve = green); b*: yellow-blue co-ordinates (positive values = yellow, negative values = blue; C* = chroma (+ve = brighter, -ve = duller); H*= hue.

3.6 Fastness Properties of marigold dyed cotton using mordants

The fastness ratings of linen fabric dyed without mordant and dyed with three different mordants are presented in Table 3.6.These results indicate that the washing fastness of the linen fabrics dyed with marigold dye were moderate to good (3 to 4). It is observed that after washing there was a change in colour of the samples which might be due to decomposition of the dye itself or breaking of bonds between mordant-dye or dye-fibre. The light fastness was of the grade good to excellent (5-7) for without and with mordants. The colour fastness to rubbing was found to be in the range of 4 to 5 i.e. good to excellent, with the linen fabric dyed with or without mordant. This may be due to more compact and complex structure formed by dye with a mordant, which increases the affinity of the dye molecules towards substrate during pre-mordanting and post-mordanting techniques.

Table 3.6:Fastness properties of marigold dyed linen using mordants

Mordants Used	Shade (%)	Wash Fastness	Light Fastness	Rubbing Fastness	
				Dry	Wet
Without Mordant	10	3	6	5	5
	30	3	6	4-5	4-5
	50	3	6	4-5	4-5
	100	3	6-7	4-5	4
Alum Pre-mordant	10	3-4	5	5	5
	30	3-4	6	5	4-5
Alum Post-mordant	10	4	5	5	5
	30	4	5-6	5	5
$FeSO_4$ Pre-mordant	10	3-4	6	4-5	4
	30	3-4	6-7	5	4
$FeSO_4$ Post-mordant	10	4	6	5	4-5
	30	4	6	4-5	4-5
Harda Pre-mordant	10	3-4	6	5	5
	30	3	6-7	5	4-5
Harda Post-mordant	10	4	5-6	5	5
	30	3-4	6-7	5	5

4. Mechanism of natural dyeing of Linen fabric

Lignin has higher molecular weight and it is a cross-linked phenolic polymer. So, it may block sites where dye molecules can penetrate into the linenfabric. Like cotton, in linen also hydroxyl groups present which are taking part in dyeing. These groups can form a coordinate bond and hydrogen bond with natural dye with the help of mordant which acts as a fixing agent. So, colour tone variations can be done by changing mordant or changing %shade of the same mordant. Colour not only depends on fibre compositions but also on colouring component and mordants. Metallic mordants form complex with tannin which is present in some amount of dye. Tannin also acts as a mordant but due to a small amount ofdye, it requires mordant to be added. Also, in the case of natural mordants such as harda that was used here for experimental work, it consists of chebulinic acid which is a type of tannin and thus helps in enhancing extent of colouration. Natural dye extract in combination with alum, ferrous sulphate and harda mordants onto linen fabric produced good improvement in colour depth (K/S). They showed shifts in their tones resulting in thebeautiful gamut of colours as compared to the dyeing obtained without using mordants.Ferrous sulphate and alum mordants are well known for their ability to form coordination complexes and to readily chelate with the dye. Thus, dyeing of linen fabric with natural dye extract may be attributed to the presence of tannin richness. Natural dyes are less substantive and thus require a mordant to fix them onto the fabric and prevent the colour from either fading with exposure to light or washing out. These pre or post-mordanting have different effects on the shade obtained after dyeing and also on the fastness properties.Alum is a white powder that is safe for hands and easy to use which produces bright shades and relatively good light fastness. It is, therefore, necessary to choose a proper mordanting method to get the desired shade and fastness properties.

5. Conclusions

The natural dyeing on linen fabric was carried out with madder, sappanwood and marigold with mordants at different concentrations. Natural dyes with the use of different mordantsgive adifferentcolour. It was observed that as the percent shade increased, the value of K/S also increased which resulted in increase indepth of colour. Linen fabric showed higher colour depth in terms of K/S values on mordanting with harda, alum

and ferrrous sulphate as compared to without mordanting. Thus, natural dyed linen fabric showed good promise to be used as wellness product.

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Advances in Biodegradable Polymers a New Route for Development of Eco-friendly Medical Textile Products: An Overview

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Abstract
In the last few years, health care professionals have faced with an increasing number of patients suffering from various skin related diseases such as wound, burn injuries and which are really difficult to treat and heal. Consumers' attitude towards hygiene and active lifestyle has created a rapidly increasing market for a wide range of medical textiles, which in turn has stimulated intensive research and development. As a result, the number of functional textiles with an antibacterialand antifungal activity incorporating both synthetic and biopolymers has increased considerably over the last few years. In a near future, textile materials treated with natural products will perhaps be the largest application in the area of medical textiles due to the irunique properties like biodegradability and excellent stability against bacteria's.The present paper report a comprehensive review on biodegradable polymers and its application in the development of healthcare textiles and allied area.

Keywords
Biodegradable Polymers, Polysaccharides, Chitosan, Gelatin, Antimicrobial Finishing

1. Introduction

Increasing global competition in textiles has created many challenges for textile researchers and industrialists. The rapid growth in technical textiles and their end-uses has generated many opportunities for the application of innovative finishes. Novel finishes of high added value for apparel fabrics are also greatly appreciated by a more discerning and demanding consumer market. Antimicrobial textiles with improved functionality find a variety of applications such as health and hygiene products, especially the garments worn close to the skin and several medical applications, such as infection control and barrier material.[1]In the last few decades, with the increase in new antimicrobial fiber technologies and the growing awareness about cleaner surroundings and healthy lifestyle, a range of textile products based on synthetic antimicrobial agents such as triclosan, metal and their salts, organometallics, phenols and quaternary ammonium compounds, have been developed and quite a few are also available commercially. Although, the synthetic antimicrobial agents are very effective against a range of microbes and give a durable effect on textiles, they are a cause of concern due to the associated side effects, such as action on non-target and microorganisms and water pollution. Hence, there is a great demand for antimicrobial textiles based on eco-friendly agents which not only help to reduce effectively the ill effects associated due to microbial growth on textile material but also comply with statutory requirements imposed by regulating agencies.[2] Some natural polymers such as polysaccharides (alginates, chitin, chitosan, heparin, chondroitin), proteoglycan and proteins (collagen, gelatin, fibrin, keratin, silk fibroin, eggshell membrane) are extensively used in wounds and burns management.[3]. Obtained by elctrospinning technique, some synthetic polymers like biomimetic extracellular matrix micro/nanoscale fibers based on polyglycolic acid, polylactic acid, poly-acrylic acid, poly-E-caprolactone, polyvinylpyrrolidone, polyvinyl alcohol, polyethylene glycol, exhibit in-vivo and in-vitro wound healing properties and enhance re-epithelialization.[4].There is a vast source of medicinal plants with active antimicrobial ingredients. Although, there are many natural products rich in antimicrobial agents, the study on their use in textiles is limited and not well documented. The relatively lower incidence of adverse reactions of herbal

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products as compared to modern synthetic pharmaceuticals, coupled with their reduced cost, can be exploited as an attractive ecofriendly alternative to synthetic antimicrobial agents for medical textile applications. Recent developments on plant based bioactive agents have opened up new avenues in this area of research. Most of the papers in this area concentrate on the technical details of applying individual natural agents, such as Neem, natural dyes, chitosan, gelatin and other herbal products (Tulsi, Aloe Vera, tea tree oil, etc.) on textile substrates and their testing [5]

2. Biodegradable Polymers for Healthcare Application

Biodegradable polymers are widely used in the regenerative medicine field along with textile substrate, for wounds and burns dressing because of their biocompatibility and biodegradability. Inducing and stimulating the wound healing process, natural polymerase is involved in the repair of damaged tissues and consequently in skin regeneration.[6] Due to their three-dimensional cross-linked polymeric networks that are soaked withwater or biological fluids, biomaterial hydrogels are employed in the pharmaceutical and biomedical area, especially for woundmanagement, tissue engineering, drug delivery, and organ transplant.[7] In addition, novel biomaterials based onrenewable, non-toxic, and biodegradable natural polymers areobtained through radiation processing. Therefore, hydrogels containing cross-linked natural polymers can be used for wounds and burns dressing.[8]

2.1. Polysaccharides

Polysaccharides administered in the form of hydrogels, some polysaccharides are extensively used for the management of wounds and burns: neutral (glucans, dextrans, cellulose), acidic (alginic acid-hyaluronic acid), basic (chitin, chitosan) or sulfated polysaccharides (heparin, chondroitin, dermatan sulfate, keratin sulfate). [9]

2.1.1. Homoglycans

Homoglycans are naturally occurring biocompatible materials used as locally modulators of the cellular response actively participating in the wound healing process in the field of regenerative medicinal textiles (tissue engineering, wound dressing), electrospun dextran, starch or cellulose are potentially useful materials for the obtaining of nanofiber matrices. [10]

2.1.1.2. Dextrans

Carboxymethyl benzyl amide sulfonate dextran (CMDBS) is a functionalized dextran with heparin-like properties and different biomedical applications, including woundsand burns dressing. CMDBS, a soluble polymer structurally similar to glycosaminoglycan heparin, stimulates wound healing in various in vivo experimental models, controls the proliferation of Staphylococcus aureus biofilm and affects proliferation and metabolism of tumor cells, smooth muscle cells. [11] Due to their peculiar (bucket-shaped) conformation, hydrated cyclodextrins are used for modern odor-control dressings; they have the ability to capture and neutralize lipophilic odor molecules. Compared to charcoal, cyclodextrins are active for longer time periods and their odor absorption capacity is enhanced by serum proteins.

2.1.1.3 Cellulose

Bioengineered cellulose is used especially as healing scaffold/matrix for chronic wound dressings, reducing pain and shortening healing time. Fig 2.1 (a) and (b) showing repeating unit of cellulose and its derivate used commonly for medicated textiles especially in wound healing applications such as for partial- and full-thickness wounds, it stimulates the granulation and epithelialization process. Wound dressings with modified cellulose can be incorporated by co-immobilization different active molecules such as enzymes, antioxidants, hormones, vitamins, antimicrobial drugs. [12] Biosynthesized in high amounts by Acetobacterxylinum (Aceto-bacteraceae), microbial cellulose (MC), also known as bacterial cellulose (BC), exhibits a great potential for wound dressings andtissue engineered skin.MC is a versatile biomaterial with a unique nanostructure, exhibiting a high mechanical strength and remark-able physicochemical properties. It is used in regenerative as a wound-healing scaffold for severely damaged skin andfor small-diameter blood vessel replacement.[13] As a natural biocompatible, biodegradable, antimicrobial, hypoallergenic and non-toxic polymer, MC is an innovative product, recommended as an alternative dressing for superficial partial-thickness burn wounds. [14] Recent studies highlight the importance of bacterial nano-celluloses (BNC) as innovative natural polymeric raw materials in biomedical area (as wound dressings) due to their special properties: biocompatibility, biodegradability, chirality, hydrophilicity, broad chemical-modifying capacity, the formation of various semi-crystalline fiber types.[15]In this respect, porous nanofibrous BNC membranes could be used for tissue repairing and remodeling or for large area skin transplantation. [16]Obtained by immersing

wet MC pellicle in chitosan solution followed by freeze-drying process, Cellulose base composite matrix exhibits much better biocompatibility than pure MC. Bioactive and suitable for cell adhesion, BC-Ch (Bacterial Cellulose and Chitosan composite) scaffolds can be used for wound dressingand tissue engineering.[17] In a recent study,different composites were prepared through impregnation of MC sheets with 2% and 4% suspensions of montmorillonite (MMT), Na-MMT, Ca-MMT and Cu-MMT.[18] Modified MMTs were obtained through cation exchange technique. MC-MMTs nano reinforced composite films are novel wound dressing materials showing a powerful antibacterial effect against escherichia coli and saureius and a potential therapeutic importance for wound healingand tissue regeneration.

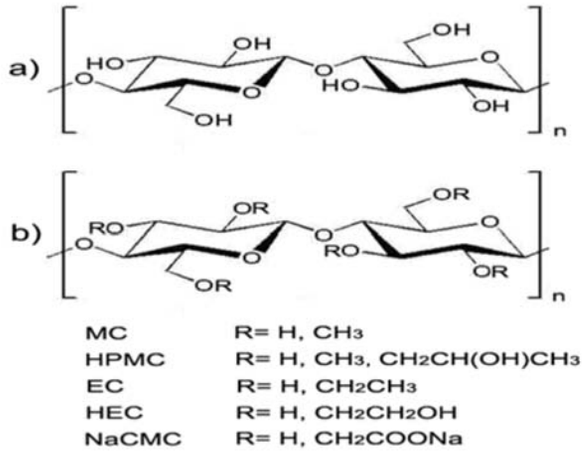

Figure 2.1. (a) Repeating unit of cellulose also termed 'cellubiose'. (b) Repeating unit of cellulose derivatives. The substituent group 'R' is indicated for methylcellulose (MC), hydroxyl propyl methylcellulose (HPMC), ethyl cellulose (EC), hydroxyethyl cellulose (HEC) and sodium carboxy methylcellulose (NaCMC).(Alessandro Sannino et.al "Biodegradable Cellulose-based Hydrogels: Design and Applications" Materials 2009, 2, 353-37)

2.1.1.4 Chitin and Chitosan

Chitin is the most abundant natural amino polysaccharide (poly-N-acetyl-glucosamine) produced annually almost as much as cellulose. It is the major component of the invertebrates, crustaceans and insects exoskeleton and of the fungi cellwall.[19]Chitosan is a natural, non-toxic and microbial resistant and biodegradable polymer, can be easily convertible in to nanostructure form (Fig.2.2).Chitosan is a poly-N-acetyl-glucose aminoglycan obtained by alkaline deacetylation of chitin, respectively by treating shrimp and other crustacean shells with sodium hydroxide.[20] It is made of randomly distributed-(1→4)-d-glucosamine and N-acetyl-d-glucosamine. [21]For the localhemostatic antibacterial, anti-inflammatory and wound healingproperties (Fig.2.2), different formulations of chitin and chitosan were obtained: water-soluble chitin (WSC) ointment as a wound healing assistant, microcrystalline partially deacetylated chitin hydrochloride as promising hemostatic material.[22]

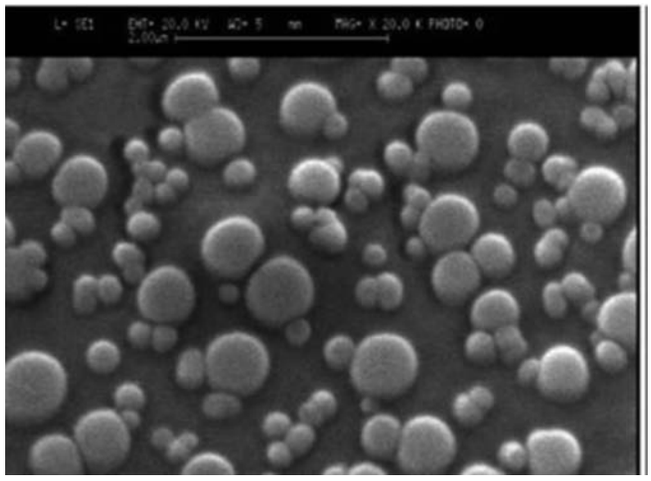

Fig 2.2: Scanning electron microscopy (SEM) image of chitosan nanoparticles

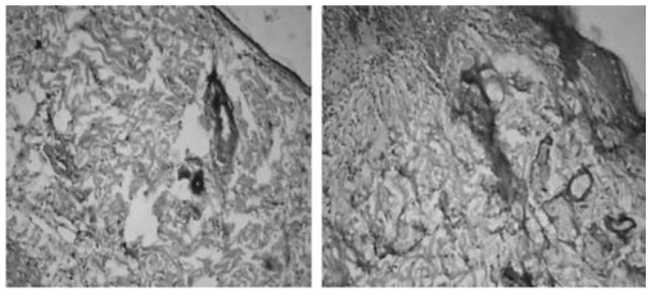

Fig 2.3: Photomicrographs of wounds treated with chitosan film

2.2 Proteins and peptides for Medical Textiles

2.2.1 Vegetable Proteins

Some proteins of vegetal origin are used for wounds and burnsdressing. Composite biomaterials prepared from soya protein and sago-starch cross-linked with glutaraldehyde (SGSY-G) is effective as wound-dressing in rat model of excision.[23]Due to their biocompatibility and biodegradability, soy- and sodium caseinate-based membranes biomaterials show promising applications in drug delivery and wound dressing.[24]

2.2.2. Collagen

Collagen is the most abundant protein in the human body and the skin. It is produced by fibroblasts and stimulates the wound healing cellular and molecular cascade, development of new tissue and wound debridement. Collagen dressings formulated from bovine, porcine or avian sources are recommended for the treatment of partial and full-thickness wounds with minimal to moderate exudates. It is contraindicated for third-degree skinburns and for sensitive/allergic patients. [25]There are numerous studies concerning the application of different collagen dressings formulations for wounds and burns: collagen sponges in the healing of experimental deep skinwounds[26], collagen glycosaminogly can complex as a dressing for gingival wounds, [27] collagen restorable membrane for oral woundsdressing, [28], Electrospun collagen nanofibres scaffolds for artificial vasculargrafts and wound repair applications, [29,30]collagen-alginic acid cross-linked thermostable and biodegradablebiopolymer as a wound dressing material.[31]

2.2.3. Gelatin

Gelatin, a natural polymer derived from collagen, is prepared from different animal by-products. In biomedical area, gelatin issued for the production of biocompatible and biodegradable drugdelivery systems and wound dressings.[32] For wounds and burns dressing, gelatin is administered in various formulations: cross-linked gelatin-alginate and gelatin sponges with wound healing properties on the full-thickness dorsal skin defects of rat,[33]EGF containing gelatin-based wound dressings in case of bulk loss of tissue or non-healing wounds such as burns, trauma, diabetic, decubitus and venous stasis ulcers, biodegradable gelatin-based films in trauma and orthopedic surgery. [34]

2.2.4. Bovine serum albumin (BSA)

Strong BSA nanofibre, made from a globular proteinwas obtained through elctrospinning directly from a BSA solution without chemical cross-linking agents, due to its biocompatibility, biodegradability and good mechanical properties, BSA fibrous structures may be used in biomedical area for suturing, wound dressing and wound closure.[35]

3. Requirements for antimicrobial finishing

The term 'antimicrobial' refers to a broad range of technologies that provide varying degrees of protection for textile materials against microorganisms. Antimicrobials are very different in their chemical nature, mode of action, impact on people and the environment, handling characteristics, durability, costs, regulatory compliance, and how they interact with microorganisms.[36] The purpose of imparting antimicrobial activity to textiles is to protect the material from microbial attack, prevent the transmission and spreading of pathogenic microorganisms, inhibit odour development resulting from microbial degradation, and creating a material that will act as preventive and/or curative treatment. Ideal antimicrobial finishing needs to fulfil a number of requirements in order to achieve the maximum benefit from antimicrobial functionalized textile products. An antimicrobial-treated material is defined as being hygienic and, therefore, should have the following requirements.[37, 38, 39]

- Effective inhibition against a broad spectrum of bacterial and fungal species,
- Non-toxicity to the consumer, manufacturer and the environment,
- Durability,
- Compatibility with resident skin microbiota, and other finishing processes,
- Avert from irritations and allergies,
- Applicability with no adverse effects on the quality or appearance of the textile.

4. Antimicrobial finishing methods

Various approaches have been used for antimicrobial functionalization of textile materials depending on the particular active agent and fiber type. In general, two different antimicrobial finishing methods can be distinguished.Antimicrobial agents can be either applied in an after-treatment process or incorporated into the polymer solution prior to extrusion or into the spinning bath (Fig. 4.1.a) [40]. Substance embedded within the fiber structure has to migrate to the surface, and should be slowly released during use in order to be active. [41] Incorporation of antimicrobial substance within a fiber matrix is suitable only for synthetic fibers. As after-treatment processes for antimicrobial finishing of natural, as well as synthetic fibers, conventional exhaust and pad-dry-cure methods have been used (Fig. 4.1.b). In addition, methods like padding; spraying, coating and foam finishing have been developed. Many other methods have also been reported, such as the use of nanosized colloidal solutions, nanoparticles, chemical modification of the biocide for covalent bond formation with the fiber (Fig.4.1.c), crosslinking of the active agent onto the fiber using cross link and sol-gel processes.

(a) (b) (c)

Fig.4.1: Antimicrobial agent is: (a) incorporated into the fibers; (b) applied on the fiber surface; (c) chemically bonded onto the fibers New Multifunctional Textiles: Antimicrobial Treatments, International Workshop, The Salonika, Greece. Available at: http://texmail.ca/002/files/ 000MNu00ItFU0mF4XF0x/ Antimmicrobial_treatment.pdf. Accessed Sep 15, 2010.

5. Advantages of Biodegradable Polymers

Natural bioactive compounds with antimicrobial properties are gaining considerable attention as attractive ecofriendly alternative to synthetic antimicrobial agents for textile applications, especially in medical and health care textiles, as they are safe, non-toxic and skin-friendly.[42]. These naturally active compounds for example, until now less employed polysaccharides and their derivatives, natural dyes, as well as some other extracts from roots, stem, leaves, flowers fruits and seed of diverse species of plants exhibiting antibacterial properties, have already been explored as textile finishing agents in their crude form or as microcapsules [43]. Polysaccharides that play an important part in surface coatings for materials used for medical applications are dextran, hyaluronic acid, Carboxymethyl cellulose, heparin, alginate and others [44, 45]. Alginate and alginate copolymers are mainly used in wound dressings due to their high absorption capacity. Hyaluronic acid is used for healing wounds in wet conditions. Artificial veins from polyethylene terephthalate are usually coated with heparin for improved biocompatibility. Vascular grafts, made from a mixture of polyurethane and heparin, have shown excellent antithrombogenicity and biocompatibility [46]. Special attention is being paid to amino polysaccharides, including chitosan, a chitin derivative, and apart from cellulose the most abundant biopolymer on Earth. Plant-based products (Aloe Vera, tea-tree and eucalyptus oil, neem, grapefruit seed and tulsi leaf extracts, etc.) represent the major group of antimicrobial agents, which consist of substances such as phenols (simple phenols, phenolic acids, quinines, flavonoids, flavones, tannins and cumarines), terpenoids, essential oils, alkaloids, polypeptides and polyacetylenes[47]. These components show, not only antimicrobial, but also antioxidant properties. This is extremely important when developing innovative biomaterials for medical devices, such as bioactive dressings and wound-healing isolation materials. For these kinds of applications it is essential to provide, besides antimicrobial inhibition, a reduction in those reactive oxygen species that are strongly implicated in the pathogenesis of e.g. wounds, causing injury with bio-molecules such as lipids, proteins and nucleic acids, as well as the depletion of mitochondrial DNA from human skin. Flavonoids are referred to be powerful antioxidants, i.e. to counteract free-radicals and prevent any damage caused by them [48], and are, therefore, used as anti-inflammatory, antimicrobial, and anti-cancer agents

6. Conclusion

The most significant antimicrobial agents used for functional textiles have been presented in this paper. Many of these e products are nontoxic, biodegradable both for humans and environment and easy to degrade within the environment. Even more, most of them promote bacterial resistance. Taping new potential antimicrobial substances, such as antimicrobial polysaccharides, cellulose and gelatin based textile products can considerably minimize the undesirable activities of the antimicrobial products. The recent developments in the bioactive material in the field of healthcare textiles has opened a new sustainable market due to their unique properties such as biocompatibility, biodegradability, nontoxicity and antimicrobial activity, which have attracted much scientific and industrial interest.Understanding the antimicrobial and antifungal materials and methods described in details through this paper help to establish material's potentials and within the field of medical textile usage.

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Imparting Antimicrobial Properties to Polyester and Polyamide Fibers-State of the Art

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Abstract
The current review is aimed at highlighting state of the art of imparting antimicrobial properties to polyester (PET) and polyamide (PA) fibers. It is divided into two main parts. The first part is concerned with general aspects related to the antimicrobial finishing of textile materials. The second part highlights state of the art of preparation of bioactive polyester and polyamide fibers and fabrics. Having in mind the current growing trends of polyester and polyamide production volumes, the realistic prospects in the field of imparting antimicrobial properties to such fibers are also outlined.

Keywords
PET and PA fibers, AntimicrobialAgents, Antimicrobial Finishing Techniques, Test Methods.

1. Introduction

The world textile industry in 2014 has experienced the most potent growth in 25 years. Fiber volumes rose by 2.8% to 85.5 million tons. This corresponds to an average per capita consumption of 12.2 kilograms. The fastest growth is generated by manmade fibers. Now these fibers have surpassed natural fiber production and hold a nearly 60.5% share of the total fiber market. No matter whether they are used in functional athletic wear, curtains, carpets, tire cords, airbags or technical textiles for road construction and industry, manmade fibers have been a part of all areas of our lives for a long time now. Furthermore, they exhibit a high level of design, freedom in research and production. Manmade fibers can be adopted to meet a variety of different applications and can be gives specific characteristics.

The manmade fiber industry has an undisputed leader: 81% of all manmade fibers are made of polyester. Fibers made of polyamide have the second largest share with 8%. Other materials make up the rest with 11%. Compared with polyester, their share is negligibly small. Measured in terms of the total fiber market in 2014 including natural fibers, polyester had a share of approximately one third. Clothing is the largest application area of this material. Thanks to its excellent price - performance ratio, polyester has continuously entered new markets. Today, it can be found in nearly all areas of final applications. For instance, this material is now increasingly being used for producing airbags, taking the place of other fibers that were almost exclusively used for this purpose in the past. In 2014, 41 million tons of polyesters were produced.

Antimicrobial finishing of textiles for biomedical purposes has become an important area of research and one of the fastest growing sectors of the textile market. The global Antimicrobial Coatings Market's worth in 2012 is $1.5 billion and is estimated to reach $2.9 billion by 2018,growing at a compound annual growth rate of 11.8% from 2013 to 2018 under normalconditions [1-3].

It is worth mentioning, that the research for imparting antimicrobial properties to textile fibers has been, until recently, limited to the natural fibers. However, the wide spread of manmade fibers, and the need for expanding its application led to a significant increase in research directed towards imparting new properties to such fibers.

Based on the above mentioned the current review is aimed at highlighting state of the art of imparting antimicrobial properties to polyester and polyamide fibers. It is divided into two main parts. The first part is concerned with general aspects related to the antimicrobial finishing of textile materials. The second part highlights state of the art of preparation of bioactive polyester and polyamide fibers and fabrics.

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Part I: General Aspects Related to the Antimicrobial Finishing Of Textile Materials

1. Necessity of Antimicrobial Finishing

There is a growing volume of literature describing the survival and growth of microorganisms in textiles and their dissemination as a health risk. Textiles are not only carriers of microorganisms, but also good media for their proliferation. When the fabric is worn next to skin, infestation may cause cross infections by pathogens and odors development[4]. The antimicrobial functional finishes are applied to textiles in order to protect the wearer and the fabric itself, several objectives being achieved by this:

- To avoid cross infection by pathogenic microorganisms;
- To control the infestation by microbes;
- To limit the deterioration of textiles.
- To control the spread of disease and danger of infection, inside and outside hospitals.
- To arrest metabolism in microbes in order to reduce the odour formation.
- To safeguard the textile products from staining, discolouration and quality deterioration.

2. Requirements for Antimicrobial Finishing

In order to obtain the greatest benefit, an ideal antimicrobial treatment should not only destroy undesirable microorganisms, but also satisfy a number of requirements concerning their effectiveness against a broad spectrum of bacterial and fungal species[5-7]

Firstly, it should be effective against a broad spectrum of bacterial and fungal species, but at the sametime exhibit low toxicity to consumers, e.g. not cause toxicity,allergy or irritation to the user. Antimicrobial-treated textiles have to meet standards in compatibility tests (cytotoxicity,irritation and sensitization) before marketing. Secondly,the finishing should be durable to laundering, drycleaning and hot pressing. This is the greatest challenge as textile products are subjected to repeated washing during their life. Thirdly, the finishing should not negatively affect the quality (e.g. physical strength and handle) or appearance of the textile. Finally, the finishing should preferably be compatible with textile chemical processes such as dyeing,be cost effective and not produce harmful substances tothe manufacturer and the environment.One further consideration is that the antimicrobial finishing of textiles should not kill the resident flora of nonpathogenic bacteria on the skin of the wearer. The skin resident flora consists of several bacterial genera, which are important to the health of the skin as they lower skin surface pH and produce antibiotics to create an unfavorable environment for the growth of pathogenic bacteria [8].Fortunately, antimicrobial agents on textiles may only reduce the density of the skin resident flora but do not completely eliminate them.

3. Antimicrobial Agents Used for Textiles

According to their mechanism of antimicrobial activity, toxicity, durability, and ecological acceptability, these agents can be divided into different groups [9]

- Biocides and biostats,
- Leaching and bound antimicrobials,
- Controlled-release and barrier-forming agents,
- Agents of poor and good washing resistance.

These antimicrobial agents differ in their chemical structure, effectiveness, method of application, and influence on users and the environment, as well as production costs [10-14].In general, antimicrobials are similar to antibiotics in that they both inhibit microbes growth. But while the purpose of antibiotics is to cure disease, antimicrobials aim to prevent transmission of disease-causing microorganisms[15]. In the case of the antimicrobial textile finishes, their activity can be biocidal or biostatic. The biocides (bactericides and fungicides) include agents that destroy bacteria and fungi, whilst the biostats (bacteriostats and fungistats) inhibit the proliferation of microorganisms. The mode of action is directly related to and strongly dependent upon the concentration of the active substance in the textile finishing. The minimum inhibitory concentration (MIC) is required for biostatic activity, but for biocidal activity the minimum biocidal concentration (MBC) should be exceeded [9,16].

For antimicrobial agents, the mechanism of action is of great importance. There are two main mechanisms of antimicrobial activity, controlled release and bio-barrier formation [14, 17]. Antimicrobial agents that function by a controlled release mechanism have not been chemically bonded to the textile fibers and the irantimicrobial activity can be attributed to their gradual and persistent release in the presence of moisture from the textile into the surrounding environment. Their antimicrobial efficiency depends directly on their concentration and solubility in water. Due to the leaching of the agent into the surrounding environment, the concentration of the active substance in the textile decreases and gradually falls under the limit of effectiveness. In contrast, antimicrobial agents chemically bonded to the fiber's surface could act as bio-barriers and kill microorganisms on contact. If covalent bonds are formed between the agent and the fiber, the dura-

bility and wash resistance of the antimicrobial agent strongly increase. However, the long lasting efficiency of such agent could be decreased by the dead microorganisms which cover the bio-barrierand cause its deactivation. As a textile finish, it is mostly used for the protection of industrial and transport filters, the production of antimicrobial shoe- socks, towels, cleaning wipes and for household textiles

3.1. Classes of Antimicrobial Agents

There are several classes of antimicrobial agents used for antimicrobial functionalization of textiles. The most prevalent antimicrobials for textile use include:

3.1.1. Oxidizing Agents

Aldehydes, halogens and proxy compounds are oxidizing agents. They attack the cell membrane, get into the cytoplasm and affect the enzymes of the microorganisms.

3.1.2. Coagulants

Primarily alcohols irreversibly denature the protein structures. Radical formers like halogens, isothiazones, and peroxo compounds are highly reactive due to the presence of free electrons. These compounds virtually react with all organic substances in particular oxidizing thiols in amino acids. Even at the lowest level of concentrations, these substances pose particular risk to nucleic acids by mutations and dimerization.

3.1.3. Triclosan

One of the most durable type of antimicrobial products is based on a diphenyl ether (bis-phenyl) derivative known as either 2, 4, 4´-trichloro-2´ hydroxyl diphenyl ether or 5-chloro-2-(2,4-dichloro phenoxyl) phenol. Triclosan products have been used for more than 25 years in hospitals and personal care products such as antimicrobial soap, toothpaste and deodorants. Triclosan inhibits growth of microorganisms by using a electrochemical mode of action to penetrate and disrupt their cell walls. When the cell walls are penetrated, leakage of metabolites occurs and other cell functions are disabled, thereby preventing the organism from functioning or reproducing. The Triclosan when incorporated within a polymer migrates to the surface, where it is bound. Because, it is not water-soluble, it does not leach out and it continuously inhibits the growth of bacteria in contact with the surface using barrier of blocking action.

3.1.4. Quaternary Ammonium Compounds

Quaternary ammonium compounds (QACs), particularly those containing chains of 12-18 carbon atoms,have been widely used as disinfectants. These compounds have a nitrogen atom bearing a positive charge which isresponsible for the various detrimental effects on microorganisms. During bacterial inactivation, the quaternary ammonium groups remain intact and retain their antimicrobial activity as long as QACs are attached to textiles[10].Cationic surface active agents (cationic surfactants), including particular quaternary ammonium salts (QASs), are important biocides known to be effective antiseptics [16]. As antimicrobial agents for textiles, mono ammonium and "gemini" or "dimeric" ammonium surfactants bearing alkyl, alkyl-aryl and perfluorinated hydrocarbon groups are used [9, 18-19]. These are active against a broad spectrum of microorganisms such as Gram-positive and Gram-negative bacteria, fungi and certain types of viruses [20].

The antimicrobial activity of QASs depends on a number of structural factors, as follows: the length of thealkyl chain, the presence of perfluorinated groups and the number of cationic ammonium groups in the molecule. The antimicrobial function arises from attractive interactions between the cationic ammonium group of the QAS and thenegatively charged cell membrane of the microbe. These interactions consequently result in the formation of asurfactant-microbe complex. This, in turn, causes the interruption of all essential functions of the cell membrane and,thus, the interruption of cellular protein activity[21-23]. QASs also affect the bacterial DNA, causing a loss of multiplication ability[24].

3.1.5. Metals and Metal Salts

For synthetic fibers, silver particles can be incorporated into the polymer before extrusion[25]or before nanofiber formation using electrospinning [26-27]. During use, silver diffuses onto the surface of the fiber and forms silver ions in the presence of moisture. The rate of silver release canbe influenced by the chemistry and physical characteristics of the fiber and the amount of silver in the fiber. Gradual release can lead to an extended period of biocidal activity[7].

Many heavy metals are toxic to microbes at very low concentrations either in the free state or in compounds. They kill microbes by binding to intracellular proteins and inactivating them[28]. Although some other metals, such as copper [29], zinc [30-31] and cobalt[32],

have attracted attention as effective antimicrobial agents for textiles, silver is by far the most widely used in general textiles [6, 7] as well as in wound dressings [33].

3.1.6. Nontoxic and Inexpensive Metal Oxides

Most of the literature about antimicrobial textile nanocomposites is focused on silver. However,other metals and metal oxides such as zinc, titanium, copper, zirconium, iron and gold show improved biocidal properties at nanoscale. ZnO and CuO nanocomposites display similar performance compared to silver while TiO_2 efficacy is limited by light availability due to its photocatalytic mechanism of action. Despite the heterogeneous range of methods, textilesubstrates, nanoparticle sizes and concentrations that can be found in the literature, some general assumptions can be made about metal and metal oxide NPs based on the collected data.Silver and copper NPs of between 1 and 15 nm showed the best biocide activity at relatively low concentrations on the fabrics (5-50 ppm or 1-2 wt. %). AgNPs of up to 50 nm, still require relatively low concentrations of around 100 ppm or 5 wt. % to have complete Gram-positive and Gram-negative inhibition effects. Titanium oxide NPs applied to textiles are generally in thesize range of 1-20 nm. With some exceptions, TiO_2 NPs showed low antimicrobial activity (an average of 70%) even at high concentrations of 10 wt. % on the fabrics. This occurs mainly because TiO2 NPs are fully effective just under UV rays, which limits their practical use in the textile industry. On the other hand, ZnO NPs need a higher average size of 30-40 nm, but with alower concentration (around 1 wt. %) than TiO2 to be effective. This is possibly due to the synergetic dual effect of the photocatalytic generation of hydrogen peroxide and the direct disorganization of the bacterial membrane. All types of metal and metal oxide NPs with diameters greater than 100 nm need concentrations comparable to the metal ions or bulk materials to achieve the same antimicrobial performance.

3.1.7. Some Synthetic Dyes

Metallic dyestuff and have been specifically made with antimicrobial activity. New series of azo disperse dyestuffs prepared by the reaction of sulphanilamidodiazonium chloride derivatives with indan 1, 3 dione, gave excellent dyeing and antimicrobial results on wool and Nylon[34]. Novel cationic dyes were synthesized, showed varying levels of antimicrobial activities, depending on their structures[35].

3.1.8. Natural polymers

The use of antimicrobial polymers offers promise for enhancing the efficacy of some existing antimicrobial agents and minimizing the environmental problems accompanying conventional antimicrobial agents by reducing the residual toxicity of the agents, increasing their efficiency and selectivity, and prolonging the lifetime of the antimicrobial agents. Also, polymeric antimicrobial agents have the advantage that they are nonvolatile and chemically stable and do not permeate through skin. Therefore, they can reduce losses associated with volatilization photolytic decomposition, and transportation. The most studied natural polymer for antimicrobial finishing of textile are:

3.1.8.1. Chitosan

Chitosan is derived from chitin, which is widely distributed in nature as structural component of exoskeletons of crustaceans and insects, in marine diatoms and algae, as well as in some fungal cell walls. The chemical structure of chitin is highly related to that of cellulose.

Chitosan and its derivatives have been recently proposed as biomaterial for a large number of applications ranging from pharmaceutical, cosmic, biomedical, food, agriculture, paper and textile. In textile field, applications of chitosan are mainly related to its antimicrobial properties. In fact, chitosan is awide - spectrum biocide with high antimicrobial efficacy against both Gram -positive and Gram negative bacteria, as well as fungi and yeast.

3.1.8.2. Sericin from Silk

Sericin is a macromolecular protein created by silk worms and constitutes 25-30% of silk protein. The sericin recovered from the degumming liquor finds applications in creams, shampoos and as moisturizing agents. Recently, it has been found that PET fabrics treated with sericin (4 % w/v) show 51 % reduction of Proteus vulgaris and 38 % reduction of S. aureus [36].

3.1.8.3. Natural Polyphenols (e.gTannins)

Tannins are natural and water soluble polyphenols contained in herbaceous and woody plants. Tannins have been reported to be bacteriostatic and bactericidal against a wide range of fungi and bacteria (e.g. S. aureus, E. coli, K. pneumoniae) [37].

3.1.9. Natural Herbal

These products can be used for antimicrobial finishes since there is a tremendous source of medicinal plants

with antimicrobial composition to be the effective candidates in bringing out herbal textiles[38].

3.1.10. Synthetic Polymers

A number of polymers have been developed that can be incorporated into cellulose and other materials, which should provide significant advances in many fields such as food packaging , textiles, wound dressing coating of catheter tubes, and necessarily aterile surfaces. The greater need for materials that fight infection will give incentive for discovery and use antimicrobial polymers.

3.1.10. 1. Quaternized Polymers and Pyridium-Type Polycations

Cationic surfactants, particularly quaternary ammonium salts (QASs), are important biocides that have been known to be effective against a broad spectrum of micro-organisms for years. The antimicrobial efficacy of QASs mostly depends on the length of the alkyl chain [9]. Polymers containing ammonium salt groups are one of the most studied classes of antimicrobial polymers[39-43].

3.1.10.2. Polymers with N-halamine Moieties

N-halamines are heterocyclic organic compounds containing one or two halogen atoms (e.g. chlorine) covalently bound to nitrogen. N-Cl bonds can be formed by chlorination of amine, amide or imide groups in dilute sodium hypochlorite solutions. N-halamines are active for a broad spectrum of bacteria, fungi and viruses [4], and their action differs from those of the other polymeric biocides. In fact, the antimicrobial properties are based on the reaction of electrophilic substitution of chlorine in the N-Cl bonds with hydrogen atoms (usually from water), and results in the release of reactive Cl+ ions. Cl+ ions link to acceptors on micro-organism wall hindering enzymatic and metabolic processes ofproteins.

3.1.10. 3. Biguanide-Based Polymers

Polymers based on biguanides (polybiguanides) are polycationic amines composed of cationic biguanide repeat units separated by aliphatic chains. Polybiguanides kill bacteria by electrostatic attractions occurring between the positively charged biguanide groups and the negatively charged bacterial cell surface[10].Moreover, cationic biguanide groups are also involved in binding the polymer to the fabric surface by electrostatic interactions with negatively charged groups (e.g. carboxylic groups in cellulose fibers) [9].One of the most used biguanide based polymer is poly (hexamethylenebigunide (PHMB).

3.1.10. 4. Conjugated Polymers

Conjugated polymers, such as polypyrrole (PPy) and polyaniline (PANI), are generally employed in textile field for their electrical properties[44]. They can be easily produced by chemical oxidative polymerisation in aqueous solutionsof the monomer. Materials (e.g. fibres, fabrics) plunged in the polymerisation bath are coated with an even and uniform layer of conjugated polymer by in situ chemical oxidative polymerisation. The presence of anions in the polymerization bath improves the formation of positive charges along the backbone chain of the polymer. The positive charges seem tobe responsible for the antimicrobial activity of such kind of polymers.

3. 1.10.5. Dendrimers

Dendrimers are a class of low-molecular weight highly-branched polymers discovered in the 1985 by Tomalia and coworkers[45]. Dendrimers have several functional groups with a central core and terminal end groups. Synthesis and modification of dendrimers have been of great interest to scientists in various applications. Quaternization of dendrimers was reported in the 2000 by Chen et al.[46] that synthesized quaternary ammonium functionalized poly (propylene imine) dendrimers with high biocide properties.Recently, dendrimers have been proposed to develop antimicrobial properties for applications to textiles [47].

4. Antimicrobial Finishing Technologies

The manufacture of bioactive manmade fibers can be accomplished through various methods, depending on the particular active agent and fiber type, have been developed or are under development to confer antimicrobial activity to textiles. In order to obtain textile materials with antimicrobial performances, the following procedures are used[48]:(1) Impregnation of the fibrous material with a solution, suspension oremulsion of the bactericidal (fungicidal) product; (2) Padding of an antimicrobial product,from its soluble state into an insoluble one on the fibrous material; (3) Binding of an antimicrobial product on the fiber through chemical bonds (ionic, coordinative, covalent); (4)Immersion of a bactericidal product either in the spinning solution or melt, during preparation of the chemical fibers.

The most adequate procedure is considered the binding of the antimicrobial product on the fiber through chemical bonds, which is achievable under industrial

conditions allowing the manufacturing of some biologically active textile materials and fabrics with durable properties under repeated washing cycles.

The antimicrobial agent must show a selective action against different microorganisms and can be applied on textile supports by means of surface treatments or by their embedding either into the solution or in polymer melts.

Chemical treatments on the surface represent an efficient solution favorable to the bioactive effect, since the active surfaces are placed on a large contact surface. Durability ofthe treatment to washing and friction depending on the bonds type established between the fiber and the active substance used at the treatment should be considered [49-50]. The treatment efficiency can be improved, using application of the above mentioned products by means of grafting techniques or reactive resins. Among the techniques belonging to the new generation of treatments, radiochemical grafting allows obtaining of materials with new properties, starting from the standard materials and functional monomers destroying several microorganisms (biocides). Grafting is a technique of modification and functionalization of polymers, focused on improving their native characteristics or adding specific properties to them.

Bulk treatments are performed by embedding the active products into the polymers, before the spinning process. Success of the treatment depends on the existing chemical compatibility of the active compound and both the polymer structure and the applied spinning procedure. In order to obtain a good distribution of the above-mentioned compounds into the core fibers, it is important to apply substances which can be dissolved or dispersed into the polymer [49, 51].

5. Evaluation of Antimicrobial Activity

Two types of antimicrobial testing methods are mostly used.

The first method is based on agar zone inhibition, and consists of the immersion of treated material in an agar culture medium containing inoculated microorganisms (bacteria orfungi). It is standardized by standard EN ISO 20645/2004, which set up a method for determining the effect of applied antimicrobial treatments on woven and knitted textiles andrelatively new ISO/DIS 20645. The ISO 11721 is a burial test. The antibacterial effect can be defined as an inhibition of bacterial growth under favorable conditions [52-53].

The second method is based on bacteria number testing and consists in determinationof bacteriostatic/fungistatic activity of the treated material which has been sterilized and inoculated with microorganisms, by numbering the bacteria/fungi colonies.

The Technical Manual of the American Association of Textile Chemists and Colorists(AATCC) presents a number of test methods that are useful for evaluation of antimicrobial finishes on textiles (Table 1).

Table 1: Antimicrobial test methods used with textiles [54]

Test methods	Observations / description
Antimicrobial activity of textile materials: parallel streak method 147 (agar plate test)	Rapid qualitative method for determining antibacterial activity of treated textile materials against Gram-positive and Gram-negative bacteria. Treated material is placed in nutrient agar inoculated with test bacteria. After incubation, antibacterial activity is determined by Inhibition zones on and around the textile.
Antibacterial finishes on textile materials, assessment of: test method 100	Quantitative method for determining the degree of antimicrobial activity of treated textiles. The amount of bacterial growth in inoculated and incubated textiles is determined through serial dilutions and subsequent inoculations of sterile agar
Antifungal activity, assessment on textile materials: mildew and rot resistance of textiles; test method 30	Four methods: method 1 involves testing fabric properties after burial in soil that contains fungi; method 2: cellulose fabric is exposed to Chaetomiumglobosumin an agar plate and the subsequent growth visually determined; method 3: exposes textiles to Aspergillus nigerin an agar plate and visually determines any fungal growth; method 4: uses a humidity jar to expose textiles to mixture of fungi spores. Any growth on the textile is visually determined.
Antimicrobial activity assessment of carpets method 174	Methods are given for the qualitative and quantitative determination of antibacterial activity and qualitative evaluation of antifungal properties of carpet samples using procedures and materials similar to those in the above test methods.

Part II: Preparation of Bioactive PET and PA Fibers and Fabrics

Customer desire for comfort, hygiene and well-being has created a large and rapidly increasing market for antimicrobial PET and PA fibers and fabrics. Numerous manufactures in the textile industry have responded to this demand by launching their brands of antimicrobial products. These products use broad -spectrum biocides such as silver, polyhexamethylenebiguinide, quaternary ammonium compounds and triclosan as the active agents. On the other hand, the use of several other biocides, such as chitosan and its derivatives, specific dyes and regenerable active N-halamine compounds and peroxyacids, is in the development stage. These products vary in their effectiveness and durability depending on the type of fabric, the biocide and finishing method used in the system.

The manufacture of bioactive PET and PA fibers and fabrics or of articles produced from them can be accomplished through:

(a) Physical fixation of the antimicrobial substrate within the fine structure of polymers via addition of bioactive reagent to the polymer chips before fiber formation, or by impregnation of the fibers or the fabrics in bactericidal solutions.

(b) Chemical bonding of the antimicrobial reagent by the preliminary modification of textile materials with the objective of increasing the content or creating on the fiber new functional groups which are able to react with the bactericidal agents.

(a) Physical Fixation of the Antimicrobial Substrates

Several approaches have been used to make antimicrobial fibers for use in clothing to eliminate odors and in carpeting to prevent fungal growth. In these products, the antimicrobial agent is incorporated into the fibers[55-56]. This means that the agent must survive the high processing temperature (typically> 200oC). In addition, the agent must diffuse out of the fibers to the microbe to kill it. This technique poses several problems, including difficulties associated with spinning the fibers and with sustained antimicrobial activity. In addition, the agents may be washed away during the laundering of the garments[57].

The antimicrobial effect of PET could be improved by the addition of silver ion exchanged zeolite. It has been reported that silver ion exchanged zeolites have antimicrobial activity [58-59].Zeolite is a collective noun for alumina - silicates which are inorganic minerals, and they either exist in the nature or are chemically synthesized. Zeolites have different crystal structures and their composition could be quite complex. Since their ion exchange capacity is excellent the material is widely used in water systems, i.e., they contain ions (i.e., Na , K, Mg etc.) that can be exchange with heavy metals during the application [60]. Antimicrobial PET fibers are obtained by preparing a masterbatch of polymer pellets (e.g., PET), silver and copper salts, and a compounding agent which provides free flowing polymer pellets which can be prepared in advance, with a long shelf life. Polymer masterbatches can produce limited color or off-white antimicrobial fibers and fabrics using conventional melt spinning manufacturing methods. Fabrics producing of such fibers are potent inhibitors of Athlete's foot fungi, gram negative and gram positive bacteria, and drug resistant pathogens[61].

It is highly recommended to use yarns containing bacteriostatic agents[62] or antibiotics[63]. Several attempts to immobilize antibiotics in PET fibers by impregnating them with biocide solutions have so far not led to their practical utilization. This mainly due to that such substances are easily and quickly washed out from the treated fibers. Furthermore, attempts to combine antibacterial agents with PET fibers through chemical bonding have also failed due to the absence of suitable functional groups that could form a chemical bond with a biocide compound.

Antimicrobial nanocomposite polyester fibers were melt spun by adding nano ZnO, loaded Linear Low Density Polyethylene (LLDPE) master batch (MB) to the PET chips. The influence of the content of nano ZnO on the antimicrobial properties, crystallization behavior and mechanical properties was studied. It was found that PET composite fibers having 1% nano ZnO showed the optimum antibacterial activity. The presence of nano particles advanced the onset of crystallization temperature and also adversely affected the mechanical properties but well within acceptable limit [64].

Shalaby et al have been prepared and characterized antimicrobial PET fibers manufactured from recycled chips[65]. Two main techniques are used to impart PET fibers the antimicrobial property. The first method was carried out by adding silver exchanged zeolite or Titanium dioxide powder (TiO_2) and their mixtures prior to extrusion step. The second method was carried out by using quaternary ammonium salts as finishing agents prior to drawing step on production line. The authors have used two QAs with different nature.

The first one is aliphatic (Al-QAS) and is named polydiallyldimethyl ammonium chloride (PDADMAC), and the second one is aromatic (Ar-QAS) and is named dimethylalkylbenzyl ammonium chloride (DMABAC). The effect of incorporation of these above mentioned antimicrobial substances (AS) to the PET fibers was studied. It was found that, the PET fibers prepared by the two techniques are effective in reducing pathological microorganisms of gram positive (Bacillus mycoides), gram negative (Escherichia coli), and nonfilamentous fungus (Candida albicans). The most effective physical method for fixation of the antimicrobial substances to the PET fibers or PET nonwoven fabrics manufactured from recycled chips was the impregnation of the fibers or fabrics in the drawing bath containing 0.3% aromatic QAS or 2% aliphatic QAs.

The effect of titanium dioxide particles (TiO2 micro and nano) on the properties of Nylon 6-based multifilament yarns was investigated. For this reason, master-batches of Nylon 6/TiO2 micro and nano-particles were prepared by melt compounding before spinning and then multifilament composites incorporating 0.03, 0.33, 0.5 and 0.7% TiO2 micro and nano-particles were successfully spun in a melt-spinning machine. It was found that incorporating micro titanium dioxide caused severe aggregation at the nylon fiber surface. By contrast, the diffusion of nano-particles within bulk of multifilament yarns was much more consistent, although aggregation of the titanium dioxide nano-particles still appeared. The results manifested the improvement of mechanical properties of the nanocomposites containing TiO_2 nano-particles[66].

The incorporation of biocides [2-substituted N-alkylimidazoles and their silver(I) complexes] into electrospun Nylon 6 nanofibers for application as antimicrobial materials was investigated. The antimicrobial activity of the electrospun Nylon-6/biocides nanofiber composites was evaluated against Escherichia coli, Staphylococcus aureus, and Bacillus subtilis subsp. spizizenii using the disk diffusion method. The electrospun Nylon-6 nanofibers incorporated with 2-substituted N-alkylimidazoles displayed moderate to excellent levels of growth reduction against S. aureus (73.2-99.8%). For the electrospun Nylon-6 nanofibers incorporated with silver(I) complexes, the levels of growth reduction were >99.99%, for both E. coli and S. aureus, after the antimicrobial activity evaluation using the shake flask method. The study demonstrated that the electrospun nanofibers, fabricated using the incorporation strategy, have the potential to be used as attractive antimicrobial materials[67].

MgO NPs incorporated Nylon-6 solutions were electrospun to produce nanofiber mats.The fire retardancy and antibacterial activity (Staphylococcus aureus and Escherichia Coli) of coated fabrics made from MgO/Nylon-6 hybrid nanofiber are better than those from Nylon-6 nanofiber[68].

Nylon-6 nanofibers containing Ag NPs (Nylon-6/silver) were successfully prepared by electrospinning. The structure and properties of the electrospun fibers were studied. The structural analysis indicated that the fibers electrospun at maximum conditions were straight and that Ag NPs were distributed in the fibers. Finally, the antibacterial activities of the Nylon-6/silver nanofiber mats were investigated in a broth dilution test against Staphylococcus aureusand Klebsiella pneumoniaebacteria. It was revealed that Nylon-6/silver possessed excellent antibacterial properties and an inhibitory effect on the growth of S. aureus and K. pneumoniae. On the contrary, Nylon-6 fibers without Ag NPs did not show any such antibacterial activity. Therefore, electrospun Nylon-6/silver nanocomposites could be used in water filters, wound dressings, or antiadhesion membranes[69].

Ultrasound-assisted coating of Nylon 6,6 with Ag NPs and its antibacterial activity was investigated. To do this,a Nylon/silver 6,6 nanocomposite containing 1 wt % metallic silver has been produced from an aqueous solution of silver nitrate in the presence of ammonia and ethylene glycol by an ultrasound-assisted reduction method. The nanocrystals of pure silver, 50-100 nm in size, are finely dispersed on the polymer surface without damaging the Nylon 6,6 structure. This silver-Nylon nanocomposite is stable to many washing cycles and thus can be used as a master batch for the production of Nylon yarn by melting and spinning processes. The fabric knitted from this yarn has shown excellent antimicrobial properties[70].

Nylon-6 nanofibers containing organic photosensitizers were investigated to demonstrate the antimicrobial properties in the application of the material to protective clothing and home appliances. Benzophenone (BP), 4, 4^0-bis(dimethylamino)benzophenone (MK) and thioxanthen-9-one (TX) were used as photosensitizers and the Nylon-6 nanofibers were prepared using electrospinning. Antimicrobial properties of the prepared nanofibers were tested against Staphylococcus

aureus and Escherichia coli. It was found that antimicrobial properties of Nylon-6 nanofibers containing MK and TX were superior to those of Nylon-6 nanofibers containing conventionally used BP. The antimicrobial effects of the nanofibers for S. aureus were superior to those for E. coli. The antimicrobial activity gradually increased as the UV irradiation time increased[71].

In this study, a series of nanofibrous membranes were prepared from cellulose acetate (CA) and PET urethane (PEU) using co-electrospinning or blend-electrospinning. The drug release, in vitro antimicrobial activity and in vivo wound healing performance of the nanofiber membranes were evaluated for use as wound dressings. To prevent common clinical infections, an antimicrobial agent, polyhexamethylenebiguanide (PHMB) was incorporated into the electrospun fibers. The presence of CA in the nanofiber membrane improved its hydrophilicity and permeability to air and moisture. The controlled-diffusion membranes exerted long-term antimicrobial effect for wound healing[72].

(B) Chemical Fixation of the Antimicrobial Substrates

More promising and widely used method for imparting bioactive features to PET and PA fibers is the preliminary modification of ready -made articles via reaction in the polymer chain or by grafting of ionogenic and nonionogenic monomers, with the objective of increasing the content or creating in the fibers new functional groups, which are able to react with biocides.Various antimicrobial agents (metal salts, quaternary ammonium compounds, polybiguanides, triclosan, chitosan, N-Halamine, etc.) have been used in antimicrobial finishing of PET and PA fibers.

1. Finishing with Metallic and Inorganic Nanoparticles

Numerous types of nanomaterials with antimicrobial properties such as Cu, Zn, Ti, and Mg have been developed in recent years[73-80].However, among all, silver nanoparticles (Ag NPs) have proved to be the most effective against bacteria and viruses, and are being exploited in textile fabrics.The major researches on the application of nanomaterials to PET and PA fibers is oriented toward activation of fibers surfaces by appropriate chemical or physico-chemical treatments that lead to improvement of the binding efficiency of nanometals.

Cotton, Cotton/PET blend and PET fabrics were treated against microbial effect byradiation - induced grafting of acrylic acid followed by metal complextaion with some divalent transition metal ions Co (II), Ni (II) and Cu (II). The microbial resistance was evaluated by testing the mechanical properties of the treated fabrics after burring for oneand two weeks in a moist soil reach with microorganisms. It was found that the metal complexation of the grafted fabrics with acrylic acid enhanced the antimicrobial resistance of the fabrics and the antimicrobial resistance could be arranged according to the metal ions as follows: copper>nickel> cobalt[81].

The possibility of applying Dielectric Barrier Discharge (DBD) plasma and grafting with vinyl monomers, Methacrylic Acid (MAA) and Hydroxyethyl methacrylate (HEMA), as treatments for fiber surface activation that can facilitate the loading of TiO_2NPs from solution onto Nylon-6 fabrics by sol-gel methodwas investigated. Antimicrobial activity of modified Nylon-6 fabrics loaded by TiO_2NPs was tested against Gram-positive (Bacillus mycoides), Gram-negative (Escherichia coli), and nonfilamentous fungus (Candida albicans). The achieved antimicrobial functions on the Nylon-6 fabrics are durable with repeated laundering processes even after five washing cycles[82].

Alkali hydrolysis was used as a practical alternative to the Dielectric Barrier Discharge Plasma (DBD) approach. It was found that the introducing of variable density of negative COOH and OH groups on the fabrics surfaces facilitates the binding affinity of ZnO NPs onto PET and PET/Cotton fabrics prepared by sol-gel method. Antimicrobial activity of finished polyester fabrics containing ZnO NPs was tested against Bacillus mycoides), Escherichia coli, and Candida albicans. The obtained results revealed that ZnO NPs - Loaded PET fabrics activated previously by alkali treatment showed antimicrobial and UV protection properties similar to the plasma activated fabrics[83].

Applying enzymatic treatments for fabric surface activation that can facilitate the loading of ZnO NPs onto PET and PET/C fabrics prepared by sol-gel method was studied. Antimicrobial activity of activated polyester fabrics and loaded by ZnO NPs was tested against Bacillus mycoides),Escherichia coli), and Candida albicans. The level of UV protection was verified by the UV Protection factor (UPF) of PET fabrics. Activated post treated PET fabrics exhibited outstanding antimicrobial and UV protection efficiency. The achieved antimicrobial function and UV protection on

the PET fabrics are durable with repeated laundering processes even after five washing cycles[84].
In order to obtain permanent antibacterial activity Dastjerdiet al. [85] treated PET fabrics simultaneously orseparately with polysiloxane emulsion and commercialcolloidal Ag NPs at different concentrations. Proposed method relies on embedding of Ag NPs in crosslinkable polysiloxane layer. The application of low concentration of Ag NPs was sufficient to reach satisfactory bacteriostaticactivity against S. aureus whereas higher concentrations of Ag NPs were required for the equivalent effect in the case of the K. Pneumoniae. Crosslinked polysiloxane provides controlled release of silver and thus, long-term antimicrobialactivity can be expected.

So no chemical irradiation procedure can be efficiently utilized for the deposition of Ag NPs onto PET and PA fabrics [86].

Many studies deal with plasma activation of PET and PA fibers before deposition of Ag NPs. Plasma treatment leads to an introduction of certain functional groups that could be potential sites for binding of Ag NPs as well as to a desired increase in fiber hydrophilicity.

Yuranova et al.[87] investigated the effect of RF oxygen plasma and vacuum-UV irradiation on subsequent chemical deposition of Ag NPs on the PET/PA fabric. Plasma-treated or vacuum-UV-irradiated samples were immersed in the silver nitrate solutions of different concentrations and afterward exposed to mild reducing agent. Deposited Ag NPs imparted antibacterial propertiesto PET/PA fabric. The minimum silver loading on the fabrics that is required for the complete inhibition of bacteria E. coli growth was also detected. In order to attain better susceptibility of hydrophobic PET fibers to hydrophilic colloidal Ag NPs, Ilic et al. [88]modified PET fabrics by RF air plasma at low pressure(0.27 mbar) before the deposition of Ag NPs. PET fabrics wereloaded once or twice with Ag NPs from 50 ppm colloidal solution. Untreated and plasma-treated fabrics loaded with Ag NPs obtained maximum bacteria reduction (E. coli andS. aureus). Plasma-treated PET fabrics preserved excellent antibacterial efficiency after five washing cycles even when they were loaded with Ag NPs only once. Unlike them, untreated fabrics had to be double loaded with Ag NPs to reach equivalent antibacterial activity after washing. Greater antibacterial activity of plasma-treated samples was due to larger amount of deposited Ag NPs. The total amount of initially deposited Ag NPs on plasma-treated PET fabrics was almost two times larger compared with equivalent untreated PET fabrics.

Although low-pressure devices, in particular RF-powered sources, allow easier control of properties and provide a greater stability and uniformity, these systems require more complex handling of textile materials and expensive vacuum pumps [89-90], which can be avoided using corona and dielectric barrier discharge at atmospheric pressure.Hence, activation of PET and PA fabrics with plasma at atmospheric pressure before deposition of Ag NPs recently gained much scientific attention [91].

Several studies demonstrated that corona discharge canbe efficiently utilized for functionalization of PET and PA fabrics before loading of colloidal Ag NPs. Corona-treatedPET and PA fabrics were dip-coated with Ag NPs from 10 to 50 ppm colloidal solution [92]. The crona - treated fabrics Loaded with Ag NPs from 10 ppm colloidal solution provided better antibacterial efficiency against S. aureus and E. coli compared with untreated samples loaded with Ag NPs.Untreated and corona-treated PET fabrics loaded with Ag NPs also exhibited excellent antifungal activity [93].Again, the contribution of corona pretreatment on Ag NPs deposition and further, antifungal activity became more evident after washing test. Differently modified PET fabrics exhibited superior antifungal behavior. In addition, the dyeing of PET fabrics with C.I. Disperse Violet 8 did not influence the antifungal activity of PET fabrics independently of the order of dyeing and Ag loading[94].

2. Finishing with Quaternary Ammonium Compounds

Cationic surfactants, particularly QASs, are important antibacterial agents that have been widely used in textiles for many years. Quaternaryammonium salts have excellent antibacterial activity toward a broad spectrum of bacteriasuch as S. aureus and E. col[95-96].

Cen et al.[97]immobilized antimicrobial QAS onto the surfaces of PET films and filter papers bygrafting copolymerization of 4-vinylpyridine and subsequent quaternization of the grafted pyridine groups with hexyl bromide. The results of both the waterborne and airborne assay against E. coli demonstrated that both the PET films and filter papers were conferred highly bactericidal properties after being surface-modified by QAS.

The polyelectrolyte multilayer films reported by Grunlan et al.[98]were prepared by alternately dipping a PET substrate into solutions of biocidal agents (i.e.,cetyltrimethyl ammonium bromide(CTAB) and/or silver containing polyethyleneimine and poly(acrylic acid). Inhibition zone measurement against S. aureus and E. coli indicated that the films made with CTAB had higher antimicrobial activity compared with the films containing either silver alone or both CTAB and silver.

A simple, efficient, and practically applicable functional approach for improvement antimicrobial properties of Nylon-6 fabrics and increase the washing durability of biofunctions was developed[99]. This finishing approach is based on grafting of the fabrics with methacrylic acid (MAA) to create additional carboxylic groups in Nylon-6 macromolecules, followed by subsequent reaction with dimethylalklbenzyl ammonium chloride (DMABAC) solution under alkaline conditions. The COOH groups react with cationic agent through ionic interaction, which led to the immobilization of QAS on Nylon-6 fabrics. The antimicrobial assessment of regular and grafted with PMAA Nylon-6 fabrics treated with DMABAC revealed that both types of fabrics are characterized before washing, by quite strong biocide effect on Bacillus mycoides, Escherichia coli and Candida albicans. Even after Laundring 10 times the grafted samples could still provide 80%, 100%, and 87.5% microbial reduction against B. mycoides, E. coli and C. albicans, respectively, in contrast with 42.6%, 65.6%, and 42.5% in case of regular Nylon-6 fabrics.

Shalaby et al [100]imparted antimicrobial properties to Nylon-6 fibers. Partial acid hydrolysis of the fibers with HCl solutions to create additional carboxylic groups in polymer macromolecules was carried out. This was followed by subsequent reaction with quaternary ammonium salt (QAS) (Dimethyl alkylbenzyl ammonium chloride - DMABAC) under alkaline conditions. The hydrolyzed Nylon-6 fibers finished with antimicrobial substrate showed excellent antimicrobial activity against Bacillus mycoides), Escherichia coli), and Candida albicans. The finished Nylon-6 fibers showed that, the imparted antimicrobial properties are durable in repeated laundering processes, even after 10 launder - Ometer washes.

An effective one-stage method has been developed by Shalaby etal. [101]for imparting antimicrobial properties to regular polyethylene terephthalate (R-PET), polyethylene glycol modified polyethylene terephthalate (PEG-M-PET), R-PET/Cotton blend (R-PET/C) and PEG-M-PET/cotton blend (PEG-M-PET/C) fabrics. The method is based on treatment of the fabrics in a finishing bath containing sodium hydroxide and quaternary ammonium compound (QAC). All the modified PET fabrics showed strong antimicrobial effect against Bacillus mycoides, Escherichia coli and Candida albicans. The achieved antimicrobial functions on the PET fabrics are durable in repeated laundering processes. Even after laundering ten times the R-PET and PEG-M-PET fabrics could still provide more than 92%, 78%, 92% and R-PET/C and PEG-M-PET/C fabrics more than 68-71%, 70-74%, 66-70% of its original antimicrobial activity against B. mycoides, E. coli and C. albicans before laundering, respectively.

3. Finishing with Poly Biguanide

Polybiguanides are polymeric polycationic amines that include cationic biguanide repeating units separatedby hydrocarbon chain linkers of identical or dissimilar length [9]. One of the most important antimicrobial agents among them is PHMB, poly (hexamethylene-biguanide) which has an average of 11 biguanide units [102-103] Wound dressings are one of the most known textile applications of PHMB, due to its low toxicity(MIC=0.5-10ppm). The literature indicates that PHMB can bind to the anionic carboxylic groups of cellulose, which are formed through oxidation of glucose rings during pre-treatment processes, such as bleaching and mercerizing [9].

The possibility of obtaining fiber materials containing polyhexa-methyleneguanidine hydrochloride fixed with glutaraldehyde was investigated. The resistance of the materials obtained to wet treatments simulating the conditions of laundering, which allows using them many times, was demonstrated. The fiber material fabricated on a viscose- PET matrix has high resistance to water treatments. The amount of antimicrobial strongly bound in the fiber material is a function of the type and conditions of fabrication of the material and the molecular weight of the polyhexamethyleneguanidine[104].

Huang and Leonas[105] examined the effectiveness of PHMB applied to polypropylene andcellulose/polyester non-woven fabrics after a fluoro-chemical water-repellent finish. The antimicrobial property of the finished fabrics against S. aureus was studied. Both treated fabrics showed that an add-on of 0.75 % in PHMB was sufficient to inhibit the growth of S. aureus be-

neath the fabric. Moreover, inhibition zones surrounded the fabrics an edge because of PHMB was probably released from the fabrics.

PHMB was also applied to a 65/35 PET/cotton blend fabric by padding and drying processes. The fabric was plugged in an aqueous solution of PHMB at a concentration of 2.3 w/v %, passed through rollers and dried in an oven at 120 °C for 5 min. Antimicrobial performances were determined against S. aureus and K.pneumoniae. Percentage reductions were 99.99 % for S. aureus and 99.97 % for K. pneumoniae. Moreover, PHMB consistently exhibited reductions more than 99 % of S.aureus and ~94 % of K. pneumoniae even after 25 laundering cycles following AATCC Test Method 143-96[106].

4. Finishing with Triclosan

Among halogenated phenols, triclosan is the most widely used biocide; it is present in many contemporary consumer and personal health-care products, detergents and household objects, including textiles and plastics. At bactericidal concentration, triclosan is very effective against a broad range of microorganisms, including antibiotic resistant bacteria, but it also has some antifungal and antiviral properties [9, 15].

Being a relatively small molecule, triclosan can also act like a disperse dye and can be used by exhaustion prior to dyeing, together with dyeing or after dyeing of PET and Nylon fibers. During the fabric use, the agent migrates to the treated textiles surface at a slow, yet sustained, rate as to provide antimicrobial efficacy [107]. Triclosan can also be directly incorporated into synthetic polymers through melt-mixing or suspension polymerization [108-109]. A number of companies manufacture and market triclosan-based fibers, yarns or fabrics. For instance, the nylon and polyester products Tinosan AM 100® and CEL® (Ciba Speciality Chemicals), the Silfresh®cellulose acetate yarn (Novaceta) and Microban® textile products (Microban International), all contain triclosan as theactive antimicrobial agent which is applied during the finishing stage or is incorporated into the fiber during extrusion[110].Finishes for fabrics including polyester and cellulose are available [111].

5. Finishing with N-halamine Compounds

N-halamine compounds have attracted much interest from researchers due to their favorable properties, such as rechargeability, non-toxicity to humans, and antimicrobial activity against a broad spectrum of Microorganisms[112-121].Also, cytotoxicity of bacteria-killing triazine-treated cotton fabric was tested, and the result showed that this treatment was not toxic[122]. It is perhaps for this reason that N-halamines are used in a broad range of applications, such as hospitals, medical devices, and water purification [123-124].

A cyclic N-halamine precursor, 1-glycidyl-s-triazine-2,4,6-trione (GTT), was synthesized and grafted onto PET fibers[125]. The antimicrobial efficacy test showed that the N-halamine modified PET could inactivate 6-log of Staphylococcus aureus (Gram-positive) and E. coli (Gram-negative) within 10 min of contact time. The antimicrobial fabrics exhibited good durability and stability to washing and storage.

Acyclic N-halamine polymers were also produced by co-polymerisation of vinyl acetate (VAc) with acyclic amide monomers, methacrylamide (MAM) and acrylamide (AM) [126]. Small amounts of acyclic amide monomers were added during co-polymerisation to maintain the properties of poly (vinyl acetate) but providing the co-polymers with sufficient amide groups required for the antimicrobial function upon chlorination. The co-polymers (i.e. poly(VAc-co-MAM) andpoly(VAc-co-AM)) were dissolved in acetone and coated onto PET fabrics. Antimicrobial activities of both chlorinated and not chlorinated coated PET fabrics were tested with S. aureus and E. coli carrying out a "sandwichtest". Poly(VAc-co-MAM)-coated PET fabrics after chlorination inactivated both S. aureus and E. coli completely,with log reductions of 6.17 and 6.00, respectively, within 1 minute of contact. In the case of poly(VAc-co-AM)-coatedPET fabrics after chlorination, S. aureus was completely inactivated with log reduction of 6.17 within 1 min, but these fabrics were unable to completely inactivate of E. coli within 1 minute, in fact the log reduction was 4.19.

PET fabrics were modified by covalently linking heterocyclic moieties, which could be halogenated, to the surfaces of the PET fibers. Antimicrobial activity was introduced into the fabrics and fibers by exposure to a source of oxidative chlorine (chlorine bleach) that converted the heterocyclic precursor moieties into N-chloramine functionalities. The antimicrobial activity could be repeatedly regenerated following its loss on challenge with suspensions of bacteria by further washing with aqueous oxidative chlorine. Biocidal polyester fabrics, fibers, and other materials potentially will be effective in reducing, or eliminating entirely, pathogenic microorganisms and odor-causing micro-organ-

isms which directly contact them[127].

Two N-halamine siloxane precursors, 5,5-dimethyl-3-(3'-triethoxy-silylpropyl) hydantoin and 3-(3'-triethoxysilylpropyl) -7,7,9,9-tetramethyl-1,3,8-triazaspiro [4.5] decane-2,4-dione, have been synthesized and coated onto PET fiber surfaces[128]. The coated PET was rendered biocidal after exposure to household bleach solution by converting the heterocyclic precursors to N-halamine moieties. The chlorinated polyester swatches were challenged with Staphylococcus aureus and Escherichia coli with contact times ranging from 1 to 30 min. The biocidal testing showed that the chlorinated samples inactivated S. aureus and E. coli within 5 and 30 min of contact, respectively. Standard washing tests indicated that the chlorinated coated fibers were very resistant to loss of the coating through hydrolyses.

The N-halamine monomer 3-(4?-vinylbenzyl)-5,5-dimethyl-hydantoin (VBDMH) was synthesized and employed to form thin films on the surfaces of PET fibers by surface polymerization with the aid of a cationic surfactant[129]. The thin film coatings could be rendered biocidal by exposure to dilute sodium hypochlorite. The antimicrobial PET was challenged with Staphylococcus aureus and Escherichia coli. Complete inactivation of S. aureus and E. coli was observed within 10 and 30 min of contact time, respectively. The chlorine bonded to the coatings was very stable under standard washing tests.

An N-halamine monomer, 3-allyl-5,5-dimethylhydantoin (ADMH), was synthesized [130]. Antimicrobial coatings of poly[1-(4,4-dimethyl-2,5-dioxoimidazolidin-1-methyl)ethylene] were prepared on plasma-treated PET fabrics via a vapor-phase assisted polymerization (VAP) process using gasified ADMH as monomer. The coatings endow the PET fabrics with an antimicrobial efficiency greater than 80% for both Escherichia coli and Staphylococcus aureus after chlorination of the N-halamine polymer with dilute bleach solution. The obtained antimicrobial effect has remarkable durability that can bear over 30 times of stringent laundering tests. Compared with other antimicrobial finishing methods, the VAP methodology offers great advantages in needless of organic solvents and small consumption of monomer. It has potential applications in a wide variety of fields such as hygienic clothing, underwear, socks, and medical textiles.

A new N-hydantoin-containing biocompatible and enzymatically degradable PET with antibacterial properties is presented[131]. Different polyesters of dimethyl succinate, 1,4-butanediol, and 3-[N,N-di(?-hydroxyethyl) aminoethyl]-5,5-dimethylhydantoin in varying molar ratios are prepared via two-step melt polycondensation. The antibacterially active N-halamine form is obtained by subsequent chlorination of the polyesters with sodium hypochlorite. The polyesters exhibit antibacterial activity against Escherichia coli. The adopted synthetic approach can be transferred to other polyesters in a straightforward manner.

A commercial m-aramid as N-halamine precursor has been coated onto PET fabric surface by pad-dry-curing process[132]. The process is accomplished by padding the scoured PET fabric through the homogeneous m-aramid solution, drying at 150°C for 3 min, and curing at 230°C for 3 min. After exposure to dilute sodium hypochlorite solution, exhibition of antimicrobial activity on the coated PET is attributed to the conversion of N-halamine moieties from the N-halamine precursor. The chlorinated PET showed high antimicrobial activity against Gram-negative and Gram-positive bacteria. The chlorinated PET fabrics coated with 10% m-aramid exhibited about 6 log reductions of S. aureus and E. coli at a contact time of 10 and 30 min, respectively. Furthermore, the antimicrobial activity was durable and rechargeable after 25 wash cycles.

Effective antibacterial modification of PET was achieved by forming a surface thermoplastic semi-inter penetrating network of polyacrylamide (PAM) and PET, followed by converting the immobilized amides to N-halamine[133]. The relationship between antibacterial efficacy and N-halamine concentration was studied. The network-modified PET was still able to provide 100% reduction of healthcare-associated methicillin-resistant Staphylococcus aureus in 20 min contact.

A novel cyclic-amine monomer, 3-allyl-5,5-dimethylhydantoin (ADMH) was synthesized and characterized[134]. ADMH alone could not be grafted onto ordinary polymers. However, the presence of triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione (TATAT) remarkably enhanced the ADMH grafting yield onto synthetic fabrics. The influences of reaction conditions on the grafting copolymerization were investigated. After chlorine bleach treatment, hydantoin units in the grafted copolymers were transformed into N-halamine structures. Treated samples exhibited potent antibacterial

activity against Escherichia coli, and the functional properties were shown to be durable and regenerable. Attenuated total reflectance FTIR spectrometry has been employed to assess the degree of chlorination of hydantoin moieties which are covalently linked to the surface of the Nylon 6, 6[135]. The N-chlorinated hydantoin functional groups are active in producing biocidal activity against pathogenic microorganisms upon direct contact with the surface molecules of the fabric. Chlorination of the treated Nylon 6, 6 causes a shift of the hydantoin amide bands which can be conveniently monitored as a quality control procedure in the production of the biocidal fabric.

6. Finishing with Chitosan

Chitosan applied to the textile industry, as an antimicrobial finish, became popular due to its ability to provide protection against allergies and infection diseases, coupled with moisture retention and wound healing capabilities.

Lee & al. [136] treated samples with chitosan and fluoropolymers using the pad-dry-cure and pad-cure methods, respectively, to impart barrier properties against microorganisms and blood to 100 % cotton and 55/45 % wool/polyester spun laced nonwoven fabrics. They assessed the antimicrobial activity and blood repellence of the samples and measured the mechanical properties to investigate the effect of finishing on handle with the KES-F system. Huh & al. [137] prepared chitosan-grafted poly(ethylene terephthalate) (PET) (C-PET) and quaternized chitosan-grafted PET (QC-PET) against S. aureus, C-PET and QC-PET showed high growth inhibition in the range of 75-86 % and still retained 48-58 % bacterial growth inhibition after laundering. Several other studies [138-140]confirmed the effect of chitosan as an antibacterial finishing agent for PET and Nylon fibers. While the application of chitosan on cellulosic textiles improves dyeability, soil release properties, and antimicrobial activity, treatment of PET fabrics with chitosan imparts a significant antistatic effect.

A woven PET with an antimicrobial activity was prepared by depositing chitosan on its surface. Firstly, the hydrophilic property of the PET surface was achieved by a plasma treatment using dielectric barrier discharge (DBD). The XPS analysis revealed an increment of oxygen-containing polar groups, such as C-O and O-C=O, on the PET surface after the plasma treatment, resulting in an enhanced hydrophilic property. The plasma-treated PET specimen was further deposited with chitosan by immersing in a chitosan acetate aqueous solution. The disappearance of the above-mentioned polar groups from the PET surface was clearly observed after the chitosan deposition, indicating the involvement of these functional groups in interacting with the chitosan. The chitosan-deposited plasma-treated woven PET possessed an exceptionally high antimicrobial activity against both E. coli (gram-negative bacteria) and S. aureus (gram-positive bacteria)[141].

Chitosan is a natural nontoxic biopolymer used widely in various fields due to the antimicrobial activities. In this study, the properties of polyester fabrics grafted with chitosan oligomers/polymers after being activated by atmospheric pressure plasmas were evaluated. The antibacterial effect was most evident when the surface of fabrics was activated by atmospheric pressure plasma for 60 to 120 seconds and grafted with chitosan oligomers. The modified fabrics also exhibited good biocompatibility. This process can be applied to a large area and used to produce antibacterial polymer fibers [142].

The properties of Nylon textiles grafted with chitosan oligomer or chitosan polymer after being activated by open air plasma were evaluated. Results showed that Nylon textiles grafted with chitosan polymer had better antibacterial performances than those grafted with chitosan oligomer. Air plasma activation at a higher speed (26 m/min) for a few times facilitated the grafting of chitosan and critically determined the antibacterial activities. Further treatment with air plasma after grafting improved the antibacterial effect. Overall, chitosan-grafted nylon textiles showed good antibacterial potential as well as biocompatibility[143].

A simple acid or base hydrolysis process was used as a pretreatment process for the Nylon 6, 6 and PET granules to improve or increase the adhesion of chitosan with these granules[144]. It was found that chitosan can be effectively coated or immobilized on the hydrolyzed Nylon 6,6 or PET granules through a covalent chemical interaction forming the salt structure of (- $NH_3^+ \cdots {}^-OOC$-) between the hydrolyzed granules and the coated chitosan at the interface. It has to be mentioned that, the present method is costly and difficult to be implemented on the industrial scale.

7. Finishing with Natural Dyes

Selected natural dyes namely madder and safflower yellow dyes as well as an eco-friendly mordants namely

alum, Zn-sulfate and tannic acid have been used to identify the proper dyeing conditions for attaining high quality natural dyeing along with imparting multifunctional properties, i.e. UV-protection and anti-bacterial properties, to the dyed PA- 6 fabric. The results demonstrate that the improvement in dyeing properties, i.e. color yield as well as fastness properties, along with the enhancement in the imparted functional properties are governed by the type and concentration of natural dye, kind of mordant, dyeing sequence and conditions. The dyes/ mordants examined exhibited high fastness properties and offered better UV-protection function and antimicrobial activity against E-coli) andS. aureus[145].

Curcuma longa rhizome (turmeric) is a medicinal plant used for fabric and food coloration. In this study Nylon 6.6 fabric was dyed with different mordants at various turmeric concentrations. The dyed fabric wasevaluated for bacteriostatic activity against pathogenic strains of Staphylococcus aureus) and Escherichia coli bacteria. The results indicate that the PA dyed with turmeric displayed excellent antibacterial activity in the presence of ferric sulfate, cupric sulfate, and potassium aluminum sulfate, and exhibited good and durable fastness properties[146].

Natural dye extract from the walnut was used in dyeing PA fabrics with different mordants. The dyed fabrics were evaluated for antibacterial activity against pathogenic strains of Staphylococcus aureus) and Escherichia colibacteria. Durability of antibacterial activity to laundering is also discussed. Results indicatethat the PA dyed with walnut displayed excellent antibacterial activity in the presence of ferric sulfate, cupric sulfate, and potassium aluminum sulfate and exhibited good and durable fastness properties[147].

A novel infection-resistant biomaterial was created by applying the antibiotic Ciprofloxacin (Cipro) to a recently developed bifunctionalized polyethylene terephthalate (polyester, "Dacron) material using textile-dyeing technology. Dacron was modified via exposure to ethylenediamine (EDA) to create amine and carboxylic acid sites within the polymer backbone. Cipro was applied to the bifunctionalized Dacron construct under varied experimental conditions, with resulting antimicrobial activity determined via zone of inhibition. Dacron segments treated at a liquor ratio of 20:1, with 5% Cipro on weight of fabric (owf), at pH 8 for 4 h at 70oC followed by autoclaving showed antimicrobial activity for 78 days (length of study). Segments treated similarly but without autoclaving lost activity within 1 day. Dyeing time and temperature did not significantly affect antibiotic release/ activity, but segments dyed at PHs higher or lower than 8 had less antimicrobial activity[148].

8. Finishing with Natural Herbals

An antimicrobial agent extracted from the seeds of Neem tree (Azadirachtaindica) was used for imparting antibacterial property to the PET / Cotton blend fabric[149]. Resin and catalyst concentrations were optimized to get the maximum crosslinking in the fabric blends using glyoxal/glycol as a crosslinking agent. The optimized concentrations were used to treat the fabric with the antimicrobial agent along with the crosslinking agent. The results showed that the treated fabrics inhibited the growth of Gram-positive bacteria (Bacillus subtilis) by more than 90% as compared to the control sample. Antimicrobial activity against Gram-positive bacteria was retained up to five machine washes and decreased thereafter. The antibacterial activity was higher against Gram-positive bacteria as compared to Gram- negative bacteria (Proteus vulgaris).

9. Finishing with Dendrimers

Dendrimers have been used as a vehicle to develop the antimicrobial properties of textile fabrics. They have large number of functional groups present in their regular and highly branched three-dimensional architecture structure. Dendrimers have unique properties owing to their globular shape and tunable cavities, this allows them to form complexes with a variety of ions and compounds; and also act as a template to fabricate metal nanoparticles.

The poly (amidoamine) (PAMAM) dendrimer was modified to provide antimicrobial properties[150]. PAMAM with primary amine end groups was converted into ammonium functionalities. AgNO3-PAMAM complex as well as a Meso Silver-PAMAM complex were formed and these modified dendrimers were characterized by a UV-Visible spectrophotometer to study the complex formation. Modified dendrimers were applied to the Cotton/Nylon blend fabric. SEM and EDX analysis were performed to study the dispersion of silver nanoparticles onto the fabric. An antimicrobial test of the treated-fabric against Staphylococcus aureus exhibited significant biocidal activities for each type of modified-dendrimer.

Herein a simple approach to fabricate hybrid

nanomaterials based on dendrimers as polymeric stabilizers for the preparation of Ag NPs in aqueous medium were presented. Solutions of these functional nanomaterials were used as finishing agents to produce antimicrobial textiles[151]. The application was tested on two different fabrics types made of cotton and PET. The thermal fixation was performed at 120 or 160°C. The antimicrobial properties of the treated fabrics were investigated using the bacteria Escherichia coli and Staphylococcus aureus. The antimicrobial effect of the treated fabrics was found which significant correlates not only with the amount of the silver content in the finishing agent but also with size of the generated Ag-nanoparticles. Furthermore, the results confirmed that the antimicrobial effect rises with increasing the dendrimers' generations suggested due to decreasing the size of the formed silver particles. By changing both parameters thermal fixation and dendrimers' generations, the strength of the antimicrobial effect can be controlled in a wide manner. This could be advantageous for applications demanding a textile with a certain antimicrobial effect.

Remarks and outlooks

It is worth mentioning, that the research for imparting antimicrobial properties to textile fibers has been, until recently, limited to the natural fibers. However, the wide spread of man-made fibers and the need for expanding its application led to a significant increase in research directed towards imparting antimicrobial properties to such fibers.

Overall the need for anti-microbial and hygiene finishes looks set to continue for the foreseeable future. Improving performance and cost-effectiveness, while meeting environmental and toxicity requirements, will continue to challenge those working in this field.

Both the improved and the newly developed finishes technologies (Plasma, Nano and Bio) are valuable tools that can project an enhanced image of the finish producers for the next textile industry revolution.

Plasma and Bio technologies are very active tools applied to synthetic fibers to modify their surfaces. In the long term the increasing importance of environmental issues will favour the use of these technologies.

A considerable amount of basic research has been devoted mostly on laboratory scales to incorporate functional groups on the textile surfaces by plasma modification. Besides plasma parameters, the reactor geometry complicates the process scaling-up.

Inorganic and metallic-based nanostructure materials have created a new interesting field in all sciences for the continuous investigations due to their unique properties. Their applications have already led to the development of new practical productions. Considering the indubitable role of textiles in human life, these new fields in textile industry have been increasingly welcomed. However, designing new applicable and affordable techniques for manufacturing scale-up production will not only create a new field of study, but meet the expanding human requirements.

The use of antimicrobial polymers offers promise for enhancing the efficacy of some existing antimicrobial agents and minimizing the environmental problems accompanying conventional antimicrobial agents by reducing the residual toxicity of the agents, increasing their efficiency and selectivity, and prolonging the lifetime of the antimicrobial agents.

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Texttreasure

The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires.

- William Arthur Ward

The Case of the Adamant Administrator

Mr. A. R. Garde

Mr. A.R. Garde had worked for 33 years at Ahmedabad Textile Industry's Research Association, Ahmedabad, as researcher, consultant and trainer in technical and management areas before he was selected to lead in 1990 as Director. In his 7 years as the CEO, he and his dozen colleagues turned around the fortune of ATIRA: the machinery, instruments and equipment was modernized, backlogs in maintenance and employee benefits were filled in, and the depreciation and reserve funds were increased substantially.

Mr. Garde's techno-managerial output is over 270 papers, 2 books, and contributions to 6 books; and over 100 papers presented at conferences within and outside India. After retirement, he has published 7 books on management (including in Marathi and Gujarati), 3 books on ethics. His one book on modern Hinduism (in English, Marathi and Gujarati) shows how Hinduism has adapted itself to become suitable for the 21st century, without having to compromise on any of its core principle.

mantra-moolaahsarva-aarambhah, Chanakya

"I had just returned from a trip to New Delhi for some work at the UdyogBhavan, in the Ministry of Textiles. Reached my office at about 5 minutes to nine, our starting time at ATIRA. Within 15 minutes, about 15 employees came to my room and ALL wanted to meet me. My suggestion that 2-3 of them should come into my room was just not acceptable; they were all agitated about something that had happened during my absence of two days. So, I suggested that we all go down to ATIRA lawn and sit near the fountain to discuss the issue, whatever it may be." Thus, in the words of A.R. Garde, the Director of ATIRA in the beginning of year 1996, began an episode that taught several lessons to the management of ATIRA.

Policy Changed

The Policy Group, consisting of about a dozen Heads of the Departments - Deputy and Assistant Directors- were concerned about the way in which the newly recruited and quite talented scientific officers were leaving for better jobs even before their first year of probation was over. ATIRA had attempted to get them to sign a well drafted two-way agreement for service of three years. Almost all new recruits said that such binding makes them uncomfortable and is not necessary. They all said they give their 'gentleman's word' that they will not leave the job before three years are over. When the PG meeting of the month was taking place, 4 out of 6 new officers had left the services of ATIRA within about 18 months of joining. The process of recruitment was of India-wide advertisement and a selection process based on a two days of interview consisting of a written subject test, general intelligence test, personality test, group discussion and personal interview by 4 seniors assessing specific traits independently. The cost of using such a selection procedure was high, but it had given good dividend over 20 years in terms of the capability of the selected individuals to work as a researcher or as a consultant. No wonder the PG was concerned about this kind of a loss, and were considering several alternatives to help stem this kind of 'exodus'.

About 8-9 months before this meeting, ATIRA had recruited an Administrative Officer to replace the person who had retired. A search for a good person was proving difficult. The practice for recruitment was delegation of authority to the head of the department for recruitment up to the Assistant levels in own department. The recruitment of scientific officers was done under the leadership of the Director, who would not be a part of the selection committee. For the selection of the administrator, the Director appointed a committee of two Deputy Directors. On selection of the person, the Director had met him before confirming the selection. Several months had passed before the new incumbent took his post. After working for about 7 months, this Administrative Officer - AO -had requested the Director to give him a loan for buying a car. His point was that his owning a car would be appropriate for his status as AO. This

request could not be granted, because the policy of ATIRA was to give vehicle loans only after completion of three years of service, including the first year of probation. The tradition in ATIRA, established over more than 45 years, was never to break any policy, not to make any exception for anyone. Exceptions, all the Directors knew, would give rise to perceptions like some are 'blue eyed boys', more equal than others. The policy for confirmation in service, if the work was found to be good, was to be confirm at the most after 1 year, as written in the appointment letter. Most of the time, such confirmation was given at the end of 6 months itself, since the output was found to be good. The new AO had become rather insistent about his owing a car, had been looking for a used car, and had just received an offer that was attractive as value for money. He wanted get the loan immediately.

As the PG meeting started generating alternatives for retaining the new officers, and discarding each idea as not quite right, an idea struck. Why not reduce the period after which vehicle loans are given to 6 months, from the previous 3 years? This change needs to be made only for the officer level and not for the assistant and the operative levels. After considerable discussions, the PG decided that such a policy should be tried out for about 5 years to verify whether this incentive helps to retain officers for at least the five-year period needed for repayment of the loan. Simultaneously, the desire of the AO to buy a car can be satisfied with the changed policy. The Director was to leave for New Delhi the same evening, so he left immediately after the meeting was over, by about 6 pm. The twin task of conveying this change in vehicle loan policy for officers to the administrative section, and of conveying to the accounts section that the AO may be given the loan, was delegated to the Sr. DeputyDirector.

Unprecedented Agitation

By the time the Director reached the lawn portion near the flag pole, the group of 15 had swollen to about 30-40. They surrounded the Director on all sides and an unprecedented 'dharanaa' began to unfold. The demand from the staff was, "Cancel the order for giving vehicle loan to the AO." It was apparent that none of them was in favour of the new AO getting this vehicle loan.The Director went on asking why they were making this demand. The answer was, because this loan is being given as a favour to the AO, against the rule of 3 years. The Director explained that in ATIRA, policy rules are never broken, and no favourites are played, no matter what level in hierarchy an employee occupies. This was not, of course, accepted; to them it was obvious that the ego of the Director is coming in the way of withdrawing a favour! The Director patiently explained how the PG had discussed the issue of retaining new officers, and has decided to change the policy. That is how the 3 year wait has been reduced to 6 months. The 3-4 assistants from the administration, one of them quite senior, unanimously told all others that this is NOT TRUE. They have not received any intimation of any policy change. Now the question was of credibility: WHO was lying or hiding the true situation? The Director or the staff from administration? Nobody expressed this sentiment openly, but all were feeling it. The 'excuse' given by the Director of having changed the policy looked exactly that-- an excuse! Nobody knew of the change in policy. The Director pleaded that some of the staff gathered there should go and meet a member of the PG who was present that day. And the feeling again was that a HoD would naturally support his boss! The arguments, partly heated, went on and on, to and fro, for quite some time. Curiously, most persons in the ATIRA building were quite unaware of this drama going on near the flag pole. No one had told any of the Assistant and Deputy Directors, who were busy in their own work in their departments, about the fact that 40 persons have surrounded the Director and are making some demand.'The man at the top' was indeed lonely, even while sitting among forty of his fellow employees! After about 100 minutes of this drama in the hot sun of Ahmedabad, the Director realised that something has gone wrong somewhere, and it would be necessary to withdraw the sanction of vehicle loan to the new AO. He conceded the demand and the dharanaa was over.

The staff went back to their work places without any further disturbance, and the Director went back to his office wondering about this totally unexpected situation and the unprecedented behaviour of the staff. He had realised early in this game on the lawns that the unions are not behind this move. Their main leaders were not in the crowd, and the crowd of 40 had members from both the unions. There was no slogan shouting against the Director, no other issue was even talked about. Just one goal: get the car loan sanctioned to the new AO withdrawn! What had gone wrong in spite of the good work done by the Policy Group on changing the loan policy? Were some principles violated by chance or by design?

Management Principles

Acharya Chanakya's concepts on management are very specific about how to start anything new: "Every beginning must be based on a policy or a project plan." मंत्रमूला सर्वारंभाः। Imantra-moolaahsarva-aarambhaahThe word mantrahas several meanings: advice, counsel, policy etc. That is how we have a Pradhaan Mantri and such designations. Interestingly, management guru Chanakya uses the word mantra in a specific sense in management. He has defined mantra as having 5 parts: beginning of a work, provision of men and materials, place and time, provision for unexpected difficulties, and the accomplishment of work. In short, mantra stands for 'project planning', the mode of a task force with a mission. This was enunciated way back in 320 BCE, 2300 years ago. Most management experts 'know' that 'project planning' was used first during World War II, and the industry picked it up in the 1950s. These experts in the West, and also managers in India, are not aware of the fact that 'project planning' was first defined clearly as above in the Arthashastra. This world famous comprehensive treatise on how to run a kingdom was authored by Vishnugupta under the name of Kautilya (of the Kautalgotra), and who developed management sutras under the name of Chanakya (son of Chanakya)

We will consider here only a few selected sutras of Chanakya in the context of mantra, as policy.

मंत्ररक्षणे कार्यसिद्धिःभवति। I mantra-rakshanekaarya-siddhihbhavati Protecting the policyleads to success in work

मंत्र विस्रावीकार्यम् नाशयति। I mantra-visraveekaaryam naashayati One who defaults on policy destroys the work

प्रमादात द्विषतां वशम् यास्यति। Ipramaadaat dvishataam vasham yaasyati Mistake results in (his) getting under control of those who are opposed (to him)

Every manger knows that a) there are no 'laws' in management, which is more an art than a science and b) it is nearly impossible to say with certainty what will happen if the management makes a mistake. However, Management Guru Chanakya has formulated several 'laws of management', in the context of behaviour of people at work. The above sutra on 'what must invariably happen when' a mistake is made is one of the best examples of a "Law of Management". The cause and the effect are neatly shown in this sutra. Obviously, the way in which 'control' by the 'opposition' will manifest has innumerable possibilities.

Let us analyse the ATIRA event described above by using these principles of management. Clearly, the Policy Group was aware of the fact that every new beginning must be policy based. This was indeed a tradition laid down firmly by the early directors of ATIRA and followed meticulously by the succeeding directors. But 'getting under control of the opposition' did happen, and the decision of'sanction of loan to the AO' had to be abandoned: 'work was destroyed'. So, somewhere, some fault must have occurred and the consequence had to be suffered. A probe into what all had happened during the two days of absence of the Director brought out some startling facts.

A Chain of Mishaps

The happenings and the comments on each are given briefly below.

- The Sr. Dy. Director to whom the communications on changed policy were delegated had sent two cryptic messages: one to administration on change of loan policy, and another to the accounts section on sanction of loan to AO. Each was a strip of about 5 cm width of an A4 size paper.
- The accounts section got totally disturbed seeing this exception to an established policy, done for the new AO. They simply decided not to follow this 'non-legal order' from the Sr. Dy. Dir. And to wait until the Director returns. Naturally, they could not and did not convey this to the Sr.DD.
- The slip sent to the administration got buried under the pile of papers on the table, was not noticed by the senior assistant, who also had joined the protest.
- The Sr. Dy. Dir., a good person, had conveyed on phone to the A.O that his application for loan has been sanctioned and he can go ahead with the purchase of car.
- The AO, being the kind of person he was, told this gleefully to all employees from the accounts section and the administration section. "Look, the Director has granted me the loan even though I have not completed 3 years"; the AO gloated publicly.
- This kind of boasting of his own importance caused even more ire among the staff.

  No wonder that the staff wanted the order for sanction of loan to the AO withdrawn, and the statement from the Director that the policy has been changed was not believed at all. In their own way, the staff was entirely justified in demanding that the loan must not be granted.

Lessons from this Case

A thorough post mortem was done of this disaster of a policy decision gone wrong in implementation. The lessons learnt for future avoidance of such mishaps were many.

1. **Delegate rightly, not correctly :** The Director left it to the most senior person in the hierarchy to communicate the decisions of the Policy Group to accounts and to administration. He KNEW that this Sr. DD is a soft and goody-goody person who never spoke badly of any person. He also behaved as if when he is good, others will also be good. He had felt that the full statement on the changed policy can be made later, under the guidance of the Director, for letting all employees know about the change and the reason behind the change -namely, an attempt to retain newly recruited officers. So, he had sent just one cryptic note to the accounts section, and another to the administration. These notes were two three lines on 5 cm strips of A4 size paper! And he telephoned this 'good news' to the AO, without even realising the possibility of misinterpretation and misuse by the AO. The Director certainly knew the 'good-ness' of this Sr. DD, and he should either have told him clearly about how to proceed for communicating the PG decision, or should have selected a more people-savvy DD or AD from among members of the PG. He had failed to do either.

2. **Selection Procedure Important :** It became clear that the new AO was not accepted by the staff under him. Their new 'boss' had not done any worthwhile improvement or even a review of the work in administration during his 6-7 months after joining. He also had made it clear that he will not look after the accounts section since he has no background in accountancy. While being recruited, he was certainly told that his responsibility will be for both sections: administration and accounts. He had nodded, meaning he understood! When the Director went into the details of how this person got recruited, he discovered 3 clear deviations from the established ATIRA policy of selecting individuals for officer's post. About 4-5 eligible candidates are called for interview, a written subject test is given, psychological tests are given and the final interview is preceded by a group discussion. The committee appointed for selection had decided to call applicants (not many had applied) one by one and not use the system meant for selection of scientific officers. They had felt that an interview would be good enough to select an administrative officer! If the psychological test for assessing the positioning on the introvert-extrovert scale were to have been given, it would have brought out a very useful trait. There is no right or wrong answer in this test, and persons who want to 'impress' by giving more 'right' answers get exposed because this test has a built-in 'distortion score'. In general, this score is higher for Indians than Americans; and we had learnt from experience that those candidates who score high on this DS usually bluff their way through at interviews, and pose as being more knowledgeable than they are. This AO had mouthed the right kind of sentiments about 'organisation being more important and administration ought to work for its goal' etc. during his interview. His behaviour toward the seniors was smooth, but toward the juniors was indifferent, to say the least.

3. **Assess performance timely :** Performance assessment of new recruits was usually done by the Head of the Department after first six months.A decision would then be taken to either confirm him in service or to give feedback for improvement.Thereafter, the review at the end of the year would be for confirmation in service or for letting the person go. In the case of the AO, it was not clear as to who will assess; the two DDs who selected the AO or the Director, who was the hiring authority in this case. Even before such assessment, the PG. led by the Director, had considered the request from the AO to grant him vehicle loan. This slip turned out to be a major mistake. A thorough review would have brought out several negatives about this person in his role as AO.

4. **Upward Communication :** The dissatisfaction among the assistant staff in administration and accounts about the way in which the new AO was functioning had not been communicated upwards to any Assistant Director and above. The Policy Group was unaware of these happenings when the discussion on vehicle loan for AO was going on. The discussion was more on 'how' rather than on 'whether' to give such a loan. The feeling at the management level that ATIRA is a place where any grievance or complaint will be heard

sympathetically was perhaps true, but in this case no individual member of the staff had a complaint! An assistant cannot go the 'boss's boss' to tell him that the 'boss' is not doing his job well. But some attempt should have been made by the Director to ask one of the DDs that had recruited the AOto get a feel on what is happening --- after about 3 months, if not after the very first month of service of the new AO.

5. **Credibility of Management :** After a few days of withdrawal of vehicle loan to the AO, the 5 cm slip sent by the DD to the administration was discovered. The news spread among all, including the 40 who were a part of the protest. One of them raised a question which all agreed was vital. The very first reaction was to ask the question that faced everyone. "Is there a date on this slip that was purportedly sent after the PG meeting? If there is, is that the date of the PG meeting or the next day? Is the ink with which the date is written the same as the text? Is the date in the same handwriting style as the sentences in the note?" Clearly, the staff was in no mood to trust the management. To cover up the matter, a note may have been prepared after the event of compelling the Director to withdraw the order of vehicle loan. Luckily, the hand writing of this Sr.DD was pretty neat and he had put the date on both those slips that he had sent on the day after the PG meeting. The genuineness of the notes was not in doubt and these were finally accepted as valid directions given after the PG meeting.
6. **"The Buck Stops Here :** The management dictum that 'the buck stops at the desk of the CEO' is indeed true; no matter where the error occurs or a fault is deliberately created, the consequence has to be borne by the CEO. In a proprietary business, or in a private limited company, or even in a public limited company, a decision of the management to make an exception and to give vehicle loan to an individual, would not be subject to question by either the unions or by the employees. They may not like it or approve of it, but they do not protest against it. In an NGO or in a cooperative society, such instances are not tolerated. Given the good and long standing tradition of 'fair and just' decisions made transparently, this aberration was intolerable. And so it was perceived, as proved by the unprecedented gherao of the Director by as many as 40 employees.

Consequences

This episode had three consequences; one short term, one medium term and one long term.

- The credibility of management, which was lost for a while, was restored.
- This Administrative Officer was found to be quite unsatisfactory when his performance was evaluated at the end of the year. He was asked to leave. Legally, he was in the probationary period, and legally again, a manager who grants leave and signs leave applications of employees etc. can be dismissed without having to give reasons in writing. So, he left quietly.
- The policy agreed upon at the PG meeting, to reduce the waiting period for granting any vehicleloan to officers from 3 years to 6 months was shelved temporarily; never to be brought in again. ATIRA had lost one good opportunity to retain talented officers longer in service.

Some other consequences were not directly from this case, but came in because of change in business environment soon after the next Director took over. Funding from the government became less and uncertain. ATIRA started recruiting staff, including scientific officers, on contract basis for each sanctioned project. If no projects were to come through, the contract would not be renewed. The need for reducing the staff strength was felt strongly, and several internal transfers were made at all levels of hierarchy. A senior officer, whose field of work had become redundant, and who had good general capability, was transferred to head the administration as AO, looking after accounts as well. This method of filling the AO post continued for quite a few years.

The lessons learnt by an organisation continue to help the next generation management in two ways: to do the right things, and to avoid the wrong ones. Acharya Chanakya's laws of management is one good source of guidance to managements in India; simply because he advises on what to do and what not to do on the basis of principles and laws based on human behaviour. The authenticity of these laws comes from the fact that these were tested out in practice for over 136 years of rule of by successive kings of the Mourya Dynasty over a large part of Bharat: from Emperor Chandragupta to Emperor Ashok. These concepts are valid today because human behaviour does not change over a short period of 2500 years!

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The series of chapters under the title, 'Graphene A Wonder Material' are being published in the Journal of the Textile Association. The nanomaterial Graphene has been attracting a lot of attention over the past few years. Thankful to its unique combination of a simple structure of bonded carbon atoms with its multitudinous and complex physical properties. This series covers the extraordinary features of graphene, its different methods of preparation and isolation, useful applications in various fields of science and technology, its science involved in the technology of textiles, and finally ending up with its future prospects.

This series is written primarily as an introductory text for the readers of those interested or already working in graphene and putting up its essence in the textile related areas, who wish to acquire a broad knowledge of graphene and its application in textiles.

The previous chapter dealt with the methods of production of graphene. There are two approaches that are being worldwide followed in graphene nanotechnology. Such approaches are popularly known to be as top-down and bottom-up. It basically confined itself into the sciences and various technologies involved in the former approach i.e. the top-down technique. Different processes that cover up under such aforementioned technique were briefly discussed.

The present chapter is the continuation of the synthesis of graphene covering different aspects of bottom-up approaches. It primarily focuses on the sciences in the bottom-up graphene synthesis technology. Various bottom-up processes that are being explored in graphene research have been briefly discussed in this chapter.

Chapter 4
GRAPHENE A WONDER MATERIAL
: Synthesis of Graphene (Part-II)

Saptarshi Maiti, Pintu Pandit, Geetal Mahajan, R. V. Adivarekar & M. D. Teli

Graphene, in the previous section was explicated based on the various top-down approaches of its synthesis. But there happens to be certain disadvantages of the top-down methods of graphene production, which leads to the growing popularity of another kind of approach widely known as bottom-up.

Direct Chemical Synthesis

All the chemical synthesis processes described in the earlier cover are top-down approaches as the processes involve the oxidation of bulk graphite, exfoliation of graphene oxide (GO), and then reduction back to graphene. In this section, a bottom-up approach of chemical synthesis of graphene, named as solvothermal method, is introduced. Here, ethanol and sodium can be used as the starting materials to synthesize sodium ethoxide followed by the pyrolization, which yields a fused array of graphene sheets. This method involves a reaction of 1:1 molar ratio of sodium and ethanol in a sealed reactor vessel at 220^{0}C for 72 h, resulting in a yield of sodium ethoxide, a graphene precursor for further reaction. It can be rapidly pyrolyzed, vacuum filtered, and dried in a vacuum oven at 100^{0}C for 24 h. The advantage of this process, is a low temperature, low-cost, and bottom-up process that can be further extended to a more controlled fabrication of high-purity and functionalized graphene. However, the quality of graphene is still not satisfactory as it contains a large number of defects.

Chemical Vapor Deposition (CVD) Process

Thermal CVD is a chemical process by which a substrate is exposed to thermally decomposed precursors and the desired product is deposited onto the substrate surface at high temperature. As the high temperature is not desired in many cases; plasma-assisted decomposition and reaction have been applied to lower the process temperature.

The advantages of CVD process include, high quality, high purity and large-scale synthesis of graphene. In addition, by controlling the CVD process parameters, control over the morphology and crystallinity of the desired product is possible. However, tailoring of high-precision atomic-level synthesis is still under investigation.

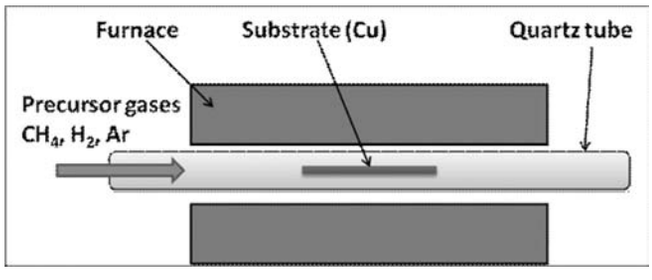

Figure 1: Thermal CVD

Graphene Synthesis by CVD Process

In 1975, Lang et al. first demonstrated the monolayer

graphitic structure growth on Pt by thermal CVD method. It was found that graphitic structure formation took place on platinum due to the decomposition of ethylene. Later, Eizenberg et al. reported the graphitic layer formation on Ni (III) using the CVD process which includes first carbon doping in single-crystal Ni (III) at 1200-1300 K for a long period of time, followed by a quenching process. In this context, rapid quenching process causes the carbon phase condensation on Ni (111) surface. Therefore, it was concluded that the carbon phase segregation on the Ni (III) was solely dependent on the rate of quenching.

Since then, almost for two decades, the single graphitic layer deposition had not been explored further due to the inadequacy in finding applications of thin graphite film. Immediately after the discovery of graphene in the beginning of twenty-first century along with the potential search for the high-speed electronic materials, graphene technology rises to an esteemed level in the field of electronics. It attracted tremendous attention to the scientific and industrial communities, owing to its unusual electronic and optoelectronic properties, high mechanical strength, and good thermal conductivity. In this context, the physics and chemistry of graphene structure were also examined considerably in order to open up the possibilities of several applications of graphene.

In 2006, the first attempt at graphene synthesis on Ni foil using CVD was observed using camphor as the precursor material carried out in a two-step process: camphor deposition on Ni foil at ~180^{0}C and subsequent pyrolyzation at a very high temperature in Ar atmosphere. Upon the investigation using TEM, it was found to have a hexagonal planar few-layer graphite-like structure. It resulted in a novel pathway of large-scale graphene growth using thermal CVD. However, large-scale mono- or bilayer growth of graphene using such method is still in demand. Obraztsov et al. reported the deposition of few-layered graphene (FLG) on Ni. A very thin layer (1-2 nm) of graphene was produced at 40-80 Mt pressure and 950^{0}C under a DC discharge of hydrocarbons as confirmed by Raman spectroscopy and scanning tunneling microscopy (STM).

Similarly, Pei et al. also demonstrated the synthesis of high-quality graphene on polycrystalline Ni surface using a thermal CVD of methane (CH_4). The FLG was synthesized at 1000^{0}C using CH_4:H_2:Ar = 0.15:1:2 with a total gas flow rate of 315 standard cubic centimeters per minute (sccm) under normal atmospheric pressure. The study also emphasized the effects of cooling rates, which significantly control the formation of different numbers of graphene layers.

Choi's group developed a large-scale synthesis of graphene on Cu foil using a CVD process. A large foil of Cu was rolled up and placed inside of a quartz tube furnace, and then the graphene was transferred onto different substrates including flexible polymer substrates using a hot press lamination process. On the other hand, Bae et al. reported the roll-to-roll production of 30 in. flexible graphene synthesized on Cu foil by using a catalytic decomposition of methane in a CVD and transferred onto a flexible PET substrate by roll-to-roll transfer process. Several other reports were found demonstrating the graphene synthesis on various metal foils and metal thin films. However, Ni and Cu have been known as the most common substrates for the growth of graphene via thermal CVD processes. Although CVD graphene synthesis on different transition metal surfaces has been demonstrated extensively, direct graphene synthesis on a dielectric surface is quite challenging since the transition metal surface plays a role as catalyst. Ismach et al. reported graphene growth directly onto insulator substrates. A very thin Cu film deposition was carried out on dielectric substrates by e-beam evaporation, followed by the growth of graphene using thermal CVD at nearly 1000^{0}C under pressure of 100-500 mT. The precipitation of graphene on such dielectric surfaces occurs due to the concurrent process of the surface-catalyzed process of Cu and the copper film dewetting leading to direct deposition of graphene. Therefore, such direct synthesis of graphene on dielectric substrates bypasses the post-synthesis graphene transfer process, which results in the inclusion of defects and contamination in graphene. However, such type of deposition needs to be further explored in order to achieve well-ordered, large-scale, defect-free graphene for electronic applications.

Graphene Synthesis by Plasma CVD Process

Plasma CVD process involves chemical reactions of the reacting gases in presence of plasma inside a vacuum chamber resulting in the deposition of the thin film on substrates, which is known as PECVD process. The plasma can be generated inside a PECVD system using plasma sources such as RF (AC frequency), microwave, and inductive coupling. By this technique, graphene synthesis can be performed at relatively low temperature compared to other CVD processes; making it more feasible for industrial appli-

cations. Moreover, catalyst-free growth can be carried out by controlling the process parameters that can easily influence the physical properties of the final products. The synthesis of thin graphitic layer using PECVD process was first demonstrated by Obraztsov et al. by DC discharge CVD of a gas mixture containing CH_4 and H2 at 10-15 Torr. In such report, Si wafer and different metal sheets of Ni, W, and Mo were used as substrates for nanocrystalline graphite (NG) growth. However, it produced a thick layer graphene. Wang et al. attempted to deposit graphene using PECVD on several substrates. They tried to control graphene deposition by varying methane concentration at different temperatures. It was observed that it resulted in the increase of graphene growth rate. Similarly, Zhu et al. also reported the synthesis of vertically aligned very thin free-standing graphene by inductively coupled RF-PECVD system on catalyst-free substrates by using hydrocarbon and hydrogen as precursor gas mixture. PECVD process can produce only the vertically oriented graphene, which is not yet demonstrated using any other graphene synthesis process. Such method produces high-purity and high-crystalline graphene; however, uniform large-area and single-layer graphene production using this process is still under detailed investigation.

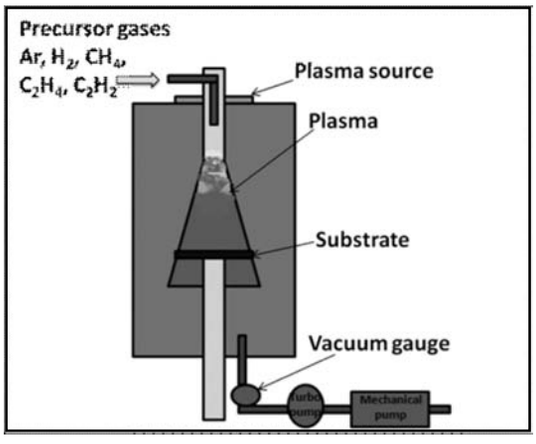

Figure 2: Plasma enhanced CVD (PECVD)

Grain and Grain Boundaries (GBs) in CVD Graphene Graphene growth on Cu by CVD process is one of the most promising and scalable methods of graphene synthesis. Hence, producing continuous layer of high-quality large-area single-crystalline graphene is becoming a challenge as there is a formation of grain and grain boundaries (GBs), which are considered as defects of graphene. The structure and morphology of the GBs have significant effect on the electrical, thermal and mechanical properties of the graphene film produced. Primarily, deposition of graphene process on Cu occurs due to the formation of nucleation sites, followed by the growth process. Therefore, based on the nucleation process, two major types of GBs are found in the structure: (i) intragranular GBs and (iii) intergranular GBs. Intragranular GBs are formed when a graphene grain formed from a single nucleation site, whereas intergranular GBs are found when two individual graphene grains are originated from two different nucleation sites and merged together at a single point. Therefore, orientation of single-crystalline graphene grain and GBs strictly depends on the crystalinity, morphology, and purity of the substrate. It has been shown that graphene nucleation sites vary with the Cu crystal planes and their orientations. Substrate surface and surface morphologies of Cu play an important role in nucleation seeds and graphene domain sizes during the CVD process. Han et al. observed that the number of graphene nucleation seed formation on polished Cu is much lower than that of the unpolished one. Hence, the domain sizes of graphene flakes are larger on the top of the polished Cu surface. Characteristics of graphene GBs are more significant in representing the transport properties of graphene. Using atomic resolution imaging, one recent report stated a technique to locate and identify when several grains attach together predominantly through pentagon-heptagon pairs. The electrical characterizations of graphene GBs show the sharp voltage drops due to the high resistance of the GBs. In particular, the grain size and the formation of the number of graphene layers are varied with different growth conditions.

Epitaxial Growth of Graphene on SiC Surface

Epitaxial thermal synthesis of graphene on single-crystalline silicon carbide (SiC) surface is one of the most renowned synthesis process, which is being explored vigorously for the last 7-8 years. The term "epitaxy" can be defined as a method that allows depositing a single-crystal substrate. The deposited film is referred as "epitaxial film" and the process is known as epitaxial growth process. It is a process to fabricate highly crystalline graphene on single-crystalline SiC substrates. When the deposited film on a substrate is of same material, it is known as homoepitaxial layer, and if the films are of different materials than the substrates, then they are called heteroepitaxial films. For example, single-layered graphite or graphene formation on the SiC is known as heteroepitaxial layer.

The investigations on the electronic properties of graphene consist of two successive directions. One of

which is based on the exfoliated graphene, and the other one is related to the wafer-scale synthesis of epitaxial graphene, that stipulates the most feasible and scalable approach toward graphene electronics. Vast conscientious research areas have been explored such as, (i) epitaxial graphene-based electronics, (ii) band gap opening, (iii) epitaxial growth mechanism, (iv) heterointerfaces of graphene/SiC, and several others, focusing on research toward a goal of improvements in large-scale graphene-based electronics.

Bommel et al. first reported the graphite formation on both of the 6H-SiC surfaces in the year 1975. In the year 2004, de Heer and coworkers reported the fabrication of ultrathin (few layers, 1-3 monoatomic graphene layers) graphitic layers on Si-terminated face of single-crystal 6H-SiC and its electronic properties. In a recent approach, Juang et al. reported the epitaxial graphene growth on a catalyst thin film-coated SiC substrate at a comparatively low temperature. It illustrated the low-temperature epitaxial graphene growth process on SiC substrate coated with thin film of Ni.

The "epitaxial graphene on SiC" research attracted huge attention both academically and industrially due to its scalability, best electronic properties as well as high-quality graphene. The major advantage of this process is large-scale fabrication of graphene on an insulator or semiconductor surface. Furthermore, epitaxial multilayered graphene over the SiC substrate behaves as an isolated graphene, which would be an added advantage of its application in graphene-based nanoelectronics. Nevertheless, the high growth temperature and very low process pressure are the major disadvantages of this process. More specifically, the final epitaxial graphene exhibits smaller grain size. Although high-quality superior-grade epitaxial graphene formation has been reported, the transfer of graphene to any other substrates is difficult, which seriously limits its versatility in a wide range of electronic applications.

Summary

All of the a forementioned techniques are popular in the individual field of experimentalists. Researchers have been working a lot since few decades on the two kinds of approaches of graphene production: top-down and bottom-up methods. However, such synthesis methods have their own advantages and disadvantages on the basis of quality of grapheme produced, scalability, purity, different physical and chemical characteristics etc. Based on the end use applications of graphene, the suitable synthesis approach is always a matter of importance.

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USTER Customer Service : the inside story

Dedicated and experienced, meet the USTER people who keep mills running smoothly

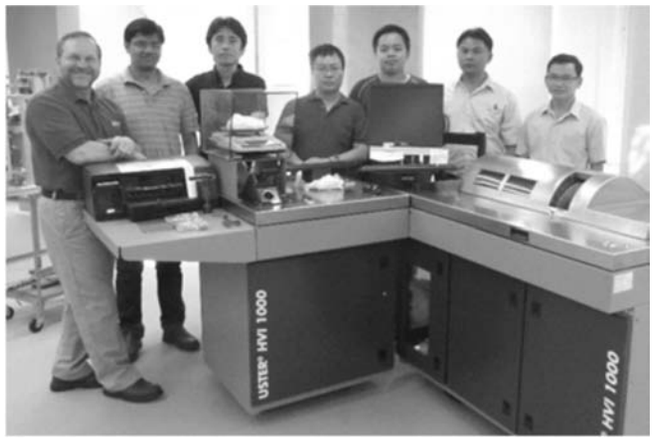
The technology is in place, the products are ready to roll… But it's people who provide the vital link to bring it all together perfectly, and keep it going as smoothly and efficiently as possible. USTER'S worldwide service teams are dedicated to giving textile mills a rapid response, with expert personnel always on hand. A phone call or a service visit - whatever is needed, customers have direct access to USTER people who can deal with a problem and find a solution.

Francis and Simon at a customer visit

Here is a typical scenario: Mehmet's phone rings, and it's a mill manager on the line. He's worried about his USTER®JOSSI VISION SHIELD performance. The call takes about 10 minutes and Mehmet gives some instructions.Shortly afterwards, the customer calls back, happy to report that the cotton cleaning system is now readjusted based on the recommendations and is again performing to his expectations. Mehmet imagines the smile on the face of another satisfied customer.

Mehmet is Service Manager with Uster Technologies Turkey, and has been with the company for 11 years. He is just one of a global network of 125 people in USTER service centers covering China, India and South East Asia, Japan, Turkey and surrounding countries, and the Americas. An agency network with another 50-plus staff covers the rest of the world.

Just as with Mehmet's mill manager in our example, all USTER customers have the direct number of their service contact - and are welcome to call any time with queries and problems. Usually, USTER service people can sort things out immediately, over the phone.



International USTER Service Training on the USTER® HVI 1000 at Uster, Switzerland

International USTER Service Training on USTER® low volume instruments (LVI) at Uster, Switzerland

If the issue is more complex, the service team will plan a mill visit. "Based on the information we have, we will look at several possible options and pack the appropriate spare parts, so that our staff are fully prepared to avoid or minimize any downtime at the mill," says Kris Suresh, Head of Service based at USTER headquarters in Switzerland. USTER offers service contracts with value added services and support, and these are well appreciated by customers, most of whom continue the service contract for lifetime of the product.

A day in the life of Prabakaran…

Prabakaran, based in Coimbatore, India, is another member of USTER's service team. Today, he starts

work at 5.30 am, driving to a customer located near Madurai - a journey of about three hours. Two days ago, he was informed about a problem with variations in mic readings in the customer's USTER®HVI 1000.

At the mill, Prabakaran checks out some possible causes of the problem: he carries out gas regulator cleaning, adjusts chamber size and air settings and calibrates the mic module. He tests some reference samples himself and asks the customer to do the same. The values match closely,so Prabakaran hands over the USTER®HVI 1000 again. The customer is very happy, and so is Prabakaran, who now writes his work bulletin, has a final discussion and handshake with the mill manager and departs, ready for a new mission tomorrow.

This one-day snapshot of an USTER staff member's work is typical for his average of 150 customer visits per year. This particular trip covered 400 kilometers. A monthly breakdown of all USTER service people's journeys shows an average of 61,000 kilometers - equivalent to 1.5 times round the world. Total travelling time each month averages 4,600 hours, or more than 190 days and nights.

Beyond expectations

USTER Service goes way beyond problem-solving. Fixing an issue in a minimum of time is one of three aspects: USTER staff investigate the cause of the problem and discuss with the customer actions to prevent any similar occurrence. On-site they take some time to train operators to execute the tests optimally and to get the most out of their quality testing and monitoring equipment. Senthil Kumar, General Manager of Service in USTER India, points out: "Customers like to take the chance to discuss application issues with us, and we are always glad to support by sharing our experiences. Often, what starts as a business connection will grow to form strong bonds? Several USTER India Service staff have more than 20 years' experience - and therefore have built close working relationships over that same time."

Ultimately, it's not only the duration which will strengthen these relationships. It's also a question of fulfilling, or exceeding, the customer's expectations when an issue occurs. "We would never say that a problem doesn't concern us or that we could not take it on. We will try to find the source, no matter which machine might be the cause - and we will always listen and advise," Senthil Kumar says. "This attitude and commitment has brought respect and recognition from customers as characteristics which make the USTER Service team special."

The other role of USTER Service

When it comes to customer satisfaction with USTER Service, nothing is left to chance. USTER carries out regular customer surveys, to gauge improvement potential. "I'm happy with the last survey result saying that 95% of customers rate their USTER service experience as all positive," says Suresh. He attributes this to a circle of success. It starts with experienced staff - 8 out of 10 of worldwide staff have been with USTER more than 10 years, so they have the detailed know-how to support customers as efficiently and effectively as possible. Satisfaction breeds trust, and service staff enjoy the appreciation they have from the customer side, creating a pleasant working atmosphere and encouraging them to stay with USTER, continuing the circle of success. "Customers are satisfied with the service but also because they rarely need the support of our service team. It generally takes years until a first issue with a new instrument occurs. This is also proven by statistics," says Suresh.

The USTER Service team also plays an important role in the company's success. Trusted service enhances overall trust in the brand, a benefit acknowledged by Uster Technologies CEO Thomas Nasiou: "Loyalty from customers has to be earned," he says. "And our Service team earns a relevant share of it. They are on duty 24/7 with a customer-focused approach and great commitment. It is not unusual for customers to tell us that they regard the standards achieved by USTER Service as the industry's defining benchmark."

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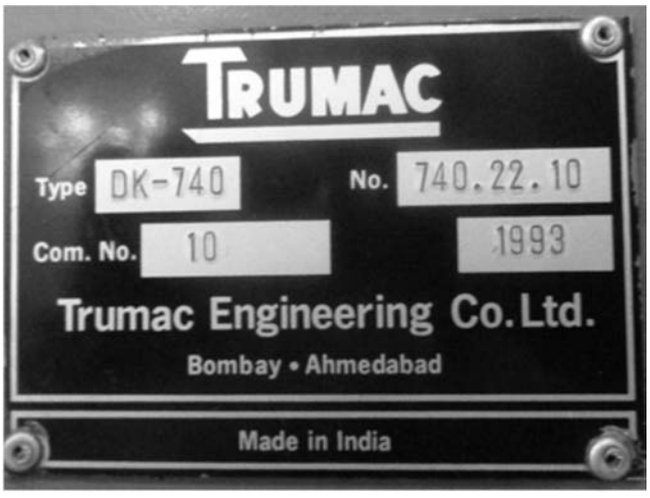
Truetzschler Technology - Old Is Gold!

Trust is a word synonymous with Truetzschler for over 125 years, and this is the main reason a small repair shop in Germany has grown into a company of global stature. The reasons Truetzschler is so trusted are simple: their products have tremendous longevity and have performed well for a period much longer than normally expected.



TT Group DK 740 Trumac Com Plate

TT Group DK 740 Trumac Com Plate

Workmanship has always been emphasised as the basis for the solid engineering and quality of Truetzschler machines. The Germans are known to give rock solid products, and Truetzschler is a standard bearer in this regard. Right from the first card DK in 1967 running at 10 kg/hour to the present TC 10 and TC 15 cards running at 200 kg/hour, it has been a continuous journey surpassing customer expectations with trend-setting technology products and unmatched services.

At Truetzschler, since the beginning, research and development has mattered the most, and short-term cost has been a secondary aspect. This philosophy has helped in developing long lasting world class products for the textile industry. As a result, Truetzschler machines are performing to the full satisfaction of the customers even 30 years after purchase!

Arvind Mills in Ahmedabad is still running the first generation DK 740 cards which were delivered in 1993. Appropriate maintenance and re-clothing at proper intervals has helped the cards to still run at their optimum speeds. A visit to the carding department shows that the cards are running with 460 cylinder RPM and still no vibrations are felt. The mill is happy with the performance and it is in no hurry to replace the cards. This it is a testimony to the robustness of the Truetzschler technology bought by the mill almost 25 years ago.

Cheran Synthetic Mills (Pallavaa Group), in the quiet town of Erode, near Coimbatore in South India, has a first generation automatic bale opener BDT 013 manufactured in 1994. The bale opener is running as well as the new version automatic bale openers in the groups nearby units. A closer look at the rail tracks reveal that there are hardly any deterioration marks on them. The maintenance team of the mill is happy with the performance. Mr DuraiPalanisamy, Executive Director of the Pallava Group, is confident that the Blendomat can still run for at least 10 more years!

Raviraj Industries in Yavatmal, Maharashtra, has the unique honour of having a DK 715 running at 30 kg/hour with a hank of 0.095 Ne. The card processes 44 mm 100% polyester fibres of 1.4 denier. Mr Mahesh Agarwal, Director, informed that the card was imported as a re-sale from and says even today that "the cards are giving the best price-performance ratio to us".

TT Limited (unit - Gajroula Spinning Mills) is a 15,000 spindle unit in Uttar Pradesh, having 8 DK 740 cards delivered in 1992-93. The cards are still running at production rates of 45 kg/hour with a cylinder rpm of 480. The mill produces 8.5 tons of quality yarn every day. The mill also has 5 DK 780 cards delivered in 1995, running at similar production rates. . Mr B C Jain, Vice-President proudly said, "We are glad we took the decision to buy Truetzschler machines".

The many examples above show that the technoloy

sold by Truetzschler almost 25 years ago is still giving customers the satisfaction that they made the right decision of purchasing Truetzschler machinery.

The DK 740 cards at TT were amongst the first lot made by Truetzschler India Private Limited, which was formerly known as Trumac Engineering Company Private Limited. In India, the manufacturing partnership of Truetzschler with A.T.E. is celebrating 40 years this year. The 'Customer First' value of both the companies has always been the driving force for creating trust among Indian customers.

It is this trust shown by valuable customers that has inspired Truetzschler and A.T.E. to continue providing the best technology with innovative features that no others have. With Truetzschler, it is truly apt to say that OLD IS GOLD!

Sweden Minister & Grasim MD discuss plans for setting-up smart textile project

Mr. Sven-Erik Bucht, Minister for Rural Affairs from the Ministry Of Enterprise and Innovation of Sweden met with Mr. Dilip Gaur, Managing Director, Grasim Industries Limited and Mr. Vinod Tiwari, COO, Pulp and Fibre Business of Grasim of Aditya Birla Group in city and discussed an innovative smart textile project and how to best to keep up with the growing demand for textiles with an alternate sustainable solution to cotton.

The Swedish Minister also visited the Aditya Birla Group's Textile Research & Application Development Centre at Kharach, in Gujarat yesterday which is India's pioneer in viscose staple fibre (VSF), a man-made, biodegradable fibre with characteristics akin to cotton.

The prime aim of this visit is to boost development on smart textiles from using viscose staple fibre (VSF), cellulosic fibre and pulp as an alternative to cotton and hence the Aditya Birla group is a natural fit with its easily blendable cellulosic fibre.

Addressing select media in city, Mr. Sven-Erik Bucht informed that Sweden strongly believes that the textile industry is about to take a giant step from being a supplier of fabrics to becoming a positive force in the development of a responsible society.

Sustainable textiles are necessary to improve people's everyday lives, the health care sector and the environment. It takes an open environment where people from many different backgrounds can meet, get involved and collaborate to find a sought-after solution and this is exactly what we are hoping for from this visit by coming together for the betterment of the society and lessen the environmental impact of the textile industry he emphasised.

It may be noted here that the Swedish Minister visit to India is part of the follow up to the joint statement by Prime Minister Stefan Löfvén and Prime Minister Mr. Narendra Modi and its implementation in the areas of innovations and research. It is also a follow up to the 'Make in India' event in Stockholm where Mr. Dilip Gaur was a part of the Indian delegation led by Mr. Suresh Prabhu Minister of Commerce & Industry of India, which aimed at exploring synergies and avenues of partnership between Indian and Swedish industries.

Speaking about the collaboration between India and Sweden, Consul General for Sweden Ms. Ulrika Sundberg said "It is inspiring to see the broad range of engagement between Sweden and India particularly Maharashtra, stretching from business and infrastructure to environment, health, skills development, culture and in this instance smart textile. Textile and other closely related industries today have an important challenge when it comes to R&D and production in an environmentally friendly and socially responsible way. With a joint project on smart textiles we will prioritize the environment and work actively to integrate this in all parts of the production line. For us, sustainability, durability, quality and functionality are all important factors for developing a circular bio-economy and I truly hope this visit enhances cooperation in tackling the same for a sustainable and healthy future"

Speaking about his visit, Minister Sven-Erik Bucht said "We are keen to explore the possibility of a joint project within the area of smart textiles using viscose staple fibre (VSF), cellulosic fibre and pulp as an alternative to cotton. Together, we need a broader approach to address the challenge of climate change and we would like to share our experiences, thoughts and ideas about the practice of a circular bio economy which will help us assume our common responsibility to the environment. My visit to the Aditya Birla group is a part of the bilateral ambition to increase cooperation and trade as well as create synergies and partnerships between

the two countries. The Swedish government is heavily involved in developing textile based on sustainable raw materials and we are very interested in supporting the further development of a globally successful textile industry. This in turn will help create jobs in both countries and will also lead to a sustainable and healthy future".

For further details visit
www.adityabirla.com /www.grasim.com / www.birlacellulose.com
Follow us on twitter @adityabirlagrp @GrasimInd

The Oerlikon group's nonwoven business unit presented itself successfully in China

Oerlikon's expanded nonwoven portfolio attracted a lot of interest at the SINCE 2017

The Swiss Oerlikon Group's new nonwovenbusiness unit received very positive feedback from visitors to this year's nonwovens exhibitionSINCE 2017, which ran from 8th to 10th November in Shanghai, China. Visitors to the attractivelydesigned Oerlikon stand were especially interested in the spunbond technology for technicalapplications.

Rainer Straub, head of the nonwoven business unit that had been newly created by the OerlikonManmade Fibers segment in the middle of the year, declared himself highly satisfied with the three livelyexhibition days in the World Expo Exhibition and Convention Centre: "The talks have shown that we areon the right path with our strategy and the development of our technologies. Especially the optimisationsof our spunbond process and the resulting increase of nonwoven qualities in terms of strength andelongation impressed the visitors".

Also greatly in demand were Oerlikon'smeltblown and airlaid technologies as well as the solutions forthe manufacturing of wipes and other disposable nonwovens, which were offered in cooperation withTeknoweb Materials s.r.l.. All in all, the Oerlikon group's nonwoven team are delighted with the positiveoutcome and can look back in satisfaction on intensive talks of high quality with customers and prospectsas well as numerous concrete inquiries.

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ADVERTISEMENT INDEX

Mr. S. Hari Shankar elected new Chairman of India ITME Society

Mr. S. Hari Shankar

Mr. S. Hari Shankar has been elected as the Chairman of India International Textile Machinery Exhibitions Society (India ITME Society) in their AGM held on 22nd Sept. 2017 in Mumbai, for the term 2017-2019.

He is an alumni of PHILADELPHIA College of Textiles & Sciences, USA. Apart from being an enthusiastic athlete, he is also an avid and well-known wildlife photographer.

He is the Joint Managing Director of Lakshmi Card Clothing Mfg. Co. Pvt. Ltd., Coimbatore. LCC is a global leader in providing complete card room solutions.He is also on the Board of Directors of M/s. PrathishtaWvg. & Knitting Co. Ltd., Coimbatore and Governing Council member of The Indian Chamber of Commerce and Industry, Coimbatore.

Mr. S. Hari Shankar is active in many associations and is on the Board of Executive Council of Textile Machinery Manufacturers' Association (India) (TMMA) since 2001 and also held the position of Chairman of TMMA from 2011-2013. He was part of India ITME Society since 2001 and held the position of Hon. Treasurer from 2013-2017.

The Vice Chairmen elected are Mr. Mehul Trivedi (The Indian Card Clothing Co. Ltd). Mr.Kaizar Z. Mahuwala(Gurjar Gravures Pvt. Ltd), Mr. Sanjay K. Jain (Confederation of Indian Textile Industry (CITI), Mr. Arvind Sinha (The Textile Association(India), Smt.SurinaRajan, IAS (Bureau of Indian Standards), Govt. of India.

Mr. KetanSanghvi (LaxmiShuttleless Looms Pvt. Ltd) has been elected as Hon. Treasurer.

India ITME Society acknowledges and appreciate the valuable contributions of immediate past Chairman Mr. SanjivLathia(Lathia Rubber Mfg. Co. Ltd) 2013-2017 and thanks him for the same.

GOTS Pre-Conference Organic World Congress - Spots on Social Compliance

GOTS Pre-Conference to 19th Organic World Congress of IFOAM - Organics International was organized by GOTS in India Habitat Centre, New Delhi, India on 8th November, 2017. This conference was first of its kind, solely focused on 'Social Compliance Issues in the Organic Textile Supply Chain'. Actually the GOTS accredited independent Certification Bodies report more than 1.4 million people working in GOTS certified facilities.

Audience

Group - Speaker Supporters GOTS Team

More than 80 high profile attendees and speakers from twelve countries - including Scholars, CSR Managers and HR Representatives of companies, Certification Bodies, Standard Setters, Government and NGOs discussed about hot spots like Income Equality within countries and globally, Land Grabbing, dealing with

non-compliances or how certification as a diagnostic tool could be supplemented by instruments or measures which provide a measurable continuous improvement process.

Three main outcomes were agreed to put to larger scale in presenting them in Track 7.A of the 19th Organic World Congress (OWC) by the GOTS Representatives Christopher Stopes and Satoko Miyoshi:

1. Social criteria in sustainability standards help improving working conditions. Improve standards with measurable criteria and keep inspection/certification as a diagnostic tool.
2. In addition or - if possible - in combination find and apply suitable aspirational approaches and tools.
3. Find and apply efficient means to draw the big brands and retailers into utilizing their responsibility for sustainability of the textile industry.

Dr. Elisabeth Bennett, Assistant Professor of International Affairs from Lewis & Clark College (Portland, Oregon, US) said: "The GOTS Pre-conference offered an important opportunity for supply chain actors, scholars, and sustainability advocates to discuss the most challenging problems and important opportunities in sustainability certifications for textile manufacturers. Perhaps most importantly, there was a robust discussion about the value of offering living wages to factory workers."

"The inclusion of social compliance rules into voluntary sustainability standards with their system of inspection and certification - such as GOTS - is still and will remain a valuable contribution to safeguarding the rights of working people. We are pleased that our stakeholders very openly shared their views and suggestions for the further development of GOTS" Herbert Ladwig, GOTS Managing director said.

Quality is Critical for Spunlace Nonwovens

USTER®JOSSI VISION SHIELDremoves contamination and minimizes waste

When textile products are intended for critical end-uses, there can be no compromises on quality. Nonwovens manufacturers, for example, must deliver the highest levels of quality when supplying fabrics for medical, personal care and hygiene applications. These products must both look and feel virtually perfect, to meet the expected standards for cleanliness and comfort, especially when they come into contact with human skin in use.

So, any contamination in these fabrics is a potentially disastrous quality risk, leading to claims and returned rejects. Zero tolerance levels for defect larger than 1 mm are standard. Tiny fragments of foreign matter in the fiber could remain visible as unsightly blemishes, as well as scratching or abrading the user's skin.Typically, fabrics for these sensitive applications are made by the spunlacing process, which starts with the fiber raw material in loose stock form. This is where it is crucial to remove any contaminants, before they reach the fabrication process. At the same time, the nonwovens producers must preserve as much valuable 'good' fiber as possible, minimizing waste to maintain plant efficiency and profitability.

Powerful technology

Cotton Batting

Contamination nonwovens

The USTER®JOSSI VISION SHIELDfiber cleaning system is the solution. It provides maximum detection of contaminants with minimal waste. Located in the ideal position, after fine opening in the blowroom, the system uses latest-technology spectroscopes to pinpoint even the smallest particles of foreign matter in the cotton or man-made fiber raw material.

Covering a much wider wavelength than conventional camera systems, USTER®JOSSI VISION SHIELDhas the power to identify and remove fragments as fine as a single human hair. At this stage in the fiber preparation routine, detection is enhanced, since the fiber tufts have the optimum opening to prevent any small contaminants being hidden inside them.

Once identified, the foreign matter pieces are automatically ejected by the system, preventing contamination of the spunlaced fabric. Some waste here is inevitable, but USTER®JOSSI VISION SHIELD controls this by continuously measuring the speed at which the fiber tufts pass through. It then uses precision valves to time each ejection perfectly, so that only the unwanted contaminant is removed, with an absolute minimum of good fiber being lost. The cost savings for the producer can be significant.

Security against quality claims

The quality demands facing nonwovens manufacturers in these key applications are stringent. For example, it is clearly unacceptable to allow any kind of stray material in hospital products such as absorbent cotton, alcohol swabs, or surgical gauze. Claims and complaints would certainly have a serious impact on the producer's reputation.

USTER®JOSSI VISION SHIELD gives spunlace producers the confidence and security to avoid quality issues in this demanding marketplace. Its technology can cope with both IR and UV light ranges and it can reliably detect various types of foreign matter. All kind of synthetics and even the finest scraps of white polypropylene - otherwise difficult to pick out - are efficiently removed, using the USTER®JOSSI MAGIC EYE in tandem with the USTER®JOSSI VISION SHIELD.

This technology combination empowers nonwovens producers to take control of contamination at the highest levels of quality and efficiency, making investment USTER®JOSSI VISION SHIELD a logical choice for fiber cleaning.

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ITMACH India, Country's Largest Textile Machinery Showbegins on 7th Dec. 2017

ITMACH India, the largest textile machinery exhibition in the country for the year 2017 is launching shortly in the capital city Gandhinagar of Gujarat, with participants from all over the world including the cream of the textile machinery industry participating. The four-day exhibition will be in place from December 7 to 10, 2017 at a modern venue 'The Exhibition Centre'. The show will host over 350 exhibitors from 10 countries in all to occupy the 40,000 square meters area of the exhibition venue.

The grand show at the out skirts of Ahmedabad is also surrounded by major textile hubs in India. Gujarat as a state is the top investors in textile sector in India for last several years and ITMACH India would bring an ideal opportunity for investors and machinery marketers to interact for new investments. Here to note that Gujarat has recently extended its flagship Textile Policy to draw further investment for the sector and backed it up by an unique Apparel Policy that incentivize garment making and employment in the state. Additionally, incentive policies from Govt. of India and other states in the country (Maharashtra, Madhya Pradesh, Telangana, Rajasthan, Himachal Pradesh, Haryana etc.) for the textile industry offers a conducive environment for growth in the post GST era.

ITMACH India would bring an opportunity to witness latest textile machinery and technology from around the world. Machinery from each segment of the indus-

try right from spinning, weaving, knitting, dyeing, printing & processing will be showcased during the show days. Visitors will get to learn about the latest trends, developments and opportunities to share their knowledge and fine-tune their ideas. In short the mega event will ensure that a plethora of business ideas are discussed and dynamic business networking is facilitated. To give a bird's eye view of the exhibitors, among the global participants are Saurer, LMW, Premier, Amsler, Rotorcraft, Jingwei, Pacific, Picanol, ITEMA, Staubli, Haijia, Rifa, A.T.E., Fong's, Perfect, Rimtex, PalodHimson, SPGPrints, Embee, Premier Evolvics and several others are participating in the show. Country wise exhibitors from Germany, Switzerland, Italy, Belgium, Netherland, Turkey, China, Taiwan, South Korea and Japan will present their latest technological innovations to visitors along with a strong contingent of Indian exhibitors.

To sum it up, ITMACH India 2017 will be showcasing excellence and innovation in textile machinery and technology. It will serve as an accredited B2B platform for the textile industry that supports adoption of technology; enhance investment, building capacity and knowledge sharing.

Venue: The Exhibition Centre

The exhibition edifice at the venue has been designed with advanced technology and amenities in Gandhinagar. As the country's largest exhibition venue, it also has under its wings an administrative block to meet the diverse requirements of the global meets, seminars, conferences, and exhibitions of both national and international levels. Both, exhibitors and visitors will be in a position to derive optimum benefit from the event. The hosts are looking forward to your valued presence in this dream venue for both global and Indian textile houses.

For Further Information:

ArvindSemlani | info@itmach.com
Cell +91 9833977743

SSM's latest application

Your way to elasticity - SSM's latest application

SSM PWX-MTC

SSM will show their newest textile machines at ShanghaiTex for the first time. The exhibition is held in Shanghai from November 27 to 30, 2017 at the Shanghai New International Expo Centre. SSM welcomes the interested crowd at booth E1 A70 and E1 D30.

The Swiss based SSM SchärerSchweiterMettler AG, the inventor of the electronic yarn traverse system, announces their participation of the forthcoming ShanghaiTex on the booth of their agent Union Trading as well as on the booth of Rieter Components.

After the successful introduction of the XENO-platform in Asia in 2016, SSM has put the focus on the X-Series this year. With the latest application for cone-to-muff and muff-to-cone winding, SSM offers a highly flexible and economical system.

To maintain a high residual elasticity of elastic Polyamide (PA) and Polyester (PES) draw textured yarns (DTY) after dyeing, the muff dyeing process with integrated SSM leading yarn winding technology is the best solution. The new SSM PWX-CTM enables the preparation of low-density muffs, while maintaining the highest possible elasticity of the yarn throughout the dyeing process. For the highest flexible and productive rewinding, the SSM PWX-MTC offers the proper solution; regardless whether muffs, hanks, dye packages on dye tubes or coreless dye packages are to be rewound.

Besides the displayed applications, SSM provides a wide range of renowned textile machines. A detailed overview about SSM machinery and supported applications of the textile process chain can be found under

Winding Solutions at www.ssm.ch

SSM looks forward to inspiring and interesting discussions concerning open projects using their latest developments.

About SSM Textile Machinery
SSM Textile Machinery, based in Horgen (Switzerland), is a subsidiary of the Rieter Group. SSM is the world's leading supplier of precision winding machines in the fields of dyeing, weaving and sewing thread preparation and enjoys success in individual segments of filament yarn production. SSM comprises the companies SSM SchärerSchweiterMettler AG in Horgen and subsidiaries in Italy and China. SSM is represented worldwide in all major markets. www.ssm.ch

For further information please contact:
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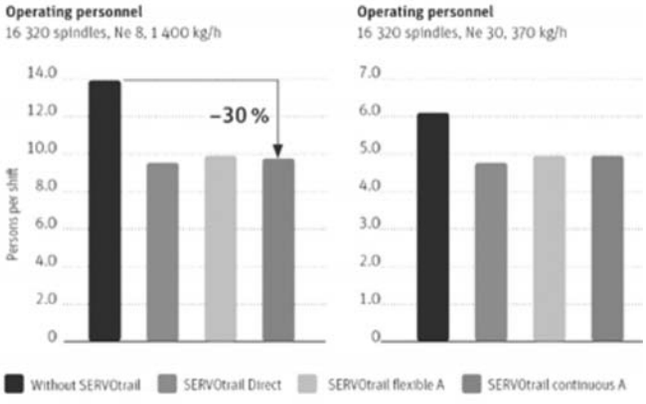
Thomas Elsener
Marketing Service
T +41 44 718 34 17
F +41 44 718 34 52
thomas.elsener@ssm.ch
www.ssm.ch

Rieter SERVOtrail - A Must for Efficient Spinning Mills

The transport system for roving bobbins offers all customers a tailor-made solution. It is maintenance-free and ensures high yarn quality and consistently good machine efficiency. Personnel savings of up to 30 % are possible.

SERVOtrail roving bobbin transport system - for efficient and quality-conscious spinning mills



With large mills and coarse yarn counts, personnel savings of up to 30 % in the ring spinning sector are possible.

The modular roving bobbin transport system SERVOtrail offers the best possible material flow between the roving frame and ring respectively compact spinning machines. It fulfills the most diverse customer requirements, thanks to various levels of automation. The functional system design and the modular combination of the SERVOtrail installation enable several levels and buildings to be linked.

Optimized personnel requirement
Whether manual or fully-automatic variants - SERVOtrail simplifies roving bobbin handling, reduces personnel requirements and consequently the production costs. The well thought-out bobbin transport shortens servicing paths for the operator. The ring spinning machines integrated into the circuit are working at optimal capacity. Above all, with fully automatic solutions and short cop runtimes of the ring spinning machine, the savings are substantial. A customer with a 16?320 spindle mill and coarse yarn can save up to 30 % ring spinning personnel.

Guaranteed yarn quality

Perfect, contact-free bobbin transport ensures consistent quality

The tilted sliding surfaces of the aluminium profile prevent soiling and are thus maintenance-free

The SERVOtrail system transports the bobbins suspended. The outer, sensitive layer of the roving bobbins therefore remains unaffected (Fig.3).

When processing different assortments, a clear distinction is made and the appropriate spinning machine correctly allocated. Controlled intermediate storage by the transport system ensures that the bobbins remain clean and dust-free. Chaotic spaces congested with bobbin trolleys and dust-covered bobbins are thus a thing of the past. Full roving bobbins are always available and the roving is supplied to the ring spinning machine in reliable quality and perfect condition.

Well considered, maintenance-free concept

Soiling, one of the greatest challenges in the spinning mill, is resolved with the SERVOtrail system by open, maintenance-free track profiles. These precisely manufactured aluminium profiles have tilted sliding surfaces (Fig. 4). That has the advantage that no dust or dirt can adhere and cleaning is not necessary. The traveling cleaner on the ring spinning machine supports the cleanliness of tracks and trains. The downtimes required for cleaning work are minimized and maintenance costs decrease.

Proven, stable components and the simple design make SERVOtrail a reliable and long-lasting system.

The right solution for every customer

Every spinning mill has its own individual requirements. Rieter offers its customers a modular transport system, that permits customized solutions due to its high level of flexibility. The following systems are available, with various degrees of automation for flexible and continuous requirements.
Productivity increases.

The SERVOtrail bobbin transport system combines many advantages: planning security, the optimal use of resources, a strict process sequence and guaranteed yarn quality. The permanent availability of full roving bobbins on the ring spinning machine makes a decisive contribution to increasing machine efficiency and productivity.

Anne Eckerle
Project Engineer
Machines & Systems
anne.eckerle@rieter.com

Lenzing launches TENCEL™ Luxe

- The new lyocell filament heralds a new era of sustainable cellulose fabrics for the premium luxury market
- Basic engineering for bigger scale industrial line started

At an exclusive event in Paris, the Lenzing Group launched a new product: TENCEL™ Luxe. The TENCEL™ Luxe branded lyocell filament is another key milestone in the implementation of the company's sCore TEN strategy and the first time that Lenzing enters the filament market. It will further support Lenzing's shift to become a true speciality player in the botanic materials market derived from sustainable wood sources.

TENCEL™ Luxe: The new player of eco-couture fabrics

TENCEL™ Luxe branded filaments are the new player for sustainable high-end cellulose textiles by offering superior aesthetics, performance and comfort level that allow them to be the perfect partner with other noble fibers such as silk, cashmere or wool. The smooth surface of the TENCEL™ branded Luxe filament gives fabrics a silky smooth feel and liquid-like drape for the most sensual silhouettes. Moreover, TENCEL™ Luxe branded filaments are naturally breathable due to their wood-based origin and offer outstanding color fastness, enabling designers to express bold color palettes where creativity knows no boundaries.

TENCEL™ Luxe: a new era in sustainable manufacturing

TENCEL™ Luxe eco-botanic lyocell filaments are made from wood pulp, which is sourced from sustainable wood in line with Lenzing's strict Wood and Pulp Policy. They are produced using Lenzing's pioneering closed-loop lyocell production process, which has received the "European Award for the Environment" from the European Union. This process ensures minimal environmental impact due to low process water and energy use and raw materials consumption.

"We are committed to setting industry standards in order to enhance the protection of our environment while making filaments for fabrics that are designed to appeal to the most sophisticatedconsumers. The launch of TENCEL™ Luxe is a further sign of our ongoing commitment towards innovation and sustainability", explains Stefan Doboczky, Chief Executive Officer of the Lenzing Group. "The expansion plan represents the next consistent step in the implementation of our sCore TEN strategy and is a commitment of Lenzing as a hub for research & development and engineering."

TENCELTM Luxe is another proof of Lenzing's innovation strength. It will open new markets for the company and for its customers and partners and will allow the company to participate in the premium segment of the fabrics market. With the help of TENCELTM LuxeLenzing will support the luxury apparel industry to redraw the borders between responsibility and high-end luxury fashion, and is part of Lenzing's ongoing commitment towards sustainability-driven innovation.

TENCELTM Luxe will be produced at the Lenzing site in Austria. Lenzing plans to expand the capacity at this site over the coming years and has started the basic engineering for a large scale commercial line for filaments. To optimize a new plant design and start up, this Lenzing site was chosen as the future manufacturing hub for TENCELTM Luxe.

"The decision for the Lenzing site in Austria as a hub for TENCELTM Luxe helps to build up a strong knowledge base for this new technology at the headquarters of the company", says Heiko Arnold, Chief Technology Officer of the Lenzing Group. "Here we can fully leverage the proximity between operations, research & development, customer service and the engineering organization to accelerate the development of this technology for the production of TENCELTM Luxe on a bigger industrial scale."

The decision about a new plant for the production of TENCELTM Luxe on a bigger industrial scale will be made in the third quarter of 2018.

For more information, please contact:

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E-mail: w.kaserer@lenzing.com

The Lenzing Group

The Lenzing Group is a world market leader headquartered in Austria, which operates production sites in all major markets as well as a worldwide network of sales and marketing offices. Lenzing supplies the global textile and nonwovens industry with high-quality, botanic cellulose fibers. Its portfolio ranges from dissolving wood pulp to standard and specialty cellulose fibers. Lenzing's quality and innovative strength

set global standards for cellulose fibers. With 79 years of experience in fiber production, the Lenzing Group is the only company in the world which is able to produce significant volumes of all three cellulose fiber generations - from the classic Lenzing Viscose® branded fibers to the Lenzing Modal® branded fibers and the TENCEL® branded lyocell fibers. In 2016 Lenzing introduced the RefibraTM branded lyocell fibers, a product innovation based on recycled cotton scraps. The Lenzing Group's success is based on consistent customer orientation combined with innovation, technology and quality leadership. Lenzing is committed to the principles of sustainable management with very high environmental standards and can underscore this commitment with numerous international sustainability certifications for its business processes as the most sustainable company in the sector. In addition to fibers, which form the core business, the Lenzing Group is also active to a lesser extent in the fields of engineering and plant construction.

ITMA 2019 Garment Sector Zooms in on Automation

ITMA 2019 Garment Sector Zooms in on Automation to Help Manufacturers Accelerate Productivity and Efficiency

The world's largest textile and garment technology exhibition, ITMA 2019, is spotlighting smart garment technologies as robots and artificial intelligence are set to revolutionalise the industry.

Automation, especially in an integrated textile and garment manufacturing chain, will help address the fashion and clothing industry's current concerns of short production cycles and sustainable business practices, according to CEMATEX, the European Committee of Textile Machinery Manufacturers.

Mr. Fritz P. Mayer, President of CEMATEX, which owns the ITMA exhibition, said: "The garment making industry is labour intensive and associated with low productivity. Things are set to change. Recently, there has been much publicity about 'sewbots', considered as a major breakthrough in garment automation. Manufacturers fast enough to ride the digital wave will find new opportunities and gain an edge over their competitors."

Mr. Vu DucGiang, Chairman of the Vietnam Textile and Apparel Association (VITAS), concurred: "The garment industry is very competitive and production cycles are now even shorter. Therefore, we need to think out of the box and leverage on new technologies to help us to be more productive and efficient. Many innovative solutions are being introduced, from processes to materials."

Mr. A.E. Roberts, Managing Director of ITMA Services, organiser of ITMA 2019, elaborated: "The digitisation of the fashion industry means that their suppliers will need to seamlessly integrate their design, material supply and production of the finished products. With integrated solutions, garment manufacturers will be able to respond well to fast and flexible production turnarounds, and cut costs by increasing productivity and reducing wastes."

With greater automation on the cards, industry players are seeing the resurgence of garment manufacturing activities in Europe and other developed economies.

Mr. Paulo Vaz, General Director of the Textile and Apparel Association of Portugal (ATP) is upbeat about prospects for Portuguese manufacturers. He said, "We are glad that there is a resurgence of textile and garment making in Europe as this benefits the Portuguese textile and apparel industry. Our manufacturers can be

more competitive by improving competencies through branding, innovation and R&D.

"By incorporating technological and creative innovation to differentiate our products, we can expand our markets. As such, it is critical for us to continually evaluate and invest in new technologies. ITMA 2019, which will be held in neighbouring Spain, will be an excellent platform for our manufacturers to explore integrated solutions, ranging from textile and garment technologies to fibres, yarns and fabrics."

Innovative garment technology showcase

To help garment manufacturers exploit technologies that optimise the manufacturing process for productivity gains, ITMA 2019 is expected to feature a wide array of innovative solutions. They range from garment making machinery to other textile processing machinery, auxiliary machinery and accessories, such as:

- Software and systems for product planning, design and related automation technology for garment making
- Equipment for product development
- Machinery for shrinking, fusing, cutting preparation, cutting and related automation technology
- Machinery for sewing, quilting and linking
- Sewing supplies and consumables
- Machinery and equipment for product finishing
- Auxiliary machinery for the garment making industry

"An exhibition such as ITMA 2019, where we can explore all the solutions, from textile to garment making, and even materials, in one location is ideal for our members. We will be organising a delegation of top garment manufacturers to study the latest trends and source new technologies that we can implement in our factories," said Mr.Giang of VITAS.

Besides a big display of technologies, fibres, yarns and fabrics, ITMA 2019 will be complemented by conferences and meetings that will add value to the visits of garment technology buyers, as well as brands and retailers.

ITMA Services' Mr. Roberts explained: "The global textile and apparel supply chain is expected to see more integration and collaboration, both vertically and horizontally. There is a lot of ongoing dialogues among stakeholders in the fashion, textile and garment industry. ITMA can be a useful focal point for discussions on the entire manufacturing value chain so that concerns can be addressed in an integrated and meaningful way."

ITMA 2019 will be held from 20 to 26 June at Fira de Barcelona, Gran Via venue. Application for exhibition space has been brisk since booking started in May. Close to 50 per cent of the space has been booked. The exhibition will showcase an integrated textile and garment manufacturing value chain. In addition to machinery, exhibits will also include yarns, fibres and fabrics, and solutions for technical textiles and nonwovens, and garment making.

The last ITMA exhibition, held in Milan in 2015, drew the participation of 1691 exhibitors from 46 countries.

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For more information on ITMA 2019, visit: www.itma.com.

Rieter celebrated Award Week 2017

RIETER AWARD 2017 AWARDED FOUR TIMES

From 28 August to 2 September 2017, Rieter Award Week 2017 was held at the Rieter Headquarters in Winterthur (Switzerland). For around three decades, the Rieter Award has been a firm component of the company's program to encourage its trainees - and is an institution in the textile industry. This year, there were four new prize winners. The Rieter Award Winners' Club now has 177 members.

L to R: Salman Ahmad (Pakistan), Mengru Li (China), and Matthew James Coats (US).

L to R:Salman Ahmad, Mengru Li, and Matthew James Coats

The Rieter judges were totally convinced by the in-depth scientific work of this year's award winners on the subjects of yarn and surface technology, textile materials, and digitization. The four prize winners from China, Pakistan, Turkey, and the US are:

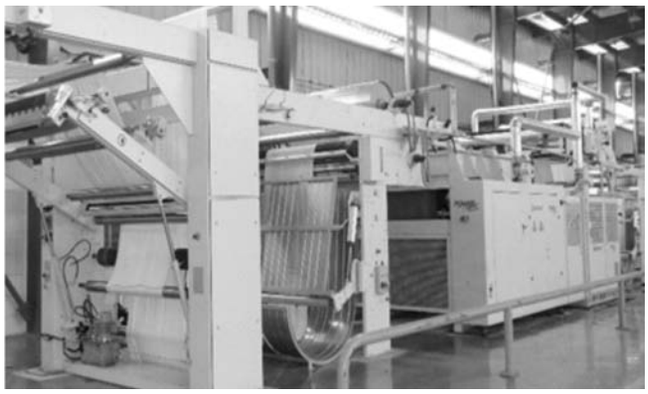
- Mengru Li, Wuhan Textile University, China
- Salman Ahmad, National Textile University, Pakistan
- DogukanVanlioglu, DokuzEylul University, Turkey
- Matthew James Coats, North Carolina State University,

Rieter congratulates the winners and is pleased with the talented textile trainees. The award included an invitation to visit Rieter Headquarters, which this year's Turkish prize winner, DogukanVanlioglu, was unable to accept. For a week, the three visiting prize winners not only got to know Rieter better, but also gained interesting insights into Switzerland. All the winners received their respective awards at a ceremony held at the university in their home country.

THE RIETER AWARD PROMOTES YOUNG TALENT

The Rieter Award has been given to students and young trainees every year since 1989. With the prize, Rieter promotes young talents and thus also supports universities and institutes in their efforts to win outstanding new recruits for textile training. The Rieter Award winners are selected globally from students and young trainees in the textile technology industry who are distinguished by their sound work and great commitment.

Traditional Textile Company in India is very satisfied with BRÜCKNER sanforizing range



BRÜCKNER Sanfor-Line at Morarjee Textiles

Morajee Textiles Ltd. has been established as early as 1871 under the name of Morarjee Goculdas Spinning and Weaving Co. Ltd. and is one of the first five companies listed on the Indian stock exchange. After an unparalleled growth and extension Morarjee Textiles is now part of the Ashok Piramal Group, a diversified and leading business group in India. With more than 100 years of experience and modern integrated manufacturing facilities for 100% cotton premium yarn dyed shirting and printed fashion fabric.

Morarjee Textiles makes cutting edge fashion a reality and is today one of the biggest players in the Indian textile industry.Morarjee Textiles counts all the premium international and domestic brands as its customers and supplies its products across the globe.

L to R: Jaiwanta Nalode (Morarjee), Andrea Corgnati (Brückner), Shailesh Tambuskar (Morarjee), Sudhir Jangale (Morarjee)

In 2015 the company bought a BRÜCKNER sanforizing range. The main components of the line are the rubberbelt compressive shrinking unit, a felt calender and the cooling cylinders. The company's Managing Director, Mr. Rajendar Kumar Rewari, confirms that this BRÜCKNER machine has been the right choice for their very light and thus particularly sensitive fabric made of 100% cotton, viscose or crepes for woman dresses and men's shirting fabric. The compressive shrinking line provides the fabric with a more stable structure, a silk-like shining surface and a smoother hand. In addition it reduces the residual shrinkage up to 3%.

The machine is easy to handle. The control of tension and the software allow to treat very light fabrics without any marks. The production speed is between 60 and 70m/min. The production team is very satisfied and they recommend this machine especially for difficult and sensitive articles.

INDIA

5th Edition China Machinex India 2017 and China Homelife India 2017 Exhibition

Date : 05th to 07th December, 2017
Venue : Bombay Exhibition Centre, Goregaon. Mumbai. India
Contact : Devisha Prajapati, Relationship Manager,
MCO-Winmark Exhibitions Private Limited
B-702, Dheeraj Heritage Residency - 1
Shastri Nagar, Linking Road Extn.,
Santacruz (W) Mumbai - 400 054 India
Tel. : +91-022- 26605550,M.: +91 9869150231
E-mail : devisha.winmark@gmail.com
Website : http://www.chinahomelife.in,
http://www.chinamachinex.in/

ITMACH INDIA - International Textile Machinery & Accessories Exhibition

Date : 07th to 10th December, 2017
Venue : Helipad Exhibition Center, Gandhinagar,
Ahmedabad, Gujarat (India)
Contact : ArvindSemlani -
M.: +91-9833977743
E-mail : info@ITMACH.com
Radhika Boddu -
M. : +91-9867127598
E-mail : info@itsexhibition.com
BhaveshThakar -
M. : +91-9375322449
E-mail : allgujaratspinnersassociation@gmail.co
Website:www.ITMACH.com

Global Innovators and Researchers Conclave

Date : January, 2018
Venue : DeenbandhuChhotu Ram University of Science and Technology, Murthal, Sonepat (Haryana).
Contact : The Textile Association (India) - Central Office
2, Dwarkanath Mansion, Near Nirmal Nursing Home,
91, Ranade Road Extension, Shivaji Park,
Dadar (W), Mumbai - 400 028 India
Tel. : +91-22-2446 1145, Fax: +91-22-2447 4971
E-mail : taicnt@gmail.com,
Mr. Arvind Sinha, President- TAI
M. : +91-9820162612
E-mail : lionasinha@gmail.com
Website : www.textileassociationindia.org

International Textile Conference on Textile 4.0 - "Global and Indian Perspective"

Date : 22nd & 23rd March, 2018
Venue : Hotel The Lalit Mumbai, Mumbai, India
Contact : Textile Association (India), Mumbai Unit
Amar Villa, Behind Villa Diana, Flat No. 3, 3rd Floor,
86, College Lane, Off Gokhale Road,
Near Portuguese Church / Maher Hall,
Dadar (W),
Mumbai - 400 028 India
Tel : 022- 2432 8044 / 2430 7702, Fax: 91-22-2430 7708
E-mail : taimumbaiunit@gmail.com
Website : www.textileassociationindia.com

14th International & 73rd All India Textile Conference

Date : 02nd & 03rd February, 2018
Venue : Kavivarya Suresh Bhat Auditorium, Nagpur,
Contact : Dr. HemantSonare, Hon. Secretary - TAI -Vidarbha Unit & Conference Chairman
The Textile Association (India) - Vidarbha unit
26, Raghukul, Pragati Colony, Near Pragati Hall,
ChhatrapatiSqure, Wardha Road,
Nagpur - 440 015 India
Mobile : 9860930380 / 8788676202
E-mail : hemantsoanre10@gmail.com
Website : www.textileassociationindia.org

2nd Global Textile Technology & Engineering Show (GTTES)

Date : 01st to 03rd February, 2019
Venue : Hall No. 7A, Bombay Exhibition Centre,
Goregaon (E), Mumbai. India
Contact : MsSeema Srivastava, Executive Director
India ITME Society
Tel. : 91-22-22020032/22828138/22851579
Fax : 91-22-22851578
E-mail : itme@india-itme.com / admin@india-itme.com;
Website : www.india-itme.com

ABROAD

ITMA 2019 - Largest International Textile and Garment Technology Exhibition

Date : 20th to 26th June, 2019
Venue : FIRA CE Barcelona Gran Via, Barcelona, Spain
Contact : Daphne Poon
Marketing Communications Director
ITMA Services Pte Ltd.
73 Ubi Road 1, #08-48 Oxley BizHub,
Singapore 408733
Tel. : (65) 6849 9362 M: (65) 94789543
E-mail : daphnepoon@itma.com
Website : www.itma.com

Hometex Tech Expo

Date : 16th to 18th March, 2018
Venue : AnajMandi Exhibition Complex,
G. T. Road, Panipat
Contact : Ms.Monica Patel
Manager- Corporate Communication
Essential Events & Trade fairs
Essential Strategic Alliance Company
Mobile : 09082044056
E-mail : mktg.essential@gmail.com,
Website : www.essentialtradefairs.com

Every effort is made to ensure that the information given is correct. You are however, advised to re-check the dates with the organizers, for any change in schedule, venue etc., before finalizing your travel plans.

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