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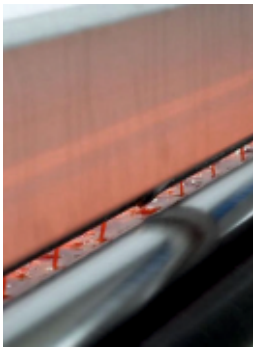
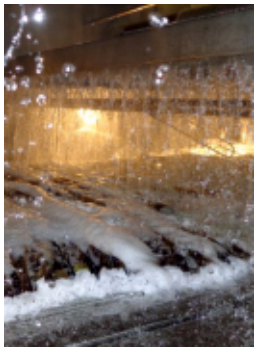


COLD PAD-BATCH DYEING



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BUSINESS NEWS

Colorant Ltd receives prestigious award

Colorant, an ISO 9001:2000 and ISO 14001:2004 company, is one of India's leading names in the branded dyes' segment. Colorant manufactures and markets the most comprehensive portfolio of high-quality, reactive dyes for the cellulosic substrate under the brand name COLRON. This includes speciality ranges like COLRON CN series and COLRON SD series for niche, high-end markets. They also custom-make dyes, including those that meet stringent parameters of international clothing labels. Then, there is a line of optical brightening agents (OBAs), christened CEEPOL, for the textile industry in India and abroad. All of their products are ecofriendly and AZO-free.

COLORANT is one of the leading manufacturers and exporters of Colron reactive dyes. It is the first Indian dyestuff company to be certified for prestigious ZDHC (Level 3) certification. The company is a government recognized 'export house' since 2007. Its a matter of great pride that Colorant Limited has received the prestigious 'Anil Mehta award' by the Dyestuffs Manufacturers Association of India for best dyestuff manufacturing unit. The function was held on 12 November 2021 at Hotel Sea Princess, Mumbai. The award was received by Mr Subhash Bhargava (Managing Director) through the hands of Padam Bhushan Rajjubhai Shroff (Chairman, UPL group) and Mr Yogendra Tripathi (Secretary, Department of Chemicals & Petrochemicals, Government of India).

Colorant Limited also received first award for their performance in domestic market for the year 2019-20 & 2020-21.

DyStar exhibits at China Interdye 2021

DyStar, a leading speciality chemical company with a heritage of more than a century in product development and innovation exhibited at the 21st China Interdye 2021 from 17 to 19 November 2021 at the National Exhibition and Convention Center (Shanghai).

China Interdye is the largest global exhibition for the dyechem industry. The trade event consists of technical seminars, conferences and events organised by exhibitors and relevant industry associations respectively.

DyStar's managers at its booth discussed various sustainable solutions which it offers to the textile supply chain. Its also showcased its latest product innovations for visitors from brands and retailers, manufacturers and production houses to enhance their manufacturing process and improve end-product quality, in addition to a full collection of 11 Cadira modules, Evo Soft range, Dianix XF2 range, Jettex Ink ranges, Remazol SAM series, WOPAPAN items, and Color Library from Color Solutions International (CSI).

As the supply chain continues to be challenged by the global pandemic, manufacturers and producers around the world are constantly looking for essential sustainable solutions to help them on their journey of production. DyStar is determined to support the global chemical industry and its customers with invaluable insights and experience from its legacy of innovations.

Cutting costs by 70% with VSD upgrade

A new control system featuring an ABB variable speed drive (VSD) is

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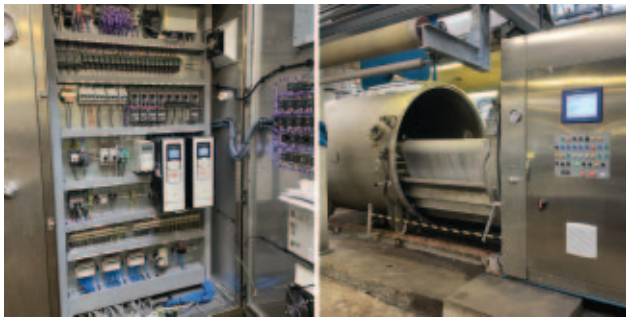
Benninger Laboratory Single End Cord Line put into operation

After 18 months of joint development, the new Benninger Laboratory Single End Cord Line is successfully in operation at Intercord Thueringen. The line runs at a speed of up to 30 m/min and is used for the development and small series production of technical yarns of the highest quality.

The latest generation of the Benninger Laboratory Line is based on the concept of a modular system that can be extended as required. This system offers almost endless possibilities for the development of innovative technical yarns and technologies. The laboratory machine was developed and implemented together with the company Intercord and takes into account special customer requirements. Yarns are impregnated, coated, dried and heat-set on the new versatile system. The masterpiece from Benninger offers excellent convertibility from laboratory to production scale. In addition, the Laboratory machine offers the possibility to conveniently test new processes, recipes and processes.

Intercord Thueringen is a German manufacturer of high-quality technical yarns for special applications. Intercord yarns are used, among other things, as reinforcing material in drive belts, hoses, tires and air suspension systems. Benninger is a Swiss textile machinery manufacturer and specialist in tire cord system solutions. The two companies have maintained a trusting professional business relationship for more than 20 years.



The 5.5 kW ABB industrial drive ensures a uniform dyeing or bleaching process by maintaining a constant tension in the wound fabric as the diameter of the reel changes.

efficiently managing the tension control and changing the size of the fabric reel as it traverses through dyeing processes for DP Dyers, based in Huddersfield, UK. The VSD's in-built PID (proportional-integral-derivative) loop allows the system to automatically match torque to the requirements of the running fabric based on the thickness and number of wraps.

The DP Dyers machine - known as a jigger - comprises a winder that feeds the fabric into the dye and a rewinder that gathers the finished product. The winder and rewinder were previously both controlled by an ageing hydraulic system, the motors of which suffered regular breakdowns. The hydraulics lacked the speed and accuracy of control needed by the winder/rewinder, resulting in uneven dye distribution.

The VSD uses its in-built PID loop to calculate the torque needed to manage the tension of the fabric running between the winder and rewinder. Meanwhile, the VSD determines the required speed of winding based on the material thickness and the number of turns of fabric, or wraps, on the lead roller. The system drives the fabric onto a roller and counts the number of wraps. The operator measures from the outside wrap to the core and inputs this to the VSD, which then calculates the fabric thickness based on the outside diameter divided by the number of wraps.

'We are getting a much more consistent product with more even dyeing due to the VSD, which constantly adjusts the web speed and torque to maintain the correct tension,' said Robert Clay, site engineer at DP Dyers. 'The control system is now much more user friendly, with the software giving the alarm history of jobs. Now we have much more data, showing a history of temperatures and times of operation.'

Prior to installing the VSD, the machine's weekly energy consumption was typically 597 kWhr costing around £50. Following installation, this reduced to 169 kWhr and £14 respectively - a reduction of around 70%.

By connecting software to its electrification, robotics, automation and motion portfolio, ABB is pushing the boundaries of technology to drive performance to new levels. With a history of excellence stretching back more than 130 years, ABB's success

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Archroma underpins presence in Switzerland

Archroma, a global leader in speciality chemicals towards sustainable solutions, recently announced the relocation of its headquarters to Pratteln, just outside Basel, and a customised R&D role for its existing Reinach site.

Archroma's new Haus der Wirtschaft (HWD) headquarters is located in a business hub that hosts the Economic Chamber Baselland with other companies, as well as a fully serviced conference and event centre. The new offices have been designed to support a smooth and efficient collaborative work and visitor experience.

Christoph Buser, Director of the Economic Chamber Baselland (Wirtschaftskammer Baselland), Heike van de Kerkhof, Chief Executive Officer of Archroma, and Silke Wischeropp, General Counsel of Archroma, at the ribbon cutting ceremony of the new Archroma HQ in Pratteln. (Photo: Archroma)

The move comes after a decade of growth at Archroma's TechCenter building in Reinach, also near Basel, which evolved from being a dedicated technical centre to hosting a growing number of corporate services and teams. With the opening of the new HWD headquarters, the Reinach TechCenter, designed to accommodate laboratories and technical expert teams, will return to its roots with focus on the global R&D and application development, supporting those of the Archroma Competence Centers (CC) which are located in Switzerland: CC Textile Finishing; CC Textile Repellents; CC Paper Coloration; and CC Paper Whiteness.

'With our new HWD corporate headquarters, we are joining a dynamic business hub,' comments Heike van de Kerkhof, CEO at Archroma. 'We are excited to refocus our Reinach site as a true 'tech hub' to provide innovative, sustainable solutions and services to our customers to help them increase the value of their products. Our science and technology expertise, coupled with in depth market, customer and regulatory understanding, provide the platforms for the creation of safer, more sustainable chemicals and practices in the industries we serve. With this latest development we are strongly reaffirming our deep commitment to our Swiss roots and presence.'

Archroma moves its headquarters to the new Haus der Wirtschaft building in Pratteln. (Photo: Archroma)

is driven by 105,000 employees in over 100 countries.

Changes and opportunities through automation

For most textiles, finishing processes are not actually the last stage. Products often need an extra touch of expertise to make them perfectly ready for the customer. At this point in the value chain, that usually means manual tasks - but now there are technical solutions and intelligent systems which can handle complex operations better, while adding extra value and assured quality.

Automation brings reliability and efficiency, ultimately saving costs to produce the right quality every time. Swiss companies are already specialized in many of these disciplines, with machinery for fabric inspection and presentation, labelling and tracking, folding and packaging. They have the technology to inspire a new vision at the post-production segment of the textile manufacturing processes. Optimization of workflows, with bottleneck management, is an obvious potential benefit. And it delivers measurable returns on investment. The wider picture with automation will prepare companies for the IoT and Industry 4.0.

Digital work flow and process control

The Swiss company Maag Brothers is a leading supplier of high-end machines for quality assurance in the final make-up processes, specifically fabric inspection, plating/folding, selvedge printing and packaging. Maag reports on a practical example from a mill in India which recognized the potential of automation.

An analysis at the customer's mill identified the main goals as modernization of the workflow at quality control and packing processes. Maag's new system covers tasks from fabric inspection to dispatch, and offers transparent and easily adjustable processes with real-time process control. Its a digital solution, resulting ina slim organization,

Folding / Plating (© 2021, Maag Brothers)

paperless and the basis for further optimization towards Industry 4.0 to exploit its full potential. The customer's own calculation showed a ROI for the installation at less than three years - along with a reduction in manpower and savings in fabric costs for shade samples.

Perfectly labelled, efficient data

Smooth processes start with a label. Swiss company Norsel is an expert in grey fabric labelling systems, for piece tracking through all textile processes. High-quality label printing and proper sealing on all kind of fabrics ensure readability and sustainability after dyehouse processes such as mercerizing, high temperature dyeing and even hot calendering. No roll mix-up during dyeing, easy sorting of fabric rolls and rapid delivery make processes in the mill much more efficient. Using RFID codes lifts fabric inventory control to the highest level, with all information readily transferred to a database and integrated through any ERP software.

Its a foolproof way to avoid the risk of human errors from handwritten notes on grey fabrics and article sheets, by opting for reliable, secure and forward-looking solutions.

New business models

The advantages of automation in mills with high-volume production are obvious: consistent quality, increased efficiency, waste reduction in some cases, as well as significant medium-term cost reductions in every case.

That description focuses on the aims of modern mills in low-cost markets. But producers in Europe and US could reach out for more. For them, automation could be a game-changer, offering unique new opportunities.

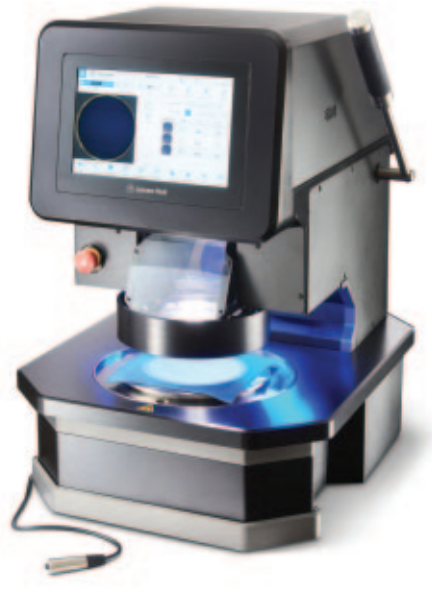
Reshoring is a growing trend now. It shows great potential and is definitely driven by sustainability and changes in consumer mindsets. Innovation transformed through automation can do much more than simply replacing the nimble fingers of humans. It also enables new business models, guaranteeing prosperous future business, alongside greater job security. Swiss Textile Machinery members are ready to take customers towards this promising future.

James Heal innovates in water resistance testing

Manufacturer of precision textile

testing instruments, James Heal, has developed an alternative solution to testing water resistance in fabrics with its new 'HydroView' hydrostatic head tester, for testing materials which have an end use that requires water resistance, to measure the penetration of water. This includes materials produced for a range of applications across the medical, apparel, geotextiles and nonwovens sectors - from protective gloves, diving dry suits, winter sports apparel, to fishing waders, roofing, tenting and ground sheets and more.

In the hydrostatic head test, the product application will define the target hydrostatic pressure; the lower a hydrostatic pressure measurement, the more easily water can penetrate under pressure. 'As more and more



brands are investing in new materials and making performance claims on water resistant/waterproofing, the hydrostatic head test is one of the most common ways to test', explains James Heal's Technical Specialist, Sara Williams.

The testing instrument manufacturer explains that their new HydroView machine is a natural addition to their growing performance testing range, a suite of instruments designed specifically for testing technical and performance fabrics. It was developed following extensive user research around hydrostatic head testing, where James Heal's product innovation team discovered that users were looking for an instrument that is more flexible and user friendly than what was currently available on the market. Powered by the belief that hydrostatic head testing should not be difficult, James Heal developed HydroView to provide users with an easier to use instrument, with integrated TestWise software, a proprietary system developed in-house.

'We felt we could add value to this type of testing by introducing our popular TestWise software to HydroView,' said Neil Pryke, Innovation Director. 'Our TestWise software used in this instrument is intuitive, has clear navigation, and requires minimal user training. An integrated camera captures an image when the user detects a drop, this supports live and post-test analysis and is further enhanced by the zoom and mark features,' added Neil.

James Heal claims to have also simplified water management with HydroView. 'An integrated pump automates the filling and emptying of the instrument for testing, and enables fine adjustment of water levels. The machine includes a wastewater drawer, removing the need for any additional plumbing which saves time and cost when conducting tests,' explained Neil.

ACHEMA 2022 to be moved from April to August 2022

ACHEMA 2022 - the World Forum for the Process Industries - will be held at the Frankfurt Fairground from 22 to 26 August 2022, instead of 4 to 8 April 2022 as originally planned. This decision was made in view of the increasing uncertainty caused by the new corona variant after

intensive discussions with the community and in the ACHEMA Committee.

The organisers see the postponement by four months to late summer 2022 as an opportunity to ensure an international ACHEMA. 'After many months of digital meetings, we want to fulfil the desire of exhibitors and visitors for a physical ACHEMA with participants from all over the world,' explains Dr Björn Mathes, member of the Board of DECHEMA Ausstellungs GmbH. This requires a comprehensive lively exhibition and the opportunity for personal contact.

After intensive discussion with partners and within the ACHEMA Committee, representing the exhibitors, the decision was made in favour of ACHEMA as a presence exhibition from 22 to 26 August 2022. With this early decision, DECHEMA also wants to give exhibitors planning security: After all, for them a major event like ACHEMA means a long-term preparation and investment effort.

With the focus topics 'Modular and Connected Production', 'The Digital Lab' and 'Product and Process Security', ACHEMA 2022 will address the issues that are preying on the mind of the process industry. In addition, the megatopics of digitalisation and climate neutrality are moving even more into the focus of ACHEMA with the 'Digital Hub' and the 'Green Innovation Zone'.

TMAS showcases sustainable finishing technologies

The members of TMAS - the Swedish Textile Machinery Association

- are proving instrumental in pioneering new sustainable processes for the dyeing, finishing and decoration of textiles.

The wasteful processes involved in these manufacturing stages are only one component in the development of viable circular supply chains for textiles that are now being aggressively established in Sweden.

At the recent Conference on Sustainable Finishing of Textiles, the delegates heard that Sweden will introduce extended producer responsibility (EPR) for waste textiles and clothing at the beginning of 2022, ahead of the adoption of a similar EU-wide EPR system in 2025. In Sweden, this is already leading to the establishment of advanced digital sorting and recycling infrastructure and from a brand perspective, H&M now leads the field in both addressing circularity from its suppliers and minimizing its own waste.

The TexCoat G4 wastes no chemistry during colour, fabric or chemistry changeovers, and only the required chemistry volume is applied to the fabric.

Swedish companies are also active in the development of new fibres derived from waste clothing, building on the country's legacy leadership in pulp and paper production.

At the Sustainable Finishing of Textiles Conference, however, it was said that all of the environmental gains made by such sustainable new fibres can potentially be cancelled out in the further processing they are subjected to - and especially in resource-intensive conventional dyeing, finishing and decoration. TMAS members Baldwin Technology and Coloreel have both developed solutions to address this issue.

During the conference, Baldwin's VP of Global Business Development Rick Stanford explained that his company's TexCoat G4 non-contact spray technology significantly reduces water, chemistry and energy consumption in the finishing process. It consistently and uniformly sprays chemistry across a fabric surface and applies it only where needed, on one or both sides.

The TexCoat G4 also wastes no chemistry during colour, fabric or chemistry changeovers, and because only the required chemistry volume is applied to the fabric, wet pickup levels can be reduced by upto 50%, leading to 50% less water and energy consumption compared to conventional finishing processes. Furthermore, several customers are combining TexCoat Spray and back-coating in series prior to the stenter. This simplifies the production process from two steps to one, delivering both drying savings and productivity increases.

Coloreel's CEO Mattias Nordin outlined the benefits of his company's technology which enables the high-quality and instant colouring of a textile thread on-demand and can be paired with any existing embroidery machine without modification. This enables unique effects like shades and gradient to be achieved in an embroidery for the first time.

Coloreel's technology enables the high-quality and instant colouring of a textile thread on-demand

Based on a CMYK ink system, Coloreel's advanced rapid colouring software and high-speed drive technology allow a single needle to carry out what previously required multiples of them to do - and with much more consistent stitch quality. In addition, existing thread dyeing plants can add a single solid colour to a thread, but by instantly colouring a white base thread during production, Coloreel enables complete freedom to create unique embroideries without any limitations in the use of colours. Colour changes along the thread can either be made rapidly from one solid colour to another, or gradually, to make smooth transitions or any colouring effect desired.

This provides big benefits when it comes to sustainability. There is a significant reduction in wasted inks, while water usage is minimized, and production speeds are increased. The technology allows setup and lead times to be reduced as well as significant flexibility in production quantities, while eliminating the need for large thread inventories.

'Its great to see TMAS members playing a pioneering part in what is now shaping up to be a vital rethinking of the textile supply chain in Scandinavia,' added TMAS Secretary General, Therese Premler-Andersson. 'All of these ideas are now gaining momentum and likely to be adopted

Archroma awarded EcoVadis Platinum medal

Archroma, a global leader in speciality chemicals towards sustainable solutions, recently announced that it has been awarded the EcoVadis 'Platinum' rating in corporate social responsibility (CSR), placing the company within the top 1% of the best rated companies in its industry.

Archroma was evaluated by EcoVadis, an organization specialized in assessing the CSR performance of companies on a global basis. The assessment focuses on 21 criteria which are grouped into 4 themes: Environment, Labour & Human Rights, Ethics, and Sustainable Procurement. EcoVadis assesses more than 75,000 companies in more than 160 countries and 200 industries.

Participating in the assessment for the fourth consecutive year, Archroma had set itself the target to reach the EcoVadis 'Platinum' rating.

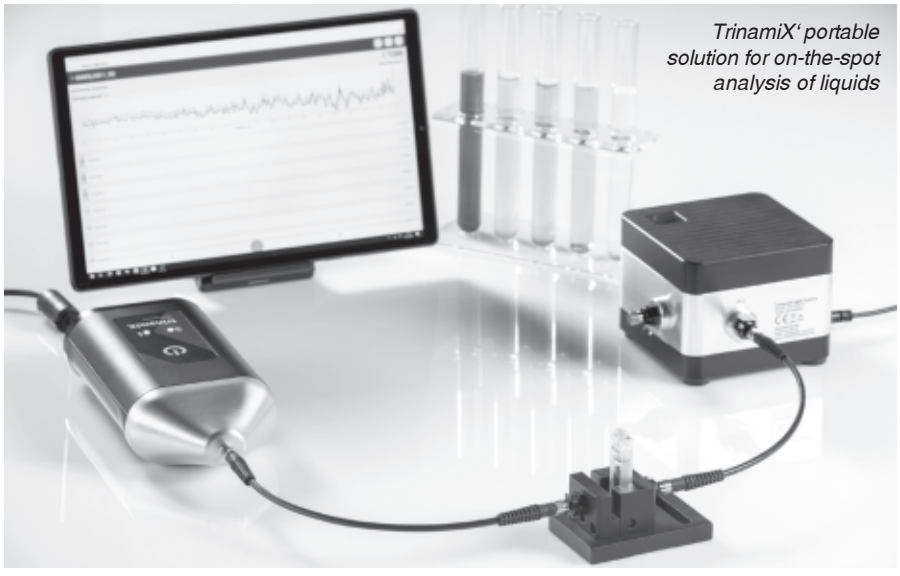
Archroma has built a strong reputation as a global leader in developing innovations and systems that help minimize resources, increase productivity and create value for its customers. The company refers to this commitment as 'The Archroma Way to a Sustainable World: Safe, efficient, enhanced, it's our nature'.

'Sustainability is a process', comments Heike van de Kerkhof, CEO at Archroma. 'We started our journey with the EcoVadis assessments only four years ago. Our progress all the way to the Platinum rating is testament to our continuous efforts and hard work to improve our societal, environmental and economic performance, and that of our customers.'

throughout the world. A more circular and sustainable industry will be the result, to the benefit of everyone.'

TrinamiX expands NIR spectroscopy portfolio

TrinamiX GmbH, a wholly owned subsidiary of BASF SE, is presenting the latest addition to their pioneering portfolio: a portable solution to grant institutions and companies immediate insights into the molecular composition of liquids. trinamiX has once more successfully transformed the established method of near-infrared (NIR) spectroscopy into an accessible, affordable, and easy-to-use solution for broad usage beyond common lab applications. By opening up the world of what is naturally hidden from the eyes, the solution enables customers across various markets to make informed decisions - right on the spot, anywhere they are.



TrinamiX' portable solution for on-the-spot analysis of liquids

For the past few years, trinamiX has been significantly miniaturizing NIR spectroscopy, thus bringing lab power to customers across various industries all around the world. Equipped with trinamiX Mobile NIR Spectroscopy Solution, they are empowered to perform detailed on-the-spot analyses of diverse solids. More recently, the company has successfully built upon their expertise and developed an additional transmission solution to grant detailed insights into what a given organic liquid is made of.

'Having a lab analyze your samples is time-consuming. It takes upto several weeks until you get to know what you are dealing with,' says Nils Mohmeyer, Head of Business Development & Sales, Spectroscopy at trinamiX. 'Our customers will be equipped with a fast and convenient way to analyze a broad variety of liquids right on the spot, wherever they are. The waiting time is reduced to minutes.' Whether it is people in small inhouse laboratories, at universities or right at production facilities; none of them need any NIR expertise in order to perform and interpret measurements - by using three integrated components: a portable high-performance spectrometer, cloud-based analytics and an app to instantly show results on a Windows PC or smartphone. The whole lab can easily be set up right where it is needed, taking the complete NIR fingerprint of organic liquids with a wavelength range of 1450 to 2450 nm.

trinamiX is on their way towards transforming how NIR spectroscopy of liquids will be performed in the future. The first customer to benefit from these advantages is BASF's brand OASE, which offers highly specific solutions for gas treatment. With BASF as a strong development partner, trinamiX has successfully tailored their transmission solution to the

compositional analysis of OASE gas treatment solutions. The result, so-called OASE digilab, enables OASE customers to continuously monitor the condition of their gas treatment process in real time.

OASE set a first example of how customers substantially benefit from trinamiX NIR spectroscopy solution for liquids. And there will be more: to offer their solution to customers across various industries and markets, trinamiX is continuously enhancing their solution, also by joining forces with further development partners.

New dates for ISPO Munich and OutDoor by ISPO

Messe München has decided to hold the ISPO Munich sports gear show permanently at the start of the winter season at the end of November 2022, instead of its previous January 2022 date. OutDoor by ISPO will meanwhile move permanently from the end of June to the end of May/ beginning of June 2022.

For 2022, this means that ISPO Munich 2022 will now take place from November 28 to 30, 2022 and the new date for OutDoor by ISPO 2022 is June 12 to 14, 2022.

The permanent shift in dates is a strategic decision due to the far-reaching market changes of recent years, the organisation says. Industry and retail are facing major shifts in the global supply chain, which have also caused changes to order cycles. Scheduling ISPO Munich in January or February, as was previously the case, is therefore too late for many industry participants. The permanently brought-forward date for OutDoor by ISPO also works much better with the new order cycles.

'In the future, ISPO Munich will not only be the meeting place for the industry's top decision makers and the ideal platform for brands to place the most important messages for the market, but also the worldwide kick-off event for the winter season. This is where retailers get an overview of the season's new products and can then start the ordering season, where decisions of industry-wide significance are made and consumers are excited, inspired and activated at the same time.'

For optimal impact, the duration of both events will be shortened to three days and a maximum size for booths will be introduced. Currently, a maximum of 150 m^2 booth size is planned for OutDoor by ISPO and a maximum of 200 m^2 booth size per exhibiting brand for ISPO Munich.

Next year, OutDoor by ISPO, from June 12 to 14, 2022, will be held once at the MOC Veranstaltungs centre in Munich.

Cationic dyeing process saves resources

Dow and Ralph Lauren Corporation have released a detailed manual on how to dye cotton more sustainably and more effectively than ever before using the Ecofast Pure sustainable textile treatment. The two companies are open-sourcing this improved dyeing process to encourage adoption in the textile industry and help standardise a more sustainable and efficient cotton dyeing system for positive environmental impact.

Ecofast Pure is a cationic cotton treatment developed by Dow with existing dyeing equipment. Ralph Lauren, the first brand to use it, partnered to optimise and implement the technology in its cotton dyeing operations, as part of its new Color on Demand platform.

Pretreating fabric with Ecofast Pure helps significantly reduce the amount of water, chemicals and energy needed to colour cotton, by enabling upto 90% less process chemicals, 50% less water, 50% less dyes and 40% less energy without sacrificing colour or quality.

'As fashion supply chains look to recover from the impacts of the pandemic, there is a critical window to build more sustainable practices into production processes,' said Mary Draves, chief sustainability officer at Dow. 'By collaborating to scale a less resource-intensive dyeing process, we can help address pressing challenges like climate change and water resiliency in the longer term.'

'We have to create scalable

solutions that have never been considered before,' added Halide Alagöz, chief product and sustainability officer at Ralph Lauren. 'This requires deep and sometimes unexpected collaboration, and a willingness to break down the barriers of exclusivity. We are proud to have partnered with Dow on this innovation and to share it openly with our industry, with the hope that it will help transform how we preserve and use water in our global supply chains.'

Recycling wastewater for the textile industry

The Fraunhofer Institute for Biomedical Engineering IBMT, Sulzbach/Germany, with its expertise in nanotoxicity and nanosafety testing, contributes to a new EC project for water saving solutions for textile industry. This industry uses a vast amount of water for different steps in the textile dyeing process. It also produces a lot of wastewater, which contains a range of chemicals and dyes.

Breakthrough innovations are needed in energy intensive industries to recycle water and create closed loops in industrial processes. 20% of global industrial water pollution comes from textile manufacturing. To reduce the high amount of freshwater used in textile industry, the EC-funded Waste2Fresh project will develop a closed-loop process for textile manufacturing factories in which wastewater is collected, recycled and used again. Novel and innovative catalytic degradation approaches with highly selective separation and extraction techniques will be developed, based on nanotechnology. According to the European Commission, such 'closed loops' would significantly reduce the use of fresh water and improve water availability in the relevant EU water catchment areas, as outlined in the Water Framework Directive.

Waste2Fresh meets the above challenges and industry needs by developing and demonstrating (to TRL 7) a closed loop recycling system for wastewater from textile manufacturing factories, to counteract freshwater resource scarcities and water pollution challenges exacerbated by energy intensive industries which are major users of fresh water (for e.g., processing, washing, heating, cooling etc).

The Waste2Fresh technology is developed to reduce current use of freshwater resources and considerably increases the recovery of water, energy and other resources (organics, salts and heavy metals). The result is a 30% increase in resource and water efficiency. The system will ultimately lead to considerable environmental improvements and accordingly reduce the EC and global environmental footprint.

Breakthrough method for evaluating odour control capabilities

Microban International welcomes the recently approved AATCC test method - TM211-2021 - that has been developed to support the textiles industry. This novel and strategically important, standardized Drager method measures the reduction of odour on materials treated with antimicrobial technologies, and partners well with existing textile test methods such as the AATCC TM100, to show the correlation between bacterial reduction and odour control. Microban was one of the early adopters of this ground breaking method that can, for the first time, provide a truly quantitative evaluation of the valuable, real-world and functional benefits of antimicrobial chemistries by quantifying odour reduction.

Antimicrobial technologies in textiles provide a proactive solution for preventing 'permastink' - the enduring odours created by the metabolism of sweat by skin flora that often persist on clothes after cleaning. These odour control formulations work on the understanding that reducing the growth of microbial populations on textiles will subsequently reduce odours generated from bacterial activity. The AATCC TM 211-2021 test method is an innovative, objective method that can articulate the efficacy of odour control technologies and provide definitive scientific evidence for these claims. Additionally, this highly sensitive test gives real-time and visual depictions of ammonia levels - created by bacterial metabolic pathways - on a colorimetric scale, in under 48 hours. The biological system can be used across the textile industry for assessing the odour capture propensity of both antimicrobial-based technologies, and other odour-reducing techniques.

Erika Simmons, Technical Director at the AATCC, explained: 'RA31 has introduced a new odour method with the addition of TM211. This new method provides a quantifiable means for evaluating the reduction of odour generated from textiles treated with antibacterial finishes. This method offers a much-needed standard for addressing odour as a factor in antibacterial finish performance. AATCC is proud of this new method and the doors it opens to innovation down the road.'

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New dye from Lanxess increases safety

Speciality chemicals company LANXESS has developed a new colorant that can be used to permanently colour polyamides (PA) and other plastics with the RAL 2003 shade of orange. The soluble organic dye Macrolex Orange HT is highly heat-stable, light fast and weather resistant and offers outstanding colour strength and brilliance.

Unlike most conventional dyes, Macrolex Orange HT is perfect for not only PA but also other common plastic types such as polycarbonate (PC) or polyphenylene sulfide (PPS), which, due to their high processing temperatures, normally pose a challenge for colorants. The new halogen-free colorant offers consistently high quality and high-precision coloration, which is particularly important for orange shades. In addition, the new 'high-voltage orange' from LANXESS is cost-efficient, thanks to its high colour strength.

The specialty chemicals company LANXESS has developed Macrolex Orange HT, a dye that can be used to permanently colour plastics with the RAL 2003 shade of orange.

'We have already extensively tested our new products under realistic conditions. In cooperation with Lanxess's High Performance Materials business unit, we coloured compounds with Macrolex Orange HT at the plastics technical centre in Dormagen and tested them for their suitability in plastics processing,' says Dr Lars May, Head of Application Technology Plastics in the Polymer Additives business unit at Lanxess.

The dyes in LANXESS's Macrolex range allow a diverse range of potential applications and offer excellent compatibility with a large number of polymer types and manufacturing processes. They also meet numerous legal requirements for use in food packaging or children's toys. The range of colorants offered by the Polymer Additives business unit comprises around 150 products and, in addition to Macrolex-brand colorants, a range of pigments and pigment preparations for use in a wide range of demanding applications.

The Fraunhofer IBMT will be primarily responsible for performing nanotoxicity and nanosafety testing during the whole technology process, ensuring that the developed system and processes meet relevant safety regulations. The institute collaborates with all consortium partners developing and using to develop approaches for ensuring that the developed nano-material-based components meet relevant health and safety standards during their use. The results of the toxicity studies will be the basis for the development of relevant safety procedures for handling and using the developed recycling technology.

The project, which started in December 2020, will run until November 2023.

Developing a new generation of enzymes

The € 6 million EU 2020 FuturEnzyme project, co-ordinated by the Spanish National Research Council, is aiming to develop more sustainable textiles, detergents and cosmetics through the development of enzymes. Its objective is to replace or reduce the use of chemical agents with microbial enzymes that can be incorporated in the manufacture of commercially available products.

Textiles, detergents and cosmetics all have complex formulas that can damage the environment and generate very high CO_2 emissions, in addition to the consumption of large amounts of energy, water and the discharge of chemical products into the environment. One of the most promising ways to alleviate this problem is based on substituting the chemical agents used in industrial processes by enzymes.

'Current enzymes cannot cope with the formulation of higher environmental quality consumer products,' said Ferrer, CSIC researcher at Spain's Institute of Catalysis (ICP-CSIC). 'It is crucial to design smart technologies based on a new generation of enzymes with higher activity, stability and lower cost, which can meet the demands of both consumers and industry.'

Enzymes will be extracted from microorganisms by applying techniques that allow the rational selection of the most suitable enzymes at each moment and for each product. The technology will combine massive analysis of biological data using supercomputers, bioprospecting, protein engineering, biotechnology and pre-industrial testing to select the best enzymes from millions of enzymes, something that has not been possible to date.

The FuturEnzyme multidisciplinary consortium is composed of 16 European academic and industrial partners from Spain, Germany, Italy, Austria, Portugal, United Kingdom and Switzerland. The FuturEnzyme project began in June this year and will run until 2025.

Chemical protective clothing market to grow even faster

The chemical protective clothing market is set to grow faster than many other performance apparel segments,

according to a report from the global business information company Textiles Intelligence. During 2021-26, the market for chemical protective clothing is predicted to grow at a compound annual growth rate (CAGR) of 9.1%. This forecast is based partly on

expectations of rapid industrialisation in many parts of the world and partly on expectations of significant growth in the number of life-threatening incidents involving hazardous materials, including chemical, biological, radiation and nuclear (CBRN) emergencies, outbreaks of disease and industrial accidents.

Another major factor behind the forecasts of strong growth will be the continuing COVID-19 pandemic and increased pressure on employers to provide suitable personal protective equipment (PPE) to workers.

In fact, the pandemic has raised awareness of the importance of PPE, and such awareness will be a major driving force behind the market's future growth. A further factor behind the strong growth forecasts is the transportation of hazardous materials. There is also a growing threat of cyber attacks which could cause chemical leaks or explosions.

In order to maintain preparedness for incidents involving the accidental release of hazardous materials, whatever the cause, there has been a rising sense of urgency in developing protective clothing for emergency responders.

Among suppliers of chemical protective clothing, there are a number of companies with long-established reputations and commanding market positions. For example, the market for single-use chemical protective garments is dominated by 3M, DuPont and Kimberly-Clark while much of the market for reusable chemical protective garments is dominated by Ansell, Dräger and Respirex International (Respirex). Furthermore, the positions of these companies look set to remain strong as demand for chemical protective clothing is expected to remain favourable.

Looking to the future, product innovations will play a pivotal role in driving market growth - including those based on integrating smart technologies into chemical protective ensembles which will enable wearers to optimise their performances by quickly gauging their workplace hazards and their own physiological states.

First post-lockdown edition of Techtextil India garners impressive responsive

After three-days of hardcore product sourcing and business networking, Techtextil India 2021 in Mumbai concluded in a strong and positive note. The trade fair emerged as a crucial meeting place for the technical textile players to rebuild their supplier links, promote industry integration and engage in lucrative knowledge exchange.

Making a spectacular comeback after the lockdown, the eighth edition of Techtextil India stood out to be a ground-breaking business platform for the technical textile sector to build a new and strong foundation in the new normal. The aim of the new edition was to promote industry unification and business recovery across the value chain of technical textiles.

Over the course of its three buzzing days, the show garnered an attendance of 4,087 visitors drawn by live demonstration of latest products, technologies and innovations exhibited by over 150 technical textile brands on the show floor.

The event received an overwhelming response, reflecting industry's keen interest to explore new developments and opportunities in technical textiles. The significance of the three-day fair was further elevated by the exclusive German pavilion. Top technical textile manufacturers from Germany, such as Autefa Solution Germany GmbH, DILO Systems GmbH, Emtec Electronic GmbH, Georg Sahm GmbH & Co, Karl

Mayer Verwaltungsgesellschaftmbh, Merz Maschinenfabrik GmbH and Oerlikon Barmag Zweigniederlassung der Oerlikon Textile GmbH & Co, displayed their latest technologies on the show floor, which garnered significant attention from the Indian buyers.

The first Digital Symposium was another major highlight of Techtextil India 2021. The forum delved into a series of crucial topics in technical textiles discussing PLI schemes, FDI opportunities and policies, investment opportunities in Tamil Nadu, & New Investment Opportunities, Sustainable Technical Textiles and Global sustainable approach for Textiles with Antimicrobial Performance.

Concluding on a successful note, Techtextil India 2021 emerged as a platform of new beginnings for the technical textiles sector and for businesses trying to retain their shape and seeking momentum after the tough pandemic phase.

Birla Cellulose to scale Liva Reviva fibres to 100,000 tons

Birla Cellulose, pulp and fibre brand of the Aditya Birla Group under the flagship company Grasim Industries Limited, recognizes the pivotal role that it can play in sustainable forest management and promoting circular economy using a collaborative approach. Birla Cellulose plans to aggressively scale up the production of circular fibre Liva Reviva to a level of 100,000 tons per year by 2024.

Liva Reviva, a circular viscose fibre made using pre-consumer cotton waste and closed loop technologies, comes with outstanding sustainability credentials such as significantly lower greenhouse gas and water footprint compared to generic viscose. It contains a unique molecular tracer backed by blockchain based traceability and is Recycled Claim Standard (RCS) certified. Under this initiative, the recycled content in Liva Reviva will be increased upto 30% in 2022 from 20% currently and post-consumer material will be gradually increased in the feedstock with increase in volumes.

It is estimated that more than 90 million ton waste is generated from fashion industry every year and less than 1% is recycled, remaining going to landfill or incineration, or leaking into the environment. Key barriers to the circular business model include limitations in recycling technologies, lack of infrastructure for waste collection and segregation, garments not being designed for recycling and lack of investments in each of these areas.

Birla Cellulose has invested significantly in development of the recycling technology and infrastructure and would continue to further invest in development of pre- and post-consumer textile waste recycling technologies, building the capacities for next generation fibres and developing reliable reverse logistics for collection and segregation.

'The world is looking for innovative solutions for mounting problem of fashion industry waste. Birla Cellulose is proud to be pivoting the collaborative effort for scaling up the circular business model; this will not only upscale the waste but also help reduce pressure on forests for virgin wood-based pulp and help fight climate change.' said Mr H K Agrawal, Designate Business Director, Birla Cellulose. 'This initiative is aligned to our vision to be a global leader in sustainable business practices in the manmade cellulosic fibre industry'.

Lenzing launches matte Tencel fibres

The Lenzing Group is expanding its sustainable offering for the denim industry with the introduction of matte Tencel branded lyocell fibres. The new fibre type is specially designed to scatter light and permanently diminish sheen in denim applications, further enabling versatility of indigo-dyed denim fabrics.

'As a leader in fibre production, we work closely with our customers and mill partners to address their product needs. Our partners wanted the option to choose denim fabrics that are less shiny, and we listened,' said Tricia Carey, Director of Global Business Development Denim and Americas, Lenzing AG. 'By implementing an innovative production process to create matte Tencel Lyocell fibres, we are setting a new standard for indigo applications.'

Combining functionality with aesthetics, the introduction of matte Tencel Lyocell fibres increases versatility in denim designs whilst reducing the ecological footprint of the resulting fabric and garment. Made with a resource efficient closed-loop production process, the new fibre type maintains all the comfort benefits of standard Tencel Lyocell fibres to bring next-to-skin smoothness while giving dark indigo dyed fabrics a deep and lustreless appearance.

In collaboration with global mill partners, Advance Denim (China),

Artistic Fabric Mills Pvt Ltd (Pakistan), Arvind Limited (India), Kipas Denim (Turkey), KG Denim Limited (India), Panther Denim/ Tat Fung (China) and Textil Santanderina (Spain), Lenzing was proud to launch the new matte Tencel branded lyocell fibres at the Kingpins Digital Show.

Lenzing takes full accountability of its production processes by providing

physical identification for every Tencel branded fibre with its fibre identification technology. The new matte Tencel Lyocell fibres are fully traceable using this technology, assuring both brands and consumers that the raw materials it uses originate from responsible resources. In the long run, this will help improve the overall sustainability of the denim industry, thanks to informed decision-making by all parties, concludes Lenzing.

Clariant opens global Competence Center in Brazil

In order to support the mining industry's efforts towards sustainability, Clariant announces a new technical facility in Brazil exclusively dedicated to developing solutions for tailings management. The Competence Center for Tailings Treatment (CCTT) opens in Belo Horizonte, state of Minas Gerais, Brazil.

Clariant's new Competence Center for Tailings Treatment will develop mining chemicals and technologies to support the industry's efforts from the heart of Brazil's mining hub. The new lab is outfitted with state-of-the-art equipment and is home to a dedicated team of R&D experts.

'Clariant is at the forefront of offering sustainable solutions for mining, and the CCTT will provide robust technical capabilities to demonstrate how our innovations can improve tailings management and waste reduction', comments Wagner Silva, Global Head of Technology, Clariant Mining Solutions.

The new CCTT is a core pillar of Clariant's Tailings Management Program, which comprises four complementary technology platforms: Flotation, Magnetic Separation, Dewatering, and Rheology Modification. Flotation chemicals for slimes, for instance, help mines recover valuable minerals that are currently going to waste, and flotation chemicals for secondary mining enable operators to reprocess old tailings. In addition, filter aids help operators dewater tailings better, leading to drier stacks and faster throughput.

George Nunes, Global Head of Clariant Mining Solutions, states: 'Our new Competence Center is an important milestone in our strategy to support the global mining industry's focus on sustainability. With this additional resource, we will continue working closely with our customers to develop relevant, practical solutions which address their most significant sustainability challenges.'

Dyecoo technology at the tipping point

With new projects planned in Bangladesh, India and South Korea, as well as the European Union and Turkey, Dyecoo is on the verge of significant expansion with its water and chemical-free supercritical CO_2 dyeing technology for polyester.

Speaking at the recent Conference on Sustainable Finishing of Textiles, Kasper Nossent, managing director for Asia, said the culmination of the company's 12-year journey in fully proving the viability of such a potentially disruptive technology was now happily coinciding with a greater commitment from the major brands.

'Many brands are facing the end of their sustainability roadmaps in the next five-to-ten years, which is allowing suppliers to get commitments from them for volumes and build their own business cases for investing in new sustainable technologies,' he said. 'That has been the hurdle - if the brands do not move, nothing happens.'

Dyecoo, which is headquartered in Weesp, Netherlands, first introduced its prototype Dyeox system in Thailand

Fully-approved mask fit for upto 100 washes

The Silver Life Mask developed by SP Science, of Bury, UK, has completed the CE registration process as a Type 2 face mask that can now be used by hospitals, health authorities, and care homes, as fully validated reusable PPE.

The Silver Life Mask

The mask is reusable for upto 100 washes at 40ºC and made from 36% recycled material. Globally, 129 billion face masks are used every month, and more and more of these masks are finding their way into the oceans.

'We are delighted with the new CE classification meaning that we are now fully approved PPE and are excited about the impact we can make,' said Dr Alan Green, environmentalist and founder of SP Science. 'Whereas a typical hospital might have used 300 disposable masks per day prior to the Covid-19 outbreak, we have received reported cases of 10,000 masks being used daily in some hospitals - a thirty three-fold increase. We also understand that several hospitals are now considering the purchase of specialist incineration devices - a huge piece of kit with a huge capital cost - for disposal. The use of Silver Life masks could significantly reduce or even remove this type of expenditure.'

'Single-use or disposable face masks are made using a variety of plastics, including polypropylene, polyethylene and vinyl - which means they can take up to 450 years to break down. Even then, the plastic stays around as tiny microplastics. These microplastics are causing fundamental problems to our worldwide ecosystems and have even been found in the Antarctic and Arctic environments. Our Silver Life Face Masks have been developed by experienced healthcare scientists and have safety, the environment, recycling and manufacturing standards at the core of their design. Sustainability is at the essence of The Silver Life Face Mask as well as its effectiveness in the current and perhaps future airborne microbial pandemics.'

The masks are based on a blend of recycled polyester and cotton.

in 2010, and subsequently installed three machines at Yeh Group in the country. Eight machines have subsequently been installed in Taiwan, at Li-Cheng (4), Far Eastern (2) Formosa Taffeta (1) and Eclat (1).

In 2019, Cleandye opened its 100% CO_2 plant in Ho Chi Minh City, Vietnam, with a capacity of ten tons a day, as the model factory for proving the Dyecoo Dyeox system - now in its fourth generation - as the only true water-free colourization process. The annual savings achievable from a single Dyeox4 machine have been proven to amount to 33.6 million litres of water and 168 tons of chemicals, as well as energy savings, compared to a traditional water-based bath dyeing system. In addition, the process is safe and non-toxic and, until recent shortages in certain parts of the world, CO_2 has been inexpensive and abundant.

Dyecoo's process dissolves pure dyes, without auxiliaries, naturally and the same quality can be achieved with the process anywhere in the world with 100% batch to batch consistency. It can also colour both yarns and fabrics without any changes to the machine.

A Dyeox4 machine, such as the machines in place at Cleandye, can now treat 3-3.5 tons of fabric or yarn per day, based on a maximum width of two metres and 160 kilos per batch and an average of 20-22 batches treated per day.

'The applications for polyester - which will remain the backbone of the textile industry for many years because it is cheap and can be produced anywhere - are endless,' Nossent said. 'The construction does not matter, although dyeing times will vary, and we are now involved in new projects for the automotive and footwear industries for example. Major brands have now endorsed the technology and we have reached the stage of proving the business case and commercial parity with conventional technologies to customers.'

Techtextil North America returns to Georgia

Techtextil North America, the key tradeshow in the Americas for technical textiles and nonwovens, assembling all vertical aspects of the technical textile industry, will return to Georgia in May 2022.

Once again co-located with Texprocess Americas, the largest sewn products and technology tradeshow in the Americas, the two shows will bring together over 500 exhibiting companies spanning 130,000+ square feet, creating the biggest and best event for the entire textile supply chain, and the only one of its kind in North America.

Techtextil North America aims to assemble all vertical aspects of the technical textile industry: from research and development, through raw materials and production processes and finally ending in conversion, further treatment, and recycling.

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Fire protection coatings market booms

Frost & Sullivan's recent analysis, Global Fire Protection Coatings Growth Opportunities, finds that a rise in the stringency of regulations and safety advisory to augment the fire safety of buildings and constructions across sectors - oil and gas, petrochemicals, chemicals, and allied industries - is expediting the demand for fire protection coatings globally. The market is estimated to garner US$ 2.74 billion in revenue by 2027 from US$ 1.94 billion in 2020, an uptick at a compound annual growth rate of 5.1%. Hydrocarbon cementitious and hydrocarbon intumescent are the main product types driving the overall market, followed by cellulosic intumescent and cellulosic cementitious.

Awareness of the benefits of deploying fire safety measurements that protect lives and property is increasing in fast-growing economies like China, India, and Southeast Asia. As a result, the fire protection coatings market will witness the highest growth in Asia Pacific (APAC). With faster development of the commercial and industrial sectors in Eastern Europe and the surging demand for both coatings, hydrocarbon and cellulosic-due to many offshore installations in western Europe, Europe will be the second-largest market, followed by the Americas (North America and Latin America) and the Middle East, Africa, and South Asia (MEASA).

'Fire protection coatings manufacturers are increasingly witnessing demand from key stakeholders of buildings and structures exposed to hydrocarbon and cellulosic fire types for more durable and faster-drying products,' said Ganesh Jayant Dabholkar, Chemicals, Materials and Nutrition Research analyst at Frost & Sullivan. 'A rising need for improved aesthetics (especially for exterior structural members) and reduced volatile organic compound (VOC) emissions will also contribute to increased market penetration for coating manufacturers.'

Dabholkar added: 'The rising demand for intumescent and cementitious coatings that form thinner layers, dry faster, and are easier to apply will drive innovation. Further, hybrid, solvent-borne intumescent coatings are increasingly penetrating the cellulosic fire protection market. Similarly, more low-density cementitious coatings will be introduced to the hydrocarbon market during the next 3-5 years.'

The most recent edition took place last recently in Raleigh, North Carolina with organisers hailing the success of the event, which, exceeding expectations, served as the ideal platform to reunite the industry.

HeiQ AeoniQ yarn aims to transform textile industry

HeiQ announces a potential game-changer for the textile industry with the introduction of HeiQ AeoniQ - a high performance cellulose yarn based on a new fibre derived from carbon negative materials. This new fibre, which is derived from third generation cellulosic biopolymers, is advancing to pilot production prior to mass commercialization. The LYCRA Company is the first to join HeiQ as a development partner.

Whether it is cotton, wool or synthetic polymers, global textile production has a significant environmental impact with the industry responsible for more than 10% of global greenhouse gas emissions and over 20% of wastewater worldwide. Conventional cellulosic fibre production uses arable land during growth and has limited design versatility, while raw materials for fossil-based synthetic materials are finite. Existing methods to recycle textile fabrics and garments made with all fibres are, for the most part, still not at scale and most fibres - whether synthetic or natural - take many years to degrade in landfills or oceans, leading to environmental build up.

HeiQ AeoniQ yarns are made out of cellulosic biopolymers that, during growth, bind carbon from the atmosphere while generating oxygen. This high-performance yarn is positioned to potentially substitute synthetic filament yarns which constitute over 60% of global annual textile output of 108 million metric tons. Further, when compared to conventional cellulosic products, HeiQ AeoniQ yarns do not draw on arable land, pesticides or fertilizer in their production.

HeiQ AeoniQ yarns are designed for cradle-to-cradle circularity and can be

HeiQ AeoniQ cellulosic yarn is made from climate positive raw materials and has the potential to be recycled repeatedly.

recycled repeatedly while maintaining consistent fibre quality. The manufacturing process is expected to consume 99% less water than cotton yarns, and HeiQ AeoniQ is designed to offer comparable performance properties to polyester, nylon and conventional regenerated cellulose yarns.

Dow introduces solvent-free silicone release coating

Dow recently announced the introduction of solvent-free SYL-OFF SL 184 Coating, an energy-efficient alternative that minimizes misting at very high product label production line speeds. A fast-curing silicone that exhibits low release force at both low and high peel speeds, SYL-OFF SL 184 coating maintains overall performance on most existing label coating equipment, including multi-roll lines.

Mist is an aerosol or 'fog' made of silicone droplets that form at the rolls coating head in high-speed release liner operations to form adhesive labels. This causes runnability issues in the curing oven, which leads to more frequent downtimes and higher maintenance costs.

Extensive laboratory and pilot plant testing demonstrates that SYL-OFF SL 184 coating allows high speed operations of upto 1,600 m/min with significant mist reduction, while maintaining other release coating attributes at high-speed process conditions. Testing also confirmed that SYL-OFF SL 184 coating offers release liner producers formulation flexibility at any speed, with fast curing rates, no migration to the adhesive, and improved substrate anchorage. The new coating also provides very stable release force over time, which is critical for adhesion to a variety of containers and flexible packaging during industrial fast and automated label delamination operations.

The new coating is solvent-free and more energy efficient because less energy per square metre is required to produce the same quantity of release liners when production lines are running at higher speeds. SYL-OFF SL 184 coating has been designed to comply with FDA and BfR XV food contact regulations, making it suitable for food labeling applications.

James Heal enhances US offering

Textile testing expert, James Heal, has announced the opening of its first US-based office and a new network of distributors, enabling it to better service its customers in the Americas. Not only is the Sterling, Virginia office now ready to support customers, but the company has further launched a dedicated online shop for American customers looking to click and buy a wide range of test materials and related accessories.

'We have always recognized the need for greater localized customer support in the Americas - now we are able to offer that,' says Dan Payne, Group President, Americas. 'It took a little longer than we had hoped, due to the pandemic, but also allowed us to build an enhanced offering for our customers.'

The James Heal office in Sterling now stocks a large range of test materials, speeding up its shipping process. Payne adds that: 'The site also boasts a demo and sample test lab, where visitors can come to try out the instruments or have us video the process and selection based on their unique application.'

PreDry

Over the past year, James Heal has also implemented an educational webinar program through which it shares its expertise on topics like abrasion and pilling, water repellency, light fastness testing and phenolic yellowing.

'We are serious about supporting our customers in the Americas and are on hand to help with whatever they need,' concludes Payne. 'Our goal is to improve every aspect of textile testing, so our customers can achieve consistent and accurate results every time.'

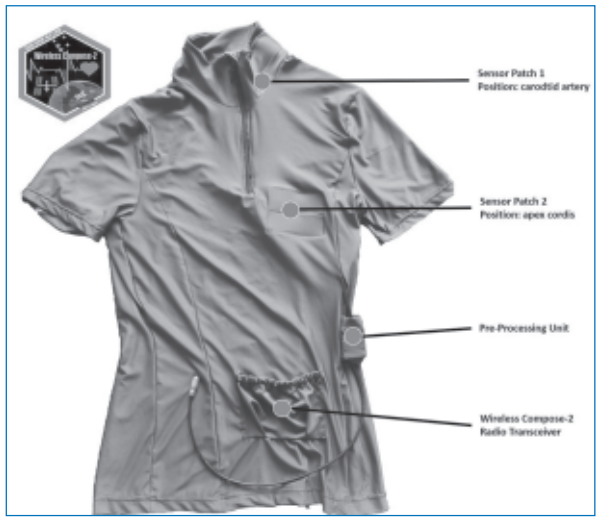
Established in 1872, James Heal is an international engineering company renowned worldwide for delivering premium quality, reliable and innovative materials testing solutions. From its core manufacturing and commercial headquarters in the United Kingdom, the company specialises in the design and production of testing Instruments

ElmaTear

and test materials (consumables), supported by industry-leading service and support.

Sensor t-shirt on the way to ISS

The new SmartTex shirt can use integrated sensors to transfer physiological data from astronauts to Earth via a wireless communication network. In this way, the effects of the space environment on the human cardiovascular system, especially with regard to long-term manned space missions, will be evaluated and documented.



Developed by the German Aerospace Center (DLR), Oberpfaffenhofen/ Germany, in cooperation with DSI Aerospace Technology GmbH, Bremen/Germany, the Medical Faculty of Bielefeld University, Bielefeld/Germany, and textile research partner Hohenstein Institute, Bönnigheimt/Germany, SmartTex will be tested for the first time as part of the Wireless Compose-2 (WICO2) project by German ESA astronaut Dr Matthias Maurer, who left for the 'Cosmic Kiss' mission on the International Space Station (ISS) for 6 months recently.

Maurer can wear this tailor-made shirt comfortably on his body during his everyday work on the ISS. For this, his body measurements were used as the basis for the cut development and the production of the shirt. The necessary sensors as well as data processing and communication modules were integrated into the shirt's cut in such a way that they interfere as little as possible and are always positioned in the right place, regardless of the wearing situation.

The SmartTex shirt is intended to provide a continuous picture of the vital functions of astronauts. This will be particularly relevant for future long-term manned space missions to the moon and Mars.

During the BEAT (Ballistocardiography for Extraterrestrial Applications and Long-Term Missions) experiment, Maurer will be the first astronaut to wear a T-shirt equipped with sensors that measure his ballistocardiographic data such as pulse and relative blood pressure.

For the future, a technology transfer of the SmartTex shirt for application in the field of fitness or even in telemedicine is conceivable.

Cleaner air for Munich

Mann+Hummel has now installed more than 400 of its Filter Cubes worldwide, spread across 140 columns and cleaning almost two billion litres of air per hour - roughly equivalent to the air demand of of 4.1 million people.

A Filter Cube column being installed in Munich

'Many people think intensively about the 1 kg of food and the 3 l of liquid they consume every day, but we very rarely think about the quality of the approximately 12,000 litres of air that each of us breathes every day,' said Jan-Eric Raschke, director air solution systems for the company, which is headquartered in Ludwigsburg, Germany. 'We all agree it would be best if our air was so clean that it did not need to be cleaned at all, but unfortunately it is not. Cities and metropolitan areas in particular face enormous challenges.'

Mann+Hummel has developed the Filter Cube technology for particularly polluted roads and junctions. The Cubes draw in the polluted air and bind over 80% of the nitrogen dioxide (NO_2) and particulate matter (PM10). The heart of the technology is a combination filter which comprises a highly effective nonwoven particle filtration layer and activated carbon layers that adsorb nitrogen dioxide. The activated carbon media absorb NO_2 very effectively due to their large surface area. The technology is characterised by a particularly low pressure drop. As a result, it effectively cleans the air with very little use of energy. Thanks to their modular design, the Filter Cubes can be assembled to form adaptable filter columns.

In addition to various locations in Germany, Mann+Hummel Filter Cubes are now used in Brazil, China, India and South Korea, and further projects are currently being planned in Hong Kong, Mexico, Colombia, Singapore, Taiwan and Thailand.

Launch of Sorting For Circularity India

Fashion for Good is launching Sorting For Circularity India, a

consortium project to understand both the pre-consumer and post-consumer textile waste streams in India and to pilot sorting and mapping solutions. The project aims to build an infrastructure towards greater circularity in the years to come.

The project brings together industry players including adidas, Levi Strauss, PVH Corp, Arvind, Birla Cellulose and Welspun India.

A key technology partner for the project is Reverse Resources, which will provide the analysis of the pre-consumer textile waste streams, in addition to designing and running the pre-consumer pilot. The project is supported through catalytic funding provided by Laudes Foundation.

'India is a critical hub, not only for textile production and consumption, but also as a global post-consumer textile waste destination,' said Katrin Ley, Fashion for Good managing director. 'This project is pivotal to understanding the size of this considerable market and providing the incentive, tools and means for the industry to benefit from the wealth of this untapped resource.'

India's position as a textiles manufacturing and consumption market provides for large streams of pre-consumer as well as domestic post-consumer waste. Pre-consumer waste is only partially recycled, with the remaining portion mostly downcycled to products of inferior quality. Domestic post-consumer waste, on the other hand, is exceptionally difficult to trace, with limited data available to understand the waste, quantities, composition and other factors key to its recycling. India is also one of the largest recipients of global post-consumer textile waste, with millions of tons, to the value of more than € 100 million, of discarded textiles imported and manually sorted through various hubs. Similar to domestic waste, limited information on this imported waste exists.

In addition to the lack of accurate information, no technologies currently exist that organise, categorise and sort materials to ensure quality textile waste is accessible for recyclers, who require sorted feedstocks in large volumes. While these are not the only challenges faced by recyclers, they are significant barriers to the growth of chemical recycling technologies in India.

'Recycling technologies are going to be the future of the industry and, to get there, we need access to traceable, high-quality textile waste for all waste streams,' said Abhishek Bansal, head of sustainability at Arvind. 'We will be looking at efficiently recycling traceable textile waste and helping to build a new textile waste value chain in India. This project is a great opportunity to help organise India's textile waste market, making it traceable and accessible to recyclers, manufacturers and brands.'

Over 15 months, the project will demonstrate a new textile value chain across three phases. Firstly, by obtaining an overall understanding of the textile waste supply chain of pre and post-consumer textile waste in India. Secondly, by identifying and piloting technologies that enable the traceability of textile waste and its accessibility to existing recyclers, and finally, by providing recyclers with access to textile waste feedstocks that meet the quality parameters of advanced recycling technologies, giving these technologies an incentive to scale in India.

With the launch of project, Fashion for Good is calling on industry stake-holders within the textile waste sector in India to collaborate. Data and resources volunteered are crucial to obtaining real world estimates beneficial to mapping the landscape and successfully testing technologies that are best placed to address the challenges.

HeiQ acquires Life Material Technologies

In line with HeiQ's strategy to increase its presence in the biobased antimicrobial and healthcare surface hygiene market, the company has acquired Life Material Technologies Ltd, Hong Kong/China. The acquisition is also a way for HeiQ Materials AG, Zurich/Switzerland, to further diversify and innovate its product range and capabilities with a view to becoming a global leader in materials innovation.

Life has developed a strong portfolio of smart ingredients and formulations with applications in numerous industries. This includes bio-based antimicrobial additives and treatments used by manufacturers of plastics, coatings, textiles, ceramics and paper that inhibit or manage bacteria, fungi, algae and other microorganisms that come in contact with treated materials. Their technology platform in the industry is using inorganic, organic and bio-based botanical active substances.

Life's 40+ products strengthen HeiQ's global product offering and will facilitate existing technology platforms into new markets, especially masterbatches, plastics and coatings. HeiQ will also gain access to hygiene technologies, such as odour absorbent additives, that complement its core antimicrobial technology.

With the acquisition, HeiQ will now have additional offices and laboratories in Thailand and Brazil. ⬣

Dyeing of surface-modified cotton with disperse dye to conserve water

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Cotton fabric is the most widely used fabric which plays an important role in international textile markets. The wet processing of the cotton fabric is long and complex which consumes a huge amount of water, energy, and textile auxiliaries[1,2]. All of these are unfavourable to the low carbon economy development and environmental protection nowadays. Almost all dyes, speciality chemicals, and finishing chemicals are applied to textile substrates from water baths. In addition, most fabric preparation steps, including desizing, scouring, bleaching and mercerizing use aqueous systems. According to USEPA, a unit producing 20,000 lb/day of fabric consumes 36000 litres of water[3,4]. In textile wet processing, water is used mainly for two purposes. Firstly, as a solvent for processing chemicals and, secondly, as a washing and rinsing medium. By 2030, the world demand for freshwater is expected to increase by 40%. As environmental awareness grows, so does the demand for textiles produced in more sustainable ways. Upto 26 gallons (100 litres) of water are needed to dye just two pounds (1 kg) of cotton fabric[5,6,7,8].

Various approaches have been applied[9,10,11,12] by various researchers for water conservation in the wet processing of cotton fabric; some of them are good housekeeping, reuse and recycling of water, and automation of processing plant. Very few researchers have tried to modify the conventional wet processing of cotton fabric. The surface modification of cotton fabric is one of the areas which can increase dye absorption and conserve water. Surface modification of cotton fabric can be done by using various physical and chemical techniques like plasma treatment, laser treatment and cationisation of cotton fabric. The surface modification of cotton can help in water conservation upto some extent, but these approaches have their limitations.

Textile processing is one of the largest industries worldwide and responsible for substantial resource consumption and pollution

In this study, new approaches of surface modification have been tried to make the cotton fabric dyeable with disperse dye without any

pretreatments like desizing, scouring and bleaching, so that large amounts of water, chemical, energy and time can be saved.

Material and methods

Resin, ecofriendly carrier dispersing agent (lisapol), acetic acid, disperse dye and cotton fabric were procured from different sources.

Application of resin

Resin was dissolved in water and the solution applied on cotton fabric as well as on cotton yarn to get the following two effects:

Process I: Dyeing cotton fabric in solid shade using disperse dye; and

Process II: Creating denim effect using disperse dye on cotton fabric.

Six solutions of different concentrations of resin (20 gm/l, 40 gm/l, 60 gm/l, 80 gm/l, 100 gm/l and 120 gm/l) were prepared.

Process I

Generally, the dyeing of cotton with reactive dye is one of the best suitable methods. It also gives good fastness properties as required. Cotton dyeing with reactive dye requires 5 to 6 washes after dyeing to remove the unfixed dye. Due to high colour discharge and chemicals in the effluent, it increases the load on ETP and the cost of treatment. In this approach, a solid shade using disperse dye on cotton fabric was developed.

In this process, the resin was applied on cotton fabric using pad-dry-cure process followed by dyeing using disperses dye without using any pretreatment to the fabric.

Table 1 : Test methods and their standards

Tensile strength	IS 1969
Tear strength	IS 6489
Bending length	IS 6490
Crease recovery	IS 4681
Colour strength	ASTM D387
Washing fastness	ISO 105 C10 C3
Rubbing fastness	IS 766 (1988)

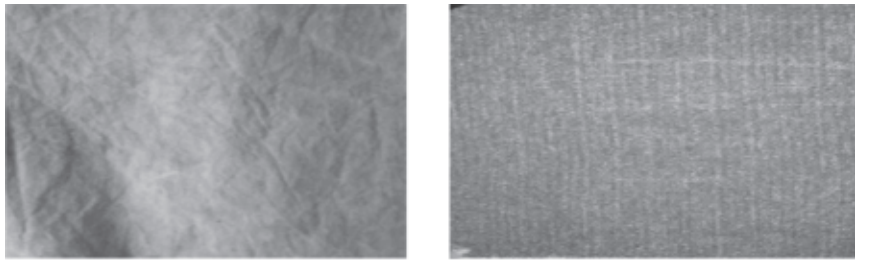
Process II

The denim industry is one of the most water-consuming industries. As per the data from sources, it takes around 6000 litres to produce one pair of jeans. In the conventional method, denim fabric is produced using indigo-dyed yarn. This dyed yarn is used in the warp after sizing, while the weft remains undyed. This denim fabric is converted into jeans or garments. To get a fading effect, these garments undergo washing treatment using enzymes and stones, depending upon the end-use requirements.

In this new approach, the resin solution was prepared by dissolving it in water at the 80°C with continuous stirring. This solution was applied on the surface of the yarn similar to sizing process using single end sizing of CCI make. This surface-modified cotton yarn is used to manufacture fabric using CCI sample loom. The woven fabric, which contains polymer resin on its surface, was directly dyed using disperses dye without applying any pretreatment to the fabric.

Table 3 : Crease recovery angle of treated cotton fabric

Conc. of polyester resin (gm/l)	Crease recovery angle	
	Process I	Process II
20	41.5	39
40	41	40
60	34	36
80	36	32
100	32	32
120	33.5	31



Dyeing using Process I *Dyeing using Process II*

Fig 1 : Dyeing effect

Characterization

The physical properties and dyeing performance of the fabrics were

Table 2 : Tensile and tear strengths of treated cotton

Conc. of polyester resin (gm/l)	Tensile Strength (N) Warp		Tensile Strength (N) Weft		Tear strength Warp		Tear strength Weft	
	Process I	Process II	Process I	Process II	Process I	Process II	Process I	Process II
20	478	450	511	470	789	690	795	695
40	464	434	494.6	455.6	761	665	783	670
60	419.5	398	488.7	435.1	731	654	764	655
80	405.7	370	468.9	415	710	630	747	642
100	368.9	355	434.6	390	695	598	729	603
120	353.6	340	403	360	678	565	708	594

Table 4 : Colour strength of dyed fabric

Conc. of polyester resin (gm/l)	Colour strength (K/S value) Process I	Process II
20	2.05	1.69
40	3.17	2.13
60	4.15	3.15
80	4.23	3.94
100	4.58	4.15
120	4.57	4.10

evaluated as per the standard given in *Table 1*.

Results and discussion

Physical properties

The physical properties were evaluated in terms of tensile and tear strength, both warp wise and weft wise, for Process I and Process II as represented in *Table 2*. It can be observed that, as the concentration of resin on cotton fabric increases, the tensile and tear strength decreases which may be attributed to the curing of the fabric. However, the tensile strength of the fabric in Process II was found to be less than in Process I which may be due to the partial removal of resin from the yarn surface because of abrasion in yarns during the weaving process.

Crease recovery angles of the Process I and Process II samples were evaluated as shown in *Table 3* and it was found that the crease recovery angle decreases as the concentration of polyester resin on the fabric surface increases. This can be attributed to the stiffness of the fabric because of the presence of polyester resin on the surface. Polyester resin, being a polymer, prevents the crease to recover; hence crease recovery angle decreases.

Colour strength

It was found that the fabric obtained using Process I provides a solid dyeing effect; while the fabric obtained from Process II gives a faded look like a faded denim garment. The dyed fabrics are shown in *Fig 1*.

The colour strengths of the fabric samples from Process I and Process II were measured using a computer colour matching system, and the colour value is shown in *Table 4*. It can be seen that, with the increase in the concentration of resin on the yarn surface, the colour strength of the fabric is increased. This increase is till 100 gm/l concentration of the resin. After that, there is no change in the colour strength. This shows the arrival of the saturation stage.

Water consumption analysis

As per the previous studies by various researchers, conventional cotton fabric completes wet processing (desizing, scouring, bleaching and dyeing) as the fabric to water consumption ratio is almost 1:100 to 1:130 which needs to be reduced using various methods. In the new approaches, fabric to water consumption ratio is reduced upto 1:40 to 1:50 which can save a significant amount of water. From *Table 5*, we can observe that Process I of cotton fabric can save upto 58% water as compared to conventional cotton processing. Similarly, Process II can save upto 66% water. This water conservation can be attributed to skipping the pre-treatment process which consumes a major part of water during the wet processing of cotton fabric. Thus, the new processing techniques can be cost-effective and time-efficient with the benefits of decreased chemicals and pollution load in the drain stream. These approaches of fabric processing need to be investigated further to evaluate their effectiveness for bulk dyeing.

Conclusion

In recent years, there has been remarkable progress in various modifications for textile wet processing to conserve water and chemicals. In the present work, two new approaches have been suggested to dye cotton fabric with disperse dye. Following are the findings of the study:

- The tensile strength of the fabric decreases as the concentration of resin increases; however, the decrease does not affect the end-use performance of the fabric adversely.
- The colour strength of the fabric increases with the increase in the

Table 5 : Water consunption analysis

Conventional process	Water consumption per 1000 kg of fabric: Conventional process of dyeing the cotton with reactive dye	Surface modified cotton: Process I	Surface modified cotton: Process II
Sizing	10000	20000 (sizing carried out as per conventional process followed by application of resin on fabric)	10000 (application of resin on warp yarn)
Weaving	Nil	Nil	Nil
Desizing	8000	No desizing	No desizing
Scouring	30000	No desizing	No desizing
Bleaching	7000	No bleaching	No bleaching
Dyeing (MLR 1:6)	36000	18000	18000
Total	**91,000**	**38,000**	**28,000**
Water Conservation in %	-	**58.2**	**66.2%**

concentration of resin upto 100 gm/l. After that, there is no change in colour strength.

- The cotton fabric dyed using Process I gives solid shade; while fabric dyed with Process II gives a fading look like faded denim garments.
- 58% of water can be saved in Process I and 66% in Process II.

The above study is based on laboratory trials; there is a need to test these approaches at the mill level. It was also found that these approaches work well for a fabric having a high mass.

Acknowledgement

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Dyeing of mulberry silk waste/wool blended fabric using Reactive Red 2 and Reactive Green 19 dyes

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Mulberry silk/wool blended fabrics are not new to the world but, due to lack of awareness, these have not yet been commercialized. Therefore, research needs to be done for appropriate utilization of silk waste and blending with other protein fibres such as wool. Blending of silk and wool is a way to incorporate better appearance and strength in the woollen fabric and increase the utility of the silk fabric[1]. Dyeing of blends which contain the fibres of highly different dye affinities must be done very carefully. In blends, interesting tone-on-tone, tone-on-white and differential dyeing are possible by selection of appropriate dyes and dyeing conditions[2]. Both, silk and wool, are protein fibres due to the presence of many amines, carboxylic acid, amide and other polar groups, so these possess similar chemical properties. Silk and wool blends are dyed in piece form or as yarn on packages and hanks. Silk is chemically related to wool because the amino groups are integral components of both fibres, thus both can be dyed with the same dyes. Silk and wool are hydrophilic in nature, wetted by water and are dyed with either acid or basic dyes through the formation of ionic bonds (salt linkages). These may also be dyed with reactive dyes that form covalent bonds with available amino groups. The dyeing system offers the advantages of a wide range of colours, including brilliant shades, one-bath dyeing method and excellent solid shades[3].

The value addition of mulberry silk waste/wool blended fabric, through dyeing, can lead to its diversified uses

Materials and methods

Textile material

Hand woven blend of mulberry silk waste/wool

in the ratio of 65:35 was used for the research work. For this purpose, mulberry silk waste was procured from Srinagar (Jammu and Kashmir) and wool fibre was procured from the local market of the Ludhiana city. Blending and spinning was done at Kullu (Himachal Pradesh), and weaving was done in Ludhiana, India.

Dyes

Two dyes were selected for the study. Details of these have been given in *Table 1,* and chemical structure of the dyes has been illustrated in *Figs 1a & 1b*. These dyes were obtained from local market of Ludhiana. Reactive dyes were selected in red and green colours *(Table 1)*.

Chemicals

The chemicals used in this study have been given in *Table 2*. These chemicals were supplied by Thames Chemicals. All the chemicals used were of laboratory grade.

Table 2 : Chemicals used

Name	Molecular formula	Purpose
Acetic acid	CH_3COOH	pH regulator
Ammonium sulphate	$(NH_4)_2SO_4$	Dye fixation
Hydrogen sulphite	H_2SO_4	Dye fixation
Caustic soda	NaOH	pH regulator
Sodium carbonate	Na_2CO_3	Dye fixation
Sodium sulphate	$NaSO_4.10H_2O$	Colour depth and exhausting agent
Sodium chloride	NaCl	Perspiration fastness
Sodium bicarbonate	$NaHCO_3$	Perspiration fastness

Table 1 : Dye materials used

Name of the dye	Molecular structure	Rs/kg
Reactive Red 2	$C_{19}H_{10}Cl_2N_6O_7S_2.{}_2Na$	260
Reactive Green 19	$C_{40}H_{23}Cl_2N_{15}O_{19}S_6.{}_6Na$	180

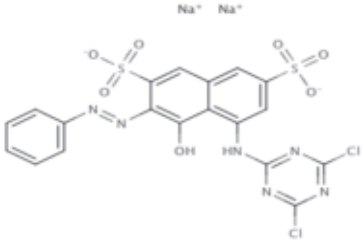

Fig 1a : Chemical structure of Reactive Red 2

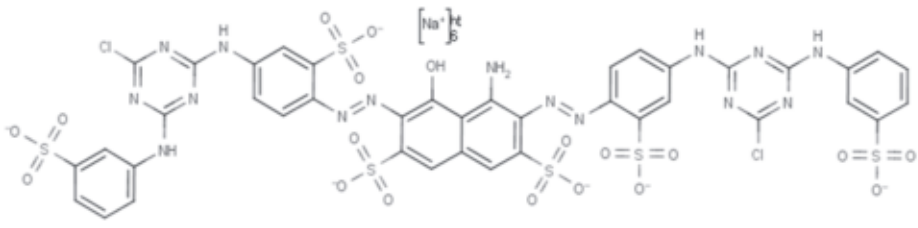

Fig 1b : Chemical structure of Reactive Green 19

Fig 1 : Chemical structures of dyes used

Dyeing of silk/wool blended fabric using reactive dyes

Dyeing procedure for dyeing mulberry silk waste/wool blended fabric using reactive dyes was followed[4].

Recipe for Reactive Red 2 dyeing

Dye	:	4% (owf)
Liquor ratio	:	1:30
Dyeing pH	:	5-7
Sodium sulphate	:	40 gm/l
Soda ash	:	3 gm/l
Temperature	:	Room temp
Time	:	60-80 min.

Procedure:

The dye bath was set up with the required quantity of dye solution having MLR 1:30. The wet test sample was entered into the dye bath at room temperature (it is a cold reactive dye) and worked for 10 min. After 10 min, salt solution was added at two stages with a gap of 10 min between each. After 30 min, soda ash was added to the dye bath for fixing the colour. The material was then worked for 40 min.

The sample was then worked in 1:30 MLR with 6% soap solution at boiling temperature for 30 min. Later, it was washed thoroughly and shade dried. Soaping was a necessary procedure to remove remaining particles of acids, alkalis and other chemical reagents after dyeing.

Recipe for hot Reactive Green 19 dyeing

Dye	:	4% (owf)
Liquor ratio	:	1:30
Dyeing pH	:	5-7
Sodium sulphate	:	30 gm/l
Soda ash	:	2 gm/l
Temperature	:	70°C-90°C
Time	:	60-80 min.

Procedure:

The dye bath was setup with the required amount of dye. The wet test sample was entered into the dye bath and the temperature was raised to 90°C. After 10 min, half portion of sodium sulphate (Glauber's salt) was added, to increase the colour depth and for better exhaustion; then the sample was worked for 10 min. Later, the remaining portion of sodium sulphate was added and the sample was worked for 30 min. Soda ash was added to the

dye bath for fixing the colour, and dyeing was carried out for another 40 min. After dyeing, the sample was taken for washing and soaping to remove the excess dye.

Analysis of fabric properties

The undyed (control) and dyed fabrics were analysed for physical and mechanical properties. The properties analysed were fabric weight, fabric thickness, bending length, fabric stiffness, darpability, crease recovery, cover factor and tensile strength. All the fabric properties were analysed using standard methods.

Statistical analysis

The data for different dyed fabric tests were analyzed on the basis of statistical analysis. The mean, standard error, coefficient of variation and their statistical significance were ascertained with the help of softwares CPCS1 and GSTAT.

Results and discussion

Mulberry silk waste/wool blended fabric was dyed using optimized dyeing procedure; the dyed and undyed fabrics were studied for physical and mechanical properties. The physical properties studied were fabric weight, fabric thickness, bending length, flexural rigidity, drapability, crease recovery and cover factor. The mechanical properties studied were tensile strength and elongation.

Analyses of physical properties of undyed and dyed fabrics

The physical properties studied were fabric weight, fabric thickness, bending length, flexural rigidity, drapability, crease recovery and cover factor *(Table 3)*.

Table 3 : Analysis of physical properties of undyed and dyed samples

Physical properties	Undyed sample	Reactive Red 2 dyed sample	Reactive Green 19 dyed sample
Fabric weight (gm/m^2)	103.667 ± 0.576	109.478 ± 0.320	108.280 ± 0.574
CV%	1.244	0.661	1.171
Fabric thickness (mm)	0.305 ± 0.006	0.414 ± 0.0105	0.395 ± 0.0618
CV%	5.0281	5.716	5.440
Warp	3.920 ± 0.0581	2.940 ± 0.102	2.450 ± 0.582
CV%	3.599	5.304	3.639
Weft	2.500 ± 0.196	1.300 ± 0.0316	1.540 ± 0.0399
CV%	5.457	3.074	3.521
Warp	149.676 ± 0.827	136.344 ± 0.290	134.886 ± 0.813
CV%	3.724	1.940	3.375
Weft	127.618 ± 0.375	118.580 ± 0.192	114.768 ± 0.2648
CV%	3.888	2.323	2.391
Overall flexural rigidity	135.800 ± 0.094	127.350 ± 0.520	126.174 ± 0.349
CV%	0.646	4.982	1.620
Drape coefficient	0.722 ± 0.005	0.956 ± 0.007	0.829 ± 0.111
CV%	1.847	1.857	3.048
Warp	145.412 ± 1.224	152.501 ± 0.999	150.000 ± 1.499
CV%	1.761	1.58	2.280
Weft	140.000 ± 0.948	140.500 ± 1.999	130.050 ± 1.870
CV%	1.395	4.140	4.700
Warp	26.013 ± 0.540	20.810 ± 1.324	22.544 ± 0.098
CV%	2.876	1.678	2.547
Weft	6.917 ± 0.870	6.194 ± 1.087	7.084 ± 0.867
CV%	1.650	2.380	3.540

Fabric weight

Usually, the weight of the fabric increases after dyeing as different dye molecules and chemicals used in the dyeing process penetrate into the fabric at the time of dyeing which are trapped under the fibre polymer system, thus the increase in weight of the fabric. Increase in the weight of the fabric after dyeing is also dependent on the size of the dye molecule as well as on the bond formation between dye and fibre polymer[5]. Increase in dye concentration is also an important factor for the increase in the fabric weight. Higher the dye concentration, higher is the number of dye molecule which results in higher fabric weight[6]. It is apparent from *Table 3* that the weight of the undyed fabric was (103.667±0.576 gm/m^2), which has increased significantly after dyeing. Although Reactive Red 2 dyed fabric with mean value 109.478±0.320 gm/m^2 and Reactive Green 19 dyed fabric with mean value 108.280±0.574 gm/m^2 also showed increase in the fabric weight, the difference between these two was not found significant. Increase in fabric weight was due to the structure of the reactive dye which forms the covalent bond with the fibre polymer and the polymer, system of the fibre held the molecule within itself. Reactive Red 2 dyed fabric showed less increase in weight as compared to the Reactive Green 19 dyed fabric. This may be due to the reason that the fabric was dyed at room temperature which leads to the improper bond formation between dye molecule and fibre polymer.

Fabric thickness

It was investigated that thickness of fabric increased after dyeing. This may be due to deposition of dye molecules within the polymer system of the fabric[5]. It can be attributed from *Table 3* that the thickness of undyed fabric was 0.305 ± 0.006 mm. As regards the fabric dyed with reactive dyes, the thickness of the fabric was found to be minimum (0.395 ± 0.061 mm) for the fabric dyed using Reactive Green 19; and thickness for the fabric

dyed with Reactive Red 2 dye was found to be 0.414 ± 0.010 mm, but these values did not differ significantly. This may be due to the washing off of many dye molecules that were being held loosely in the fibre polymer system.

Bending length

From the data furnished in *Table 3,* the mean bending length of undyed fabric in warp direction was perceived to be 3.920 ± 0.0581 cm; whereas, the fabric dyed with Reactive Red 2 dye showed highest value of the bending length with the mean value of 2.940 ± 0.102 cm. The bending length for fabric dyed with Reactive Green 19 was 2.450 ± 0.582 cm; this value was found to be significantly lower than the mean bending length of the fabric dyed using Reactive Red 2 dye.

The bending length of undyed fabric in weft direction was 2.500 ± 0.196 cm. Reactive Green 19 dyed fabric showed highest value (1.540 ± 0.039 cm) for bending length in weft direction although this value was not significantly different than the mean bending length of Reactive Red 2 dyed fabric which was found to be 1.300 ± 0.031 cm *(Table 3)*.

Flexural rigidity

Flexural rigidity is the measure of stiffness. Flexural rigidity in warp direction for undyed fabric was 149.676 ± 0.827 mg/cm. Flexural rigidly for Reactive Red 2 dyed fabric was 136.344 ± 0.290 mg/cm, and it was observed as 134.886 ± 0.813 mg/cm for the fabric dyed using Reactive Green 19 dye. These two values were not significantly different from each other *(Table 3)*.

It was observed form the data furnished in *Table 3* that undyed fabric showed highest value (127.618 ± 0.375 mg/cm) of flexural rigidity in weft direction. Observed value of flexural rigidity in weft direction for the fabric dyed with Reactive Red 2 dye was 118.58 ± 0.192 mg/cm, which was significantly higher than the mean value of the fabric dyed using Reactive Green 19 (114.768 ± 0.264 mg/cm).

Maximum overall flexural rigidity observed for the undyed fabric with the mean value was 135.80 ± 0.094 mg/cm. For Reactive Red 2 dyed fabric, it was measured as 127.350 ± 0.520 mg/cm.

Drape coefficient

There is strong correlation between flexural rigidity and drape parameters. Drapability under the influence of gravity is significantly affected by bending properties. A higher flexural rigidity prevents the fabric to form folds[7]. It is noticed from *Table 3* that drape coefficient of the undyed fabric was found to be 0.722 ± 0.005. Drape coefficient was observed as 0.9562 ± 0.007 for fabric dyed using Reactive Red 2 dye, and 0.8298 ± 0.111 for the Reactive Green 19 dyed fabric. These two mean values were not significantly different from each other.

Crease recovery

Table 3 elicits the crease recovery angle of the undyed and dyed fabrics. The observed crease recovery angle in warp direction for undyed fabric was 145.412 ± 1.224. Crease recovery angle in warp direction was maximum (152.501 ± 0.999) for fabric dyed using Reactive Red 2 dye followed by Reactive Green 19 dyed fabric with the mean value of 150 ± 1.499. There might be crosslinking between the fibre molecules which hinder the molecular and fibrillar slippage, and stabilise the structure, thereby increasing the crease recovery angle[8].

The crease recovery angle of undyed fabric was 140 ± 0.948. This value did not differ significantly with the crease recovery angle (140.5 ± 1.999) of the fabric dyed with Reactive Red 2 dye; the crease recovery angle of the Reactive Green 19 dyed fabric which was found to be 130.05 ± 1.870. These values were significantly lower than mean crease recovery angle of undyed and Reactive Red 2 dyed fabric *(Table 3)*.

Cover factor

Data presented in *Table 3* reveals that the cover factor for undyed fabric was found to be 26.013 ± 0.540 in warp direction. Cover factor in warp direction was found to be 20.810 ± 1.324 and 22.544 ± 0.098 for the fabric dyed using Reactive Red 2 and Reactive Green 19, respectively. The values of cover factor for dyed and undyed fabrics were not significantly different from each other.

As regards the value of cover factor in weft direction, it was found to be 6.917 ± 0.870 for the undyed fabric. Value of cover factor was observed as 6.194 ± 1.087 and 7.084 ± 0.867 for the fabric dyed using Reactive Red 2 and Reactive Green 19, respectively. Following the similar trend as of warp direction, these values again did not show any significant difference.

Analyses of mechanical properties of undyed and dyed fabrics

Tensile strength and elongation were studied for undyed and dyed fabrics for evaluating the mechanical properties *(Table 4)*.

Tensile strength

Table 4 elicits that the tensile strength in warp direction for undyed fabric was 59.062 ± 0.986 kg/cm^2, which was significantly lower than the

Table 4 : Analysis of mechanical properties of undyed and dyed samples

Mechanical properties	Undyed sample	Reactive Red 2 dyed sample	Reactive Green 19 dyed sample
Warp	59.062 ± 0.986	62.388 ± 0.671	61.342 ± 0.369
CV%	3.734	2.527	1.466
Weft	42.154 ± 0.559	45 ± 0.374	43.03 ± 0.755
CV%	3.039	2.145	4.020
Warp	13.940 ± 0.050	14.933 ± 0.211	15.608 ± 0.155
CV%	0.817	3.316	2.664
Weft	20.478 ± 0.1913	18.944 ± 0.039	20.760 ± 0.916
CV%	2.409	3.940	2.230

mean tensile strength of the fabric dyed using Reactive Red 2 dye, which was found to be 62.388 ± 0.671 kg/cm^2. In case of fabric dyed using Reactive Green 19, the mean tensile strength was 61.342 ± 0.369 kg/cm^2, and this was found to be non significant with the mean tensile strength of undyed and Reactive Red 2 dyed fabric. This may be attributed to fact that reactive dyes form covalent bonds with one of the many groups in the protein fibre. However, most of the covalent bonds are with the amino groups, since these are numerous than the other bonds which increase the single yarn strength[9].

Data presented in *Table 4* reveals that the tensile strength for undyed fabric in weft direction was 42.154 ± 0.559 kg/cm^2. The value of tensile strength for fabric dyed using Reactive Red 2 dye was 45 ± 0.374 kg/cm^2, whereas the mean value of tensile strength for Reactive Green 19 dyed fabric was 43.03 ± 0.755 kg/cm^2. Increased tensile strength may be due to progressive consolidation of yarns on wet treatment that, in turn, enhanced the cloth count[10].

Elongation

Research findings revealed that the mean percent elongation of the undyed fabric was 13.94 ± 0.050 %. Between the two dyed fabric, the elongation was found to be lowest (14.933 ± 0.211 %) for Reactive Red 2 dyed fabric. The value of the percentage elongation was observed as 15.608 ± 0.155 % for the fabric dyed using Reactive Green 19; this value was significantly higher than the mean elongation of the fabric dyed with Acid Green 16 for which the observed value of elongation was 16.744 ± 0.369 %.

Elongation for undyed fabric in the weft direction was 20.478 ± 0.1913 % which decreased to 18.944 ± 0.039 % when the fabric was dyed using Reactive Red 2 dye *(Table 4)*.

Conclusion

From the results of the present study, it can be concluded that the mulberry silk waste/wool blended fabric can be dyed easily and effectively. The value addition of mulberry silk waste/ wool blended fabric, through dyeing, can lead to its diversified uses in the apparel and home textiles. This study will be helpful for the traditional dyers in improving the dye uptake and colour fastness quality of traditional textiles which will enhance their domestic and export marketability. It will also help dyers in diversifying their product range.

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Huntsman wins award for excellence in manufacturing of dyes

Huntsman, a global manufacturer and marketer of differentiated chemicals, has won the coveted award for excellence in manufacturing of Dyes and Dyestuff and remarkable contribution towards the chemical and petrochemical industry by The Federation of Indian Chambers of Commerce & Industry (FICCI), a leading Industry federation in India.

'We are extremely honoured to receive the award from FICCI for our commitment to manufacturing excellence in the Dyes and Dyestuff category. This recognition reaffirms our position as a leading global manufacturing company focused on developing sustainable solutions for the textile industry worldwide, as well as augmenting our vision of sustainability aligned to the environmental, social, and governance frameworks.' said Mark Devaney, Vice President Manufacturing and Operations Excellence, Huntsman Textile Effects.

Mark added, 'It also showcases our commitment to ensuring safe products and workplaces, efficient processes, as well as overall performance excellence. I am also particularly proud of the team at the Huntsman Baroda site. Their continuous effort for driving improvements in safety, sustainability and efficiency in relation to our manufacturing practices is commendable.' Huntsman Textile Effects brings innovations in textile dyes, chemicals and digital inks to iconic brands and retailers around the world. It operates a global dyes and chemicals manufacturing unit in a designated industrial zone of Padra in Baroda, Gujarat. The facility is spread across 62 acres and offers developing sustainable textiles solutions with advanced technology along with direct and indirect employment to over 800 people.

Antibacterial activity of Aloe vera on textiles

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Aloe vera *(Aloe barbadensis miller)* gel is the clear, jelly-like substance found in the inner part of the aloe plant leaf. Aloe latex comes from just under the plant's skin and is yellow in colour. *Aloe barbadensis miller* contains 99.3% water and 0.7% non-aqueous constituents, such as glycoproteins, polysaccharides etc. Glycoproteins speed the healing process by stopping pain and inflammation, while the polysaccharides stimulate skin growth and repair. These substances may also stimulate the immune system. It is said to be a natural cleaner, powerful in penetrating tissues, relieving pain associated with joints and muscles, bactericidal, a strong antibiotic, virucidal when in direct contact for long periods, fungicidal, anti-inflammatory, instrumental in increasing circulation to the area, breaking and digesting dead tissue, and moisturizing tissues. The strongest antibacterial effect is found in the extracts of the aloe leaves and in the gel made from the inner leaves. It contains glycoproteins and polysaccharides etc. *Aloe barbadensis miller is* one such product exhibiting antimicrobial activity. Recent advances in the field of dentistry have promoted the use of *Aloe barbadensis miller* for treatment of various oral diseases and periodontal conditions.

The application of antimicrobial textile finishes include a wide range of textile products for medical, technical, industrial and apparel sectors

There are different polysaccharides in *Aloe barbadensis miller*, such as glucomannan with different molecular weights, acetylated glucomannan, galactogalacturan, glucogalactomannan with different compositions as well as acelylated mannan or acemannan *(Fig 1)*. Acemannan is a long chain polymer consisting of randomly acetylated linear

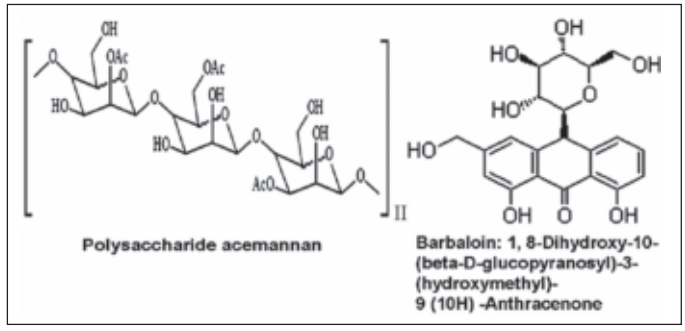

Fig 1 : Components in Aloe barbadensis miller responsible for antibacterial activity

D-mannopyranosyl units with immuno modulation, antibacterial antifungal and antitumour properties.

Ecofriendly antimicrobial finishing on cotton woven fabric using *Aloe barbadensis miller* extract at various concentrations in presence of ecofriendly crosslinking agent glyoxal by pad-dry-cure technique has been reported. Similar kind of study in presence of citric acid was also reported in the literature. Both the qualitative (AATCC 147, 1998) and quantitative (AATCC 100, 1998) evaluation was done to assess the degree of antibacterial activity of the *Aloe barbadensis miller* treated cotton fabric.

The current trend deals with the potential of biotechnology in the textile industry. Now, there is a good deal of demand for the fabric with functional/ speciality finishes in general, but antimicrobial finishes in particular to protect human beings against microbes. The application of antimicrobial textile finishes include a wide range of textile products for medical, technical, industrial, home furnishing and apparel sectors. Though a number of commercial antimicrobial agents have been introduced in the market, their compliance to the regulations imposed by EU Biocide Product Regulation (BPR) and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of US is still unclear. Recent developments on *Aloe barbadensis miller* have opened up new avenues in this area of research.

The present investigation aims at developing an ecofriendly natural herbal finish from *Aloe barbadensis miller* extract for textile applications. An extensive study was conducted to assess the antibacterial effectiveness of the *Aloe barbadensis miller* by employing standard test methods, and the findings are discussed in this paper.

Materials and methods

Fabric

Bleached cotton fabrics with the following specification were used:

Ends per cm - 85
Picks per cm - 95
Weave - Plain
Count - 13 x 8 Ne, carded.

Chemicals

Citric acid and methonal.

Extraction

Aloe barbadensis miller gel was extracted from Aloe vera plant available at the institute campus.

Equipment

Padding mangle, launder-o-meter, SS Extractor and curing chamber.

Experimental procedure

500 gm of grinded *Aloe barbadensis miller* leaves were taken into a jacketed SS extractor and subjected to steam purging which helps in removal of volatile impurities such as pesticides. The desired solvent was added in the ratio of 1:4 to 1:6 of *Aloe barbadensis miller* solvent. Extraction was done for 2-4 hr at temperatures of 40-45°C. The mixture was constantly stirred and samples of decoction were taken out at regular intervals to check the concentration of the active material in the extract. When the concentration level becomes almost constant, the mixture was drained and filtered using a centrifuge. The methanolic crude extract was treated with 1% aqueous hydrochloric acid for 30 min after removal of neutral impurities with methanol which makes the extract in aqueous form. The extract was washed with water at 90°C which removes the residual trace of methanol present in the extract. The filtrate (extract) is transferred to a storage vessel.

Antimicrobial finish application

The fabrics were immersed in the 1, 3 and 5 gm/l concentrations of methanol extracted *Aloe barbadensis miller* for 5 min and padded individually in the presence of citric acid to maintain 5.5 pH. It was again immersed in the solution for another 5 min and repeated the squeezing process to get a wet pickup of 80% on weight of the fabric. The fabric was then dried at 80°C for 3 min and cured at 110°C for 2 min on a lab model curing chamber.

Evaluation

Antimicrobial assay

Agar well diffusion method was used to analyse antimicrobial properties of samples. The medium was prepared on petri dish. The samples were punched, and a small circle of samples were placed in the medium and kept undisturbed for 24 hr. The zone formation indicates the capability of antimicrobial action of the *Aloe barbadensis miller* both in the original solution and cotton samples treated with that solution.

The bacteria were swabbed uniformly across a culture plate. A filter-paper disk, impregnated with the compound to be tested, was then placed on the surface of the agar. In agar well diffusion method, the material required for process had been kept under UV treatment for 15 min. After UV treatment, the petri plates were labelled properly and streaked with bacterial strain using cotton swab from left to right and vice-versa. Then, by using well puncture, holes were created and *Aloe barbadensis miller* solution was injected.

Fourier-transform infrared spectroscopy (FTIR)

FTIR (Fourier Transform Infrared Spectroscopy) test of *Aloe barbadensis miller* was carried out on FTIR instrument, ABB Bomem, MB 3000, Canada available in Bannari Amman Institute of Technology, Sathyamangalam, Tamil Nadu, India.

Gas chromatography-mass spectrometry (GC-MS)

Aloe barbadensis miller was analysed by using GCMS (Gas Chromatography and Mass Spectrometry). It was tested at VIT University, Chennai. India. Perkin Elmer, Clarus 680, US was used in the analysis and employed a fused silica column, packed with Elite-5MS (5% biphenyl, 95% dimethylpolysiloxane; 30

m x 0.25 mm ID x 250 µm df) and the components were separated using helium as carrier gas at a constant flow of 1 ml/min.

Whiteness index

The treated samples were tested in a reflectance spectrophotometer (Gretag Macbeth) with D65 light using Colour icontrol software interfaced with IBM PC.

The CIE Whiteness Index value (CIE WI) was determined for the fabrics using AATCC test method 110-1995.

Whiteness Index was measured by using the CIE Whiteness index using D65 for 10° observer. The calculation for CIE Whiteness is:

$W_{CIE} = Y + 800 (x_o - x) + 1700 (y_o - y)$, where

Y is the tri-stimulus value for the sample;

x and y are the colour coordinates for the sample as this calculated using the Illuminant/observer condition; and

x_o and y_o are the colour coordinates of the achromatic point.

Antimicrobial activity assessment of treated cotton fabric

The samples treated with *Aloe barbadensis miller* are tested for analyzing its antimicrobial properties. The medium was prepared on petri dish. The bacteria used were gram negative (Escherichia coli) and gram positive bacteria (Bacillus thuringiensis). The samples were punched and a small circle of samples were placed in the medium and kept undisturbed for 24 hr. The zone formation indicates the capability of antimicrobial action of *Aloe barbadensis miller* over cotton fabric.

Qualitative assessment by Agar diffusion method (ISO 20645) was used to evaluate antimicrobial activity. The dyed fabric and undyed control fabric samples were placed in intimate contact with AATCC bacteriostatis agar that was previously inoculated with inoculums of test organisms in petridishes. The two test organisms used in this study were *Escherichia coli* and *Bacillus thuringiensis*. The plates were incubated at 37°C for 18-24 hr. After incubation, a clear area of uninterrupted growth underneath and alongside the test material indicates antibacterial effectiveness of the fabric.

Results and discussion

Fourier transform infrared spectroscopy

FTIR spectrum of *Aloe barbadensis miller* is shown in *Fig 2*. Analysis of the spectra is done and the chemical groups identified at different frequency range are shown in *Table 1*. It has been observed from the analysis of the IR spectra that different functional groups are present in the *Aloe barbadensis miller* such as hydrogen bonded alcohol, phenols, alkanes, alkenes, alcohol, ethers, carboxylic acid and ester. The spectrum shows major peak at 3323.35 cm^{-1} and the other peaks are at 2947.25, 2835.36, 1653.00, 1448.54, 1409.96, 1112.93, 1014.56 and 567.07 cm^{-1}. It is observed that the band 3323.35 cm^{-1} corresponds to the hydrogen bonded alcohol and phenols. The bands at 2947.25 cm^{-1}, 2835.36 cm^{-1}, 1448.54 cm^{-1} and 1409.96 cm^{-1} correspond to C-H stretching of alkanes. The band at 1653.00 cm^{-1} corresponds to C=C stretching. The bands at 1112.93 cm^{-1} and 1014.56 cm^{-1} could be related to C-O vibration of alcohol, ethers, carboxylic acid and ester. The band at 567.07 cm^{-1} corresponds to C-H bonds of alkenes.

Gas chromatography mass spectrometry

The chromaticity diagram obtained from the GC-MS analysis of *Aloe barbadensis miller* is shown in *Fig 3*.

GCMS analysis of the chromatogram has been done and the name of the chemical compound, its structure and the molecular weight of

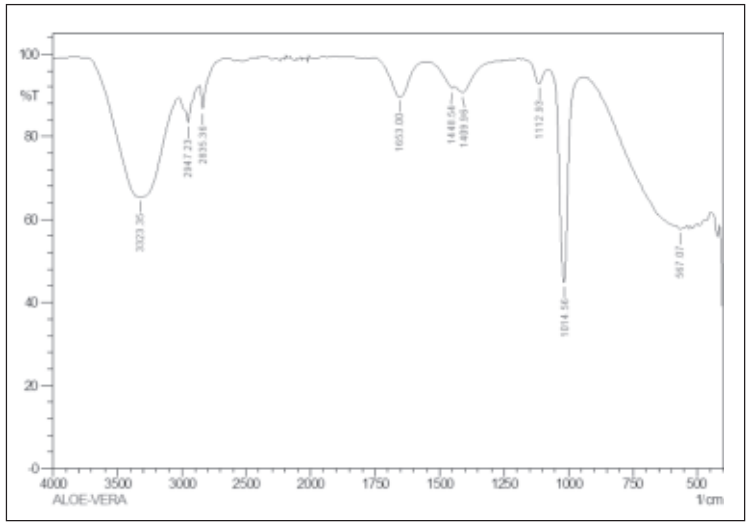

Fig 2 : FTIR spectra of Aloe barbadensis miller

Table 1 : Analysis of FTIR spectra

Bond	Frequency range	Type of compound	Intensity
O-H	3323.35	Hydrogen bonded alcohol, phenols	Variable, sometimes broad
C-H	2947.25	Alkanes	Strong
C-H	2835.36	Alkanes	Strong
C=C	1653.00	Alkenes	Variable
C-H	1448.54	Alkanes	Strong
C-H	1409.96	Alkanes	Strong
C-O	1112.93	Alcohol, ethers, carboxylic acid, ester	Strong
C-O	1014.56	Alcohol, ethers, carboxylic acid, ester	Strong
C-H	567.07	Alkenes	Strong

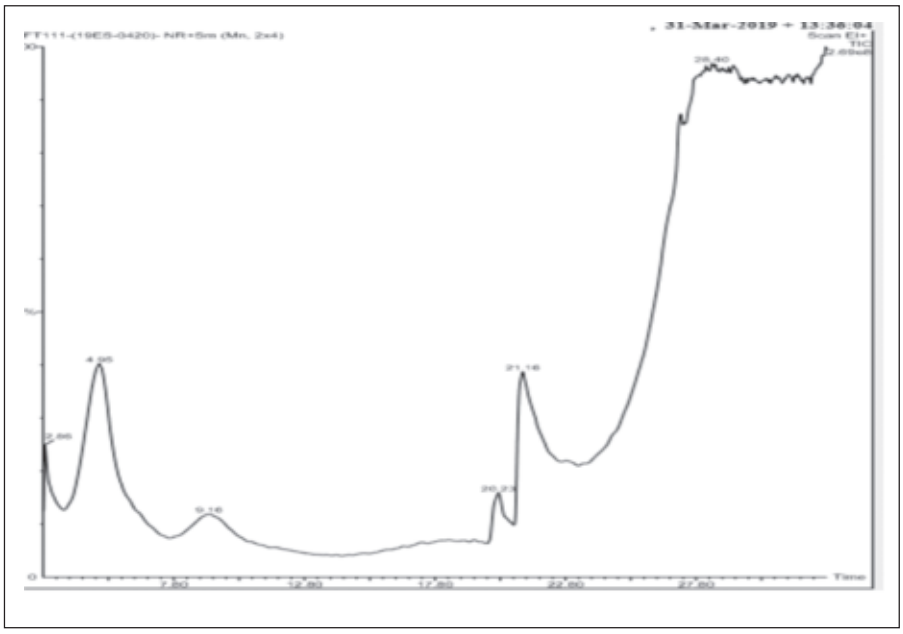

Fig 3 : Chromaticity diagram of Aloe barbadensis miller

Table 2 : GCMS analysis of Aloe barbadensis miller

Name of Compound	Room Temp.	Chemical	Mol. wt.	Structure
6-Nitroundec-5-ene	2.86	$C_{11}H_{21}O_2N$	199	
1-hexyl-2-nitrocyclohexane	4.6	$C_{12}H_{23}O_2N$	213	
2-Tetradecanol	9.16	$C_{14}H_{30}O$	214	
Methoxyacetic acid	20.23	$C_{16}H_{32}O_3$	272	

the identified compounds are shown in *Table 2*. Overall, four different compounds were identified. The molecular weight of such compounds according to the structure varies from 199 to 272. The lowest molecular weight compound, 6-Nitroundec-5-ene, has the chemical structure $C_{11}H_{21}O_2N$ and one of the highest molecular weight compounds were found as methoxyacetic acid, 3-tridecyl ester with the chemical structure $C_{16}H_{32}O_3$.

Table 3 : Whiteness index values

Fabric	Whiteness index
Original fabric	122.80
1 gm/l fabric	103.58
3 gm/l fabric	95.85
5 gm/l fabric	87.88

Whiteness index

Table 3 shows the whiteness index value of four samples in which the 5 gm/l *Aloe barbadensis miller* treated fabric has lower value when compared to the original bleached fabric and 1 gm/l and 3 g/l *Aloe barbadensis miller* treated fabrics. With increase in concentration of *Aloe barbadensis miller*, the fabric samples became slight yellowish due to the presence of hydrogen bonded alcohol, phenols, alkanes, alkenes, alcohol, ethers, carboxylic acid and ester in the chemical structure as detected in FTIR study.

Antimicrobial activity assessment

Aloe barbadensis miller treated samples were subjected to antimicrobial testing by using gram negative bacteria *(Escherchia coli)* and gram positive bacteria *(Bacillus thuringiensis)*. Zone of inhibition of gram negative and gram positive bacteria is shown in *Fig 4*.

As observed from *Fig 4*, 1 gm/l, 3 gm/l and 5 gm/l show 12 mm, 15 mm and 17 mm zone of inhibition, respectively, for gram negative bacteria. The original stock solution of *Aloe*

Fig 4 : Zone of inhibition against gram negative (left) and gram positive (right) bacteria on various samples

barbadensis miller has zone of inhibition of 20 mm for gram negative bacteria.

It is also depicted in *Fig 4* that 1 gm/l, 3 gm/l and 5 gm/l show 10 mm, 13 mm and 15 mm zone of inhibition, respectively, for gram positive bacteria. The original stock solution of *Aloe barbadensis miller* has zone of inhibition of 19 mm for gram positive bacteria.

The fabric exhibited high antimicrobial property at 5 gm/l concentration. This is due to the fact that antimicrobial agent gets attached to the substrate through bond formation on the surface. The attached antimicrobial agent disrupts the cell membrane of the microbes through the physical and ionic phenomenon. The finishing agent inhibits growth of micro-organisms by using an 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.

Exhibition of less zone of inhibition for gram positive bacteria *(Bacillus thuringiensis)* is the reflection that *Aloe barbadensis miller* does show less antimicrobial activity against this bacterium. Possible causes of such phenomenon have been discussed in the literature. The microbes, such as bacteria, viruses, fungi, and parasites, are living organisms that evolve over time. Their primary function is to reproduce, thrive and spread quickly and efficiently. Therefore, microbes adapt to their environments and change in ways that ensure their survival. If something stops their ability to grow, such as an antimicrobial, genetic changes can occur that enable the microbe to survive. There are several ways this happens due to natural biological causes such as selective pressure, mutation, gene transfer, societal pressure, inappropriate use etc.

Conclusion

Aloe barbadensis miller was characterised by FTIR, GCMS, whiteness index and antimicrobial activity. The FTIR spectrum shows major peak at 3323.35 cm^{-1} and the other peaks are at 2947.25, 2835.36, 1653.00, 1448.54, 1409.96, 1112.93, 1014.56 and 567.07 cm^{-1}. In GC-MS analysis, it is found that the lowest molecular weight compound, 6-nitroundec-5-ene, has the chemical structure $C_{11}H_{21}O_2N$ and one of the highest molecular weight compounds is found as methoxyacetic acid, 3-tridecyl ester with the chemical structure $C_{16}H_{32}O_3$. With increase in concentration of *Aloe barbadensis miller,* there is reduction in whiteness index and fabric samples became slight yellowish due to the presence of hydrogen bonded alcohol, phenols, alkanes, alkenes, alcohol, ethers, carboxylic acid and ester in the chemical structure as detected in FTIR study. The fabric was treated with *Aloe barbadensis miller* solution and evaluated for antimicrobial activity against gram negative bacteria *(Escherchia coli)* and gram positive bacteria *(Bacillus thuringiensis)* by agar Well Diffusion method. Zone of inhibition measured for the different treated fabric indicates that *Aloe barbadensis miller* solution on cotton fabric performs as a good antibacterial agent against gram negative bacteria *(Escherchia coli)* and gram positive bacteria *(Bacillus thuringiensis)* and imparts antibacterial property to the fabric. This gives opportunity for the apparel and textile industry to use *Aloe barbadensis miller* treated fabric in developing innovative and hygienic apparel products in the future.

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AD

Synthesis and chemical processing of polybenzimidazole fibres

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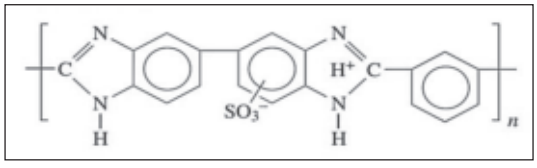
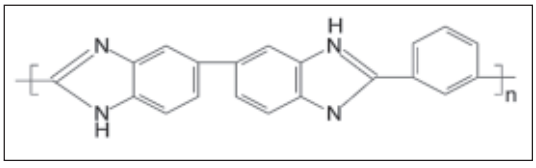
Polybenzimidazole (PBI) is a high-performance polymer that has arisen recently and is acknowledged because of its enormous thermal stability and chemical resistance[1]. It possesses the highest glass transition temperature of 425°C among all commercially produced organic polymers, high temperature of decomposition (500-600°C), strong oxidation tolerance and, at cryogenic temperatures, it retains excellent strength. PBI has wide applications due to its superb thermal and mechanical properties at high temperatures[2]. After the 1967 Apollo spacecraft crash, AFML and NASA investigated PBI fibre as a non-combustible material for flight suits that could save ample money in oxygen-well-off conditions for optimum safety for astronauts or pilots[3,4]. The



Scheme 1 : Poly (2,2¢-(m-phenylene)-5,5¢-dibenzimidazole)[1]



Scheme 2 : Sulphonated PBI[2]

ladder-like shape of poly(2,2'¢-(m-phenylene)-5,5'¢-dibenzimidazole) causes an increase in thermal stability *(Scheme 1)*. High conjugation inside the polymer structure imparts an orange colour that cannot be wiped out on bleaching.

To improve the flame resistance of the fibre, most of the PBI fibres are processed with sulphuric acid *(Scheme 2)*. Better flame retardancy can be obtained by substituting sulphuric acid with phosphoric acid.

Importance

Polybenzimidazole (PBI) polymer, which has a remarkable thermal and chemical resistance, is one of the greatest significant polymer classes for high-performance textile enterprises. A PBI fibre is made of a long chain aromatic polymer having fused imidazole structure that might be utilized in specific fabric forms together with fibres, fabrics, and nonwovens for numerous precise purposes. Defensive technical textiles and environmentally friendly textiles which incorporate fuel cells, carbon capture systems and osmosis strategies are the principal application regions of PBI fibres[5-8].

Polybenzimidazole (PBI) polymer is one of the greatest significant polymer classes for high performance textile enterprises

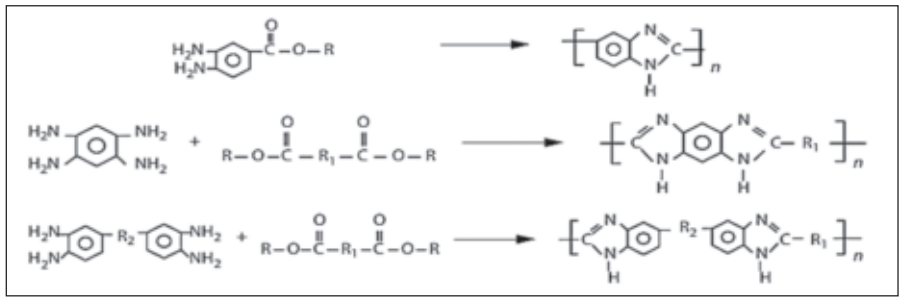
The PBI is made of tetraaminobiphenyl and diphenyl isophthalate, which is shaped by dry spun as a solvent from an imbecile with dimethylacetamide, bringing about an unnecessarily chemical reactive high-performance fibre that does not burn in air. When presented to fire, it has no melting point and does not spill. Even when exposed to flame or intense heat, the PBI fibre and fabrics retain their resilience, dimensional equilibrium, and considerable

strength without embrittlement. In extreme cases, it emits no smoke. It fits well on traditional cloth machines, with manufacturing properties identical to polyester. It may be used or blend with other fibres in 100% shape, like cotton; it has high moisture recovery and sporadic modulus with consolation residences[9]. Celazole PBI (polybenzimidazole) is a linear heterocyclic polymer that has remarkable strength. An engineering thermoplastic usually noted for its somewhat high glass transition temperature (T_g) of 427°C, broadly diagnosed for its excessive strength, high modulus, and solubility in few solvents. With temperature, pressure, and time, it can be moulded for use in high overall performance applications. It might be aggravated with other polymers, or cast directly into a coating, film or membrane. Its specific structure provides homes, unlike different engineering resins[10]. PBI (polybenzimidazole) is a high-performance polymer that is thermally stable. PBI is used in the different applications including plastics, sterile resin and composites. The synthesis of PBI and fibre and moulded resin characteristics and packages and the new advances in the era of composite manufacturing[11,12] are explored.

Synthesis of PBI

Conventional method

The first aliphatic PBIs were invented by Brinker and Robinson while, on the contrary, Vogel and Marvel revamped their strategy and were able to synthesize the first aromatic PBIs[13]. From that moment on, many techniques have been invented for synthesizing PBIs[14-16]. Regarding the thermal properties, it had been found as illustrated several types of PBIs[17]. The general path for synthesising PBIs from aromatic tetraamines (bis-o-diamines) and dicarboxylates is seen in *Scheme 3*[18]. Generalised monomers are seen on the left side, while the final PBIs are on the right-hand side. Both R1 and R2 are aromatic and aliphatic, and can contain numerous groups, such as ether,



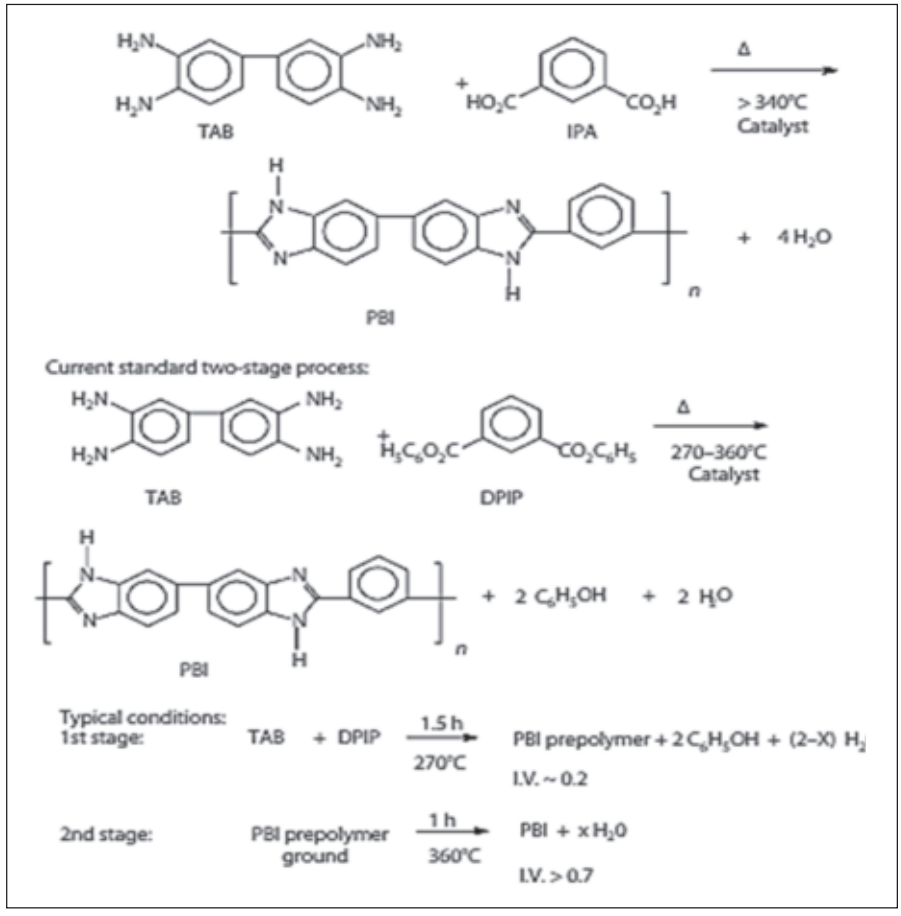
Scheme 3 : Polybenzimidazoles synthesized from different monomers[18]

ketone, sulfone etc. Phenyl groups are seen in *Scheme 3*. The use of naphthyl groups can be substituted.

General case

Poly[2,2'-(m-phenylene)-5,5'-bibenzimidazole] is the commercially active PBI that has gained the most interest, and it is also synthesised in two ways: one is a traditional two-stage reaction and the other is a single-stage reaction *(Scheme 4)*. It can be proceeded by either melt or solution polymerization.

In *Table 1*, the main difference between these two strategies is outlined. Either melt or solution polymerization of PBI takes place and the mechanism and reaction kinetics were noticed, and its very important to state out that polymerization should take place under anaerobic circumstances, otherwise aromatic amines appear to form oxides. It appears that PBI produced under nitrogen conditions has a wagered quality (less gel) than that produced in a vacuum. A voluminous bubble is formed due to the entrapment of gaseous by-products due to a two-stage



Scheme 4 : Two routes to synthesize PBI[19]

Table 1 : Significant variations in polymerizations through single and two stages[19]

	Single-stage polymerization	Two-stage polymerization
Major monomers (DPIP)	TAB and Isophthalic acid (IPA)	TAB and Diphenyl-isophthalate (DPIP)
Reaction temperature and time	400°C for 1 hr	1st stage: 270°C for 1.5 hr 2nd stage: 360°C for 1 hr
By-products	Water	Phenol and water
Anti foaming agent	No	Yes
Catalysts	Needed	Optional
Cost	Medium	High

polymerization scheme. By raising the internal pressure of the reactor to 2.1-4.2 Mpa (300-600 psi) or by adding an antifoaming agent, this foam may be completely suppressed. In single-stage polymerization, foam is not formed in excess amount. In quick, severe purity is required. The key impurities in 3,3',4,4'-tetraaminobiphenylphenyl are triaminobiphenyl (~2.9%) and various extraneous impurities (0.2%). Throughout polymerization, the former can also barely affect chain growth, while the latter may also result in branching and gelation. These impurities must be limited to trace quantities.

Formation of fibre

Dope preparation

Dry spinning is the best way for PBI fibre preparation, but it is also possible to use wet spinning and dry-jet wet spinning. PBI gets dissolved in only a few solvents such as sulphuric acid, dimethylformamide, dimethylsulfoxide, and DMAc, but DMAc is still preferred[20,21]. LiCl (1-5 wt%)or zinc chloride ($ZnCl_2$) (based on the weight of DMAc) is applied to the spinning dopes consisting of 25-26 wt% PBI and have viscosity calculated around 2000-3000 poise at room temperature to prevent dopes from the formation of gel or phasing out. LiCl is mostly preferred because of leaching during the subsequent washing process.

Dry spinning process

Three fundamental stages are important for the dry spinning process: a spinneret collection, a circulated dry column, and a take-up unit. With a diameter of approximately 75-100 µm, a spinneret has 50-1000 holes and the take-up speed ranges from 150-500 m/min. In the dope, design improvements are made and tested by a gear pump at 70-110°C to the spinneret, holding the temperature of the jet face at around 100-150°C. Therefore, much of the vaporization of DMAc takes place with the formation of the fibre. The method is carried out by the circulation of N_2 at a temperature of around 200-220°C in a dry chamber of 6.6 m in length. In addition, the thorough cleaning of the as-spun fibre with water eliminates the residual DMAc. The as-spun fibre is weak, with a hardness of about 0.11-15 N/tex (1.3-1.7 gm/day), a modulus of about 2.6-4.4 N/tex (30-50 gm/day) and a split elongation of about 100-120%.

Hot drawing

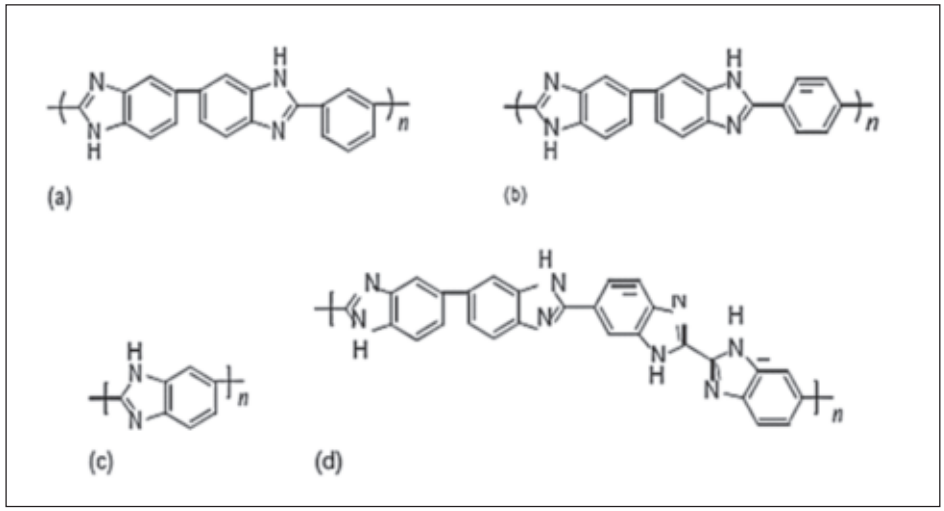
By running the dried laments through the heat muffle furnace at about 400-440°C depending on the velocity, the as-spun fibre is hot-drawn to increase the fibre properties. The distorted rolls before and after the muffle furnace perform the job of preserving the laments precisely at various velocities as shown in *Scheme 5*. Spin-line stress is responsible for the elongation of the laments and for arranging the polymeric structure within the material. The initial module rises from 3.3 to 11 N/tex (36 - 122 gm/day) while the draw ratio ranges from 1 to 4; and elongation at break decreases from 110% to 18%.

Sulphonation and stabilization

The drawn PBI yarn is acid-treated and stabilized to form a salt with the imidazole ring structure to protect PBI fabrics from shrinkage during burning. Sulphonation is carried out in a sulphuric acid bath (2%) for 2 hr at 50°C by dipping a hot-drawn PBI thread. Stabilisation of sulphuric acid-treated fibre is carried out by moving it again through a heat muffle furnace of approximately 380-440°C depending on the speed of processing. During treatment, the same shrinkage of a PBI fibre is reduced from >50% to <10%.

m-PBI

Poly(2,2'-m-phenylene-5,5'-bibenzimidazole) or m-PBI, as can be



Scheme 5 : Separate polybenzimidazole chemical structures[22]
(a) m-PBI, (b) p-PBI, (c) AB-PBI, and (d)i-AB-PBI

seen in *Scheme 5a*, is the first and most extensively studied PBI/PA complex. In 1995, this synthesis was initiated by Wainright et al based on separate methods of synthesis and characterization[22]. It was discovered during this analysis that a PBI membrane could be cast from a solution of DMAc, imbibed with PA, and maintains conductivity at high temperatures. This analysis eventually led to the fact that PBI could be used in fuel cells as a membrane. Many workers have also been focusing on characterizing m-PBI as well as other variants of PBI.

p-PBI

One of the highest performing PBI membranes for use in fuel cells[23] is poly(2,2'-(p-phenylene)5,5'-bibenzimidazole) or p-PBI (Scheme 5b). It was observed that p-PBI was hard to process due to the stiff nature of its backbone. High-molecular-weight (4.2 dL/gm) p-PBI was synthesized by the US Air Force Materials Lab in 1975, but the process took a long time to manufacture the high-molecular-weight polymer, and p-PBI was left unstudied for some time because it could not be spun into fibres as easily as m-PBI.

AB-PBI

Poly(2,5-benzimidazole) or AB-PBI *(Scheme 5c)* is the simplest known PBI structure that can be prepared using commercial monomers[24]. It is prepared using only the 3,4-diaminobenzoic acid monomer which comprises of all the property of diamine and acid. Also, the homopolymer, copolymers, crosslinked polymers and substituted polymers containing AB-PBI have been observed[25], which shows that AB-PBI has been prepared through both conventional imbibing and the PPA process.

Chemical properties

Tribological high-temperature properties of PBI

High-Performance Fibre (HPPS) and its blends are lightweight, chemically neutral, and thermally robust and self-lubricating, rendering them an outstanding performance under harsh conditions for tribological applications. It also makes the use of components made from HPPs in dry sliding conditions where lubrication is not possible or difficult to apply[26]. Tribological high-temperature properties of polybenzimidazole (PBI) then again, polybenzimidazole (PBI) has a 427°C glass transition, which allows it to stand at high-temperature conditions. It has a higher modulus and hardness than other HPPs as well. Thus, at room temperature, it has good scratch resistance against a stainless steel indenter[27]. The behaviour of PBI under a load, temperature range (100-200°C) and the friction coefficient was found to be reasonably independent of load before the limiting pressure velocity (PV) value is achieved, after which the friction coefficient reduces[28]. The PV value can be also used as a measure of the amount of frictional heat produced during rubbing and the function of average touch pressure (P)[29-32]. When the PV limit was achieved, then the friction coefficient value falls which causes frictional heating and the consequent softening of the polymer at the rubbing interface. The temperature rises with the decrease in PV value. PV is not a property of materials; by modifying the working state, it adjusts. The wear rate of amorphous polymers is at its most reduced not long before the glass transition, and afterward rises sharply[33]. At the interface, the bad wear made over a critical temperature is connected with adhesive wear. The creation of a transfer layer is favoured by the strong adhesion of the polymer to the counter surface. These effects are distinguished by the unambiguous effect of load and temperature on the tribological properties of polymers due to their consequences for the material transfer process and the properties of the material transferred[34,35].

The self-lubricating action of the polymer as polymers are rubbed against steel counter surfaces is known as a transfer layer[36]. According to thickness, coverage and homogeneity, the transfer layer is defined. An effective transfer layer is generally described as a thin, uniform and solid layer of material that has been transferred by adhesive wear from one surface to another[37]. The creation of transfer layers is related to the arrangement of polymer and polymer molecular structures. The formation of the transfer layer is dependent on the induced frictional heat; in-situ thermography techniques were used to analyse the distribution of temperature inside tribological contacts and to compare it with the thickness and morphology of the transfer layer.

PBI has good efficiency at high pressures under non-lubricated conditions at the same temperature range, with a T_g of 427°C. The basic purpose of this analysis is to recognize the influence of the load at high temperatures on the tribological activity of PBI. PBI specimens were inspected at contact pressures of upto 56 MPa and temperatures of 280°C[38,39]. For the wear conduct of the polymer just as the construction of the transfer layer on the counter surface, the tribological properties of the PBI-steel structure have been explored. To determine frictional heat generated during rubbing, in-situ IR thermography of PBI-sapphire contacts was used. Through the creation of the transfer layer[40-48], the temperature distribution inside the touch was established.

Flame and thermal stability

The PBI fibre retains its physical and mechanical properties during and after exposure to a large range of temperatures. Fibre is exposed to a wide range of temperatures conveyed by physical qualities such as conservation of strength, mass and length. PBI shows remarkable high temperature stability. Any of these observations are summarised by *Figs 1 & 2 and Table 2*[49]. The PBI thermogravimetric (TGA) study shown in *Fig 2* shows that PBI

Table 2 : Thermal stability of PBI fibre[49]

Temperature (°F/°C)	Useful life
1100/600	3-5 sec
840/450	5 min
750/400	1 hr
625/330	24 hr

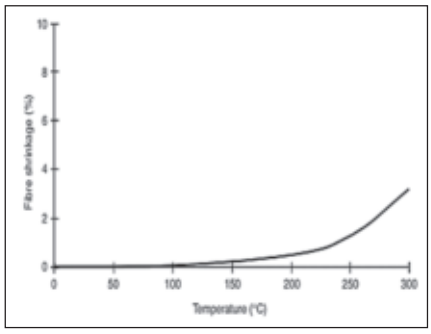


Fig 1 : Thermal linear shrinkage of PBI fibre after 24-hr exposure[49]

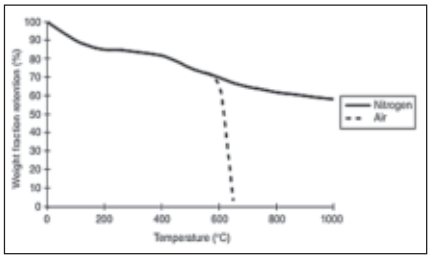


Fig 2 : Thermogravimetric analysis of PBI fibre in air and nitrogen[49]

maintains integrity in the air upto 450°C and in nitrogen over 1000°C[50].

Heat release and emission of smoke and gas

The release of heat is an indicator of how much material energy contributes to pyrolysis and the burning reaction. This property is added so that the safety substance must not add to the threat by increasing the amount of fuel available and the material used to shield people from the blaze. PBI fabric, as calculated by the US Federal Aviation Agency, has negligible heat release (FAA). In addition, since PBI fibre does not burn in air, it emits little to no smoke and off-gases up to its decomposition temperature, the two-minute average heat release is less than 10 kw/m^2. For other typical high-temperature fibres, the specific optical smoke density of PBI is 2 compared to a value of 3 to 8[51-53].

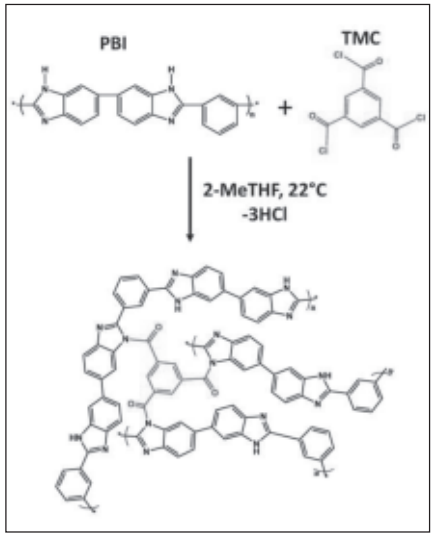
Chemical resistance

The chemical resistance of the PBI fibre to inorganic acids, bases and organic chemicals is far better than other fibres. Chemical resistance is expressed by exposing particular substances to PBI fibres and then measuring the fibre's strength retention after exposure. This tolerance to some of the more typical chemicals is shown by the findings in *Fig 2*.

Chemical processing

PBI and TMC crosslinking

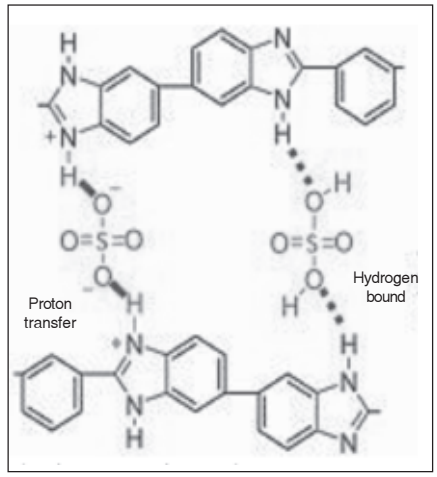
The possible crosslinking reaction between trimesoyl chloride (TMC) and PBI in anhydrous 2-methyl tetrahydrofuran (2-MeTHF) at 22°C is shown in *Scheme 6*. On PBI imidazole rings, the acyl chloride groups of TMC react with the secondary amines, form tertiary amide groups, thereby crosslinking the chains of PBI. Zhu et al stated that crosslinking reaction rate of PBI depends on the degree of swelling of PBI in THF[54]. The 2-MeTHF sorption in non-crosslinked PBI is then determined by immersing PBI membranes (cast without nonwoven) in 2-MeTHF and observing their changes in mass at different immersion periods to establish a proper crosslinking duration. At the immersion time of t, the mass uptake of 2-MeTHF by the PBI membrane is called M_t and the equilibrium mass uptake (after one week of immersion) is referred to as M_{inf}. In glassy polymeric films, there are usually two levels of solvent sorption. Fickian sorption, which can be defined by an essentially linear segment, follows the initial step. The Non-Fickian sorption is the second stage. Non-Fickian sorption occurs when the polymeric matrix will be relaxed[55,56].



Scheme 6 : Chemical crosslinking reaction between PBI and TMC[57]

Chemical interactions between PBI and H_2SO_4

Polyprotic acid doping of PBI membranes is used to enhance their conductivity and reduce swelling in fuel cell applications[58,59]. In gas membrane preparation, the acid doping technique has also been used to tighten the PBI microstructure and increase its ability to sieve size[60]. The possible interactions of PBI and sulphuric acid are illustrated in *Scheme 7*. Two sulphuric acid molecules may be involved in each PBI repeating unit, which results in a strongly entangled polymer network. Therefore, because of the heavy hydrogen bonding, the acid-doped PBI hollow fibres can have strong solvent resistance characteristics. More specifically, using a very low sulphuric acid concentration, doping may occur at room temperature, which encourages the process of alteration.



Scheme 7 : Possible interactions between PBI and H_2SO_4[61]

Electrospinning of PBI and PBI/silica composites

PBI is only soluble in very limited number of solvents. High-boiling polar aprotic solvents, such as N-methyl-pyrrolidone (NMP) and N-dimethyl acetamide (DMAc), as well as mineral acids (H_2SO_4, polyphosphoric acid) and hefty organic acids, such as trifluoro-acetic acid (TFA), are used as common solvents. Using solution casting of the

respective PBI solutions, membranes may be prepared. Spinning them into fibres is another conventional method of converting polymers. The electro-spinning approach to the manufacturing of PBI/silica composite materials has recently been adopted.

Mixed polycondensation PBI with up to 25% of silica nanoparticles (Ludox HS-40) and electrospun were the DMAc solutions. Using a revolving counter electrode, it was possible to obtain nonwoven electron microscopy, SAXS, and IR spectroscopy investigations of the fibres exposed that the silica nano-particles were also combined into the fibres. By hot pressing the nonwovens at approxi 300°C *(Fig 3)*, the prepared nonwovens could be transformed into very thick membranes. Using p-xylene dichloride as a crosslinker, this step can also be paired with a crosslinking step of partially directed fibres. Typical fibre diameters were between 150 and 300 nm. To date, the quantity of silica integrated has been too limited to be considered as a template for the manufacture of mesoporous PBI fibers to produce productive percolating porosity. In addition, the use of other inorganic particles (conducting proton itself) to produce a homogenous nonwoven membrane will be considered.

Synthesis of different types of PBIs

Requirement of different chemicals for synthesis of different types of PBI is mainly powdered polybenzimidazole, iodomethane, 1-methyl-2-phenylbenzimidazole (MBI), and 2-phenylbenzimidazole (BI). The route of synthesis is depicted in *Scheme 8*.

N-lithium salt of polybenzimidazole

A total of 3 gm of PBI was dissolved in 200 ml NMP in a 500 ml round bottom flask. To dissolve the PBI under nitrogen, the mixture was refluxed for 2 hr. The PBI solution was then purified to extract undissolved PBI at room temperature, which was less than 5%. The PBI N-lithium salt was obtained by applying to the PBI solution 0.25 gm of lithium hydride, heating to 80°C and stirring for 18 hr under nitrogen.

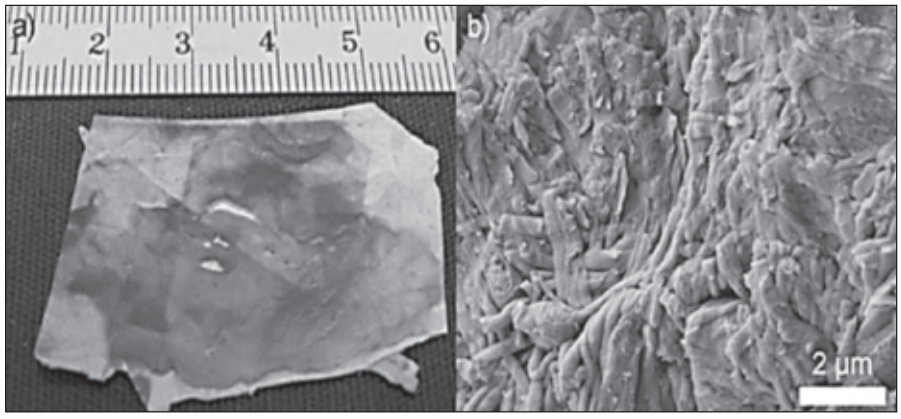


Fig 3 : a) Image of the hot-pressed membrane, scale in centimetres; b) SEM image of the hot-pressed membrane, showing the dense packing of the original fibres [62]

Poly (N methylbenzimidazole) (PMMBI)

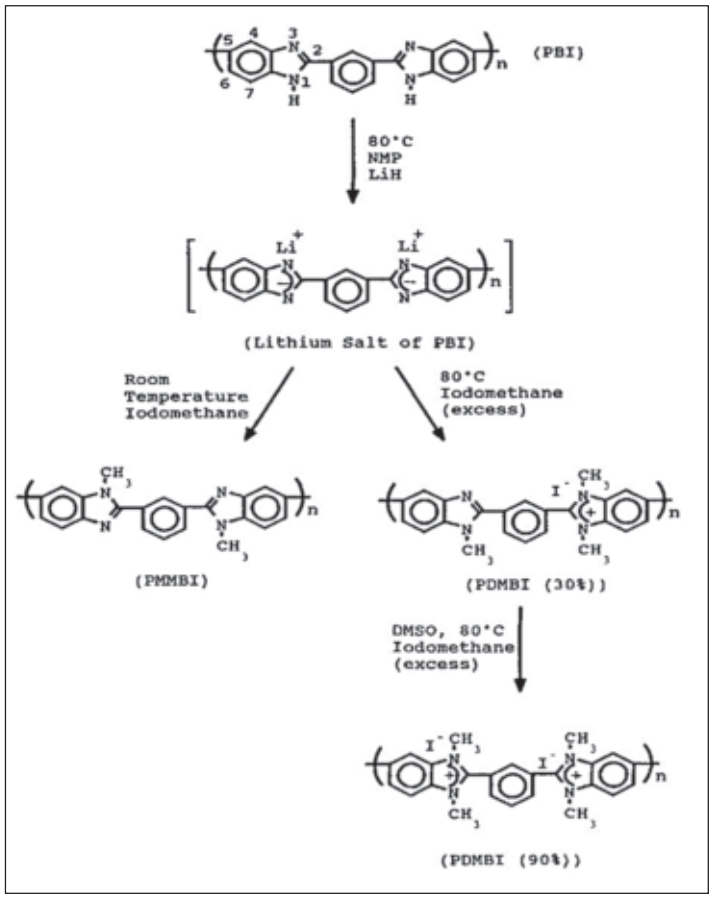
The freshly made N-lithium salt from 3 gm of PBI was cooled to room temperature. 2.76 gm of iodomethane was added to the PBI solution and stirred for 6 hr at room temperature. To extract excess lithium hydride, the solution was then purified. In acetone, PMMBI was precipitated and then purified by dissolving in NMP and precipitating in acetone twice, followed by 3 hr acetone extraction in Soxhlet to clear the trapped NMP solvent. At 100°C overnight, the polymer was cured in a vacuum oven. The product was characterized by 300 MHz proton NMR, FTIR, viscometer and TGA.

Poly (N1,N3-dimethylbenzimidazolium) iodide (PDMBI)

Approximately 9 gm of iodomethane was applied dropwise to the freshly developed N-lithium salt of PBI in NMP under the nitrogen atmosphere for a period of 30 min at 80°C. The solution was stirred after the addition of iodomethane until the yellow PDMBI had completely precipitated. The polymer was extracted by filtration. PDMBI was further purified by dissolving in DMSO and precipitating three times in a mixture of toluene and acetone, followed by washing for 3 hr with water and removing Soxhlet in acetone. The solids were dried at 100°C overnight in a vacuum oven. The 300 MHz proton NMR study revealed 100% methyl group replacement on N1 and about 30% methyl group replacement on N3 (PDMBI, 30%). The Volhard 13 method of iodide titration gave 21±1% iodide by weight, which was more than expected, and some impurities (LiI) may have created the excess iodide.The resulting polymer did not produce iodide counter-ions if the crude PDMBI (30%) solution was treated with methanol or water to decompose excess lithium hydride before precipitation, and may instead contain any methoxide or hydroxide counter-ions. By applying excess iodomethane to a DMSO solution of PDMBI (30%) at 80°C and stirring for 20 hr in a closed device, further methylation on N3 could be carried out.The substance was then purified three times by acetone precipitation. Approximately 100% substitution on N, and above 90% substitution on N3 is seen by the NMR study. By the Volhard process, iodide ion titration indicated 31±1% of iodide by weight, corresponding to more than 70% of iodide by mole.

N1,N3-dimethyl-2-phenylbenzimidazolium salt (DMBI)

1 gm (mp 96±1°C) of 2-phenyl-1-methylbenzimidazole was dissolved in 10 ml of NMP and heated to 80°C. Dropwise, 2 gm of iodomethane was added, and it was mixed for roughly 6 hr. The solvent was extracted at 120°C by vacuum distillation. The solid DMBI (mp 275±1°C) was washed with acetone and blended with acetone, and NMP was recrystallized. The iodide



Scheme 8 : Structures of polymers and their methylation reactions[63]

titration shows 37± 1% by weight.

PBI acid-filled

Non-sulfonated or sulfonated PBI fibre in an acid PBI absorbed solution can be used in a fuel cell as an electrolyte. The voids are closed by the swelling of the acid-imbibed fibres in the cloth. To make the membrane gas-tight and avoid the passage of gases through the fabric during the operation of the fuel cell, it is important to close these voids.

The chosen fabric comprises of PBI fabrics that can be either sulfonated or non-sulphonated. PBI is a simple polymer with a preference for acids in intense conditions that will maintain the acids. Essentially, the sulfonated cloth, which is crosslinked, will retain additional volumes of acid with less mechanical loss than uncrosslinked fabric. It is ideal to have a limited diameter for the fibres of the fabrics used in the invention, i.e. in the range of about 10 to about 500 d. More ideally, the diameter of the fibres is about 20 deniers. Tiny dimensional fibres are required to have a thickness of 0.5 to 5 mils for the resulting cloth.

Polymeric fibre, ideally PBI cloth that can be imbibed with acid, is covered with a PBI paste or gel containing about 70-99.9% by weight of acid, and preferably around 95-99% by weight of acid, between 0.1 to 100 µM (preferably 10-30 µM).The PBI paste or gel is prepared by combining the PBI polymer flake with an acid solution that helps the polymer to swell and form a matrix at room temperature that has a gel or paste-like consistency.

The cloth is immersed in an acid solution for a time until the desired fabric is picked, adequate to allow acid imbibition without sacrificing the fabric-like shape. Phosphoric acid, sulphuric acid, triflic acid, methane sulfonic acid, and mixtures thereof, in a liquid, are currently favoured acid solutions. Phosphoric acid is especially favoured for the invention's use of unsulphonated fabrics. The most common acid solution currently consists of phosphoric acid and water or methanol. However, for this and other chosen acids, other suitable solvents, e.g., such as DMAC and NMP, or mixtures of these solvents with and/or methanol, are identified and can easily be calculated by a specialist in the field.

The acid solution can consist of about 5% by weight (wt %) to about 100% by weight of the acid and from about 0 to about 95% by weight of the solvent. The acid solution contains around 50% acid and 50% water or methanol in a currently desired embodiment.

The fabric is immersed in an acid bath in one vivid example of the process. The cloth and acid are mixed in an acceptable mixing jar in another embodiment. This mixing can be achieved at room temperature, but it may be possible to use any temperature between the freezing point and the acid's boiling point. The mixture is optionally heated to allow cloth imbibition to occur more easily than at room temperature. The mixture is desirably heated to approximately 30°C. The heating stage is carried out from 30 sec to approximately 8 hr. There is a desirable heating time of around 5 min to 2 hr. For example, a fabric made of unsulphonated PBI fibre can absorb less than about 65-70% acid with respect to the chosen fibre in the fabric. Sulphonated PBI fibre cloth, on the other hand, is crosslinked and can imbibe more than approximately 65-70% acid and still maintain adequate mechanical properties. The resulting acid-soaked cloth is dried to about 200°C at room temperature, and ideally to about 80°C. Removal of residual solvents such as DMAC, NMP, water, and/or methanol is carried out at around 180°C. The acid is trapped by this drying step, creating the acid-imbibed cloth. The voids in the fabric are closed by the swelling of the acid-imbibed fibres during fuel cell service, which renders the fabric gas-tight (i.e. an effective barrier to gas transmission) and avoids the leakage of gases through the fabric.

The resultant acid-imbibed cloth produces heavy acid loads of around 40-95% acid by weight of the imbibed fabric, according to these techniques. Generally, about 50% by weight or more acid is sufficient for a cloth to act sufficiently as an electrolyte in a fuel cell. More ideally, the cloth contains, by weight of the imbibed fabric, around 50-75% acid. The amount of acid imbibed in the resulting cloth depends on the choice of threads, the fabric, the

Table 3 : Data of preliminary laboratory phosphoric acid treatment of extruded PBI fibre[65]

	Estimated Dry wt (gm)	Orig. fiber wt (gm)	% acid used	Temp (°C)	Time in acid (sec)	Time in H_2O (sec)	Time in oven 1st drying (sec)	Time in oven 2nd drying (sec)	Wt after 2nd drying (gm)	Drying condition (in oven) (°C)	Acid pickup (APU) wt (%)	Note
1	0.60	0.7	30%	room	60	15	300	100	0.68	180	14.3%	
1	0.63	0.74	50%	room	60	15	300	100	0.76	180	20.8%	
3	0.60	0.71	85%	room	60	15	300	1(0	0.67	180	11.0%	
4	0.70	0.82	30%	room	60	15	300	100	0.78	180	11.9%	
5	0.65	0.77	50%	room	60	15	300	100	0.79	180	20.7%	
6	0.70	0.83	85%	room	60	15	300	100	0.83	180	19.1%	
7	0.71	0.83	30%	room	60	0	300	100	1.14	180	61.6%	
8	0.62	0.73	50%	room	60	0	300	100	1.29	180	107.9%	
9	0.67	0.79	85%	room	60	0	300	100	1.88	180	180.0%	
10	0.76	0.89	30%	50	60	15	300	100	1	180	32.2%	
11	0.65	0.76	50%	50	60	15	300	100	1.02	180	57.9%	
12	0.71	0.84	30%	40	60	15	300	100	0.84	180	17.6%	
13	0.70	0.82	50%	40	60	15	300	100	1	180	43.5%	
14	0.34	0.4	50%	60	60	15	900	100	0.52	105	52.9%	with tension
15	0.34	0.4	50%	60	60	15	900	100	0.51	105	50.0%	
16	0.36	0.42	50%	45	60	15	1800	0	0.51	105	42.9%	
17	0.34	0.4	50%	45	60	15	1800	0	0.53	105	55.9%	
18	0.38	0.45	50%	45	60	15	1800	0	0.48	105	25.5%	with tension
19	0.37	0.44	50%	45	60	15	1800	0	0.46	105	23.0%	with tension

tightness of the weave in the woven fabric, the temperature, the time of soaking, and the concentration of acid in the solution, which can be regulated by it. A benefit of the method is that the acid formation occurs over such a short period in comparison to prior methods which take about 10 to 72 hr. The electrolyte has reduced cost and increased efficiency[64].

Extruded PBI fibre washing

To dissolve the spinning solvent, PBI fibre is washed in hot water and then space drawn in a heated oven to maximise its tensile properties. The fibre is then processed by submerging the fibres in a bath for 48-52 sec from entry to exit of the device with 50% (wt) aqueous phosphoric acid (the fibre was immersed in the liquid for about 25 sec). The temperature of the bath stood at 35°C. The fibre is then pressed to dry and cleaned at room temperature with water. Then dry the washed fibre in a non-contact air oven running at 350°C. The dry fibre is then heat-treated at 565°C in a nitrogen-blanked oven within the polymer structure to fix the acid. Subsequent methods of textile preparation culminated in the development of phosphonated fibre as a two-inch staple fibre. The 1.5 denier per filament (dpf) cut staple fibre has a tenacity of 2.00 gm/dN, 10.88% elongation at the split, and 17-20% acid collection. By mass equilibrium, acid pickup values are calculated and checked by elemental analysis. Mass balance : Acid content comes from a mass balance that evaluates the fibre's weight gain. Moisture is separated from the sample, and the dry PBI from the creel separates the remaining mass. For a second balance, around the acid concentrations in the wash, waste-water, and intake, the balance is then checked.

Acid content was extracted using elemental analysis by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The percentage of a certain variable present in a sample is calculated by the ICP-OES equation. The existence of 5.51% phosphorous was deterred by ICP-OES in the case of the example fibre. Phosphorous is is present as phosphate on the example fibre (PO). At about 32%, phosphorous is found in phosphate. The inclusion of 5.51% phosphorous thus tells us that the pickup of phosphate (acid) is around 17%. The data presented in *Table 3* by the preliminary laboratory (phosphoric acid treatment) of extruded PBI fibre is further explained.

Application

The application for Project FIRES continues to use a mixture of 40% PBI and 60% p-aramid. In several fabric constructions, this blend is presently available. It is most widespread in a ripstop or modified plain weave of 7-7.5 oz/yd^2 in the US. In the above case, the alteration is the periodic insertion of p-aramid filaments in a PBI matrix[66] configuration. The tear-resistant properties of a standard ripstop are provided by PBI matrix, while the abrasion-resistant properties of the smooth-surfaced plain weave are provided. Internationally, this blend is available in ripstop, twill, and modified simple (matrix) weaves at weights ranging from 205 gm/m^2 to 220 gm/m^2. As compared to cotton, PBI has low modulus, high moisture recovery, and comfort characteristics. These characteristics make PBI, and PBI blends, very useful such as shoulder straps, harness webbing, chinstraps, helmet suspension, lap belts etc. The mix is popular as flash hoods for firefighters, military forces and various industrial flash fire applications in a knit shape. Also available in this mix

are different light-weight woven constructions (e.g. 4 oz/yd^2 twill, 6 oz/yd^2 twill) etc for coverall-type apparel used for industrial flash-fire safety. When PBI blends 70% FR rayon, 20% PBI and 10% lyocell, another 3-fibre mix offers a very supportive, naturally flame-resistant base-layer cloth. Four varieties of PBI fabrics are currently on the market for firefighter gear: PBI Gold, PBI Matrix, PBI TriGuard and PBI BaseGuard.

A blend of three types of high-performance fibres, Lenzing FR, including PBI, and MicroTwaron, is the PBI TriGuard fabric. It is intended for the safety of the blaze, comfort and durability. It is approved for use in the clothing, special forces, motor-sports, petrochemical, gas utility, and electric utility sectors of Wildland Firefighter. For auto racing racetracks, PBI TriGuard and PBI Gold knits are also used. PBI BaseGuard is a type of soft, lightweight, and durable knitted fabric designed to provide fire protection along with moisture control and toughness as a next-to-skin base layer in the clothing systems of firefighters. Based on short cut fibre and uncrimped fibre, PBI fibre goods are available. *Fig 4* presents a segmentation of the global polybenzimidazole fibre industry.

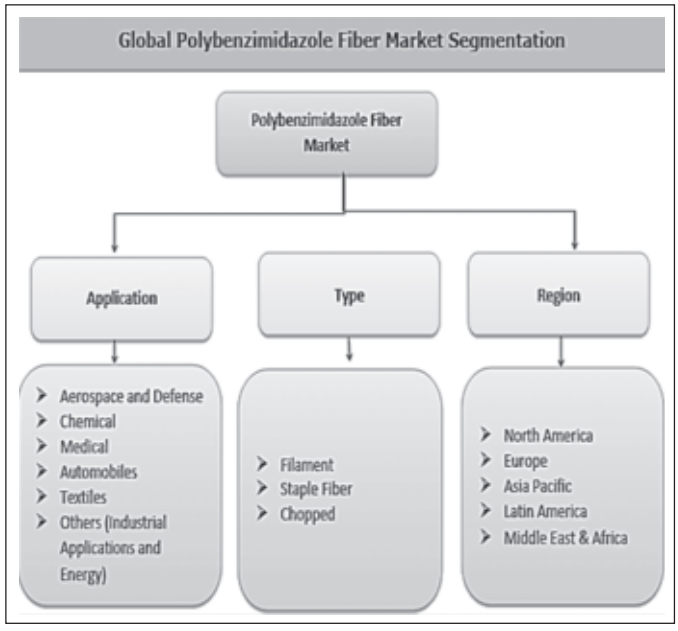


Fig 4 : Global Polybenzimidazole Fibre Market Segmentation[67]

There is also a non-garment application that also makes use of PBI in its extruded fibre form and is achieved by cutting the fabric into small lengths and inserted in an ablative insulation sheet for use in solid rocket engines. The use of PBI fibre is not limited to just firefighter clothing and textile applications. This type of PBI in its solid rockets will be used by NASA's next-generation space launch system or SLS[68].

Coating of PBI film for enhancing energy absorption hypervelocity effect

Micro-meteoroid atmospheric debris (MMOD) impacts at hypervelocity range of 7-15 km/s in low earth orbit (LEO), which is a crucial issue for spacecraft. Just 7% of the object orbiting earth in space is usable and the remainder is space debris, which poses major threats to the service life of spacecraft[69-71]. In addition, these objects can inflict significant harm to their structure at the high speed of the craft, even though space agencies such as NASA, ESA etc actively track thousands of objects in space, and millions of particles remain untraceable[72]. The orbital space system must, thus, be robust enough to survive these minor impacts of hypervelocity. There is a protection device consisting of multi-layer insulation to protect against the effects of hypervelocity to neutralise the effects of the LEO environment. A coating of PBI polymer is used to reduce the area density of the spacecraft to mitigate the LEO effect, offering a less complicated configuration, thereby enhancing safety with a lower area density[73]. In addition, PBI has a high transition temperature of 425°C for glass, typically decomposes at 500-600°C and also has high preservation of power at cryogenic temperatures[18].

Future scope

Over the past decade, with the help of PBI fibre, the resulting research has gone into the manufacture of high-performance garments and numerous containment applications. Since the economic factor is the incentive for growth, the environmental concerns affecting us these days should be given more focus. The adjustments in the microstructure of the PBI under varying environmental conditions must be fully understood to make more improvements in the mechanical, thermal and chemical properties of PBI products. Polybenzimidazole (PBI) fibre is classified as a high chemical resistance synthetic textile fibre that is inflammable in the air. When exposed to flame and even at temperatures of 560°C, PBI fibre does not show any melting point and thus does not spill. Now and then, owing to the increasing need for lightweight production and increased demand for safety and protection, the industry is experiencing substantial growth. Moreover, relative to other synthetic fibres, the beguiling and tactile quality displayed by these fibres handout their market growth. However, the high costs associated with the manufacture of PBI fibres are, to some degree, dissuading the market.

Conclusion

As a flue gas filter cloth for coal-fired boilers, asbestos substitute, fuel cell electrolyte, moulded PBI resin, PBI membranes, PBIs can be a propitious material and it is all possible because of its excellent chemical, physical and thermal properties. In addition, outstanding thermal stability of polybenzimidazole raises the growth of the market performance protective apparel such as disposable gloves, firefighter clothing, welding apparel,

astronaut space suits, and fabrics for aircraft frames. PBI fibres, however, are used for plastic augmentation exertion.

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AD

Combined scouring-bleaching of banana fibre using hydrogen peroxide and sodium hydroxide

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Natural fibres are in great demand today for textile purposes as these have eco-friendly characteristics like biodegradability and easy renewability. India provides diverse agro-climatic conditions, providing fibres of various types. Among these, fibres from banana pseudo stem show good promise[1,2].

Scouring cum bleaching is the removal of unwanted dirt and staining, and usually involves the use of one of the four main staining agents, namely sodium hypochlorite, hydrogen peroxide, calcium hypochlorite and sodium chlorite. The process involves three main steps, namely (a) dipping the fibre with a bleaching agent and other required chemicals; (b) raising the temperature to the recommended level and maintaining that temperature for the required time; and (c) washing and drying the cloth[3,4].

Generally, bleaching with the help of bleaching powder or sodium hypochlorite was performed at room temperature. However, bleaching with the help of hypochlorite bleaching units of textile bleaching processes generates more adsorbable organic

The proposed combined scouring and bleaching method has proved to be efficient

halides (AOX) (17-18 mg/l) and that is why they are subject to the category of restricted chemicals, which are not environmentally friendly. From the point of view of quality control, the error is that the whiteness produced by these staining agents is not permanent. They also use a lot of water (45-80 l/kg of thread/cloth). On the other side, exposure to hydrogen peroxide hardly produces AOX in contaminated water; water consumption is also relatively low (40 l/kg of fibre/yarn/fabric)[4].

In scouring cum bleaching, most of the impurities like dirt, dust etc present in banana fibre material are removed by pressure boils under alkaline conditions. Hydrogen peroxide bleaching process is ecofriendly and processed at pH 10.5 - 11 and at a temperature of 80-85°C for 60 min where sodium silicate acts as a stabilizer. Hydrogen peroxide extraction requires a large amount of steam (2.5 kg/kg of fabric), thus adding to the cost of fuel. Modern gasoline is expensive because of the rapid depletion of the fuel tank. Thus, it is environment friendly, but the rising fuel amount tends to make hydrogen peroxide bleaching process as uneconomical[5,6,7].

Conservation of energy is the only step essential to overcome the mounting problems of the worldwide energy crisis and environmental degradation. The approach, therefore, should be based on the process intensification, making most of the energy used in a process and, if not possible, process modification so as to reduce the energy requirements. One such approach is the combined scouring and bleaching of banana fibre, which has the potential of saving the energy[8,9].

Materials and methods

Materials

The grey 100% banana fibre was used for the study. The chemicals namely, hydrogen peroxide and sodium hydroxide, manufactured by Fisher Scientific Ltd were used for the functions of scouring, bleaching agent, and bleaching activator, respectively.

Table 1 : Time & temperature graph of the process of scouring cum bleaching

Trial	NaOH (gm/l)	H_2O_2 (gm/l)	Temp. (°C)
1	3	8	50
2	3	12	50
3	3	16	50
4	3	8	70
5	3	12	70
6	3	16	70
7	3	8	90
8	3	12	90
9	3	16	90
10	4	8	50
11	4	12	50
12	4	16	50
13	4.	8	70
14	4	12	70
15	4	16	70
16	4	8	90
17	4	12	90
18	4	16	70
19	5	8	50
20	5	12	50
21	5	16	50
22	5	8	70
23	5	12	70
24	5	16	70
25	5	8	90
26	5	12	90
27	5	16	90

The commercial sodium silicate manufactured by Jasmacyclene was used as the stabilizer.

Methods

To find out the best result trials were carried out at different temperature level and different combinations of sodium hydroxide and hydrogen peroxide. In case of sodium hydroxide, the minimum value of concentration was 3 gm/l and maximum concentration was 5 gm/l. In case of hydrogen peroxide, the concentration was 8 gm/l and maximum concentration was 16 gm/l *(Table 1)*.

At different temperature levels, combined scouring and bleaching was carried out on grey banana fibre using Paramount hot water bath, keeping material-to-liquor ratio (MLR) as 1:50. After the treatment, fabric samples were rinsed with fresh water and dried in air.

Process sequence

Grey Banana fibre
↓
Modified scouring & bleaching
↓
Hot wash
↓
Cold wash

Determination of quality parameters

This was done to determine the quality of parameters such as whiteness index, yellowness index, weight loss and absorbency test of the scoured cum bleached banana fibre. The new developed process was found to be successful in terms of savings in time, money and energy.

Weight loss

This can be calculated by using given below formula:

$$\text{Weight loss \%} = \frac{W_1 - W_2}{W_1} * 100$$

where W_1 = weight of grey banana fibre (in gm); W_2 = weight of scoured cum bleached banana fibre (in gm).

Water absorbency

Water absorbency of grey as well as scoured cum bleached fibre was determined by measuring time in seconds with the help of a water drop.

Whiteness and yellowness index

Whiteness and yellowness index of scoured cum bleached samples were evaluated on I-color spectrophotometer.

Results and discussion

In all the above recipes, it is observed that the best recipe is 4 gm/l sodium hydroxide, 16 gm/l hydrogen peroxide and 90°C temperature for alkaline hydrogen peroxide bath containing simultaneously sodium hydroxide as an activator and commercial stabilizer sodium silicate.

Table 2 : The results of the process of scouring cum bleaching

Trial	NaOH (gm/l)	H_2O_2 (gm/l)	Temp. (gm/l)	Whiteness index	Yellowness index	Weight loss %	Absorbency in sec
1	3	8	50	10.52	49.46	14.0	0.52
2	3	12	50	13.52	47.66	16.8	0.51
3	3	16	50	14.52	46.66	17.01	0.48
4	3	8	70	11.82	46.76	24.4	0.46
5	3	12	70	15.02	44.25	25.01	0.45
6	3	16	70	15.86	41.01	25.98	0.43
7	3	8	90	23.40	46.35	28.36	0.42
8	3	12	90	25.08	48.93	31.74	0.40
9	3	16	90	26.28	49.23	34.25	0.38
10	4	8	50	15.72	38.64	32.12	0.44
11	4	12	50	16.27	36.35	28.20	0.43
12	4	16	50	14.65	33.67	26.70	0.41
13	4.	8	70	14.56	32.06	21.05	0.40
14	4	12	70	14.96	34.01	23.60	0.38
15	4	16	70	16.08	31.24	24.12	0.35
16	4	8	90	19.37	35.69	28.21	0.33
17	4	12	90	20.26	32.04	32.24	0.32
18	4	16	90	26.40	31.01	39.16	0.28
19	5	8	50	19.35	32.06	25.12	0.39
20	5	12	50	20.26	34.01	27.20	0.37
21	5	16	50	25.40	31.24	29.70	0.35
22	5	8	70	22.18	35.69	32.05	0.34
23	5	12	70	24.02	32.04	34.60	0.30
24	5	16	70	25.61	31.43	35.12	0.29
25	5	8	90	27.04	30.25	37.21	0.28
26	5	12	90	28.76	29.25	38.24	0.28
27	5	16	90	29.02	29.14	39.36	0.26

Various parameters like whiteness index, yellowness index, weight loss, and absorbency have been evaluated for assessing the quality of scoured cum beached fibre with various methods *(Table 2)*.

In the current scenario, in Industry, the quality control in manufacturing is becoming more important besides the cost control. Therefore, in addition to time and energy saving benefits, there is stress on prediction of quality parameters like whiteness index, yellowness index and improvement of absorbency. The major need of any textile industry process is the whiteness of final material.

The results generated by various components of all the recipes used the effect of change in hydrogen peroxide and sodium hydroxide concentrations. It is observed that the change in temperature causes maximum variation; whereas the change in concentration of sodium hydroxide and hydrogen peroxide causes variations in all properties.

It is observed that the banana fibres lost its weight due to removal of lignin component and its impurities, and improved its absorbency and whiteness index through alkali treatments along with bleaching agent and commercial stabilizer. The new developed process is found to be successful in terms of savings of time and energy.

Conclusion

The proposed combined scouring and bleaching method using sodium hydroxide as an activator along with a commercial stabilizer has proved to be efficient in giving results at par with the conventionally followed sequential scouring and bleaching. This will lead to substantial reduction in time of pretreatment and reduce the time and energy requirements.

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AD

Effect of antimicrobial coating on silk cotton fabric for protective wear

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The protective clothing is a vital wear used to protect the medical professionals from microorganisms and also to save the patients from harm using non-sterile garments. Medicinal plants play a major role in world health care systems and an impressive number of modern drugs have been isolated from natural resources[1]. A variety of plants are used as healing agents for human diseases and incorporate biologically active compounds[2]. In recent times, different range of natural plants and biodegradable polymers are being utilized for developing new products for medical textiles. From the plant kingdom, one of the copious sources of natural plant is *Rhizophora mucronata*. Mangroves are known to be a rich source of various secondary metabolites and these higher plants are widely used for traditional medicine practices[3]. The *Rhizophora mucronata* plant study results also show that the extracts showed better activity against human, animal and plant pathogens[19].

At the present time, textile fabrics with protective properties are important in medical and apparel categories

Mangrove plant extract bioactive molecules have been used for centuries to treat several health bacterial and fungal growths[4]. For healthcare issues, herbal medicines are valuable and readily available resources. The nature has delivered numerous group of plants with medicinal significance for different disease specifications[5]. Despite the fact that a huge variety of plants are persistently analyzed for their antimicrobial effects, still there is a search for natural antibiotic genetic resources which have been evaluated in many plants to identify their active constituents holding antimicrobial activities[6]. The present research work aims at developing antimicrobial medicated fabrics for protective healthcare applications.

Materials and methods

Materials

Fabric

The textile silk cotton fabric with the count of 2x40s and satin weave was selected for the study. The fabric was scoured and bleached prior to the application of finish and converted into protective apparels.

Natural plant

The leaves of *Rhizophora mucronata* were selected for the study on the basis of their medicinal and skin disease curing properties, collected from a forest near Chidambaram, India.

The *Rhizophora mucronata* leaves were shadow dried for about two days and converted into powder form by using automatic machines. 50 gm of fine powder was mixed with 200 ml of ethanol for 7 hr using soxhlet apparatus by hot extraction method. After the extraction process, the solution was kept for solvent evaporation for about 10 hr.

The precipitate of the extract was scraped from the apparatus as per the requirements. Then, the obtained precipitate was stored in a tight container at 4°C and kept under refrigerator for some time. Based on the need of requirement, the extract was diluted and utilized for further end use[10,11].

Methods

The fabric samples were coated and the temperature, time, pH and M:L ratio were optimized using the Box and Benhen statistical model. The optimized parameters were: temperature - 40°C; time - 2 hr; pH - 7; and concentration - 10% and 20%. The extracted solution was coated with the material liquor ratio of 1:10 onto cotton fabric by pad-dry-cure method of finishing using pneumatic padding mangle machine. The coated fabric sample was then dried at 80°C for 10 min to remove the moisture. After coating, the cotton samples were analyzed for both, antibacterial and antifungal activities.

Various methods were used for identifying the phytochemical constituents in the *Rhizophora mucronata* extracted solution and evaluating the antimicrobial activity on coated silk cotton fabric samples as below.

Preliminary phytochemical screening

The qualitative phytochemical analysis method is used to identify the presence of active phyto constituents in extract such as alkaloids and tannins. The preface test was done on the extracted solution as per test norms.

- Test for flavonoids: 1.5% v/v of hydrochloric acid and a few drops of Wagner's reagent were added to acidify the plant extract of 1.0 ml; the formation of brown or reddish precipitate indicates the presence of flavonoids.
- Test for tannins: 0.5 ml of aqueous ferric chloride solution was assorted with the 1.0 ml of the extract content in the conical flask. In 5 min duration, the mixed solution turned into a bluish black colour. After some time, the colour disappears and, on addition of a few drops of dilute sulphuric acid in the flask, a yellowish brown colour precipitate was observed which indicates the presence of tannin compounds[12-15].

Antibacterial activity assessment of coated fabric samples

- AATCC-100-1998: Quantitative approach of assessing antibacterial activity by Broth Dilution Test - The 5"x 5" size of natural silk cotton samples were cut from the *Rhizophora mucronata* solution roofed (untreated, 10%, and 20% coated). In the 700 ml of Elenmeyer conical flask, the 100 ml of nutrient broth solution was taken and sterilized for approximately 20 min at 121°C. After 20 min, the solution was allowed to cool[16]. Then, the coated natural cotton samples were transferred into the conical flasks. The conical flasks with material samples were incubated in shaker at 37°C for approximately 24 hr. After incubation, their absorbance was measured at 600 nm.
- AATCC-147-1998: Qualitative method of assessing antibacterial activity by Agar diffusion test - The antibacterial activity of the *Rhizophora mucronata* extract was analyzed using AATCC standard qualitative test method of agar well diffusion method.
- **Preparation of bacterial cultures:** The two pathogenic bacterial and one fungal cultures were developed from Microbial Type Culture Collection (MTCC), Department of Biotechnology Laboratory, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India. The developed bacterial and fungal cultures were specifically gram positive bacterial pathogens Staphylococcus aureus and Klebsiella pneumonia gram negative bacterial pathogens such as Pseudomonas and Escherichia coli. The developed bacterial cultures were maintained on nutrient agar slant and additionally isolated in a fridge at 4°C.
- **Antibacterial activity assessment by agar well diffusion method:** The antibacterial activity of *Rhizophora mucronata* extract was determined by diffusion into the pores of agar[17]. 20 ml of nutrient agar was prepared and allowed for sterilization at 121°C for about 15 min. The petri plates had been autoclaved in warm air oven at 121°C for 45 min. The ethanolic extract was transformed into 100 µg/ml concentration. The nutrient agar of 20 ml was dropped into the petri plates and allowed to solidify. Then, the plant extract was poured in the developed well and the plates were incubated for 24 hr at 37°C. After 24 hr, the antibacterial activity of the test organism was evaluated against the Staphylococcus aureus and Escherichia coli by measuring the zone of inhibition.

Antifungal activity assessment of coated fabric samples

AATCC 30-1993: Antifungal activity assessment by broth dilution test - 400

Table 1 : Identification of phytochemical components from Rhizophora mucronata

Plant phytochemicals	Ethanolic extract
Flavanoids - Wagner's test	+
Tannins - Ferric chloride test	+

Table 2 : AATCC 100 absorbance tests

Sample	Absorbance values (at 670 nm) Gram positive Staphylococcus aureus pathogen	Absorbance values (at 670 nm) Gram negative Escherichia coli pathogen
Uncoated sample	1.03	1.09
10% conc coated silk cotton sample	0.97	0.94
20% conc coated silk cotton sample	0.76	0.79

ml of Elenmeyer conical flask containing 50 ml of PD broth was prepared and sterilized at 121°C for 15 min. It was then allowed to cool. The natural silk cotton material samples were inserted directly in to the conical flasks, and it was kept for approximately four days. Then, the growth of fungi within the conical flask was checked.

Finish durability study

The finish durability of the coated natural silk cotton material was performed for the sample of length 4x4 cm. The sample selected for the test was washed for 5-25 cycles at a temperature of 37°C and with detergent.

Results and discussion

Phytochemical screening and testing

The qualitative phytochemical screening of *Rhizophora mucronata* extract test results are shown in *Table 1*.

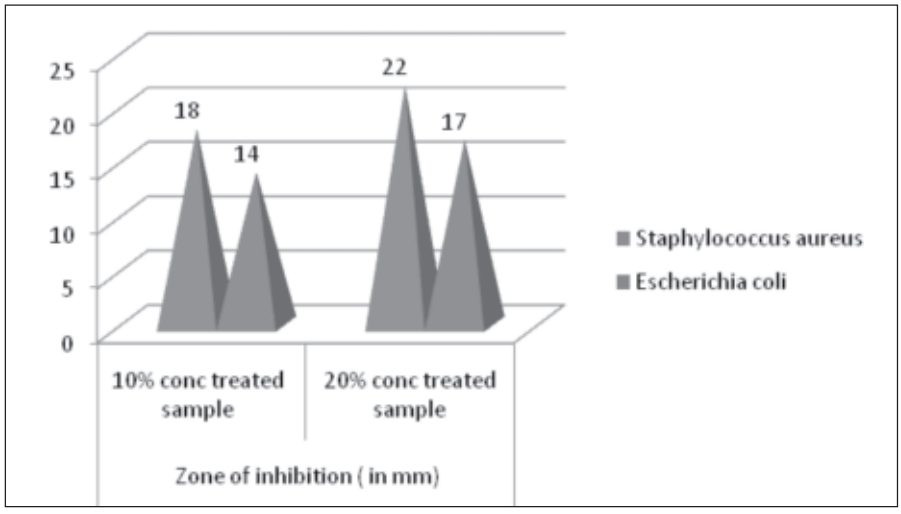
The test results revealed the presence of phytochemical constituents in the extract such as tannins present in the *Rhizophora mucronata*. The precipitate shade represents the presence of the additives that possess antimicrobial activity. Flavonoids are found to be an active antimicrobial component against a wide range of microorganisms due to their ability to combine with extra cellular, soluble proteins and bacterial cell wall. The presence of tannins in the roots of *Rhizophora mucronata* implied that tannin may be the agent responsible for antibacterial activity in this study. The component tannin expresses better antibacterial activity[18].

Antibacterial activity assessment by Broth dilution test

The reduction value of absorbance is directly proportional to the concentration of the cells in the extract coated samples as shown in *Table 2*. The absorbance bacterial values of the samples were compared. It was found that the material coated with 20% concentrated confirmed very low absorbance values as compared to 10% covered and uncoated natural cotton samples. This suggests that 20% concentrated with material does no longer aid the increase of bacteria.

Table 3 : Antibacterial zone of inhibition (in mm) against gram positive and gram negative bacterial pathogens on ethanolic extract of Rhizophora

Developed pathogens	Zone of inhibition (in mm)	
	10% conc treated sample	20% conc treated sample
Gram positive - Staphylococcus aureus	18	22
Gram negative - Escherichia coli	14	17



Antibacterial activity Assessment by zone of inhibition

Antibacterial activity assessment by Agar diffusion test

The antibacterial activity of the *Rhizophora mucronata* extract has been shown in *Table 3*. The antibacterial activity zone of inhibition test results of *Rhizophora* extract against gram positive and gram negative bacterial pathogens, namely Staphylococcus aureus and Escherichia coli by agar well diffusion method, are shown in *Table 3*.

The zone of inhibition test results of *Rhizophora* ethanolic extract showed good antibacterial activity against gram positive pathogen such as Staphylococcus aureus (22 mm) than the gram negative pathogen Escherichia coli (17 mm) in 20% concentration extract treated fabric sample than the 10% concentration extract treated fabric sample. The coated silk cotton sample exhibited better bacterial efficiency over the gram positive pathogens when compared to the gram negative pathogens.

Antifungal activity assessment by Broth dilution test

It was found that from the results that there was less growth of fungi in

Table 4 : AATCC 30 absorbance tests

Selected samples	Absorbance values (at 670 nm) Aspergillus niger
Uncoated material	1.02
20% conc coated silk cotton material	0.84

Table 5 : Finish durability test		
Finish wash durability		Absorbance values (at 670 nm)
Uncoated material	Before washes	1.09
20% Conc coated	After 5 washes	0.87
silk cotton material	After 10 washes	0.96
	After 15 washes	0.99
	After 20 washes	1.03
	After 25 washes	1.06

the conical flask containing 20% concentrated coated silk cotton samples when compared to the untreated sample. The results prove that the higher concentration coated silk cotton samples have superior antifungal activity as shown in *Table 4*.

Finish durability study

From the various levels of wash factor results, it is proved that the herbal coated silk cotton sample can withstand upto 15- 18 wash cycles *(Table 5)*.

Conclusion

The phyto additives along with flavonoids and tannins reveal advanced antimicrobial and antifungal activity. The antibacterial check have confirmed more stages of antibacterial activity in 20% concentration extract coated silk cotton cloth sample in opposition to gram positive and negative bacteria such as Staphylococcus aureus than in Escherichia coli. Based on the qualitative phytochemical screening and antibacterial activity assessments, the extract coated cloth samples proved that they will likely be more appropriate for the clinical applications. The end durability tests indicated that the completed coating turned capable of preserving 12-18 washes on clothes.

At the present time, the textile fabrics with protective properties are more important in medical and other apparel categories. Hence, this study will supply concept for growing ecofriendly, antimicrobial covered fabrics for hospital practitioners in healthcare disciplines in addition to raw materials from 100% herbal resources; it is renewable, ecofriendly, cost-efficient and has environmental benefits.

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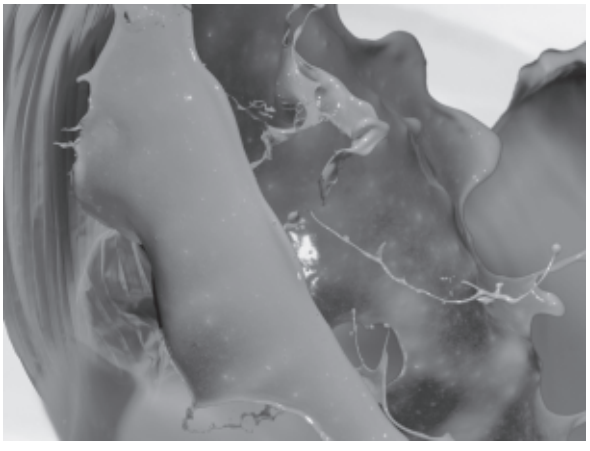
AD

Dyes, Auxiliaries and Polymers

AVITERA SE Rose gives textile mills a competitive advantage

Huntsman Textile Effects has released the latest addition to the third generation of its revolutionary AVITERA SE polyreactive dye range with the introduction of AVITERA ROSE SE for brilliant bluish-red shades. The innovative new dye significantly outperforms the best available dyeing technologies for cellulosic fibres and blends, delivering substantial water and energy savings, exceptional overall fastness, and reduced costs.



AVITERA ROSE SE slashes the water and energy required for production by upto 50%, thanks to its unique low-temperature and high-speed wash-off technology. It further delivers excellent right-first-time performance, with outstanding compatibility, levelling properties, and on-tone build-up. The cost-effective formulation reduces recipe costs for medium-dark shades while both minimizing processing costs and eliminating reprocessing. It also increases mill output by upto 25% or more.

'The latest addition to our third-generation AVITERA dyes opens new possibilities for designers and brands, with beautiful, long-lasting brilliancy across bluish-red shades along with optimal environmental and economic sustainability. Bringing ecofriendly performance and cost savings together in this way is a true innovation for an era of more demanding consumers and stricter environmental standards,' said Lutfu Okman, Vice President Global Revenue, Huntsman Textile Effects.

Using AVITERA ROSE SE, brands can stand out with brilliant bluish-red textile products in a broader shade gamut. The dyes offer very good light fastness levels for classic bluish trichromatic element, with exceptional overall fastness performance. Products dyed with AVITERA ROSE SE have the highest chlorine resistance, tailormade for stringent Japanese and US laundering requirements, and are suitable for use with Huntsman's HIGH IQ Lasting Color Eco color-retention program. With minimal chance of cross-staining, they are ideal for red-white striped cotton knit fabric.

AVITERA ROSE SE is fully compliant with the most stringent industry and brand-specific restricted substance lists. It is Bluesign approved and suitable for STANDARD 100 by OEKO-TEX certified textile products.

Sanitized Puretec delivers optimal antimicrobial performance

SANITIZED AG, the Swiss expert in antimicrobial solutions for longlasting freshness in textiles presents a new product portfolio: Sanitized Puretec, a non-leaching, metal-free and particle-free antimicrobial solution for textiles to prevent the buildup of odour-causing bacteria, the technology provides long-lasting effects without release of the active ingredient, making it a safe and sustainable solution even after many washes.

Sanitized Puretec offers a unique solution for brands and retailers producing synthetic sportswear by allowing consumers to wear the products they love for longer periods of time before having to wash them again. This provides brands and activewear users with peace of mind by delivering long-lasting freshness on textiles. From hitting the gym to running errands, the technology allows consumers to remain confident and comfortable even throughout their busiest days.

As demonstrated in various microbiological tests, Sanitized Puretec guarantees optimal odour

Sanitized Puretec™ technology delivers optimal antimicrobial performance for all fibre types.

Removing contaminants from groundwater

Hydrogeologist Professor Thomas Boving from the University of Rhode Island in the US and colleagues at EnChem Engineering are testing a new technology which quickly removes and destroys hazardous chemical compounds from soil and groundwater.

The PFAS compounds extracted from the ground are destroyed using an ultraviolet light technology inside this trailer. (Photo courtesy of EnChem Engineering Inc)

If proven effective, the technology could be used to clean up PFAS and what are known as 'forever chemicals' that contaminate drinking water supplies for around one-third of Americans. PFAS compounds do not break down easily in the environment and can lead to many serious diseases.

Professor Boving said the solution has two stages. 'First, we flush the compounds out of the ground by pumping in a sugar molecule that has the ability to remove PFAS from the soil and groundwater. Then, we pump the solution out of the ground and hit it with a chemical oxidation process to destroy the compounds.'

Once the contaminants have been pumped out of the soil and groundwater, they are processed using an ultraviolet light technology that breaks the chemicals into their basic elements inside a 40 ft steel container which can be transported to other contaminated sites.

control performance-even with ongoing washing and wearing. The product portfolio delivers added value to textiles by easing product maintenance and enhancing usability and performance.

Sanitized Puretec technology can be easily integrated into existing application techniques such as pad and exhaust and is compatible with other functional performance finishes. It exhibits excellent wash fastness and temperature stability and is dermatologically tested to be non-sensitizing to the human skin, making it safe for an abundance of textile applications.

Sanitized Puretec odour control solutions have been tested through 40 washes using ASTM E3162-18, the industry standard wash durability method approved by the International Antimicrobial Council (IAC). As for the microbiologcal test method, the IAC recommends ASTM E2149-20 for the Puretec technology. Using IAC Certified laboratories with IAC verified test reports, brands and retailers can be assured that products have been tested by trained and proficient microbiology professionals.

Smart bandage with multiple biomarkers

A research team at the National University of Singapore (NUS) has developed a smart wearable sensor that can conduct real-time, point-of-care assessment of chronic wounds wirelessly via an app. VeCare technology can detect temperature, pH, bacteria type and inflammatory factors specific to chronic wounds within 15 min, enabling fast and accurate wound assessment. It consists of a wound sensing bandage, an electronic chip and a mobile app. The bandage comprises a wound contact layer, a breathable outer barrier, a microfluidic wound fluid collector and a flexible immunosensor.

VeCare is the first wound assessment platform that can detect bacteria type and probe inflammatory factors, in addition to measuring acidity and temperature, within a single 15 min test. The immunosensing bandage enables rapid assessment of wound microenvironment, inflammation and infection state by detecting multiple chronic wound-specific biomarkers from wound fluid using an electrochemical system. The microfluidic wound fluid collector attached to the sensor directs and boosts wound fluid delivery to the sensor by upto 180%. In addition, a chip integrated with flexible electronics is connected to the sensor to transmit data wirelessly to an app for convenient, real-time wound assessment and analysis onsite. The chip component, powered with a rechargeable battery, can be reused for subsequent applications.

The VeCare platform comprises (clockwise from bottom left) a chip, wound sensor, bandage and app for real-time, point-of-care chronic wound monitoring.

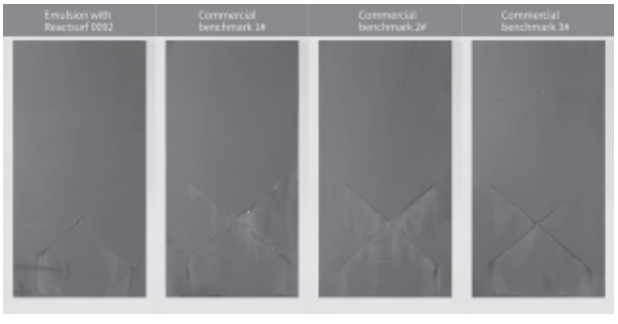
The next step for the research team is to further develop VeCare to meet safety, regulatory and mass production considerations. The team will explore the incorporation of other appropriate biomarkers suitable for

other wound types and utilise data in existing clinical workflows to improve diagnosis and treatment.

Solvay launches reactive waterborne emulsifier

Solvay has developed Reactsurf 0092, an alkylphenol ethoxylates-free (APE) and non-ionic reactive water-based emulsifier for solid epoxy resins mainly for use in industrial coatings and paints or binders.

Solvay's unique and versatile Reactsurf 0092 technology allows for the formulation of high-performance waterborne epoxy-based coatings which can match or exceed that of solvent-based (SB) coatings but with an appreciably lower level of volatile organic compounds (VOCs). Solvay is continuously developing and supplying products to meet the sustainable development challenges and regulatory requirements that its customers are facing for cleaner, healthier paints and coatings formulations.



After 500 hours salt spray test (ASTM B-117) on cold rolled steel plate, epoxy emulsion paint with Solvay's Reactsurf 0092 and high pigment volume concentration (PVC) shows better corrosion resistance than all benchmarks.

The new, cost-effective, environmentally and processing friendly emulsifier offers easy handling by combining both characteristic external and internal emulsification phases with no additional chemical modification required.

'Solvay's Reactsurf 0092 emulsifier incorporates a highly reactive functional crosslinking group, a perfect balance and synergy between emulsification and epoxidation to achieve a highly reactive emulsifier,' said Dr Rong Er Lin, Research & Innovation Manager, Solvay Novecare Coatings, Asia Pacific. 'This offers good particle size control for optimum emulsion coalescence and consistency without reduction in strength and provides excellent application performance and emulsion stability of paints and coatings.'

Metal-free odour resistance

A Bluesign-certified peppermint oil odour resist treatment is being introduced by Polartec as part of its Eco-Engineering initiative. With the switch to peppermint for metal-free odour resistance treatment across its line of performance fabrics, Polartec, Andover, MA/US, a Milliken & Company brand, now has an easily renewable, highly sustainable and biodegradable solution for inhibiting odour at the source.

Performance fabrics have long included anti-odour additives to improve product quality, lifespan, and reduce energy usage through washing. Knowing that body odour occurs when bacteria metabolize fatty acids and proteins in sweat, and secrete waste, the company turned to peppermint oil, which effectively inhibits the growth of odour-causing microbes in the fabric. The odourless peppermint oil-based treatment was proven in R&D trials to achieve a 99% microbial reduction, even after 50 wash cycles (as per industry standard testing JIS L1902).

Hydrophilic block silicone emulsions for textile industry

Cosmo Speciality Chemicals, a 100% subsidiary of Cosmo Films Ltd, has developed hydrophilic block silicone emulsions that exhibit better softening properties because of their lower rotational free energy than C-O bonds as compared with any other traditional non-silicone softeners.

Non-toxic and ecofriendly, the agent is suitable for a wide range of applications while providing an outstanding effect in the textile industry. With remarkable lubricity and hydrophilicity, the innovative softener improves water absorbency and smoothness of the fabric along with improving the efficiency of cutting and sewing in. LYOSIL BHL can be used on cotton like knits, woven, terry towels etc.

Teflon reimagined

Chemours has developed a bio-based and non-fluorinated stain repellent technology - Teflon EcoElite finish, the first plant-based repellency finish under the Teflon brand.

Teflon EcoElite finish repels water and water-based stains on a variety of fabrics without impacting feel or breathability.Teflon EcoElite finish is also upto three times more durable than other non-fluorinated, water-repellent finishes. Therefore, it continues to repel water and water-based stains for 30 or more washes. The composition of Teflon EcoElite finish contains 60% renewably sourced raw materials (ASTM D-6866-12). Thus, its production leaves a smaller environmental footprint.

Fabrics treated with Teflon EcoElite finish look newer longer, so people can

live, work, and play without worry. Beyond peace of mind, Teflon EcoElite finish extends the life of textiles-keeping them out of landfills longer. This biobased finish is durable and made with non-GMO renewable resources. It is the only product on the market featuring a robust mix of performance and sustainability benefits.

Fabrics treated with Teflon EcoElite finish require 25% less drying time and wash well in cold water. Reduced energy use, combined with longer useful life, helps consumers save money while lessening their carbon footprint.

Chemours is collaborating with the textile industry to improve the stain-fighting ability of apparel, linens, and textiles used in homes and cars. Many leading brands have evaluated and approved its use. The product behind Teflon EcoElite brand, Zelan R3 finish, meets a diverse range of demanding criteria to meet the challenge. Regional regulatory authorities have given permission for its manufacture and use.

Three-layer waterproof fabric for intense activity

Albion has partnered with Pertex, the specialist in lightweight and durable technical fabrics to bring to market the first cycling products to use Pertex Shield Air, a new high breathability three-layer waterproof fabric. The range consists of the Zoa insulated jacket, rain shell and burner, designed as a system that can be used together, or as standalone products, depending on the conditions and activity.

'The Zoa range is the culmination of many months' thinking, designing, refining and testing, and we are excited to now be bringing these products to market,' said Graeme Raeburn, lead designer at Albion. 'Zoa products answer a direct need for cycling-specific clothing geared towards the outdoors and adventure, and feature a number of considered details to make time spent on or off the bike using them easier and more comfortable. Working with the best fabric, insulation and trim suppliers in the market, and with a focus on responsible sourcing, we believe that Zoa can set a new standard for modern, technical and versatile cycling products.'

The Zoa insulated jacket is a highly functional outer or mid layer using a 100% recycled Pertex Quantum outer fabric and Primaloft Gold Eco breathable insulation. It is lightweight but warm, wind and weather resistant. The Zoa rain shell is based on a 100% recycled Pertex Shield Air main fabric that features an air permeable nanofibre membrane to provide extremely breathable waterproof protection.

AATCC method quantifies fibre shedding

AATCC TM212-2021, Test Method for Fiber Fragment Release During Home Laundering, provides a standardized method for quantifying fibre fragment shedding in the ongoing challenge to combat aquatic pollution. These fragments are sometimes referred to as 'microfibres' or 'microplastics.'

AATCC TM212 was developed to provide a means to determine the mass of fibre fragments released in an accelerated laundering setting. This method provides the global industry with a consistent and uniform test method to follow. Originally assumed to be a plastics problem, natural fibres are also appearing in marine life's food cycle. AATCC TM212 is not limited to manmade fibres, as it can be used to determine the fibre shedding potential of natural fibres and blends.

The standard is the result of collaboration, not only within AATCC committee RA100 Global Sustainability, but among stakeholders from several organizations including The Microfibre Consortium, headquartered in the UK, and the Cross Industry Agreement of European signatories.

Although unofficial and proprietary methods have been in use, AATCC

TM212 is the first global standard published to address the issue of quantifying fibre fragment release. The test method was developed and approved by consensus from a diverse group of experts from around the world and across related industries.

Ancillaries

Natural solutions to producing fire resistant fabrics

Finishing is the process that gives fabrics many of their most important characteristics. Camira Fabrics supplies high-end interior fabrics for everything from homeware to public transport, meaning flame-retardant finishes are a top priority. Collaborating with Future Fashion Factory, the company is moving toward a new finish that meets the same performance standards with a much smaller environmental impact: reducing water, energy and chemical usage for more efficient and sustainable manufacturing.

To investigate natural flame-retardant finishes, Camira collaborated with Professor Parik Goswami at the University of Huddersfield. For Parik, the opportunity aligned perfectly with Huddersfield's commitment to the Textiles 2030 initiative, which aims to accelerate, the shift towards sustainability and circularity in the UK.

Parik and his team in the Technical Textiles Research Centre undertook lab testing of new natural chemical alternatives, supported by Colin and Mick's commercial insight to develop solutions that would meet industry standards.

The result was a promising set of findings which shed light on the potential performance of a natural flame-retardant finish. Even more exciting, the new solution could be added to the fabric in the dye bath as part of a one-step dyeing and finishing process.

Camira produces fabrics at scale to meet large orders from around the world. Flame retardance is one of the most popular properties for these customers and needs to be imparted

through a finishing process after the fabric has been dyed and woven. Every stage of the manufacturing process adds time, energy, water or chemicals - as well as room for costly mistakes. As well as the time, risk and complexity associated with current methods, changing regulatory standards pose an entirely new challenge which limits business opportunities.

Camira's wool/bast fibre fabrics have a natural inherent flame retardancy offering a sustainable solution for some sectors, but for other wool fabrics, which require chemical flame retardant treatments, the industry is in need of a more sustainable solution.

Removing an entire stage of the manufacturing process would massively reduce the energy, water and chemical resources needed to produce Camira's fabrics - and by simplifying the process and reducing the margin of error, it would enable more consistent results to satisfy customers' quality specifications.

Camira is currently investigating commercial sources of natural chemicals which will enable them to scale up and commercialise the new technique. The novel approach could be applicable in markets that are still closed to the company, creating new opportunities worldwide. Bringing an innovative solution to market could even give Camira a new revenue stream.

Cotton nonwoven absorbs oil spills

Seshadri Ramkumar, a professor of chemical countermeasures and advanced materials at the Department of Environmental Toxicology of Texas Tech University, Lubbock, TX/US, in collaboration with his research team and Jayalakshmi Textiles Pvt Ltd, Aruppukottai/India, has developed a sustainable cotton product that can absorb oil instantaneously.

Using untreated low-grade cotton, an absorbent, nonwoven mat called Towelie has been developed, capable of collecting 50 times its own weight in oil. Raw, low-micronaire cotton is hydrophobic, meaning it will float on the surface of the water without sinking - ideal for toxic oil absorption.

While most commercial oil-absorbing materials are synthetic, Towelie is made of natural materials that are biodegradable and safe for

Designed for marine environments, Towelie can absorb oil while repelling water

marine life. The product is ready for distribution and available in 100% cotton or 90% cotton formulations - both are reusable and environmentally safe.

Air permeability tester from James Heal

Used to test the resistance of the flow of air through woven, knitted and nonwoven textile materials, James Heal has launched the AirPro air permeability tester. It is supplied with

the intuitive TestWise software, which has pre-loaded standards, a 'Quick Test' function and full flexibility to create an individual standard. Minimal operator training is required. The

TestWise software offers flexibility with standards and comprehensive reporting options.

Different test head sizes are also available in the tester from James H Heal & Co Ltd, Halifax/UK, which are suitable for a range of applications and standards. Changing test heads is quick and can be done without disconnecting wires and changing the pressure. The illuminated test bed can accommodate large samples, suitable for a variety of different materials, and medical grade air valves keep airflow consistent.

The new equipment is suitable for a range of applications, to test to a range of different international standards. AirPro is used to measure the resistance of the flow of air through products including performance apparel, medical textiles, PPE, infant products such as bedding, nonwovens, geotextiles etc.

Baldwin brings new connected technology

Baldwin Technology Company Inc showcased its new portfolio of optimized LED-UV curing, IR drying and automated cleaning solutions - all specifically designed for corrugated high-graphics printers at the European Federation of Corrugated Board Manufacturers (FEFCO) Technical Seminar, held recently. The company's corrugated portfolio offers three systems that can be installed individually or as a complete solution, enabling a connected system for printers.

Baldwin's FlexoCleanerBrush removes hickeys in four seconds and can clean plates within three to four minutes, increasing print quality and providing a cleaner, safer work environment. This automated cleaner removes fibres, debris and fine lines from printing plates at the beginning, during or at the end of a job, allowing printers to achieve optimal quality with minimal downtime. Designed to replace all manual activities, this cleaning system eliminates skin contact with wash agents, increasing workers' safety.

For wide-format flexo corrugated box printing, Baldwin's AMS Spectral UV has engineered CorruCure, a new

generation of LED-UV technology that offers more than a 60% reduction in power consumption in an ultra-compact UV lamp head. This revolutionary solid-state curing system, designed specifically for corrugated LED printing, emits almost no heat or ozone, and accommodates width-switching. It also enables the curing of high-value decorative solutions, such as full-gloss, spot and matte coating effects on a variety of corrugated substrates, making it the ideal addition for product enhancement.

Lastly, Baldwin's FlexoDry2 infrared dryer, developed for corrugated flexo printing presses, utilizes patented Diamond IR lamps capable of reducing energy consumption by upto 30%, when compared to traditional IR dryers with aluminum or gold reflectors.

Dramatically improved drying enhances colour definition, and reduces or eliminates marking, while allowing full-speed printing. The system offers an optional integrated hot-air knife with temperature control to provide better surface drying. Taking safety into consideration, the FlexoDry2 comes with an integrated safety light curtain as standard and an optional camera vision system.

Emtec Electronic's tactile sensation analyzer

Studies indicate that the way a fabric feels to the touch - i.e. its handfeel - strongly influences a consumer's decision to buy. Traditionally, manufacturers of textiles and nonwovens use hand panels comprised of individual judges to assess a material's haptic properties. This can be a time-consuming process and is often influenced by several external factors, since the human sense of touch is a complex and inherently subjective experience.

In contrast, theTactile Sensation Analyzer from Emtec Electronic presents a unique approach: a sound analysis in two different frequency areas determines a material's softness and roughness. Parameters such as stiffness, plasticity, hysteresis and elasticity are then measured with a deformation measurement, i.e. how much a product deforms under a certain load and how well it recovers after deformation. Specific algorithms can combine these individually measured parameters into so-called handfeel values, which correlate very well with the human tactile sensation.

Independent evaluations from the industry designed to test the functionality and efficacy of the TSA device have consistently found the results to be highly comparable to the results of physical tests and hand panels.

Processing and Machinery

Taking automated finishing to the next level

Knopf's Sohn, a leading contract finisher of technical textiles, has installed a fully automated Montex stenter at its plant in Helmbrechts, Germany.

The Montex machinery range is constantly being upgraded to meet evolving customer needs for greater automation, ease of operation and energy optimisation. The latest ten chamber line at Knopf's Sohn, with a working width of up to 2.0 metres, was engineered to specific requirements in order to accelerate the company's move to fully automatic control of its production, and high scaffolding was required for its installation.

The line benefits from two integrated ECO Booster modules to provide high energy savings. These compact, air-to-air heat exchangers, installed within the roof structure of the line, exploit energy from the exhaust gas to preheat upto 60% of the incoming fresh air entering the stenter.

The use of a single ECO Booster unit has been calculated to save upto 35% in energy costs, based on fixation processes. Fully automatic operation,

High scaffolding was required for the installation of the line which benefits from two integrated ECO Booster modules to provide significant energy savings.

set at the Monforts Qualitex control unit, ensures there is no additional burden on the machine operator.

The line is powered by Exxotherm indirect heating, which practically eliminates the yellowing which can be experienced during the treatment of certain polyamide and elastane-based fabrics, and is also equipped with a Conticlean circulating air filter system for constant high drying capacity, thanks to the automatic cleaning of fluff from the filter system during production.

Knopf's Sohn operates a total of five stenters, but the Montex takes automated finishing for the company to a new level.

The latest Qualitex visualisation software offers operators reliability and easy control with its full HD multi-touch monitor and slider function, dashboard function with individual adaptation to operating states and faster access to comprehensive recipe data management.

With the Monformatic control system, the exact maintenance of the dwell time in combined treatment processes (drying and heat-setting) can be monitored.

Knopf's Sohn Managing Director Uwe Zuleg at the new Montex controls

When the heat-setting point is reached, the fan speed is automatically adjusted, keeping energy consumption fully under control.

Right fibre, right fabric, automatically

Nonwoven materials cannot really be better than the fibers they are made of. But there is a real threat to the quality of nonwovens caused by contamination. Fibre cleaning is the solution and bundle size is the key detail: small contaminant particles can hide inside bigger bundles, making them especially difficult to locate when the material is more compressed. Uster Jossi Vision Shield N is ideally positioned in the line to overcome this, directly behind the fine opener. This ensures that the fibre bundles pass the spectroscopes in their most open state.

Uster Jossi Vision Shield N is the result of surveys, close collaboration with international nonwovens companies and countless hours of field tests. Installation is easy, since the fibre cleaner's slim design fits perfectly into existing lines - and readily copes with the high output of standard production lines. For best detection results, the fibre cleaner is tuned to identify the typical contamination types in nonwovens, including coloured fibres.

While other technologies use conventional colour cameras, the built-in spectroscopes of Uster Jossi Vision Shield N operate on a much greater wavelength range. This enables detection of contamination within the 'invisible' range of infrared and ultraviolet light, and even contamination fragments of the same or similar shade as the fibers themselves - down to the fineness of a human hair.

Uster Jossi Vision Shield N is made in Uster, Switzerland. So is Uster EVS Fabriq Vision N, the nonwovens quality assurance system which ensures a consistently high rate of fault detection using automated inspection during the production process.

The Uster nonwovens systems lead to total fabric quality assurance by using automated control during intermediate inspection. Uster EVS Fabriq Vision N locates any visible faults objectively and consistently. Defects in every roll are located and recorded in a defect map, at full line running speeds.

Uster EVS Fabriq Vision N enables seamless integration of an inspection system into any production process - and ideally into nonwovens manufacturing lines - detecting contamination, holes, irregularities and any other defect. Installation is simple and flexible: a fixture bar bridges the full width of the process line, holding as many spectroscopes as required for the application.

Uster Jossi Vision Shield N contamination sorters detect and eliminate contamination at the fibre preparation stage, before it becomes shredded into smaller particles.

The combination of Uster automated contamination removal and quality assurance is the best solution today for nonwovens producers to protect quality, avoid material waste and take full advantage of the potential for process optimization.

India's printing company transforms business with Baldwin's technology

Maruti Printing transformed its business as the first printer in India to adopt the latest LED-UV curing technology from AMS Spectral UV, a Baldwin Technology company. The hybrid system, which includes traditional UV modules, has been in production for nearly two years and has significantly expanded the offset printer's capabilities for its customers, including adding the ability to print on all types of plastic substrates.

Not only does Maruti have the distinction of being an LED-UV trailblazer in India, but it also is first in the market to upgrade a highspeed, high-performance Heidelberg Speed Master 72F+L six-colour printer with coating tower - which prints upto 15,000 sheets per hour - with AMS Spectral UV's high-power AMS XP9-I Series LED-UV and P3 Smart UV curing modules.

In January 2020, Maruti took delivery of two AMS XP9-I Series LED-UV modules to cure colours in the interdecks. The modules are ideal for the highest-speed curing situations that require consistent peak intensity to the substrate, which is the case for Maruti's offset printing standard of perfection with every cure.

To cure ink, as well as a growing variety of LED coatings, Baldwin's AMS Spectral UV modules can be located after print units, or in the press delivery after the coater. When inks and coatings are cured with LED-UV, they become instantly dry via photopolymerization, allowing for printing on any substrate, including plastics and metallized stocks. Plus, work can be immediately finished and sent to the bindery once it comes off the press, without the need for heat, spray powder or drying time.

'Our XP9-I Series LED-UV modules, powered by our robust NS Series chips and our all-new SC-I generation control system, deliver the highest level of curing performance and are particularly suitable for the harsh Indian production environments, where extreme temperatures and humidity often pose a challenge for inferior equipment,' said Hemant Desai, Managing Director of Baldwin Technology's Baldwin Vision Systems in India, the sole distributor for AMS Spectral UV products in the region. 'There is an emerging group of Indian printers that are seeking to achieve the highest possible levels of quality and productivity, and Maruti's vision matched up well with ours.'

In addition, Maruti took delivery of two P3 Smart UV curing modules for installation at the end of the press to cure any type of UV coating and expand the company's scope of coating compatibility to general UV coatings in order to offer its customers the widest range of UV printed choices in the Indian market.

The P3 Smart UV housings are completely liquid-cooled to ensure safe, consistent performance and increased uptime, and modules feature a universal design, so that any unit can fit any print unit location. P3 modules can be changed, inspected and cleaned quickly and easily, without tools, and lamps slide and lock into place smoothly and securely.

'The system also features AMS Spectral UV's InteliLED IoT solution for constant monitoring and remote trouble-shooting, which have become especially important in these pandemic times,' Desai added. 'The technology allows for real-time and historical monitoring of UV output to ensure uninterrupted curing results. Real-time data is measured, trended and historically analyzed for any variances in temperature, electrical function and UV output that could lead to downtime or a reduction of curing performance every second for the life of the equipment. Maintaining rich, granular data related to system performance can help identify and correct issues long before they arise.'

Asian Dyer

ASIAN DYER is a specialized bi-monthly journal for all those involved in chemical processing of textiles, be it in fibre or yarn or fabric form. It offers unparallel technological information on dyestuffs, speciality chemicals and auxiliaries, processes and machinery for dyeing, printing and finishing, testing equipments and utilities. In every issue, it covers general technological developments and features of specific interest to the processing sector and is proud to enjoy the highest standards of editorial content.

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CALENDAR

2022

January

21-23 **Dye Chem World 2022**, Tirupur, India
www.SDC.org.uk

29 **Seminar on Technical Textiles**, Vapi, Gujarat
www.textileassociationindia.com

February

08 **Press Conference Swiss Textile Machinery**, Switzerland www.swissmem.ch

May

17-18 **Denim Premiere Vision**, Berlin, Germany
www.denim.premierevision.com

17-19 **Techtextil North America**, Atlanta, Georgia, US
www.techtextil-north-america.us.messefrankfurt. com

June

02-04 **Intertex Portugal**, Porto, Portugal
www.intertexportugal.com

14-18 **ITM 2022**, Istanbul, Turkey
www.itmexhibition.com

21-24 **Techtextil Frankfurt**, Frankfurt, Germany
www.techtextil.messefrankfurt.com

August

22-26 **Achema 2022**, Frankfurt am Main, Germany
www.achema.de

September

06-08 **Cinte Techtextil China**, Shanghai, China
www.cinte-techtextil-china.hk.messefrankfurt.com

November

18-20 **Asia Coat + Ink Show 2022**, Shanghai, China
www.showsbee.com

20-24 **ITMA Asia + CITME 2022**, Shanghai, China
www.itmaasia.com

28-30 **ISPO Munich 2022**, Munich www.ispo.com

December

08-13 **ITME India**, Noida, UP, India
www.india-itme.com

2023

June

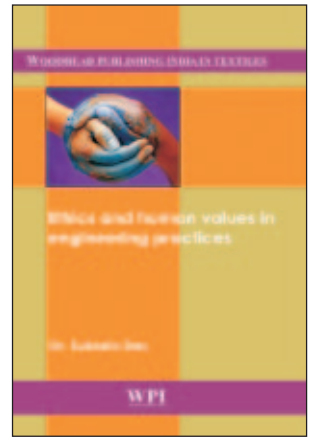
08-14 **ITMA 2023**, Milan, Italy www.itma.com

BOOK REVIEW

Ethics and Human Values in Engineering Practices

Publisher: Woodhead Publishing; Pages: 116

This book emphasizes on basic human values and engineering ethics which deal with understanding the moral values that ought to guide the engineering profession, resolve the moral issues in the profession and justify the moral judgment concerning the profession and professionalism which require certain attitudes and typical qualities expected from a professional. Engineering is viewed as an experimental process on a social scale involving human subjects. Role of multinational organizations, ethics in computers, internet functions, military development and environmental ethics have been discussed towards sustenance and progress for the engineers.

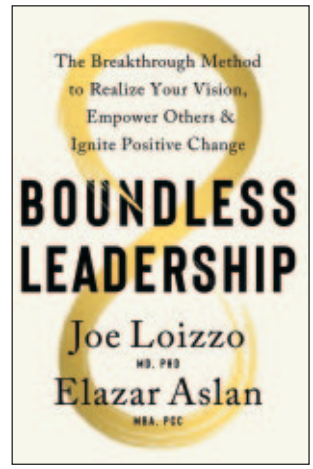


The book is aimed at industry professionals, retailers, factory heads, academicians and students intending to join any industry in the areas of management, production, R&D and quality assurance covering engineering and environmental ethics, moral values, human rights and global issues.

Boundless Leadership

Joe Loizzo and Elazar Aslan
Publisher: Shambhala; Pages: 296

Boundless Leadership provides a complete and systematic roadmap to finding meaning in one's work, realizing full leadership potential, and inspiring team with resilience, innovation, compassion and confidence.



This book offers accessible, real world applications to bring ease to leading oneself and others, and provides examples from the authors' experience with clients, including CEOs of multi-billion-dollar businesses, entrepreneurs and managers trying to balance the complex challenges of work and life. Each section offers a practical application to ease daily challenges, including clarifying intentions for better decision-making, improving accountability and responsibility for better team collaboration, and embodying purpose to optimize impact on one's organization and society at large. It is especially needed during this explosion of remote working and provides advice and guidance to remain productive and joyful when the work environment is in flux.

WE LOVE CELEBRATING TOGETHER

The last year has been an utter roller coaster.
All we need is a Shubh Arambh to
reunite and celebrate together, cherish each other's company and
make the most of this healthy recovery, from this dark phase.

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Let us add prayers & good wishes this new year.

Happy New Year

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