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Cotton

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Content

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News

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The World Cotton Research Conference (WCRC) Monthly Webinar Series

The ICAC, ICRA and Cotton Incorporated are delighted to inform you that a monthly WCRC-7 Plenary Lecture Series called 'COTTON WEBINARS' is being launched on the World Cotton Day 7 October 2020 at 9.45 AM (Washington DC time). The webinars will be scheduled on a specified day in the first week of every month. The lectures will feature two presentations (30 min) each day by eminent globally renowned experts followed by a Q& A session. The lectures will be translated simultaneously into French and Spanish.

ICAC, ICRA and Cotton Incorporated have introduced a series of monthly webinars leading up the seventh installment of the World Cotton Research Conference, which will be held 2-7 October 2021 in Sharm el-Sheikh, Egypt. The webinars are free to all but a meeting ID and passcode are required. Details about the upcoming speaker and webinars, as well as a list of past webinars and links to watch them, can be found below.

https://icac.org/News/NewsDetails?NewsId=2368&YearId=2021

7 October 2020

Game-Changing Science & Technologies for Cotton

- Dr Ibrokhim Abdurakhmonov, Minister of Innovative Development, Uzbekistan

Exciting Digital Technologies for Cotton Farming

- Dr Kater Hake, Cotton Incorporated

4 November 2020

Climate Change: Physiological Implications and Challenges

- Dr Raja Reddy, Mississippi State University

Climate Change: Management Implications and Challenges

- Dr Michael Bange, CSIRO

2 December 2020

Soil Health

- Prof Rattan Lal, Ohio State University, USA

Battling Bollworm Resistance to Bt Cotton

- Prof Bruce Tabashnik, University of Arizona

6 January 2021

Achieving High Yields and Fine Quality of Cotton with Agronomic Technologies

- Prof Hezhong Dong, Shandong Academy of Agricultural Sciences

Novel Genetic Traits for Cotton Improvement

- Prof Keerti S Rathore, Texas A&M University

3 February 2021

Genes, Jeans and Genomes: What We Now Know about the Evolution of Gossypium and the Origin of Polyploids

- Prof. Jonathan Wendel, Iowa State University, USA

Increasing Automatic and Robotic Applications in Cotton

- Dr Edward Barnes, Cotton Incorporated

3 March 2021

The Challenges with Cotton Sustainability

- Allan Williams, Australia's Cotton Research and Development Corporation

Is Cotton a Water-Guzzling Crop?

- Marcelo Peytas, Argentina's National Institute of Agricultural Research

7 April 2021

Genomic-assisted Breeding in Cotton

- Dr Mehboob-ur-Rahman of the National Institute for Biotechnology and Genetic Engineering

The Power of Cotton Genomics

- Dr John Yu, research geneticist with USDA-ARS and adjunct professor with Texas A&M University

5 May 2021

Importance of Non-HVI "High Volume Instrument" Cotton Fber Properties

- Dr Eric Hequet, Paul Whitfield Horn Professor and Associate Vice President for Research, Texas Tech University, USA.

Wealth from Waste: Cotton by-product value Addition

- Dr Prashant Patil, Vice Chancellor, Mahatma Phule Agricultural University, Rahuri-India

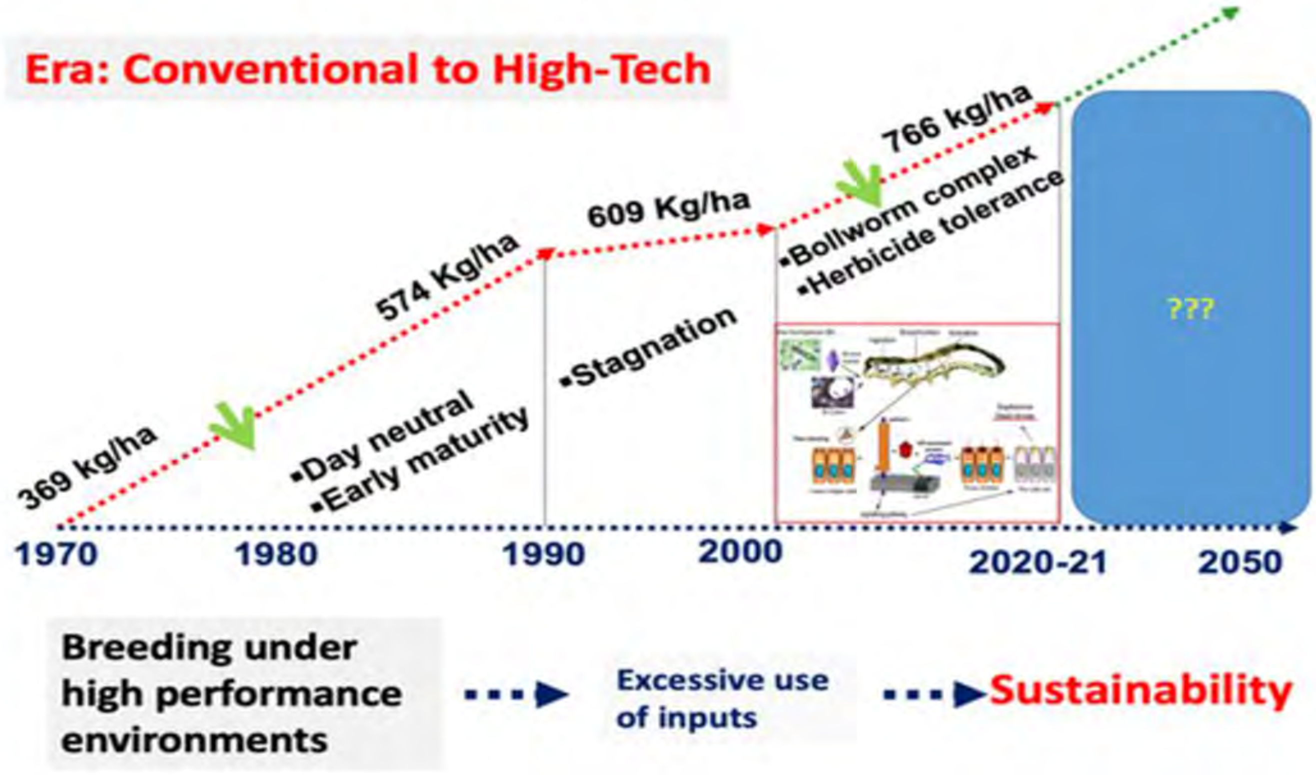
Genome assisted breeding in cotton

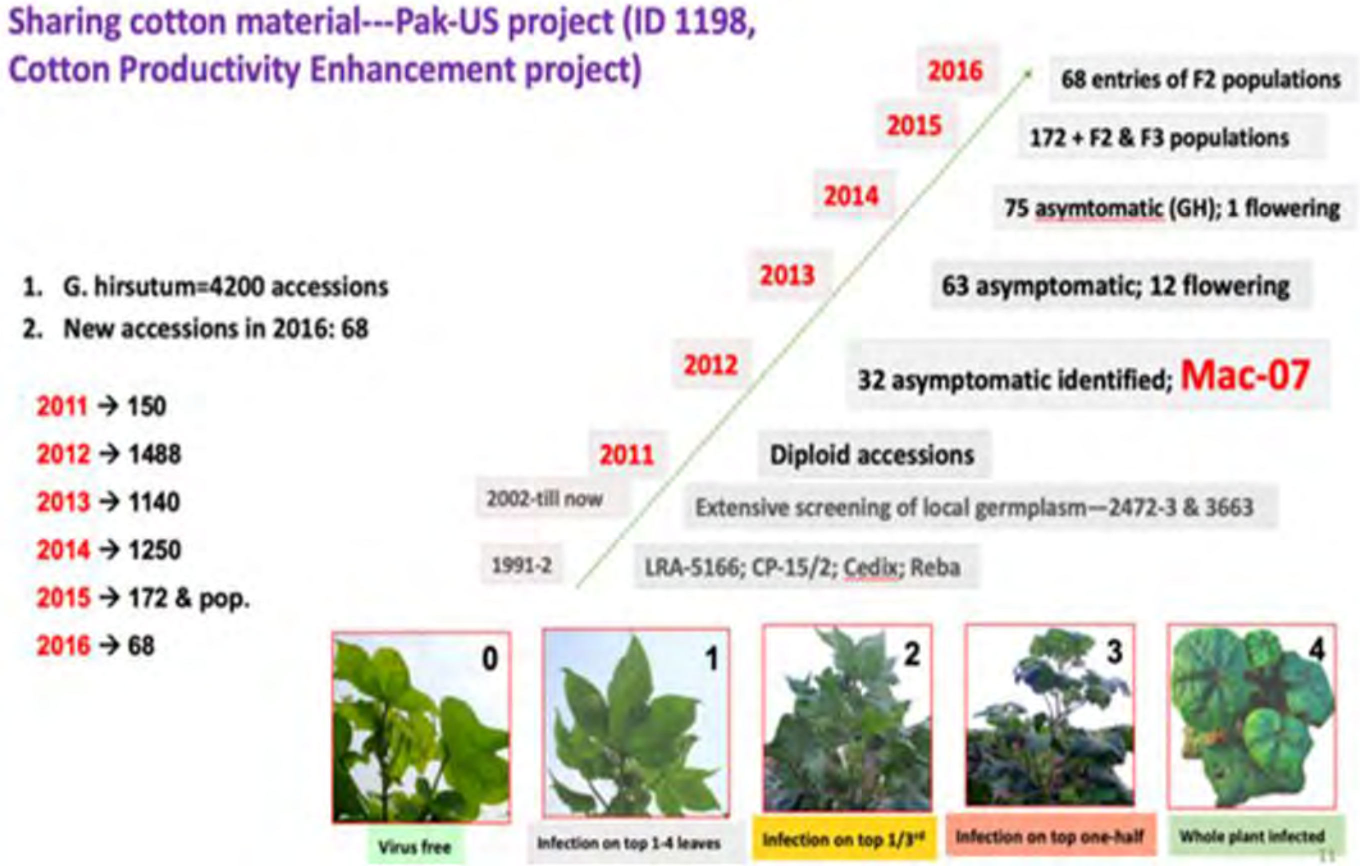
(Highlights of the WCRC-7 Webinar. Summarized by Dr Sandhya Kranthi, ICAC)

Email: Sandhya@icac.org

Mehboob Ur Rehman
Group Leader Plant genomics and Molecular breeding lab
Agriculture Biotechnology Division, National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad, Pakistan

- India, Africa, Pakistan show yield gaps between potential yield and actual yield thereby bringing down the world average.
- Increases in cotton production using conventional technologies to high end technologies were recorded over the last 20 years, but more recently the emphasis has been on sustainability.
- Climate change, particularly temperature and salinity impacts cotton production adversely. Collaborative studies at NIBGE have helped identify germplasm lines that could combat heat stress.
- Pink bollworm is a re- emerging major pest of cotton in addition to whiteflies and thrips. Amongst diseases, the cotton leaf curl virus is a major issue. Pakistan expects a 50% decrease in production due to various adverse factors this year.
- Genome assisted breeding, mutation breeding, GM technology and genome editing technology have been adopted for genetic enhancement of cotton. Genome and gene editing technologies have been helping in precision breeding.
- Germplasm resources appear to be duplicated across the world. Phenotypic and genotypic characterization on a massive scale could help to identify unique germplasm lines.
- Over several years elite cultivars had to be withdrawn at regular periodicity because of new Leaf curl virus strains that overpower the cultivars. Multilocation field evaluation
- of germplasm across nations, for resistance to leaf curl virus through good phenotypic/ genotypic platforms is essential especially in leaf curl hotspots like India and Pakistan.
- Burewala, Multan and Kokharan strains are genetically different. However, Burewala strain appears to be no longer prevalent in the field. The old strains are re-emerging. Breeding for leaf curl resistance was successfully achieved by screening material between Pakistan and Mexico resulting in IR- NIBGE11 using MC07 as the source of resistance under the Pak-Mexico project.
- Similarly, a Pakistan-China screening program identified a genotype that is tolerant to temperatures above 45°C. Screening was done in the field for the entire growth period.
- Mapping populations have been developed using interspecific crosses between *Gossypium hirsutum* x *Gossypium barbadense* and are being used in breeding programs.
- About 6705 quantitative Trait Loci (QTL) markers have been developed apart from the identification of several markers in collaborative programs.
- Climate resilient varieties are being bred to combat climate change.


Era: Conventional to High-Tech
369 kg/ha
574 Kg/ha
609 Kg/ha
766 kg/ha
•Day neutral
•Early maturity
•Stagnation
•Bollworm complex
•Herbicide tolerance
???
1970
1980
1990
2000
2020-21
2050
Breeding under high performance environments
Excessive use of inputs
Sustainability


Sharing cotton material---Pak-US project (ID 1198, Cotton Productivity Enhancement project)
1. G. hirsutum=4200 accessions
2. New accessions in 2016: 68
2011 → 150
2012 → 1488
2013 → 1140
2014 → 1250
2015 → 172 & pop.
2016 → 68
2016
68 entries of F2 populations
2015
172 + F2 & F3 populations
2014
75 asymtomatic (GH); 1 flowering
2013
63 asymptomatic; 12 flowering
2012
32 asymptomatic identified; Mac-07
2011
Diploid accessions
2002-till now
Extensive screening of local germplasm—2472-3 & 3663
1991-2
LRA-5166; CP-15/2; Cedix; Reba
0
1
2
3
4
Virus free
Infection on top 1-4 leaves
Infection on top 1/3rd
Infection on top one-half
Whole plant infected

The power of cotton genomics

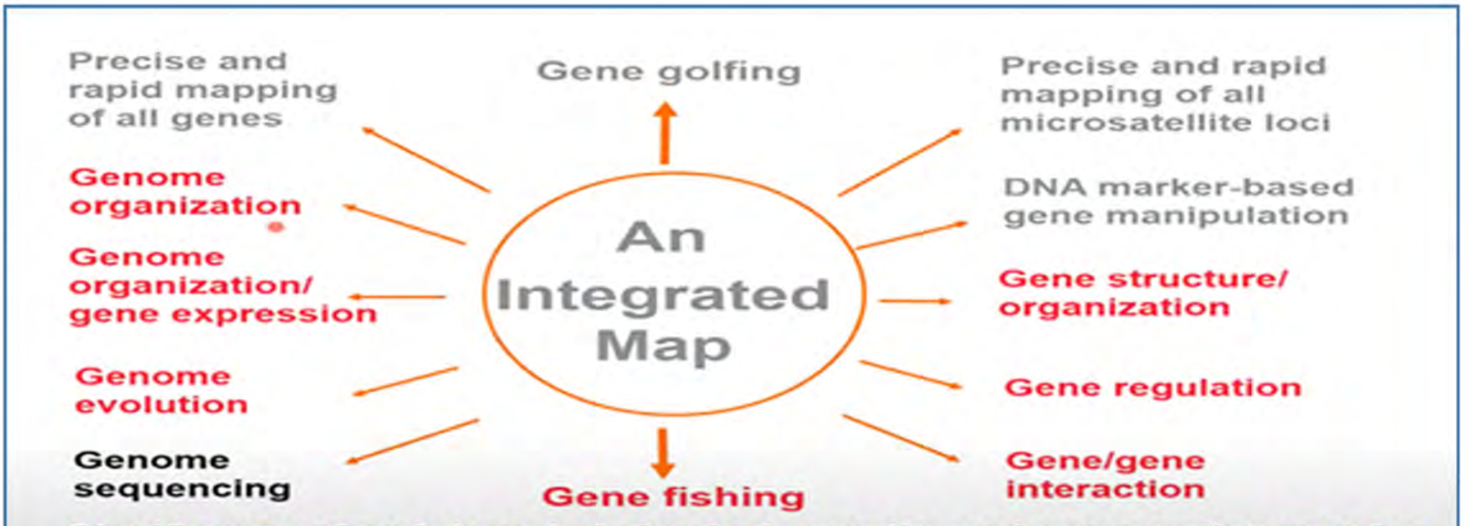
(Highlights of the WCRC-7 Webinar. Summarized by Dr Sandhya Kranthi, ICAC)

John Wu

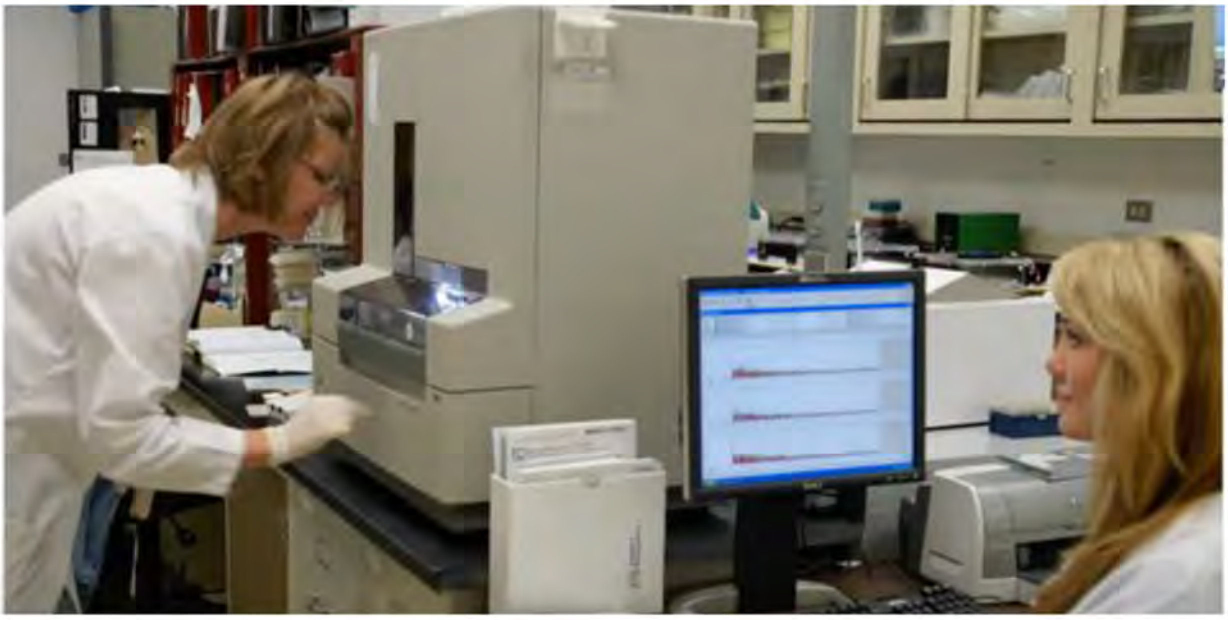
Research Geneticist, USDA-ARS, and Adjunct Professor, Texas A&M University, USA

Dr. John Wu began his story that facilitated his journey as a cotton scientist who transitioned from conventional cotton breeding into molecular breeding. The identification and characterization of markers for actual use in breeding programs was highlighted through examples that he elegantly discussed. Some of the points he highlighted in the presentation are as follows:

- Genetic base of cultivated cotton has become very narrow. The two main factors responsible for the narrow genetic base are the lack of easier tools for gene transfer and that biotechnology centered around private companies.
- The International Cotton Genome initiative (ICGI) has been contributing immensely towards generating resources and sharing genomics knowledge across the world. The agreement between US and China on cotton genome initiative greatly catalyzed the genome sequencing efforts.
- ICGIU facilitated mapping of genomes of *G. raimondii* (2012) *G. arboreum* (2014) and *G. hirsutum* (2015) which laid the foundation for genome studies. As of now, at least a dozen Gossypium species have been sequenced.
- in addition to the genome sequencing, the ICGI accomplished identification and characterization of markers, QTLs, annotated protein coding genes and formation of one centralized database on cotton genomics with bioinformatic tools.
- Texas Marker 1 an inbred extract derived from DPL-14 is recongnized as the genetic standard for upland cotton. An integrated map of chromosome number 12 in the cotton *G.hirsutum* genome was presented.
- Fibre-development genes were characterized more from A subgenome than D genome; but more transcription factors from D genome were identified than A genome. Interaction of the two subgenomes in one nucleus enhances fibre production and development.
- Fatty acid profiles using high seed oil containing lines in the germplasm were identified in collaborative programs.
- Fungal disease tolerance, salt tolerance and drought tolerance genes on chromosomes were identified, characterized and used for breeding.
- Gene silencing was carried with bacterial leaf blight susceptibility genes using virus induced gene silencing mechanism.
- Enhancement of centralized cotton database and bioinformatics tools for improved cotton breeding can facilitate precision breeding across the world.
- About 45000 images of germplasm are available in the database. Genetic, genome and phenotypic information about germplasm lines are provided and are accessed by cotton breeders across the globe. Researchers from 114 countries provided the data.
- *Gossypium hirsutum* germplasm collections are being characterized using more than 105 simple-sequence-repeat (SSR) markers.
- Species specific marker bands were used for introgression and in correcting misidentification of germplasm.
- Cotton genetics is moving into molecular genetics for addressing functional genes. Full potential of this area can be exploited with the continuation of elaborate project collaborations between laboratories and their scientists across the globe.



Significance of an integrated physical, genetic, and comparative map for cotton genome research. It is a "freeway" for rapid isolation of numerous mapped genes and QTLs, and for many other biological studies.



Cotton DNA run with ABI-3130 Genetic Analyzer

Susceptibility genes of bacterial blighted cotton were silenced by VIGS. Seedling growth was not affected by VIGS-GhSWEET10. Picture taken at three weeks after gene silencing. Cox et al., 2017

Silencing of Cotton Bacterial Blight Susceptibility genes

Indian Cotton: The love hate relationship with water

Dr. C.D. Mayee
South Asia Biotechnology Centre (SABC)
charumayee@yahoo.co.in,
Web: www.sabc.asia

Despite substantial gains in production over the last 19 years after the introduction of Bt cotton, the average cotton yield in India is stagnant (around 500 kg lint per ha.) since 2010-11, a typical Indian cotton yield syndrome. In 2013-14, India's best national average yield was 565 kg lint per ha was far below the world's average yield of 940 kg per ha. Low and unstable yields due to poor crop performance and resource poor farmers characterize the rain fed areas of Deccan plateau of Central India covering nearly 60 % of cotton area. The low average yields of Indian cotton are often blamed on the availability of water at critical times in Central India. However, in the best of water availability in North India the yield is just double of rain-fed areas of Central India (620 kg per ha).

Therefore, mere availability water does not improve yields. A recent study indicated that in the Central India where nearly 12% cotton area is under drip irrigation have an average yield of 940 kg lint per ha as against the flood-irrigated 28% cotton area of North Zone. Use of controlled water in cotton has been highly rewarding and is also supported by series of studies carried out under all India coordinated research Project on cotton. It is necessary to know that water has a love-hate relationship with cotton crop and hence neither too much water nor no water is the real cause of low average cotton yield in India. Large scale adoption of controlled water use on 40 % irrigated cotton area can easily enhance Indian cotton yield to 1000 Kg per ha in immediate future. May be a policy directive in this direction would be useful.

A new Ligon-lintless mutant (li_y) in upland cotton

Efrem Bechere, PhD
Research Geneticist, USDA-ARS, CGRU, 141 Experiment Station Road, P.O. Box 345. Stoneville, MS 38776

Cotton fiber mutants are useful tools for understanding the genetics and physiology of cotton fiber development. Currently, there are two naturally occurring dominant lintless mutant lines, Ligon-lintless-1 *(Li_1)*, Ligon-lintless-2 (Li_2), and one man-made mutant line, Ligon-lintless-x (Li_x) that exhibit extremely short lint fibers. Here we report a new lintless mutant which is the result of artificial chemical mutagenesis. In 2008, the cotton line MD 15 (PI 642769) was mutagenized with 3.2% v/v ethyl methane sulfonate (EMS). In 2010, a single Ligon-lintless type plant was identified among the 2,000 M_2 mutant progeny plants and was designated li_y. This plant was crossed with the wild type MD 15 with the objective of determining the genetic control of the lintless trait. Unlike Li_1, Li_2 and Li_x, which are controlled by a single dominant gene, this new lintless trait is controlled by a monogenic recessive gene designated as li_y. The li_y plant is very short and stunted and has an okra leaf phenotype. The li_y gene is not allelic to either Li_1 or Li_2. The genetic loci controlling these four Ligon-lintless mutations are located on four different chromosomes.

This new lintless mutant will be useful in further investigating fiber elongation in cotton.

REFERENCES

Efrem Bechere, David D. Fang, and Marina Naoumkina. A New Ligon-Lintless Mutant (*liy*) in Upland Cotton Journal of Cotton Science Pages: 168-174 (Featured Article)

Fang, D.D., Naoumkina, M.A., Thyssen, G.N., Bechere, E., Li, P., Florane, C.B. 2020. An EMS-induced mutation in a tetratricopeptide repeat-like superfamily protein gene (Ghir_A12G008870) on chromosome A12 is responsible for the liy short fiber phenotype in cotton Journal of Theoretical and Applied Genetics. 133(1):271-282. https://doi.org/10.1007/s00122-019-03456

Naoumkina, M.A., Bechere, E., Fang, D.D., Thyssen, G.N., Florane, C.B. 2017. Genome-wide analysis of gene expression of EMS-induced short fiber mutant Ligon lintless-y (liy) in cotton (Gossypium hirsutum L.) Genomics. 109:320-329

Comparison of Ligon-lintless mutant phenotypesof *Gossypium hirsutum*. Open bolls of: A. MD 15 (WT); B. *Li1;* C. *Li2;* D. and E. *liy;* F. mature seeds of MD 15 and *liy;*G. MD 15, *liy,* and *Li1* plants in the field.

Innovative Cellulose Bioconversion Green Technologies

Dr. Saed Ahmed Samy Yousef
Associate Professor, Kaunas University of Technology. K. Donelaičio St. 73, 44249 Kaunas, Lithuania
Email: ahmed.saed@ktu.lt

Currently, millions of tons of cotton-based waste (e.g textile waste, end-of-life cotton banknotes, lint-microfibers, etc.) are produced annually accompanied by large amounts of emissions, what causes several serious environmental and health problems. In order to valorization this sector and integrate it into a circular economy principle within the concept of sustainability, Assoc. Prof. Samy Yousef (Kaunas University of Technology) and his research group have developed three full Green/eco-friendly technologies to extract cotton, glucose, and energy products from textile waste and end-of-life euro banknotes using mechanical, thermal, chemical, and biological treatments. In the first technology cotton and cellulose nanocrystals were recovered from textile waste, end-of-life cotton banknotes using chemical technology composed of two main processes: leaching process using nitric acid (conc. <60%) to remove dyes followed by dissolution treatment using green switchable hydrophilicity (SHS) or Dimethyl Sulfoxide (DMSO) solvents to dissolve the polyester component. Finally, the liberated cotton was purified using a bleaching process **(Fig. (1-3))**. Based on the published results, this technology has a recycling rate (93%), profitability (1466 $/ tonne), greenhouse gas emissions (-1,534 CO_2-eq/ tonne). It is worth mentioning the polyester fraction was extracted from the spend solutions using rotary evaporation in case of DMSO and by adding CO_2 to the spend solution at 0°C in case of SHS. While in the second technology, textile waste, cotton banknotes, and lint-microfibers generated from clothes dryer have been treated thermally using mini-pyrolysis plant in converted into 38% oil and 46% gas (textile waste), 40% oil and 44% gas (cotton banknotes), and 31% oil and 48% of gas (lint-microfibers) **(Fig. (4))**.

Whereas the biological process has been used in the last technology to convert end-of-life euro banknotes into glucose with a yield 96% and all the involved processes are shown in **Fig. (5,6)**. All experiments of the developed technologies were performed on the basis of the concept of Technology Readiness Levels within TRL4-6. Now, we are looking for industrial partners to upscale the developed technologies and spinning the recovered cotton into yarns, and fabric preparation for textile production again. Regarding the recovered energy products (oil and gas), currently, we are working on upgrading them to improve their quality, to be ready for using in the energy sector.

REFERENCES

1. Yousef, S., Kuliešienė, N., Sakalauskaitė, S., Nenartavičius, T., & Daugelavičius, R. (2021). Sustainable green strategy for recovery of glucose from end-of-life euro banknotes. *Waste Management*. https://doi.org/10.1016/j.wasman.2021.01.007
2. Yousef, S., Eimontas, J., Zakarauskas, K., Striūgas, N., & Mohamed, A. (2021). A new strategy for using lint-microfibers generated from clothes dryer as a sustainable source of renewable energy. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2020.143107
3. Yousef, S., Tatariants, M., Tichonovas, M., Kliucininkas, L., Lukošiūtė, S. I., & Yan, L. (2020). Sustainable green technology for recovery of cotton fibers and polyester from textile waste. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2020.120078
4. Yousef, S., Eimontas, J., Striūgas, N., Trofimov, E., Hamdy, M., & Abdelnaby, M. A. (2020). Conversion of end-of-life cotton banknotes into liquid fuel using mini-pyrolysis plant. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2020.121612

5. Yousef, S., Hamdy, M., Tatariants, M., Tuckute, S., El-Abden, S. Z., Kliucininkas, L., & Baltusnikas, A. (2019). Sustainable industrial technology for recovery of cellulose from banknote production waste and reprocessing into cellulose nanocrystals. *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2019.06.026
6. Yousef, S., Tatariants, M., Tichonovas, M., Sarwar, Z., Jonuškienė, I., & Kliucininkas, L. (2019). A new strategy for using textile waste as a sustainable source of recovered cotton. *Resources, Conservation and Recycling*. https://doi.org/10.1016/j.resconrec.2019.02.031
7. Yousef, S., Eimontas, J., Striūgas, N., Tatariants, M., Abdelnaby, M. A., Tuckute, S., & Kliucininkas, L. (2019). A sustainable bioenergy conversion strategy for textile waste with self-catalysts using mini-pyrolysis plant. *Energy Conversion and Management*. https://doi.org/10.1016/j.enconman.2019.06.050

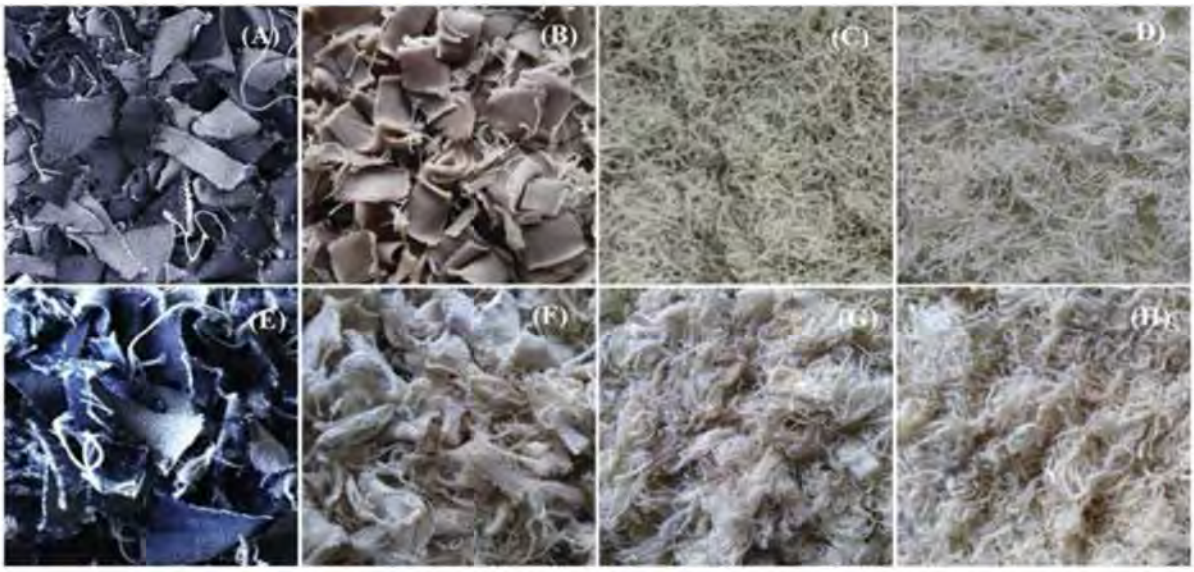


Fig. (1): Waste denim fabric before and after being subjected to leaching and dissolution treatments: A, E) untreated samples, B, F) bare fabric, C, G) treated fiber at the middle of dissolution process, and C, G) treated fiber at the end of dissolution process.

Fig. (2): Waste jeans separation flowchart

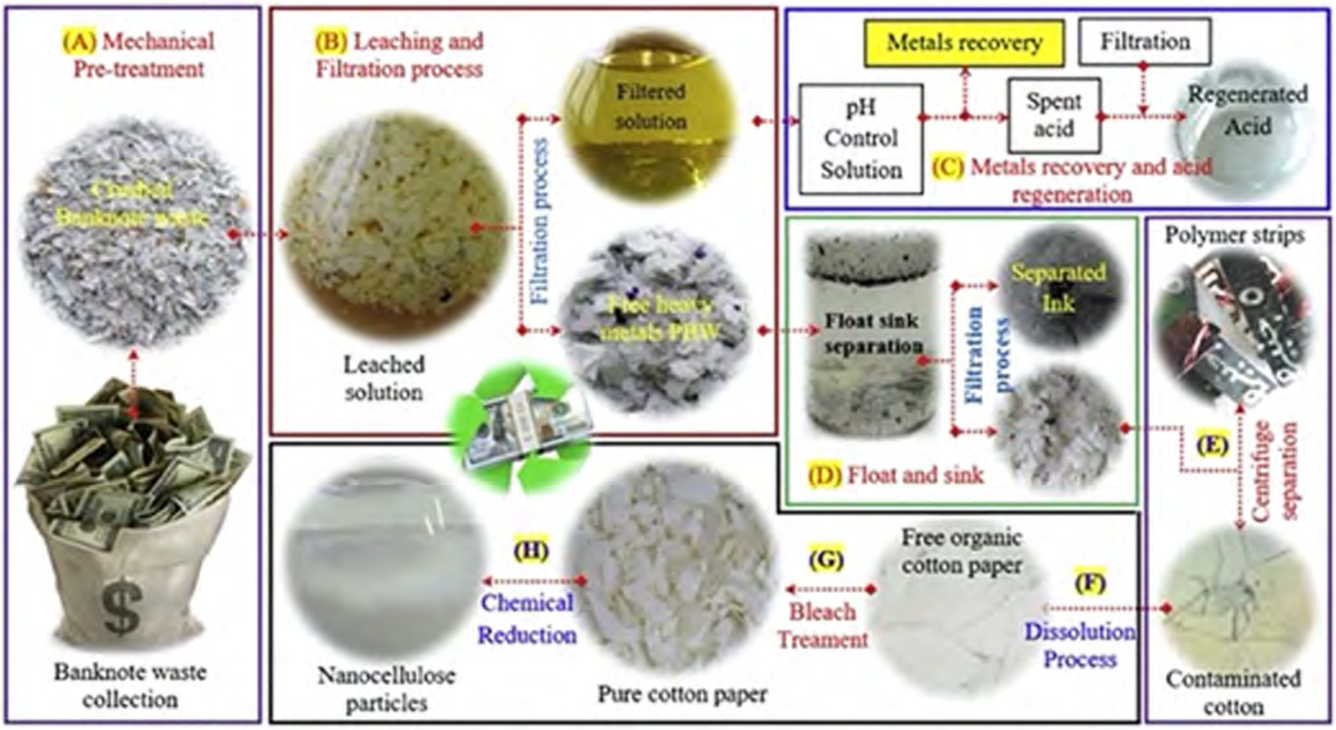


Fig. (3): Waste banknote separation flowchart.

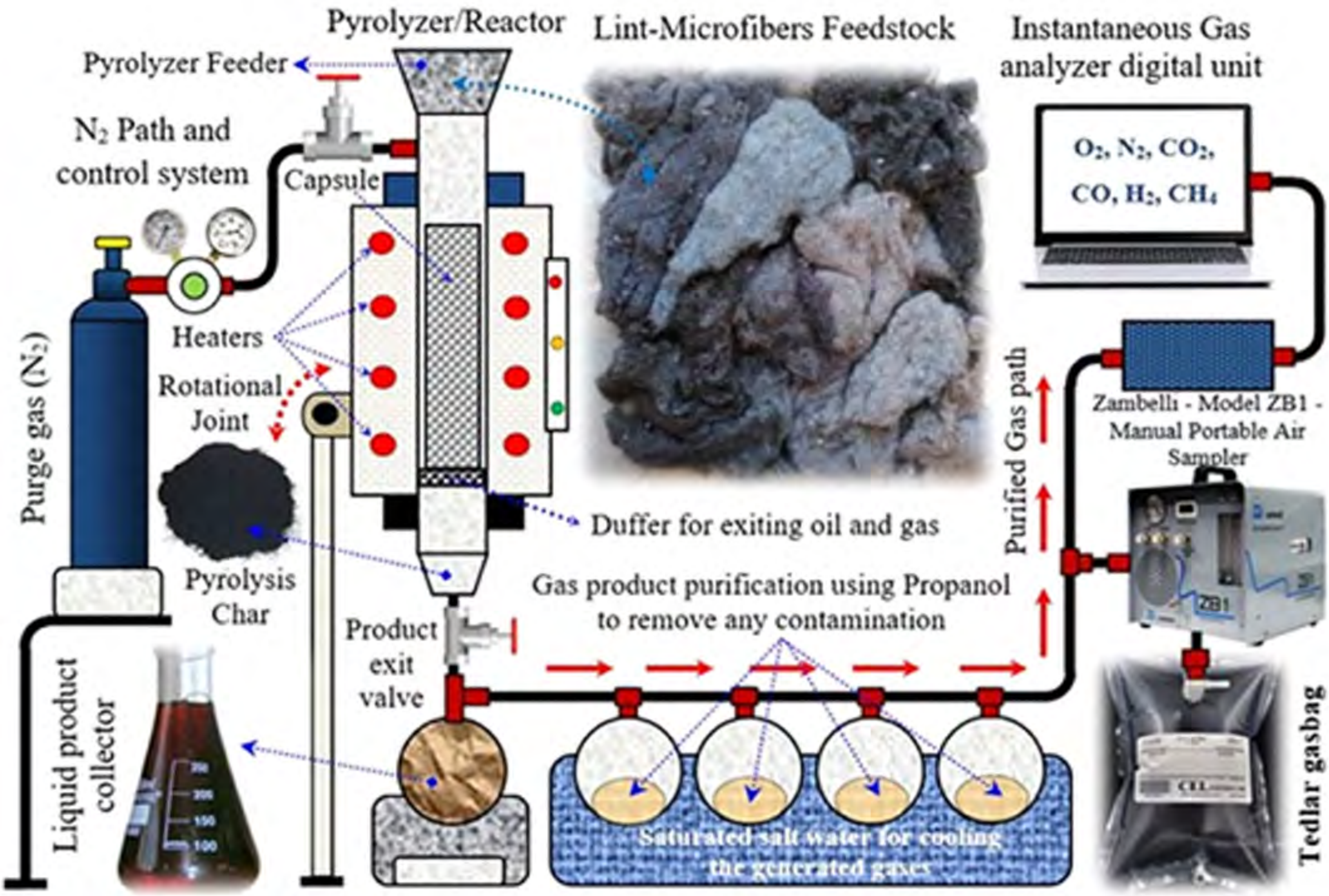


Fig. (4): Schematic dawning of the pilot pyrolysis process and products of purification and collection.

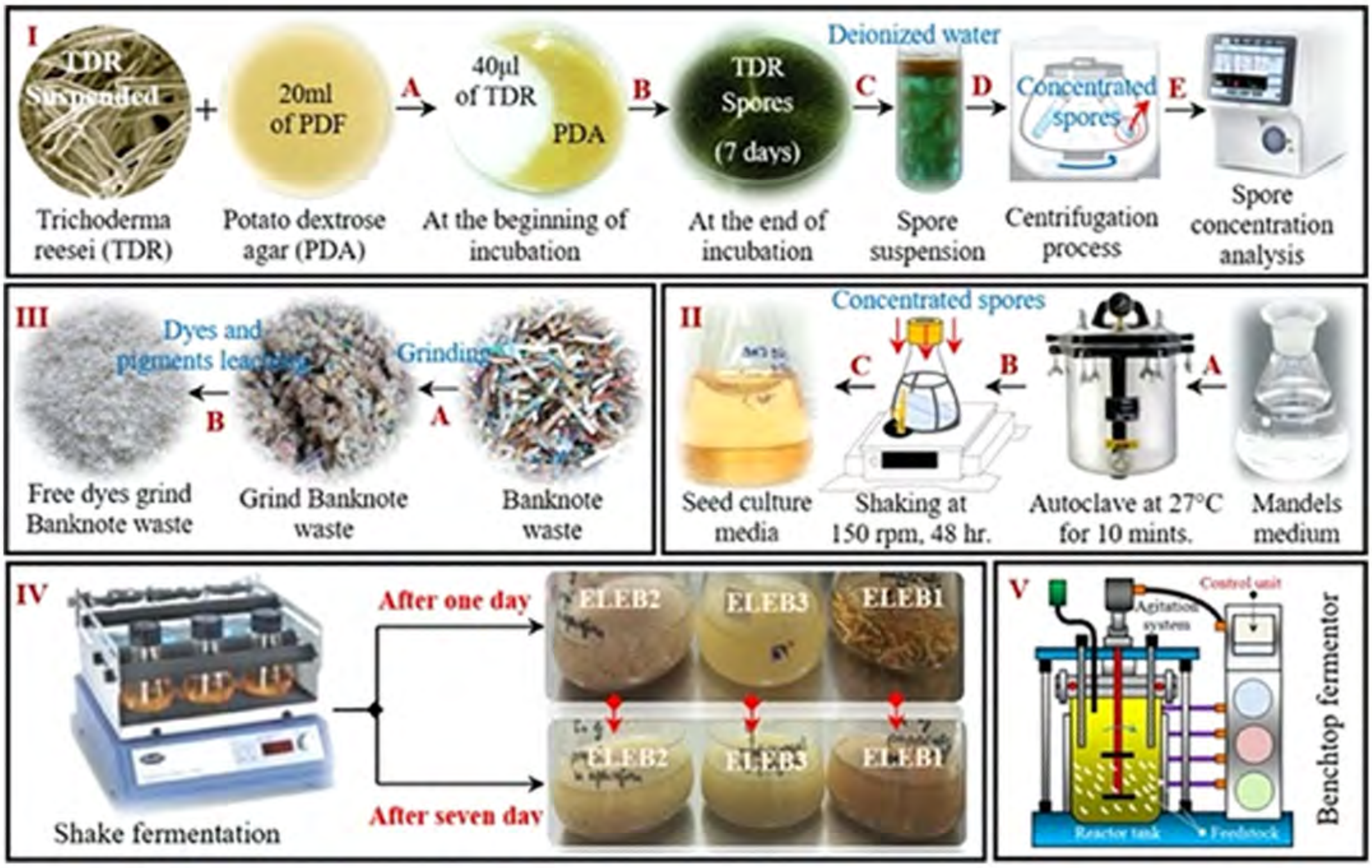


Fig. (5): The layout of the developed bioconversion strategy.

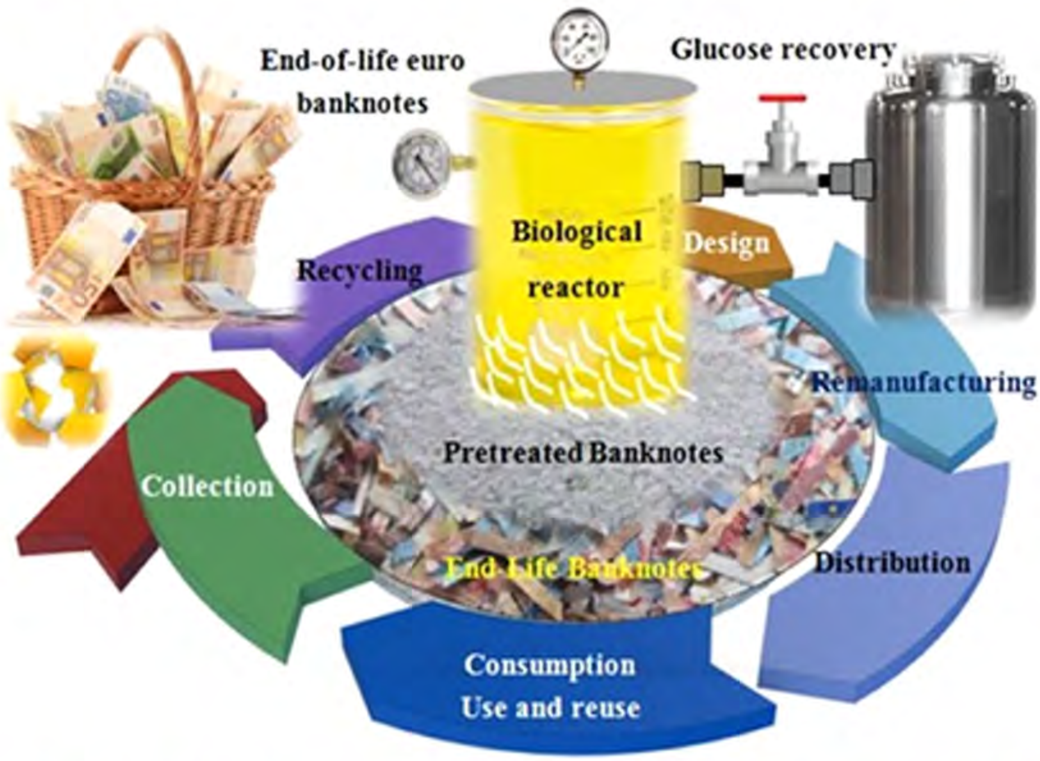


Fig. (6): End-of-life euro banknotes circular economy principle.

Innovative applications of nanotechnologies for functional cotton textiles

Dr. N. Vigneshwaran
ICAR-Central Institute for Research on Cotton Technology, Mumbai 400019, India. Email: Vigneshwaran.N@icar.gov.in

Nanotechnology is revolutionizing the entire domain of scientific research resulting in unveiling of novel & unpredicted products in the markets. The impacts of nanotechnology were felt earlier in textile industry followed by pharma, electronics, energy, transportation, robotics, pulp & paper, food & health and agriculture & allied sectors. As early in the year 1998, Nanotex® Company was founded to replicate the natural water repellency of plant surfaces in the surfaces of textile materials. Today, the impact of nanotechnology is felt in all areas of cotton *viz*., breeding of cotton for targeted modifications, nano-fertigation, nano-pesticides applications, nano-sensors for precise farming, nano-clays & nano-hydrogels for soil improvement, nano-finishing of cotton textiles and production of nanocellulose from cotton fibres.

Nanotechnology refers to the manipulation of materials in the nano-size range for desired properties. The nano-size range mainly denotes 1 to 100 nm while higher range is also included if the material is of polymeric nature. The main concept is that the material should exhibit size-dependent properties in the defined size range. The size-dependent properties include surface area to volume ratio (SAR), surface plasmon resonance, quantum confinement effect, super conductivity, super para-magnetism, etc. Two major approaches are available for production of nanomaterials: one is top-down approach, where in the bigger particles are reduced in size to form nanomaterials and, another is bottom-up approach, wherein the atoms / ions are aggregated in controlled manner for produce nanoparticles.

The impact of nanotechnology in cotton textiles started two decades ago with a promise to impart novel and efficient characteristics for the cotton materials. Though cotton is the king of the fibres, it has many drawbacks when compared to other synthetic counterparts. The major problems faced in cotton textiles include the microbial attack and corresponding odour development, wrinkle development on usage, lack of hydrophobicity and UV transparency. These problems restrict the use of cotton in sportswear, medical textiles, agro-textiles and other technical textiles. Though many chemical and polymeric finishing agents are available to overcome few of the above said problems, they do have their own limitations. Nanomaterials are being used to impart the required functionalities on the cotton with minimized problems.

Antimicrobial finish

Nanomaterials of silver, zinc oxide, titania are used to impart antimicrobial finish to the cotton textiles. Apart from their inherent property, the nanosize enhances their antimicrobial efficacy. Nanosilver inhibits the growth of microorganisms both by release of silver ions that in turn interfere with the microbial metabolism by binding with the enzymes. Nanoparticles of zinc oxide and titania exhibit antimicrobial property by both heavy metal toxicity and photocatalytic activity. The research team at ICAR-CIRCOT, Mumbai developed technologies for the production of antimicrobial finished cotton textiles using nanosilver and nano zinc oxide. Figure 1 shows the nanosilver coated cotton fabrics. Addition to metal and metal oxide nanoparticles, polymeric nanoparticles (like nano chitosan and nanolignin) are also good candidates for antimicrobial finish.

Figure 1. Cotton fabrics (below) treated with Nano silver (above). The colour is due to the surface plasmon effect of Nano silver

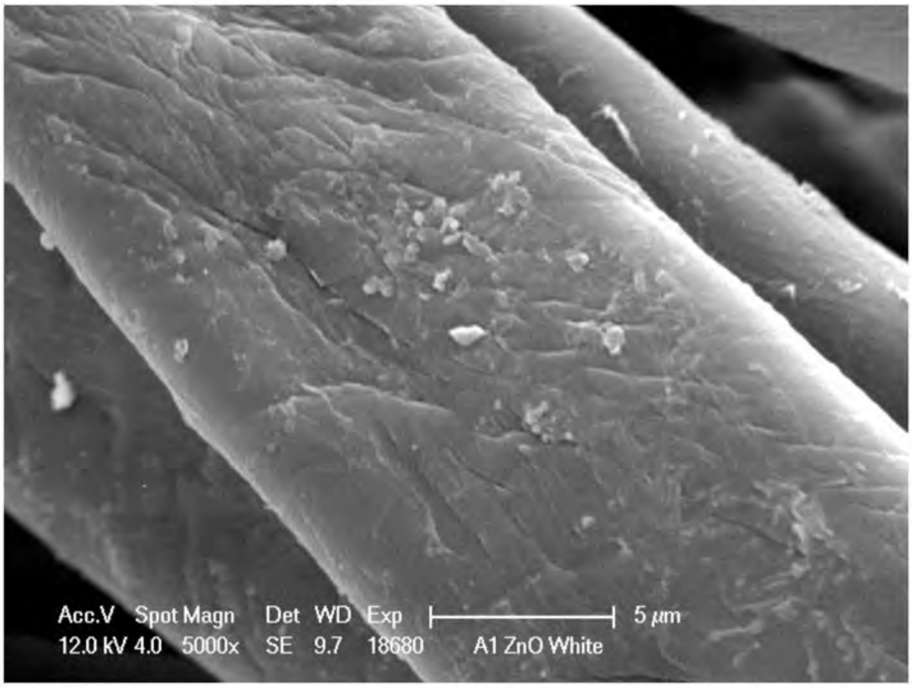


Figure 2. Scanning electron micrograph of cotton fibres impregnated with nano-ZnO

UV Resistant Finish

UV resistant finish helps the cotton fabrics to restrict the entry of UV rays. Conventionally various chemical finishing agents and dark colored dyes are used to restrict the entry of UV rays. With the developments in the use of nanomaterials, the requirement of pigments has drastically reduced without affecting their activity. Nano-ZnO and Nano-titania are the well-demonstrated nanomaterials being used for UV resistant finish. Figure 2 shows the scanning electron microscopic view of nano-ZnO deposited on the surface of cotton fibres using the technology developed at the Institute. The UV-absorbing property is mainly due to the semi-conducting property of metal oxide nanoparticles like nano-ZnO and nano-titania. Organic nanoparticles like nano-lignin can also impart UV-absorbing property to cotton textiles.

Self-cleaning property and Superhydrophobicity

The photocatalytic activity depends on the band gap of metal oxide nanoparticles and, generally they fall in the UV-range. Hence, UV light is required for photocatalytic activity of nanoparticles. To overcome this issue, doped nanomaterials are being evaluated to have visible light induced photocatalytic activity. Thus, produced nanoparticles can be applied on textiles to impart self-cleaning property, wherein the deposited organic dirt can be oxide by nanoparticles on exposure to light. Apart from photocatalytic activity, self-cleaning property could be achieved by Lotus Effect® or superhydrophobicity. To obtain the superhydrophobic water repellent surfaces (water contact angle above 150°) on cotton fabrics, silica nanoparticles coated with water repellent agents are generally used.

Flame retardant finish

Environmental concerns of fluorinated & organophosphorus compounds results in exploration of different nano-based methodologies to impart flame retardancy to cotton textiles. The limiting oxygen index, that indicates the flame retardant property of a fabric, increased from 18.6 to 23 when the cotton fabrics were coated with sodium hypophosphite, maleic acid, triethanol amine and nano-titania (Lessan et al. 2011). Cotton functionalized with epoxy and carboxyl via grafting cotton with nano-emulsion consisting of glycidyl methacrylate and acrylic acid was treated for functional finishing by the traditional pad-dry-cure process and it resulted in excellent flame retardant property (Mohamed et al. 2014). Another research group explored the use of nano-titania on cotton fabrics in the presence of polycarboxylic acid [1,2,3,4-butane tetracarboxylic acid (BTCA)] with sodium hypophosphite as catalyst and chitosan phosphate through conventional pad-dry-cure method; and, this expressed flame retardancy and antibacterial property (El-Shafei et al. 2015).

Nanofinished Cotton Face Mask

The outbreak of COVID-19 has greatly influenced the way in which humans interact, work and go in their routine life. Among the various personal protective equipment (PPE) used to safeguard our life, face mask or respirator plays a significant role. Though synthetic fiber based masks are routinely used for medical purpose, 3-ply cotton mask is recommended for use by common people. To increase the filtration efficacy of these cotton masks, addition of electrospun nanofiber layer plays a significant role. Through electrospinning process, uniform layer of nonwoven nanofibers could be obtained from a polymer solution or melt. This layer can be sandwiched between cotton fabrics for improved filtration efficiency. Figure 3 shows the electrospun nanofibers of cellulose acetate.

Standards & Safety

The standardization in the field of nanotechnology is being handled by five international agencies *viz*., International Organization for Standardization (ISO), European Committee for Standardization (CEN), British Standards Institution (BSI), ASTM International and OECD Working Party on Manufactured Nanomaterials (WPMN). The Division of Occupational Health and Safety of National Institute of Health has released the *Nanotechnology Safety and Health Program 2014* to help the researchers and other stakeholders in the field of nanotechnology to familiarize with safety precautions to be followed in the field of nanotechnology. Similarly, the National Institute for Occupational Safety and Health published the *Building a Safety Program to Protect the Nanotechnology Workforce: A Guide for Small to Medium-Sized Enterprises 2016* for the benefit of people involved in the nanotechnology related enterprises. These documents are available freely online and it will support while taking the advantage of nanomaterials.

Nanotechnology started to make its impact visible in the field of cotton textiles and cotton biomass utilization. The established workforce around the World is producing novel processes and products using nanotechnology for application in cotton. Apart from solving the existing problems, nanotechnology also helps to evolve newer products and finishes in cotton textiles. With responsible use of nanotechnology, the cotton finishing and cotton biomass value addition sectors are bound to benefit from this revolution.

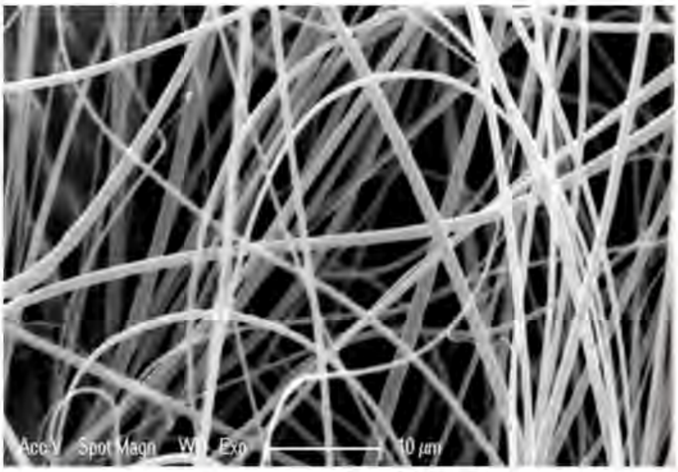


Figure 3. Electrospun nanofibers of cellulose acetate.