ANNUAL REPORT 2017-18

THE BOMBAY TEXTILE RESEARCH ASSOCIATION
L. B. S. Marg, Ghatkopar (W), Mumbai - 400086
Tel. : (O) 022-25003651/2652 Fax: 022-25000459
Email : info@btraindia.com

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We have great pleasure in presenting the 64th Annual Report of The Bombay Textile Research Association (BTRA). It highlights the R & D and other activities of BTRA and also presents the Audited Statement of Accounts for the year ending 31st March 2018.

1. INTRODUCTION

The industry has its cyclic periods of ups and downs but innovation, research and product development has to be a continuous activity which no industry can afford to ignore. In addition, the Indian textile industry also needs to pay immediate attention to human resource needs at all levels.

The industry needs to look at more challenging high-end products manufacturing which is knowledge based such as technical textiles; such a move from conventional to technical textiles needs a change in mindset which becomes imperative sooner or later. Efforts in product / process development and diversification in to more knowledge based products is the need of the hour. Hence, BTRA has taken major steps with financial assistance from the Government of India to develop expertise in technical textiles and provide service to the industry.

We at BTRA strongly believe that in addition to various policy initiatives on fiscal, infrastructure and other areas, an important area often not given enough importance is R & D, particularly product / process development, cost reduction and efficiency in operations. The essence of R & D is (i) to make the existing products better, faster and at affordable prices and (ii) to develop new products. BTRA also is strengthening its training activities for providing need-based training to technical/supervisory and operator levels. BTRA has been working on these and other thrust areas and a glimpse of some of the work carried out during the period under review is briefly highlighted as follows.

Overview

- **On-going sponsored projects -** The number of on-going sponsored projects is eleven (including one newly initiated project) for the period under review. Details are as follows.

- ✓ Under the project 'Studies on radiation induced modification of textile materials', research work on 'Functional finishing of cotton fabric By electron beam synthesized silver nanoparticles' was carried out. In this work, a radiation induced synthesis of silver particles in cotton fabrics, padded with different initial concentration of aqueous alcoholic silver nitrate solution, has been accomplished by exposing them to different doses of electron beam (EB) radiation in an inert environment. The treated fabrics were characterized for the surface morphology in Scanning Electron Microscopy (SEM) and Ultraviolet

protection factor (UPF). In SEM images, these are seen as dispersed on the fibre surface and their dimensions fall in nano range. The deposited particles have an average size of 81 nm. Deposition of silver particles conferred the fabric with UV-blocking property. The values of ultra-violet light protection factor could be altered by varying the solution concentration and to a less extent by EB dose. Ultraviolet protection factor (UPF) of treated fabric remained similar even after ten washing cycles when carried out as per standard washing procedure.

- ✓ In this project on 'Atmospheric pressure plasma treatment for enhancing the conducting properties of textiles doped with intrinsically conductive polymers', natural and synthetic fabrics were pre-treated with atmospheric pressure plasma with dielectric barrier discharge method, to improve the binding of conductive polymers (Polypyrrole and polyaniline) coating on substrates for improving conductivity. A range of gas mixtures in dielectric barrier discharge and treatment times were employed to investigate plasma induced effect on surface roughness and hydrophilicity. The changes in Wettability and morphology were studied by wicking measurements and scanning electron microscopy. Effect of the plasma treatment on binding strength was analyzed by studying abrasion resistance and surface resistivity. It was found that both highest conductivity and strongest interfacial bonding (improved adhesion) were achieved by helium-oxygen plasma pre-treatment for polyester, Polyester-cotton blend substrate. The increase in hydrophilicity and surface functionalisation, gave improved adhesion. Atmospheric ageing of polypyrrole coated fabrics can also be controlled using plasma pre-treatment.

- ✓ In 'Adhesion improvement for coated textiles by atmospheric plasma treatment' project, plasma treatment of nylon fabric was carried out at atmospheric pressure using helium gas. Wicking height showed the improved wettability of the plasma treated samples. SEM images of the plasma treated fabric showed the surface roughness. Plasma treated fabric was coated with PU polymer and adhesion force between the fabric and coating was measured by peel bond test. It was observed that with increase in plasma exposure time there is significant improvement in peel bond strength. Tensile strength of the nylon was increased slightly at lower plasma treatment power and time.

- ✓ Project on 'Analysis of Eco Management in Indian textile Industry' - Compared to other stages of textile production, textile processing industry exceedingly

impacts on environment due to high resource consumption profile in terms of water, chemicals, energy and release of highly contaminated effluent. The industry often lacks the understanding, skills and managerial capacity to respond to these environmental issues. Therefore to create awareness about the necessity of an assessment study and improvement in their performance on Environmental issues, BTRA has undertaken this project. BTRA audited 6 textile processing houses for eco management awareness and eco management implementation in their units. Analysis is being done for ETP, boiler flue gas emissions, noise level, chemical management system and utility/energy conservation practices. Also, effluent samples (both inlet and outlet) were collected for its characteristic analysis.

- ✓ Project on 'Development of electronic servo control drive industrial TFO twister for heavy denier filament yarn' – The drawback of conventional gear drive TFO twisters are high energy consumption, difficulty in maintaining low twist level in industrial yarns, etc. BTRA fabricated a TFO machine with servo controlled drive that saves power to the extent of 25% compared to conventional gear drive machine. This machine was displayed in the PlastIndia 2018 exhibition.

- ✓ Project on 'Development of cotton waste based oil absorbent for oil spill clean-up' - Oil spill clean up is a global concern due to its environmental and economical impact. Various commercial systems, including synthetic fibres like polypropylene, have been developed to clean up the oil spillage. But these methods pollute environment in another way such as disposal of used oil sorbents, non biodegradable in nature (hence non eco-friendly), etc. Hence, in this project work, waste cotton, which is bio-degradable, is used as oil absorbent, after subjecting in to various modifications. Raw cotton waste has been procured and cleaned in a trash separator to separate out lint, trash, and micro dust of cotton fibre. The cleaned cotton waste was processed in a needle punching machine to make a nonwoven lap. Water and oil absorbency property of this cotton waste was studied. To enhance the hydrophobic and oleophilic property of cotton by various techniques will be applied in the future work.

- ✓ Project on 'Nanofibre Application to Enhance the Anticlogging properties of Geotextiles' - If the pore size of geo-filter is larger than the fine soil particle, too many fines could reduce the discharge capacity and increase the filter resistance. The smaller but apparent pore size is needed to prevent clogging.

Deposition of thin nanofibrous web with small pore size on geotextile can help to reduce this problem. Electrospinning is an efficient and versatile technique to obtain fibers with very small pores and diameters ranging from several microns to tens of nanometers. In this project, Nylon 6 polymer is selected for the spinning of nanofiber and deposits the same on the surface of spunbonded Polypropylene to minimize the pore size and improve the anticlogging properties of geotextle. Required spinning parameters are standardized for Nylon 6 in the needle less electrospinning machine with wire electrodes. Deposition time is standardized to obtain the required pore size of the nanofiber mat. Further experiments on study of clogging behaviour and water permeability of the PVD substrate with nanofiber mat is going on.

- ✓ Project on 'Melt spinning of PVDF/ZnO nanostructure hybrid filament for wearable smart textile' - Among the different types of smart materials, piezoelectric materials are the most widely used because of their fast electromechanical response. Zinc oxide is a piezoelectric material and its high aspect ratio nanostructure shows excellent piezoelectric properties. PVDF (Poly vinylidenefluoride) also shows good piezoelectric property. Under this project, synthesis of ZnO nanorods is done successfully and melt-blended with the PVDF in different percentages. Spinning of the blended polymer is in progress.

- ✓ Project on 'Development of Test Method for Analyzing Hexavalent Chromium (Cr+6) Content in Dyes, Pigments and Textile Auxiliaries' - Hexavalent chromium (Cr+6) is a known mutagenic and carcinogenic substance. Cr+6 is commonly found in textile dyes, pigments, paints, inks leather products and textile auxiliaries. Due to the high toxicity most of the government regulations restricted the use of Cr+6 in consumer products. At present the only test method available to test Cr+6 is ISO method for leather products. This test method is not suitable for dyes and pigments due to the high matrix interference. Under this project an attempt will be made to develop a test method to test Cr+6 in dyes and pigments. About twenty five dyes and pigments including chrome pigments and few textile auxiliaries were collected from various manufactures. The total chromium content in these dyes and pigments were estimated by microwave digestion followed by ICP-OES analysis. It was observed that in most of the chrome based pigments, Chromium content is very high. This chromium could be either in trivalent or hexavalent or in both the forms. Hence to segregate the trivalent and hexavalent chromium

various studies were done to achieve the final goal.

- ✓ Under the project 'Studies on performance enhancement of textile effluent treatment plant by electron beam method', simulated industrial effluent samples of desizing, scouring, dyeing and printing processes were prepared separately at BTRA by adding chemicals such as dye, synthetic size, alkali, colour and pigment with known concentrations. All these samples were allowed to undergo conventional biological treatment and activated sludge process. BTRA fabricated laboratory model activated sludge system consisting of aeration tank and settling clarifier. Using this system, studies were undertaken to determine the efficiency of biological treatment process to reduce pollutional load in effluent samples. Efficiency of biodegradation was measured in terms of COD and BOD reduction. The results of the study indicate that activated sludge process works efficiently only for desizing effluent because this effluent contains starch that is biodegradable matter. Whereas, this system is not so effective on effluents containing refractory organic materials such as PVA, synthetic dye, oil, etc. Micro-organisms (bacteria and fungi), present in activated sludge process, were not able to degrade the complex structure of organic compounds results in sludge bulking.

- ❖ **Product Development Assistance to the industry**

- ✓ In needle-punch nonwoven and hydro-entanglement pilot plants, 48 samples are developed for applications such as thermal insulation, viscose spun lace, etc.
- ✓ In the pilot plant of Technical Textiles Weaving, 29 samples (of 15 m in length) are developed for applications such as tyre cord and filter fabric

- ❖ **Calibration, Technical Services and Training**

- ✓ BTRA calibration laboratory received accreditation from NABL as per ISO/IEC 17025:2005 standards for Mass, Balance and Volume. BTRA is ready to provide calibration services to other NABL accredited testing laboratories for Mass, Balance and Volume parameters.

- ✓ BTRA undertakes extensive liaison and consultancy services to solve problems of quality, maintenance, productivity, water / energy conservation, etc., at various levels from time to time. Also special studies such as vendor selection, valuation of fixed assets, manpower planning, etc. are undertaken for the mills. For the period under review, BTRA provided services in the areas of Accredited partner

audits, boiler efficiency audit, Verification of EPI, PPI and Width of fabric on loom and on table, etc.

- ✓ BTRA conducted several training programmes at the mills' premises covering subjects such as Technology, Upgradation, Quality Control and Value Addition for chaddar manufacturers, Fabric Inspection, Size Application and Evaluation, Cuprammonium fluidity test and Good Work Practices & Utility Conservation. Also, BTRA imparted training (theory and practical) at the testing laboratories/pilot plants covering subjects such as Technical Textiles (Geotech), Textile Terminology and Processing, Yarn testing and sizing, Sizing and Testing, Mechanical & Chemical Testing and General elements of textiles. Total number of personnel trained, during the period under review, were 304

- ✓ BTRA staff Mr. Vijay Gawde attended a three day training programme titled 'Training of Master Trainer' for the job role of Lead Trainer QP, which is jointly organised by Management & Entrepreneurship and Professional Skill Council (MEPSC) and National Skill Development Council (NSDC) at New Delhi between 7th and 9th September 2017 and successfully cleared the certification to be the first Master Trainer from Textile Segment.

❖ **Others**

- ✓ Under Centre of Excellence for Geotech, BTRA soil mechanics laboratory has started its testing activity. It undertakes 13 soil classification and other related soil tests for the industry. Test optimization work is in progress for many other tests.

In a nutshell, research and development and consultancy activities at BTRA were directed towards innovative product / process or test method development and providing essential database for the industry. In the years ahead, BTRA will strive to make its mark in the area of technical textiles, utilities conservation, plasma processing, application of nanotechnology, biotechnology, information technology and instrumentation.

2. ON-GOING SPONSORED PROJECTS

2.1 Studies on Radiation Induced Modification of Textile Materials

Under this project, research work of 'Functional finishing of cotton fabric by electron beam synthesized silver nanoparticles' is discussed in the following paragraphs.

Introduction

Cotton fibres offer very little protection from UV light due to its chemical nature. There are many

attempts to develop finishes which can enhance the UPF characteristics of the fabric.Increase in cover factor is one of them which will increase the UPF value up to certain limit and levels off. Further, very high cover factor will adversely affect the handle and permeability characteristics of the fabric. There are organic or inorganic based UV shielding materialsalso available. Ideally, these materials should have very good affinity to fibres and should be durable to laundering conditions. Organic UV shielding materials are benzotriazole, benzophenone, salicylic acid and esters; and these mainly absorb UV rays. The mechanism by which inorganic materials provide UV shielding is not certain. Some researchers suggest that they provide UV shielding *via* reflecting/scattering most of the UV rays through its high refracting index whereas others suggest that they absorb some part of UV radiation. Researcher studied extensively the mechanism behind the UV shielding property of TiO_2. They found that TiO_2 works as UV blocking additive mainly through UV absorption, and the scattering and reflection mechanisms are prominent where it has weak or no absorption.

Some metal nanoparticles have interesting novel properties and incorporation of these particles in the fabric results in enhancing the functional performance of the fabric. Such as incorporation of silver nanoparticles in cotton results in enhancing antimicrobial and UV blocking properties. These silver particles have been generated using chemical, biological and radiation approaches. However, radiation approach has several advantages such as room temperature process, cleaner reaction system, control over particle size and size distribution through tuning of reaction dose and dose rate parameters over other methods and that's why ionizing radiation methods have been utilized effectively to generate metal nanoparticles.

Electron beam (EB) radiation is one of the highly effective ionizing method due to its very high throughput of electrons in its beam path which can instantly interact with water to generate many reactive products like hydrated electrons, hydrogen atom and hydroxyl radicals. These reactive products can interact with aqueous alcoholic silver nitrate salt solution to produce metallic silver.In this work, we carried out in-situ generation and deposition of silver nanoparticles on cotton fabric using electron beam radiation technology. UV blocking property of this treated cotton fabric was studied. We also carried out the effect of washing on the durability of this functional attribute.

Materials

A plain-woven cotton fabric (ready for dyeing) was used as a textile material for all the experiments. The specifications of which are given in the Table-1.

Table-1
Cotton fabric specifications

Fabric	GSM (g/m^2)	Thick-ness (mm)	Thread count EPI/PPI (denier)	
			Warp	Weft
Cotton	206	0.29	108 (266.4)	72 (250.5)

Methods

In-situ generation of silver nanoparticles by EB radiation

The cotton fabric samples were first padded 2-dip-2-nip with an aqueous alcoholic $AgNO_3$ solution with different silver nitrate concentrations. The padded fabric gained almost 90% constant wet-pick up. These padded fabric samples were later kept in zip lock polyethene bags in nitrogen atmosphere for further EB radiation exposure.These padded fabric samples were irradiatedwith three different EB dose values in a 500 KeV electron beam system at BARC, Mumbai. After irradiation samples were kept in zip lock bag for 3h and then washed with water to remove residual un-reacted chemicals. These were finally dried in air. Treated samples were characterized by SEM analysis and UPF value of fabric.

Washing

Wash durability of such treated fabric was performed as per ISO standard 105-C10:2006 (E) test number A (1) conditions. Typically, each washing cycle of 30 min required 5 g per litre of standard soap in water with fabric to liquor ratio of 1:50 at washing temperature 40 ± 2°C and carried out at a stirring speed of 40 ± 2 rpm. After completion of washing, the fabric was thoroughly rinsed with water.

Characterization

Scanning electron microscopy (SEM) and energy-dispersive X-ray Spectroscopy (EDS) analysis

Surface morphology of sample was observed on a Hitachi FlexSEM1000 microscope (Japan). A mixture of signals of BSE (Back Scattered Electron) and UVD (Ultra Variable-Pressure Detector) were used to map the surface features for better contrast. All SEM images were taken at 7 kV potential difference. EDS analysis was also carried out to find the composition of elements present on the surface of the sample.

Ultra-violet protection factor (UPF) measurement

Ultra violet protection factor of all treated samples was measured by UV 2000 Lab sphere instrument (U.S.A.), as per AATCC 183-2004 procedure. Instrument was first calibrated using standard samples. For each measurement, a swatch of fabric was placed at the sample transmittance port of the integrating sphere, and spectra were collected from 3 different locations of the fabric in the transmittance range of 290-400 nm (UV-A range 315-400 nm and UV–B range 290-315 nm). A plot of transmittance (%) *vs.* wavelength

(nm) was obtained along with the total UPF values for each sample.

Results and Discussion

Characterization

SEM analysis

In the Figure-1a, silver particles are clearly detected from EDS analysis on the surface of fabric sample padded with aqueous alcoholic silver nitrate solution (Silver nitrate concentrations: 1.0% wt./vol.) and irradiated with electron beam radiation (dose: 50 kGy). In the Figure-1b, SEM images at different magnifications (5000, 10000, 15000, 20000 and 25000×) nicely reveal the presence and distribution of silver particles on the fibre surface. These are seen as covering the entire surface of the fibre quite uniformly at lower magnification but at higher magnification such as 25,000×, some aggregation of the particles could also be seen. The estimation of particle size from SEM images using ImageJ analysis software reveals that their sizes vary from 26 nm to 173 nm with a mean size of 81 nm (margin of error = 7 nm at 95% confidence level).

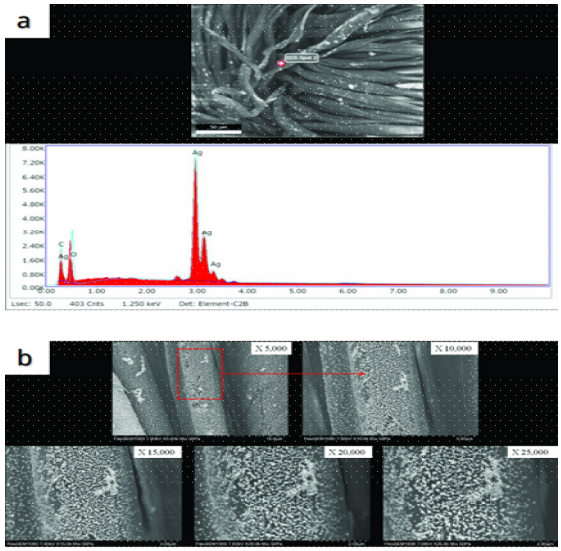


Figure-1: (a) EDS and (b) SEM images of radiation synthesized silver nanoparticles on the cotton fabric at different magnifications

UPF analysis

UPF is the ratio of the average effective ultraviolet radiation (UV-R) irradiance transmitted and calculated through air to the average effective (UV-R) irradiance transmitted and calculated through the fabric (Crews *et al.*, 1999). Total ultra-violet protection factor for samples were measured before and after washing and are presented in the Figure-2.

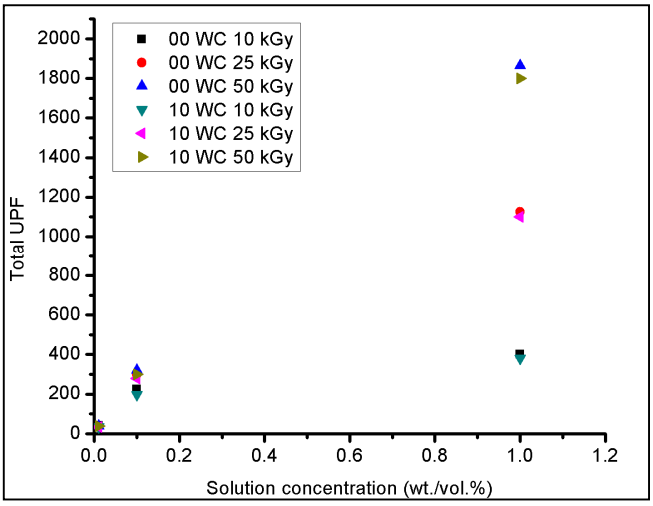


Figure-2: UPF values of silver deposited cotton fabric
(WC refers to Washing Cycle)

There is no appreciable change in UPF value even after 10 washing cycles. It is seen that UPF value rapidly increases with concentration of silver nitrate solution, and at 1% (wt. /vol.) the UPF values at different doses mirrors with that of silver particle deposition. At very low concentration 0.01%, UPF values of the fabrics are below the desired value of 40. Therefore, the UPF value of fabric can be readily adjusted by selecting the concentration of silver nitrate solution for padding, and to a small extent by changing electron beam dose. Since cotton fibres show degradation at high doses, low dose of EB irradiation is preferred choice for sample preparation.

Conclusions

Electron beam has been successfully used for the synthesis of silver particles in the cotton fabric. In SEM images, these are seen as dispersed on the fibre surface and their dimensions fall in nano range. Deposition of silver particles conferred the fabric with UV-blocking property. The values of ultra-violet light protection factor could be altered by varying the solution concentration and to a less extent by EB dose. UPF characteristic was found to be durable even after ten standard washing cycles.

2.2 Atmospheric Pressure Plasma Treatment for Enhancing the Conducting Properties of Textiles Doped with Intrinsic Conductive Polymers

In this work, natural and synthetic fabrics were pre-treated with atmospheric pressure plasma with dielectric barrier discharge method, to improve the binding of conductive polymers (Polypyrrole and polyaniline) coating on substrates for improving conductivity. A range of gas mixtures in dielectric barrier discharge and treatment times were employed to

investigate plasma induced effect on surface roughness and hydrophilicity. The changes in Wettability and morphology were studied by wicking measurements and scanning electron microscopy. Effect of the plasma treatment on binding strength was analyzed by studying abrasion resistance and surface resistivity. It was found that both highest conductivity and strongest interfacial bonding (improved adhesion) were achieved by helium-oxygen plasma pre-treatment for polyester, Polyester-cotton blend substrate. The increase in hydrophilicity and surface functionalisation, gave improved adhesion. Atmospheric ageing of polypyrrole coated fabrics can also be controlled using plasma pre-treatment.

2.3 Studies on effect of plasma treatment for adhesion improvement of coated technical textiles

Under this project, research work on 'Effect of atmospheric pressure plasma surface modification on nylon 66 fabric coated with polyurethane' is discussed in the following paragraphs.

Introduction

The purpose of the coating is to provide its carrier material with specific functional properties for suitable application. The surface of the synthetic fibre is generally inert, making the fibre difficult to wet and hard to chemically bond to coating material, as a result the adhesion between the fibre and coating material becomes inferior. In order to improve adhesion to coating, fibres are usually subjected to controlled surface treatments by wet chemical methods. However, chemical modifications have some disadvantages. For example, conventional methods are time consuming and in most cases, are accompanied by a decrease in fibre strength. Moreover, these conventional treatments can also lead to environmental pollution. Therefore, we propose to explore plasma techniques. Surface modification of textile fibres by cold plasma is simple and cost effective. It produces no pollution and is becoming increasingly popular.

Plasma, known as fourth state of matter besides solid, liquid and gas, is a mixture of ionised gases consisting of electrons, ions, neutral atoms, free radicals and ultra-violet radiation. Plasma, as a very reactive material, can be used to modify the surface of a certain substrate typically known as plasma activation or plasma modification. Recent development in the plasma treatment of textile materials has revealed that it has an enormous potential as an alternate technology for the textile processing in terms of cost saving, water saving and eco-friendliness. In this study, atmospheric pressure plasma is used for the surface modification of nylon 66 fabric for adhesion improvement with PU coatings.

Materials and Methods

Materials

A woven nylon 66 fabric with an area weight of 95 g/m^2 is used in this study. Polyurethane (commercial name: TUBICOAT MP SP) was supplied by CHT India. Helium gas (He) with 99.995% purity was procured from INOX air products, India.

Plasma Treatment of nylon fabric

Plasma treatment of nylon was carried out on atmospheric pressure plasma reactor. Plasma exposure time, power, distance between the electrodes and rate of gas flow are the variable process parameters on the plasma machine. Optimisation of the plasma process parameters was carried out by varying the power and time. The other two parameters vis distance between the electrodes and helium gas flow was kept constant.

Application of PU coating on the nylon fabric

PU foam was applied on the plasma treated nylon fabric with knife over roller coating method using hand coating machine. After application of PU coating drying and curing of the coated samples were carried out. Similarly, untreated nylon sample was also coated with PU to study the effect of plasma treatment for adhesion improvement.

Characterization Techniques

Surface tension of Polyurethane

Easy Drop standard drop shape analysis system (KRUSS GmbH, Hamburg, Germany) equipped with high-speed camera IEEE1394b interface was used to measurement the surface tension of polyurethane. Young-Laplace fit method is used for surface tension analysis.

Wicking measurement

The rate of vertical capillary rise on plasma-treated samples was measured using the method described in ISO 9073-6; 2000 (E). Test specimen strips were suspended vertically in the liquid and checked for the increase in the capillary height at predetermined time intervals up to 20 min.

Adhesion strength test

The adhesion strengths of untreated and plasma treated coated fabrics were determined by a peel bond strength test. The peel bond strength of coated samples was measured according to the IS 7016 part 5- 2011 test standard with a Tinius olsen, peel bond tester. Five different measurements were performed and average value is considered as bond strength of the coated fabric.

SEM analysis

Surface topographical modifications in the nylon samples

before and after plasma treatment were investigated by scanning electron microscopy (SEM) on JEOL SEM model JSM 5400 (Tokyo, Japan).

Optical emission spectroscopy

Spectra of the plasma discharge emissions were recorded with a computer controlled Ocean Optics spectrometer (Flame –T). The spectrometer operates in the wavelength range of 200 nm to 1050 nm. Real time spectra of helium plasma were recorded using OceanView 1.6.3 software and post analysis of the recorded spectra was done using PLASUS SpecLine 2.13 software.

Mechanical properties

Tensile strength of the untreated and plasma treated samples were carried out on pyramid tensile testing machine model Tinius olsen H50KL Aimil. ASTM D 5035 -2015 standard test method was used. Average of the five test specimen was considered as the tensile strength of the fabric.

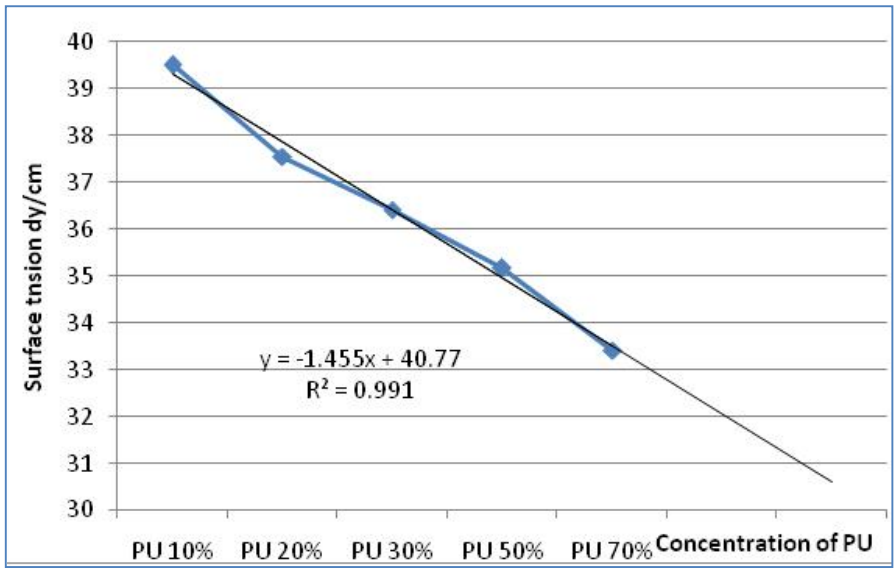


Figure-3: Surface energy of PU with different concentrations

Results and Discussion

Surface tension of polyurethane

Polyurethane (commercial name: TUBICOAT MP SP) was used for the adhesion study. Five different solutions were made in various concentrations and surface tension of prepared PU solutions was measured using Young-Laplace fit method. Surface tension is plotted vs. concentration. Liner regression - correlation is used to predict the surface tension of the 100% PU. Surface tension of 30.4 dy/cm was obtained with R^2=0.992.

The surface energy of the untreated nylon samples was 50.9 dy/cm^2 which is quite high than the PU coating chemical (30.4 dy/cm) hence the bonding between the PU polymer and untreated nylon fabric is inferior. After plasma treatment the surface energy of the treated samples was reduced (measurement of surface energy of the treated samples is difficult due to hydrophilic nature of the sample hence the wicking height was measured) as a result of reduced surface energy the bonding between the coating and plasma treated samples is improved as discussed later.

Wicking Measurement

The height of capillary rise was recorded for different wicking durations up to 20 min for plasma treated and untreated fabrics. The value of capillary height recorded for predetermined time for both untreated and plasma treated samples is plotted against the wicking time.

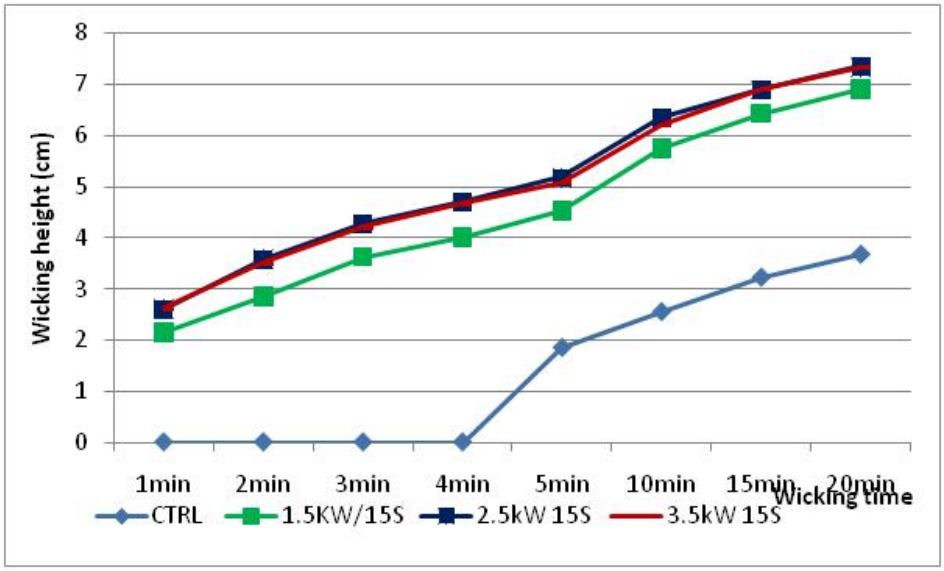


Figure-4: Effect of plasma on wettability of nylon fabric

Figure-4 shows the changes in wicking height of the samples treated with plasma under different discharge powers. It can be observed that after plasma treatment the wicking height of the nylon fabric is increased significantly and when plasma discharge power is increased the wicking ability is improved further. However, after 2.5 kW power there is no change in wicking height. Hence it can be said that plasma power of 2.5 kW is sufficient to get the optimum improvement in wicking.

Adhesion strength

Adhesion is the force required to separate the coating layer form the fabric. Adhesion force was measured as

peel off strength of the untreated and plasma treated nylon coated samples and is given in Figure-5. The adhesion bond strength of plasma treated coated samples showed 20 - 60% increase compared to the untreated coated sample. The highest peel bond strength value was obtained at a plasma power of 3.5 kW and plasma time of 30 sec. Increase in adhesion strength may be attributed to better wettability of the plasma treated samples. It is also observed that longer plasma treatment duration at higher power does not give the better adhesion force. This may be due to saturation of the plasma species at 2.5 kW power and further increase in power does not result in increase plasma species hence adhesion force remained unchanged or slightly reduced.

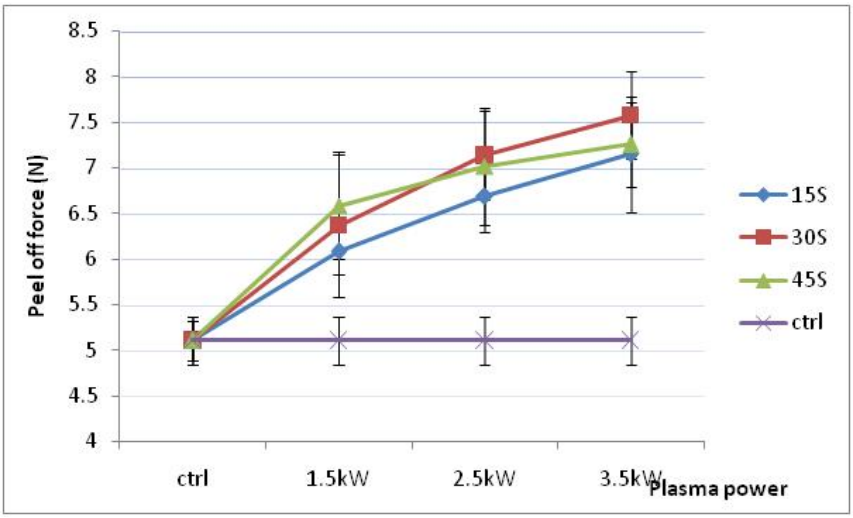


Figure-5: Effect of plasma treatment on the adhesion properties of nylon coated samples

Surface morphological analysis by SEM

Figure-6 shows SEM images of untreated and plasma treated nylon samples. Morphological changes on the surface after helium plasma treatment can be observed (Figure-6B). The untreated (Figure-6A) nylon has smooth and clean surface, while plasma treated fabric shows rougher surface. It is clear that helium plasma treatment etched the surfaces. Morphological alteration of the nylon surface might lead to improved mechanical adhesion due to the roughening effect.

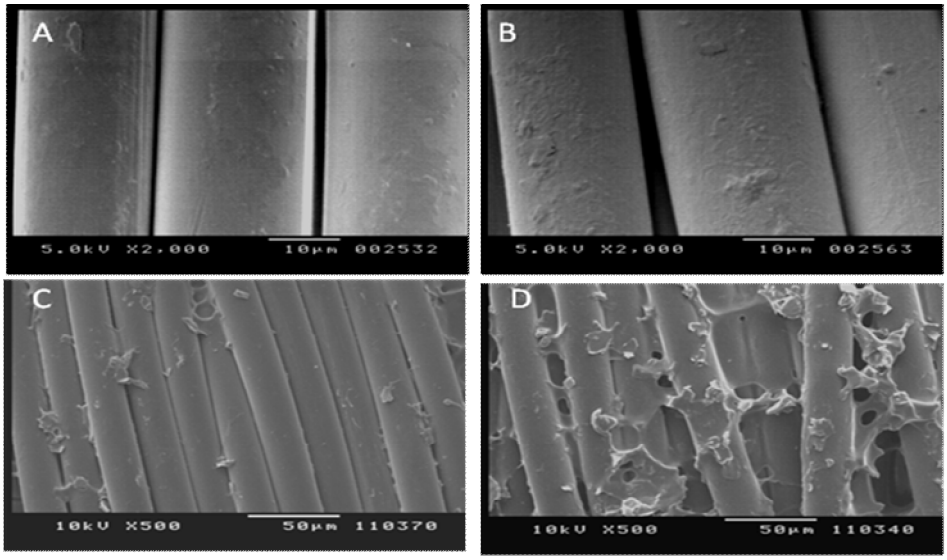


Figure-6: SEM images (A) Untreated nylon, (B) Plasma treated, (C) Untreated coated surface view after peel off, (D) Plasma treated coated surface view after peel off

Figure-6C shows untreated samples after peel off testing, Coating is removed smoothly. The smooth surface after removal of coating may be due to the non-adhesion of the coating with fabric and hence the coating is removed smoothly. The other image of (Figure-6D) plasma treated coated sample after peel off testing. A considerable amount of PU film is left on the fabric surface. This shows that there is better mechanical adhesion between the fabric and PU coating after plasma treatment.

Optical emission spectrometer analysis

Optical emission spectrometer (Flame T) was used to analyse the chemical species formed by the plasma. The spectrum of radiations emitted by helium plasma was grated and OES intensities were measured as a function of wavelength. The emission spectrum obtained in the wavelength range of 550-750 nm for atmospheric helium plasma at 1.5 kW is shown in Figure-7. On ionization, helium emits photons at different wavelengths such as at 706 nm, 655 nm, 667 nm, 587 nm, 728 nm, 388 nm, 356 nm, and 336 nm. Atomic lines of helium (He) at wavelengths 706.52 and 667.82 nm are the most intense, among the all other atomic lines detected. This shows that the hydrophilic He groups are incorporated on the fabric after plasma treatment. The results of wicking and adhesion improvement are in agreement with the results of OES analysis. The He groups incorporated by helium plasma are responsible for improved wettability and adhesion strength.

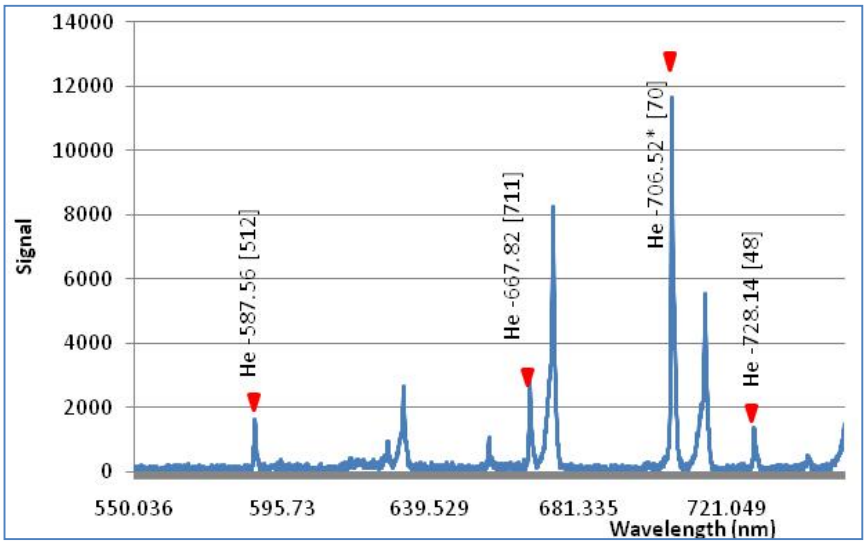


Figure-7: Optical emission spectra of the helium plasma at various powers

Mechanical properties

The effect of plasma exposure time and discharge power on the tensile properties of nylon fabric is evaluated in warp direction and depicted in Fig. 6. The initial tensile strength of untreated nylon fabric was 27.9 N/mm. After plasma treatment the strength was slightly increased to 29.1 N/mm. this may be due the surface roughness created after plasma treatment. The rough surface increases the cohesion between fibres and improves the strength.

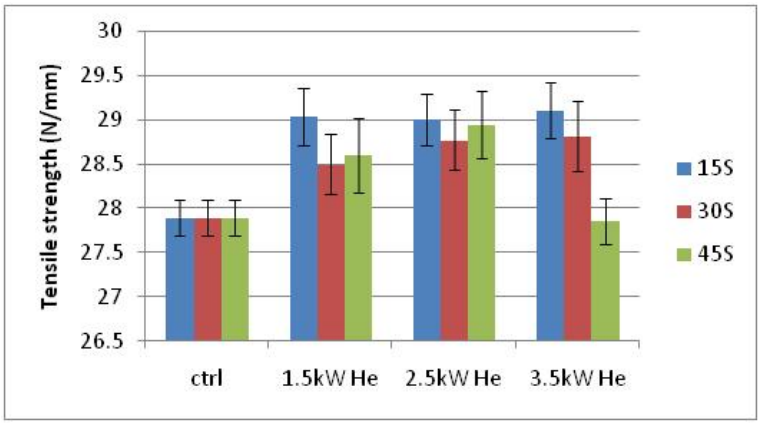


Figure-8: Tensile strength of the nylon fabric, effect of plasma treatment

Conclusions

Plasma treatment of nylon fabric was carried out at atmospheric pressure using helium gas. Wicking height showed the improved wettability of the plasma treated samples. SEM images of the plasma treated fabric

showed the surface roughness. Plasma treated fabric was coated with PU polymer and adhesion force between the fabric and coating was measured by peel bond test. It was observed that with increase in plasma exposure time there is significant improvement in peel bond strength. Tensile strength of the nylon was increased slightly at lower plasma treatment power and time.

2.4 Analysis of Eco-management in Indian Textile Processing Industry

The major thrust area that has been observed is lack of environmental responsibility in the textile industry. Some of the corporate companies have their own environmental management system (EMS) but small units are lacking in the same. Compared to other stages of textile production, textile processing industry exceedingly impacts on environment due to high resource consumption profile in terms of water, chemicals, energy and release of highly contaminated effluent. The industry often lacks the understanding, skills and managerial capacity to respond to these environmental issues. Therefore to create awareness about the necessity of an assessment study and improvement in their performance on Environmental issues, The Bombay Textile Research Association (BTRA), Mumbai with the help of Ministry of Textiles (MOT), has taken this Green Initiative project for the Indian textile industry.

The project focuses on the following.

- Analysis of current status of awareness regarding environmental protection in textile Industries.
- To understand chemical management system in textile mills and creates awareness about harmful effects of restricted substances on human and aquatic life.
- Encourage textile mills to adopt environmental policy, conduct environmental review and introduce environmental Programme.
- Defining problems faced by industry regarding environmental protection.
- Developing recommendations and to provide best practice guidelines for improvement in the Environment Management System.

Current status - Till the end of December 2017, we have audited 6 textile processing houses for eco management awareness and eco-management implementation in their units. Analysis is being done for ETP, boiler flue gas emissions, noise level, chemical management system and utility/energy conservation practices. We have collected effluent samples (both inlet and outlet) for its characteristic analysis.

2.5 Development of electronic servo control drive industrial TFO twister for heavy denier filament yarn

Two for One twister has number of advantages over ring winder such as (i) production of long length yarn (ii) higher productivity per spindle (iii) less pre and post twisting operations and (iv) low manpower requirements. In the last two decade, many improvements have been made in different zone of the TFO twister to reduce the energy consumption, lower noise level, gentle handling of yarn etc. To reduce the energy consumption, manufacturers have given importance on design of spindle. In the driving mechanism, servomotor can be used for the same purpose in place of induction motor with inverter. Recently Manufacturers are using servomotor in TFO twister for normal and fancy yarns. Introduction of the multiple servomotors in TFO twister for industrial threads to individually control the speed of different zone is a tricky process.

For industrial applications, such as sewing threads, cargo slings, Tyre cords, FIBC etc., we require heavy denier (800-5000) and bigger packages up to 8 to 10 kg. Consequently we need bigger diameter of supply packages having diameter around 300 mm. The existing machine consumes more power for driving these spindles with heavy load. It is also not possible to maintain low twist level which is one of the requirements for industrial threads. With introduction of servo controlled device, the power consumption will go down by almost 30 to 40% and low twist level can be maintained. A commercially developed full length servo controlled machine drive will therefore save power and money. Using this machine, achievable savings in power consumption will be approximately Rs. 4 lakhs per machine in a year to the user.

In this project, proposed machine has been developed successfully. Power consumption of developed machine is 25% less than the conventional gear drive machine. Machine was exhibited in Plastiindia 2018 exhibition.

2.6 Development of cotton waste based oil absorbent for oil spill clean-up

Oil spill occurs over the seas, water bodies and land surfaces due to tanker disaster, war, operational failure, accident and natural disasters during the production, transportation, storage and use of oil. Oil spills into land, river or ocean and impose a major problem for the environment. So it is necessary to clean the water or land immediately after the oil spill. Removal of crude oil and petroleum products that are spilled at sea is a serious problem in the last few decades.

Oil spill clean up have a global concern due to its environmental and economical impact. Various commercial

system including synthetic fibres like polypropylene have been developed to clean up the oil spillage. Polypropylene is non biodegradable hence non eco-friendly. Again for sustainable environment, disposal of used sorbents is also a major issue. To over come these problems, other alternative option available is using natural fibre like cotton which is bio-degradable. In India, high cotton production is accompanied by generation of tons of cotton waste each year and this waste created environmental problem due to disposal issues. Most of the cotton waste is disposed off by burning, which in turns increase carbon dioxide level in atmosphere which adds on the global warming. Hence the use of cotton waste as oil absorbent will be a green initiative to control pollution in a dual manner. Hence in this project work an attempt will be done to use waste cotton as oil absorbent, after subjecting to various modifications.

Experimental Work

Raw cotton waste has been procured from textile mills from Mumbai. The procured cotton waste has been cleaned in a trash separator to separate out lint, trash, and micro dust of cotton fibre. The cleaned cotton waste was processed in a needle punch machine to make a non woven lap. Water and oil absorbency property of this cotton waste was studied. To enhance the hydrophobic and oleophilic property of cotton, various techniques like graft co polymerization, chemical modification, nano technology etc. has been proposed in the future work.

2.7 Nano-fibre application to enhance the anti-clogging properties of geotextiles

Introduction

Geotextiles are permeable textile materials used with sand, soil and rock in various areas of geotechnical structures like roads, river and sea bank protection, canal lining, landfills, airport railways etc. They are may be woven, non-woven or knitted as per the requirement of end use application. Among the various functions of geotextiles, filtration is an important function to separate the water from the soil. This is because of the fact that geotextiles are porous to liquid flow across their manufactured plane and also within their thickness.

Prefabricated vertical drains (PVD) are one kind of geo-filter for the consolidation of soil before the building of structure. This consist of a plastic core with formed flow path grooves on both sides along its length acts as free draining water channel even at large lateral pressure, surrounded by a geotextile (filter) that maintain the hydraulic capacity of the grooves and preventing clogging by soil intrusion. These geosynthetic vertical drains are used for the purpose of expediting consolidation of slow draining soils. This system has been used to improve the properties of foundation soil for

railway embankments, large structure, airports and highways etc.

Under lateral soil pressure the internal water flow paths of PVD became clog by fine soil particles, if the pore size of filter is larger than the fine soil particle, too many fines could reduce the PVD discharge capacity and increase the filter resistance. The smaller but apparent pore size is needed for the filter jacket to prevent clogging and maintain the hydraulic capacity of the grooves. Deposition of thin nanofibrous web with small pore size on geotextile can help to reduce this problem.

Electrospinning is an efficient and versatile technique to obtain fibers with very small pores and diameters ranging from several microns to tens of nanometers. Due to fine fiber diameter, very large surface area to volume ratios and small pore size can be obtained. These are the ideal requirements for filtration. The filtration performance of nanofibers is strongly related to their pore structure parameters, i.e., percent open area (POA) and pore-opening size distribution (PSD). Hence, the control of the pore of electrospun webs is of prime importance for the nanofibers that are being produced for these purposes. The selection of polymer for the fiber spinning depends on the application.

Nylon 6 is one of the widely used polymers for filter production due to their good mechanical and physical properties and they have good thermal and chemical resistance as well as wettability and hence, Nylon 6 could be electrospun into ultrafine fibres. So it could be employed as a membrane material for water filtration.

In this study we have chosen Nylon 6 polymer for the spinning of nanofiber and deposit the same on the surface of spunbonded Polypropylene to minimize the pore size and improve the anticlogging properties of geotextiles. Properties related to clogging and filtration of prepared PVD has been compared with conventional PVD.

Experimental

Materials

Fiber grade Nylon 6 was purchased from local market of Mumbai (India). Spunbonded nonwoven Polypropylene fabric was collected from Techfab (India) Industries Ltd, Daman (U.T). Acetic acid (MW 60.05 g/mol) and formic acid (MW 46.05 g/mol) was procured from Merck life science pvt ltd., Mumbai (India). All these chemicals were used as it is without further purification.

Methods

Spinning solution preparation

The measured amount of Acetic acid and formic acid in 2:1 ratio were taken in a conical flask and stirred using magnetic stirrer. The polymer

was added slowly during stirring and kept for 2h at 70°C.

Electrospinning

The needleless electrospinning machine from ELMARCO (NS IS500 U) with wire electrode was used for the nanofiber spinning. Nylon 6 nanofiber was deposited on spunbunded polypropylene fabric and electrospinning parameters such as concentration of polymer, positive electrode voltage, negative electrode voltage, electrode distance and relative humidity were standardised.

SEM analysis

Morphology of Nylon 6 nanofibers was observed by Scanning Electron Microscope (SEM JEOL JSM 5400). All samples were sputter coated with gold prior to SEM analysis. Fiber diameter was measured by image software Image J. From those SEM images, as many as 150 fibers were selected from each sample at different positions and average of those readings was recorded.

Pore Size Analysis

Quantachrome's 3G porometer operating under windows ® the 3G win software was used for the analysis of pore size. Pore size was measured by ASTM D 6767 (standard test method for pore size characteristics of geotextiles by capillary flow test).

Water Permeability Test

Water Permeability test of the substrate fabric with nanofiber was measured by ASTM D4491. The test was conducted at 100 mm constant water head with 70 mm diameter of sample.

Results and Discussion

Effect of polymer concentration on Electro-spinning

Effect of polymer concentration on spinnability and fiber diameter was studied by varying the concentration of Nylon 6 in the solution. Polymer quantity was varied within a range to find out the suitable quantity for continuous spinning of fine nano-fibers without any beads. During spinning, other parameters such as distance between electrodes, voltage of top electrode, voltage of bottom electrode, width of deposition, carriage speed, RH %, temperature and deposition time were kept fixed. Fiber quality was investigated by SEM and diameter of fiber was measured from those images. 13 wt% was considered suitable based on diameter CV%. This 13 wt% concentration was kept fixed for other set of experiments.

Effect of positive voltage on fiber diameter and pore size

The effect of positive voltage on fiber diameter and pore size of nanofiber mat was investigated by changing the voltages at the increasing step of 2.5 kV. During spinning, other

parameters such as polymer concentration, top electrode voltage, distance between electrode, relative humidity % and deposition time were kept fix. Fiber quality was investigated by SEM and diameter of fiber was measured from those images. Based on the observations, 35 kV was kept fix for further set of experiments.

Effect of negative voltage on fiber diameter and pore size

The effect of negative voltage on spinnability and fiber diameter was studied by changing the negative voltages with increasing step of -2.5 kV. During spinning other parameters such as concentration, positive voltage, distance between electrodes, relative humidity %, deposition time and carriage speed were kept fix. Fiber quality was investigated by SEM and diameter of fiber was measured from those images using image J software. Based on the observations, -15 kV was kept fix for further set of experiments.

Effect of Distance between the electrodes

To study the effect of distance between positive and negative electrode, electrospinning was done at different collection distance with 10 mm increasing steps. During spinning, polymer concentration, positive voltage, negative voltage, relative humidity %, temperature, deposition time and carriage speed were kept fix. Fiber quality was investigated by SEM and diameter of fiber was measured from those images using image J software. Based on the values and observations, distance was kept fix at 130 mm for further set of experiments.

Effect of Relative Humidity% on electrospinning

To study the effect of relative humidity on fiber diameter, the polymer solution was electrospun at varying relative humidity%. Other parameters such as concentration, positive voltage, negative voltage, electrode distance, temperature, deposition time and carriage speed were kept constant during spinning. Fiber quality was investigated by SEM and diameter of fiber and pore size was measured by the method mentioned earlier. In this case also no such regular trend was observed in fiber diameter and pore size of nanofiber mat. So, minimum RH at 45% was kept fix for the further set of experiments.

Effect of deposition time on pore size and water permeability

Thickness of mat inversely proportionate to water permeability so at standardized spinning parameters, thickness of nanofiberous mat was standardized by varying the deposition time from 0.5 minute to 5 minute. Significant increase in pore size and water permeability was found at 1 and 0.5 minute of deposition. As increase in pore size is not favorable to enhance the anticlogging property of PVD, 2

minute of deposition time was kept fix for the further investigation.

Conclusion

Required spinning parameters are standardized for Nylon 6 in the needle less electrospinning machine with wire electrodes. Deposition time is standardized to obtain the required pore size of the nanofiber mat. Further experiments on study of clogging behaviour and water permeability of the PVD substrate with nanofiber mat is under progress.

2.8 Melt spinning of PVDF / ZnO nanostructure hybrid filament for wearable smart textile

Introduction

Among the different types of smart materials, piezoelectric materials are the most widely used because of their fast electromechanical response. A classical definition of piezoelectricity is the generation of electrical polarization in a material in response to a mechanical stress. Ceramics are well accepted piezoelectric material but for certain applications polymeric piezoelectric materials are suitable over the ceramic because of their unique properties such as higher piezoelectric stress constant, processing flexibility, toughness, high strength and high impact resistance.

A low level of piezoelectricity was first reported in polyamide but polyamides have not been widely employed in applications due to its low room temperature piezoelectric response and its problem with moisture uptake. In addition to polyamide, other polymers such as polyvinyl chloride (PVC) and polyacrylonitrile (PAN) also show piezoelectric behaviour but PVC shows very low piezoelectric coefficient and poling of PAN is difficult due to strong dipole interaction between nitrile groups.

Piezoelectric property in Poly (vinylidenefluoride) PVDF was first observed by Kawai in 1969. During his research Kawai found that thin PVDF films that had been poled exhibited a very large piezoelectric coefficient, 6-7 pCN^{-1}, a value which is about ten times larger than had been observed in any other polymer. After this finding, PVDF gained interest among the research community for various applications. From the structural point of view, it is a semicrystaline and polymorphic material shows at least four crystal phases at different processing condition. Among the four crystal phases the β phase shows piezo, pyro and ferroelectric characteristic due to the all trans-conformation in orthorhombic unit cell. The most stable α phase of this polymer is formed during melt crystallization. This stable α phase can be transformed to β phase by application of mechanical force below the temperature 100°C. The polarisation process further helps to improve the piezoelectric property by increasing uniformity in alignment of dipole moments in the unit cell of β phase. Other than the mechanical

stretching, the enhancement in β phase content is also possible by incorporation of nanoparticles in the polymer.

Based on above mentioned hypothesis, effect of various nanofillers such as amino modified double wall carbon nanotube, carbon black and multiwalled carbon nanotube on β phase content as well as different electric behaviour of PVDF/nanofiller composite has been studied by the researchers.

In addition to the above mentioned nanofillers, it also has been reported in literature that, incorporation of ZnO nanoparticles enhances the mechanical and crystallisation properties of polypropylene/polylactic acid nanocomposite filament. The ZnO nanorods reinforced nylon 6 composite filaments show drastic improvement in mechanical properties compared to ZnO nanoparticles reinforced nylon 6 composite filaments because the increase in aspect ratio of nanostructure helps to induce and retain the alignment of polymer chain to fibre axis due to higher degree of interaction with polymer chain along their length. Zinc oxide is a piezoelectric material and its high aspect ratio nanostructure shows excellent piezoelectric properties.

Authors have not studied the effect of zinc oxide nanorods on the piezoelectric property of Nylon 6 may be due to low degree of piezoelectric coefficient in Nylon 6. On the other hand PVDF shows good piezoelectric property so it is expected that, the incorporation of ZnO nanostructure having high aspect ratio in PVDF during melt spinning will help to improve further the pezoelectric properties as well as mechanical properties of PVDF to higher degree. Studies based on this hypothesis have not been reported in literature. Therefore, incorporation of ZnO nanostructures having different aspect ratio in PVDF during melt spinning and its contribution to enhance the β phase content, piezoelectric property and mechanical properties of PVDF can be explored. Melt processing of polymers into fibres is a preferred technique at the industrial scale because of economy and production speed, but only challenge is the uniform dispersion of nanostructures in polymer melt. The use of plasma technology to functionalize the nanorods for better dispersion in polymer during melt spinning can also be explored.

From the application point of view, now a days PVDF polymer has numerous application as membrane, static pressure sensor, actuator, transducers in medical field and also its possible application as nanogenerator to harvest the power from the low frequency human body movement. The performance of this developed PVDF/ZnO nanostructure composite filament as nanogenerator to harvest power from the low frequency body

movement and its use for charging personal electronics can be explored. Currently power bank is used for the same purpose. In medical field, ceramic piezoelectric material is being used for some applications, so the performance of fabric consisting of these filaments to monitor the heart beat, body movement and respiration of patients can also be explored.

Experimental

Scanning electron microscopy

Morphology and dimension of ZnO nanorods were investigated using scanning electron microscope JSM 5400 by JEOL (Japan) after gold coating.

Melt blending of nanorods with PVDF

Melt blending of ZnO nanorods was done using Omega 20 twin screw extruder from Steer India combined with palletiser.

Wide Angle X-Ray Diffraction analysis (WAXRD)

Wide angle X-ray diffraction analysis of powdered samples were carried out on XPert Pro Panalytical instrument (Model no. PW3040/60). During test, applied current and accelerating voltage was kept 30 mA and 40 kV respectively. This produced X-rays of wavelength 1.54 A° (CuK_α) and the diffraction patterns were obtained with 2 values ranging from 10 to 60°.

Results and Discussion

Characterization of ZnO nanorods

ZnO nanorods were synthesized using the method mentioned in earlier section and characterised using SEM. SEM images of nanorods are shown in Figure-9. Nanorods were polydisperse in nature. The average length and diameter of rod was measured 12 µm and 450 nm respectively. Purity of synthesised nanorods was investigated using wide angle X-ray diffraction technique. A typical XRD pattern of ZnO nanorods Is shown in Figure-10. The unit cell of the crystal found to be hexagonal from the appeared peaks. It is well agreed with the JCPDS card no. 36-1451. Further, the intensities of peaks are different which indicates that the growth of various planes is anisotropic. In the spectrum no impurity peaks were detected, which indicates that the synthesised nanorods are highly pure.

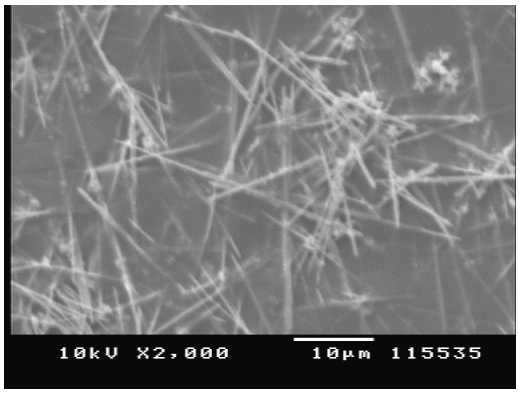


Figure-9: SEM image of synthesized ZnO nanorods

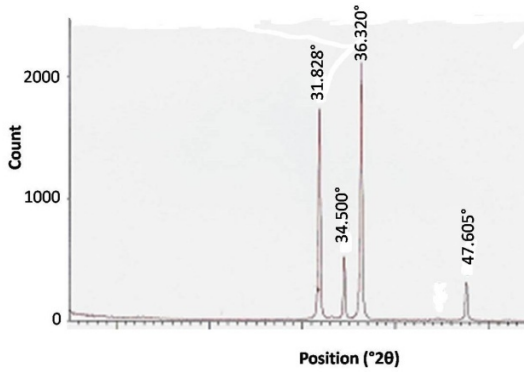


Figure-10: WXRD spectra of ZnO nanorods

Melt blending of ZnO nanorods with PVDF

Uniform dispersion of nanorods in the polymer is important for the spinning of good filament with better properties. For the uniform distribution, first nanorods at different percentage was dispersed in volatile liquid medium and then mixed with polymer with stirring. After proper drying, polymer was taken to twin screw extruder for meltblending and cutting.

Conclusion

Synthesis of ZnO nanorods is done successfully and meltblended with the PVDF in different percentages. Spinning of the blended polymer is in progress.

2.9 Development of test method for analysing hexavalent chromium content in dyes, pigments and textile auxiliaries

Chromium is a naturally occurring metal found in small quantities associated with other metals. Although chromium can exist in all oxidation state from 0 to 6, Cr3+ and Cr6+ are the most prevalent. Even though trivalent chromium is an essential nutrient, hexavalent chromium is a known mutagenic and carcinogenic substance. Hexavalent chromium (Cr+6) is commonly found in textile dyes, pigments, paints, inks leather products and textile auxiliaries. Due to the high toxicity most of the government regulations restricted the use of hexavalent chromium in consumer products.

At present the only test method available to test Cr+6 is ISO method for leather products. This test method is not suitable for dyes and pigments due to the high matrix interference.

Hence during this project an attempt will be made to develop a test method to test Cr+6 in dyes and pigments. Once the method is validated as per the international validation protocol the same will be submitted to Bureau of Indian Standard (BIS) to formulate the same as national standard.

Experimental work

About twenty five dyes and pigments including chrome pigments and few textile auxiliaries were collected from various manufactures from Mumbai. The total chromium content in these dyes and pigments were estimated by microwave digestion followed by ICP OES analysis. It was observed that in most of the chrome based pigments Chromium content is very high. This chromium could be either in trivalent or hexavalent or in both the forms. Hence to segregate the trivalent and hexavalent chromium various trial and errors has been worked out. Few among them are as follows

- Studies on the effect of various acids and alkalies on hexavalent chromium
- Studies on the effect of oxidation and reduction agents on hexavalent chromium.
- Studies on the effect of microwave digestion and conventional acid digestion on hexavalent chromium
- Effect of various temperatures on hexavalent chromium.
- Effect of activated charcoal on hexavalent chromium
- Effect of bleaching agents on hexavalent chromium

Since separation of Cr+6 from dyes and pigments is a challenging job, the above mentioned experimental trials are not shown positive results to achieve the final goal. Hence further investigations are needed and the same will be taken in the current fiscal year.

2.10 Studies on performance enhancement of textile effluent treatment plant by electron beam method

Typical simulated industrial effluent samples of scouring, desizing, printing and dyeing process were prepared separately by adding chemicals such as dye, synthetic size, alkali, color and pigment with known concentrations. All these samples were allowed to undergo conventional biological treatment - activated sludge process.

Biological reactor for an activated sludge process

The activated sludge system was applied in a lab-scale acryl vessel, which consisted of an aeration tank and settling clarifier. Wastewater was fed into the aeration tank to maintain hydraulic retention time (HRT) of 24 hrs in aeration tank. The water was aerated with diffusers to maintain dissolved oxygen concentration of

2mg/L. The settling tank was fabricated in such way that settled sludge can be recirculated to aeration tank in order to maintain mixed liquor suspended solids (MLSS) at 2000-3000mg/L by returning or wasting the sludge. The activated sludge process was applied to investigate the efficiency of biological treatment process to reduce the pollution load in Textile ETP. Efficiency of biodegradation was measured in terms of % COD & BOD reduction. The values of chemical oxygen demand and biochemical oxygen demand (BOD) were measured according to IS-3025 (Parts-58 & 44) respectively.

Figures-11a, 11b and 11c show the values of COD, BOD and % reduction of organic matters of the raw wastewater through conventional biodegradation process at 24 hrs hydraulic residence time. From Figure-11a, the average COD value of scouring, desizing (starch), desizing (PVA), dyeing (Corazol Red dye) and printing effluent were 1130, 1004, 1171, 820.5 and 1087 respectively. These values decreased to 711, 418, 836, 558 and 648.5 respectively as per conventional biodegradation process. Accordingly 37, 58, 29, 32 and 40 % reduction in COD was achieved. Similarly Figure-11b represents the average BOD value of scouring, desizing (starch), desizing (PVA), dyeing (Corazol Red dye) and printing effluent. % BOD reductions achieved are 45, 53, 18, 38 and 46%.

The above experimental trial clearly indicates that activated sludge process only works efficiently for desizing effluent which contains starch as biodegradable matter. Where as not so effective for effluent containing refractory organic matters such as PVA, synthetic dye, oil etc. Microorganisms (Bacteria and fungi) present in activated sludge process notable to degrade the complex structure of organic compounds and results in sludge bulking.

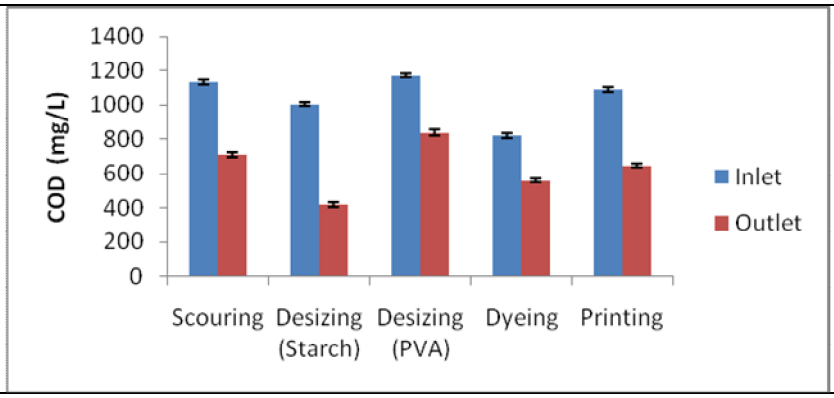


Figure-11a: COD Reduction

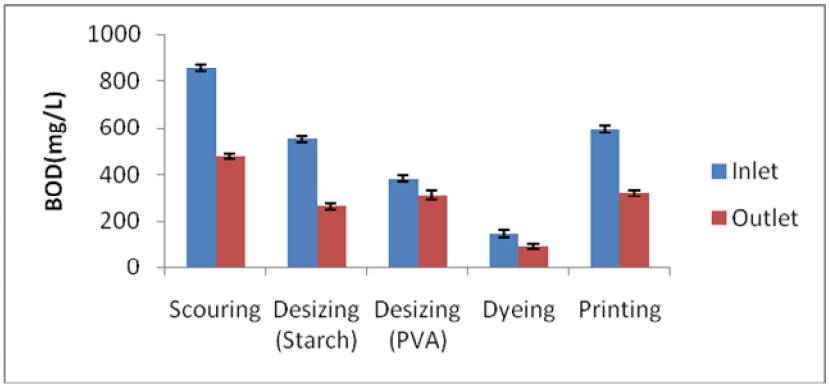


Figure-11b: BOD Reduction

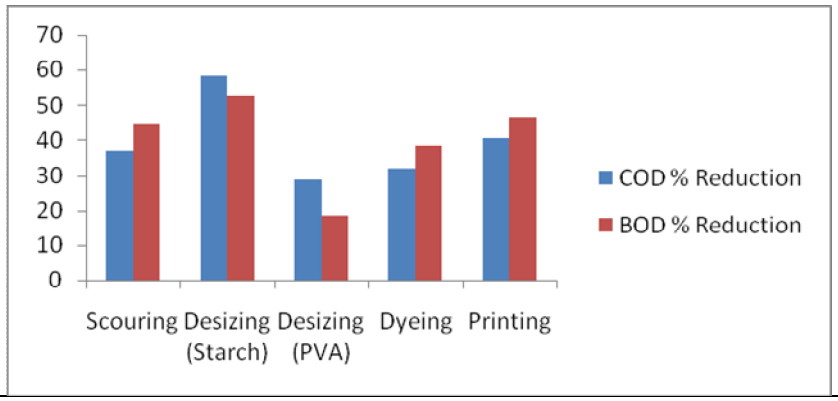
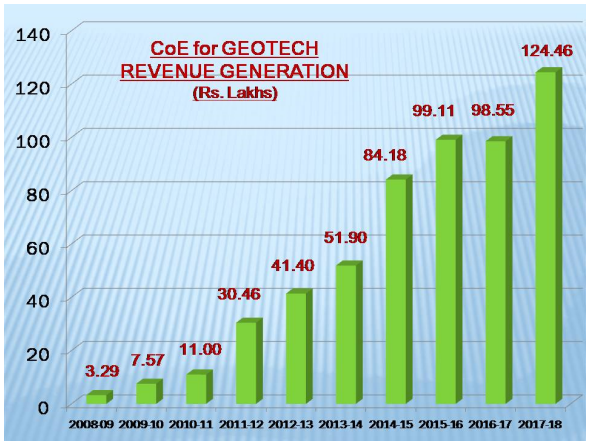


Figure-11c: COD & BOD % Reduction

2.11 Centre of Excellence for Geotech



BTRA is recognized (based on earlier experience, expertise and facility) as a Centre of Excellence for Geotech by the Ministry of Textiles, Government of India. State-of-Art facilities for testing Geotech are set up at BTRA. The new laboratory have all testing facilities for geosynthetic products like Geotextiles, Geomembranes, Geocomposites, Gabions, Geosynthetic Clay Liner, Geogrids, Prefabricated Vertical Drain etc. Also, BTRA is strengthening its information resources on Geotech by procuring various books and test methods.

The Geotech Laboratory at BTRA is accredited by Geosynthetics Institute (GSI), Folsom, Pensylvania, USA under the GAI – LAP Accreditation Programme for 24 tests of geosynthetics products. It is pertinent to mention that BTRA is the first institute in India and probably only the third institute outside USA to get this coveted accreditation. What this means to the geosynthetics producers and users is that they can get the products tested in BTRA with utmost confidence that the accuracy of the results are as good as any other GAI-LAP accredited laboratories. They can get the tests done in India, thus saving time and money without compromising on the quality of the results.

Soil Mechanics Laboratory

BTRA Soil Mechanics Laboratory has started the following tests for soil classification and other related tests as per Bureau of Indian Standard Test Methods.

Soil classification tests	***Other soil tests***
1) Specific Gravity (IS 2720 Part-3) **2)** Particle Size Analysis (dry/wet) (IS 2720 Part-4) **3)** Liquid Limit (IS 2720 Part-5) **4)** Plastic Limit (IS 2720 Part-5) **5)** Shrinkage Limit (IS 2720 Part-6) **6)** Natural Moisture Content (IS 2720 Part-9) **7)** Differential / Free Swell Index (IS 2720 Part-40)	**1)** Standard Proctor Compaction Test (IS 2720 Part-7) **2)** Modified Proctor Compaction Test (IS 2720 Part-8) **3)** Unconfined Compressive Strength (IS 2720 Part-10) **4)** Triaxial Shear Test (IS 2720 Part-11) **5)** Direct Shear Test (IS 2720 Part-13) **6)** California Bearing Ratio (CBR) Test (IS 2720 Part-16)

BTRA staff attended the following related to Geotech.

Conferences / Meetings Attended

- Meeting on 'Standardisation in Geosynthetics' organised by Bureau of Indian Standards at Mumbai on 27th October 2017
- 3rd National Conclave on 'Standards for Technical Textiles' Organised by FICCI at New Delhi on 3rd November 2017. A paper on 'Standardisation in Geotech Sector' was also presented at this Conclave.
- Awareness seminar on Geosynthetics organized by Regional Textile Commissioner Office, Navi Mumbai and PWD, Goa held at Goa on 5th December, 2017. A paper on 'Geosynthetics in Construction Industry' was also presented at this Conclave.
- Indian Geotechnical Conference 2017 – Geo Nest at Indian Institute of Technology, Guwahati from 14th to 16th December, 2017

- 21st meeting of Geosynthetics Sectional Committee (TX-30) in joint session with 10th meeting of Industrial Fabrics Sectional Committee (TX-33), held at Bureau of Indian Standards Office, Mumbai, on 9th January, 2018
- Centre of Excellence Meeting, held at Textile Commissioner's Office, Mumbai, on 16th January, 2018
- AMC meeting under the scheme for the promotion of Geosynthetics (Jute) in North East Region, held at Udyog Bhavan, New Delhi , on 18th and 19th February 2018
- Expert panel meeting of BIS on Geosynthetics (TX-30) , held at Office of Indian Technical Textiles Association, Mumbai, on 22nd March 2018

Training

- BTRA staff were trained on operational aspects of newly installed Multi Station Tensile Tester at Geotech Lab by Mr. Daniel from M/s. Walter Bai, Switzerland on October 2017

Exhibition Participation

- Technotex 2017 Exhibition held between 12th and 14th April 2017 at Mumbai
- Nonwoven Tech Asia 2017 Exhibition held between 8th and 10th June 2017 at Mumbai
- Textiles India 2017 Exhibition held between 30th June to 2nd July 2017 at Gandhinagar
- Techtextil India 2017 Exhibition held between 13th to 15th September 2017 at Mumbai

3. CALIBRATION LABORATORY

BTRA has set up a calibration laboratory to cater to its own needs as well as provide calibration services to other NABL accredited testing laboratories.

Calibration of measuring Instruments having accredited traceability is one of the primary processes used to maintain instruments accuracy and is also the requirement of accredited testing laboratories. Now, BTRA calibration laboratory received NABL accreditation as per 17025:2005 laboratory standards for Mass, Volume and Balance. BTRA is ready to provide calibration services to other NABL accredited testing laboratories for Mass, Balance and Volume parameters for the following ranges.

Parameter to be calibrated		Range
• Balance	:	1 mg to 5 kg
• Weights	:	1 mg to 5 kg
• Volumetric glassware	:	0.5 ml (500 µl) to 100 ml

For building the calibration lab we have used most of the in-house resources available, without incurring any additional direct cost to BTRA towards the procurement of basic required infrastructure. The most important is knowledge and expertise required to prepare documents, formats, procedure as per the standards etc. and are available in-house. Second requirement is the lab with the infrastructure i.e. well furnished lab, instruments to maintain environmental condition, gadgets to monitor environmental condition, balances, standard weight of certain class of accuracy etc. Well furnished Lab was available with the electronics department is used as a calibration lab.

To maintain the temperature and humidity of window AC, dehumidifier and digital RH meter cum barometer was installed. Master equipments such as balances and standard weights - One balance 220 g and weights 1 mg to 200 g E2 class, 1 mg to 200 g F1 class, 500 g, 1 kg, 2 kg and 5 kg of F1 class are procured, whereas the 3 kg and 5 kg balances were used from other departments of BTRA (which were not working and beyond repair reported by manufacturer) and get repaired by us and made use of this. After generating enough data of calibration we faced NABL audit and got the accreditation for the parameter of mass, balance and volumetric glassware's.

From January 2017, we have communicated to the different labs in and around Mumbai through email and fetched some of the enquiries and work, at the same time we did the calibration work for the different testing departments of our own institute. Total certificates issued for mass, balance and volumetric glassware till December 2017 were 94. For further push up, the dedicated marketing will help in getting more and more samples for calibration.

4. TECHNICAL SERVICES

BTRA has provided extensive liaison and consultancy services to solve problems of quality, maintenance and productivity at various levels for the textile units. The details are given below.

4.1 Overview

- ✓ **Technical investigations carried out** : 68
- ✓ **Technical enquires attended** : 385
- ✓ **Local mill visits made [man-days]** : 77
- ✓ **Outstation mill visits made [man-visits]** : 175

4.2 Type of Assignments Undertaken

- ♣ LIVA Accredited Partner Audits for 64 units
- ♣ Boiler Efficiency Audit in a mill
- ♣ Fabric inspection training for a mill
- ♣ Verification of EPI, PPI and Width of fabric on loom and on table

Product Development Assistance to the industry

- In needle-punch nonwoven and hydro-entanglement pilot plants, 48 samples were developed for various applications such as thermal insulation, viscose spun lace, etc.
- In the pilot plant of Technical Textiles Weaving, 29 samples (of 15 m in length) were developed for various applications such as tyre cord, filter fabric, etc.
- In the Plasma Treatment Machine, twenty metres of fabric were processed for two academic / research institutes

5. TESTING SERVICES

BTRA Test Laboratories had undertaken wide-range of testing activity such as Fibre Properties, Yarn Properties, Fabric Properties, Fabric Defect analysis, Chemical Testing (chemicals & auxiliaries), Eco-parameters Testing, Geotextiles Testing, Soil Testing, Technical Textiles Testing (other than Geotech), Microbiology Testing, Scanning Electron Microscope Studies, Special Testing [Flammability, static charge measurement, FT-IR / DSC / TGA / X-ray / GPC analysis, Melt Spinning trials, etc.] and Material Testing (non-textile items such as water, paint, oil, etc.). Total number of tests conducted for the period under review is 30164 and section wise details are as follows.

5.1 Overview

Test Particulars	Number of Tests
Physical Testing	9666
Chemical Testing and Eco-parameters, Chemicals / Dyes / Auxiliaries Testing and Material Testing ***(non-textile items, water, oil, etc.)***	10959
Fabric Defect Analysis	317
Geotextile Testing	5379
Technical Textiles Testing ***(other than Geotech)***	
Microbiology Testing	418
Scanning Electron Microscope	406
Special Testing ***(Flammability, static charge, FTIR / DSC / TGA / X-ray / GPC studies, Melt spinning trials, etc.)***	2927
Calibration Testing	92
TOTAL TESTS CONDUCTED	**30164**

5.1.1 Proficiency Testing Programs Participation

During the period under review, BTRA Test Laboratories participated in the following proficiency testing programs in order to maintain its laboratory performance at par with national / international laboratories.

- ASTM Proficiency Test Program on 'Woven Fabrics'
- AATCC Proficiency Test Program on 'Fibre Identification & Analysis'
- AATCC Proficiency Test Program on 'Colour Fastness'

5.1.2 New Machinery / Instruments added

- Absorbency Test System
- COD – Analyzer
- Combo PH/EC/TDS Tester
- Computerised Yam Twist Tester
- Computerised CSP Tester
- Electro Spinning Machine
- Fabric Tensile Tester
- Flue Gas Analyser
- Hot Plate with Magnetic Stirrer
- Microwave Digestion System
- Multi Station Tensile Tester
- Oxygen Meter
- Peristalic Pump
- Trash Separator

5.1.3 New Test Methods Launched

BTRA undertakes the following new test methods as per national and international standards.

- Polymer Tests (Thermal Analysis) using Differential Scanning Calorimetry (Perkin Elmer DSC 8000) - Oxidative Induction Time (OIT) / High Pressure OIT
- Polymer Tests (Morphological / Structural Analysis) using Perkin Elmer Frontier Near Infra Red (NIR) Spectroscopy - IR and NIR analysis for Identification of Polymer/Fibres, Coating type, Changes in functional groups after chemical modification and many more
- Dilute Solution Viscosity Measurement of Polymers (Inherent / Intrinsic / Relative Viscosities) as per ASTM D1243 / D2857 / D4603 Test Methods
- Formaldehyde Content in Auxiliaries as per GOTS
- Allergenic Disperse Dyes
- Glyoxal Content in Textiles
- Polycyclic Aromatic Hydrocarbons (PAH)
- Identification & Quantification of Virgin / Recycled Polyester Fibre
- Heavy Metal Content in Water using AAS
- Formaldehyde Content in Chemicals and Auxiliaries using HPLC (detection limit - 1 ppm)
- Surface Tension of Liquids and Films using KRVSS Drop Shape Analysis System
- Particle Size Analysis for Dry Powders
- Determining deterioration of visibility due to smoke released on combustion of materials [using Smoke Visibility Tester] as per UIC 564.2 OR Appendix-15 method
- Determination of Toxicity Index [Fume Toxicity Tester] as per N.C.D. 1409 method
- Standard Test Method for Using Seeded-Agar for the Screening Assessment of Antimicrobial Activity In Carpets [ASTM E 2471]
- Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings [ASTM C 1338]
- Standard Test Methods for Mildew (Fungus) Resistance of Paper and Paperboard [ASTM D 2020 Method A]
- Standard Test Method for Resistance of Emulsion Paints in the Container to Attack by Microorganisms [ASTM D 2574]
- Measurement of antibacterial activity on plastic surfaces [ISO 22196]
- Standard Specification for Retro-reflective Sheeting for Traffic Control [ASTM D 495]
- Weatherability Testing of various products
- Performance Testing of various Chemicals and Auxiliaries used in Textiles (Application and Evaluation)
- Evaluation of Sizing Agents as well as Sizing and Weaving Trials

5.2 Technical Textiles Testing

BTRA carried out in total 5379 tests for geotextiles and for technical textiles (other than Geotech). The following types of testing of technical textiles are undertaken at BTRA.

- FILTER FABRICS - Woven/ Nonwoven
- GEOTEXTILES – Woven / Nonwoven
- PVD BAND DRAIN
- GEO-MEMBRANE LINER
- GEO-GRID
- ROPE GABION
- METAL GABION
- NONWOVENS – Wadding, Cover Stock, Face Mask, Interlining, Absorbing/Shoulder Pads, Insulation Pad and Carpets [Nonwoven Type]
- COATED FABRICS
- AUTOMOTIVE TEXTILES
- MEDICAL TEXTILES
- OTHER TECHNICAL TEXTILES - Narrow Fabrics, Conveyor Belts up to 13 Mm Thick [Dumbbel Shape], Nylon Ropes up to 12 Mm, Composites - Glass Composites / Glass Composites/Mats and Glass Roving / Fabrics

Apart from conducting usual tests such as weight per square metre, weight per linear metre, thickness / density, yarn number, etc., certain unique tests are also undertaken. They are as follows.

- ✓ **FILTER FABRICS** (Woven and Nonwoven): Tear Resistance (Trapezoid Strength), Grab Strength, Water Permeability, Air Permeability, Pore Size by Porometer, Apparent Opening Size, Bursting Strength, Breaking Strength & Elongation

- ✓ **GEOTEXTILES** (Woven and Nonwoven): Abrasion Resistance, Apparent Opening Size, Bursting Strength, CBR Puncture Strength, Cone Drop Test (Dynamic Puncture Test), Grab Breaking Load Machine Direction & Cross Direction, Grab Tensile Strength & Elongation, Index Puncture Resistance, Mullen Bursting, Pore Size by Porometer, Seam Strength, Static Puncture Strength (CBR Puncture Strength), Tensile Strength & Elongation (Warp and Weft), Tensile Strength (Before & After Exposure UV Xenon Arc), Trapezoid Tear Strength, UV Resistance Exposure to Light, Moisture & Heat in Xenon Arc, Water Permeability, Water Permeability of Filter, Wide Width Tensile Strength Machine Direction & Cross Direction

- ✓ **PVD BAND DRAIN**: Tensile Strength & Elongation (Wide Width), Water Permeability of Filter, Tensile Strength of Core, Grab Strength & Elongation at Break for PVD Composite, Trapezoid Tear for Filter Component only

- ✓ **GEO-MEMBRANE LINER**: Density, Tensile Strength, Tear Strength, Puncture Resistance, Carbon Black Content, Melt Flow Index, ESCR, 2% Secant Modulus of Polyethylene Geomembrane

- ✓ **GEO-GRID**: Tensile Strength & Elongation (Single Rib) / Multi Rib, Carbon Black Content, Melt Flow Index, Aperture Size & Number of ribs per metre

- ✓ **ROPE GABION**: Size, Tensile Strength, Identification of material [TGA / DSC], UV Resistance

Exposure to Light Moisture & Heat in Xenon Arc, Tensile Strength (Before & After Exposure UV Xenon Arc), Tensile Strength of Rope after Thermal Treatment (Heating)

- ✓ **METAL GABION**: Size, Thickness of Wire, Tensile Strength of Wire

NONWOVENS

- ❖ **WADDING**: Compressional Recovery, Air Permeability, Thermal Conductivity,
- ❖ **COVER STOCK**: Mass [EDANA], Absorbency [EDANA], Liquid Strike through time [EDANA], Wicking Rate [EDANA], Tensile Strength & Elongation [EDANA]
- ❖ **FACE MASK**: Pore Size, Bacteria Filtration Efficiency [In-house Method]
- ❖ **INTERLINING**: Mass per square metre, Thickness [EDANA], Tensile Strength & Elongation, Heat Shrinkage
- ❖ **ABSORBING / SHOULDER PADS**: Mass per square metre [EDANA], Thickness [EDANA], Absorbency [EDANA]
- ❖ **INSULATION PAD**: Mass per square metre [EDANA], Thickness [EDANA], Thermal Conductivity
- ❖ **CARPETS** (Nonwoven Type): Mass per square metre, Thickness, Compressional Recovery, Hexapod Tumbler Test, Lisson Test [Treading Wheel test], Taber Wear Index [up to 300 cycles], Colour Fastness to Light up to 5 Rating, Dimensional Stability – Heat/ Water, Flammability at 45O, Horizontal Burning Rate, Pill (Camphor / Methanamine) Test, Tuft Withdrawal Strength (Piled Carpets), Static Charge measurement, Surface Resistivity, Volume Resistivity, Antimicrobial Activity, Antimicrobial Activity, Antifungal Activity

- ✓ **COATED FABRICS**: Mass per square metre, Thickness, Tensile Strength & Elongation, Tongue Tear Strength, Single Rib Tear Strength, Bonding Strength Bonded / Coated, Application of Adhesive, Water Vapour Transmission [ASTM E: 96 by Gravi Test Instrument], Identification of Coating by FTIR, Taber up to 300 cycles, Hydrostatic Pressure Heat Test, Removal of Coating, Identification of Fibres, Yarn Count, Threads/Inch, Martindale Abrasion Test – 10,000 rubs, Pliability, Blocking Test, Gelling Test, Flexing Test [Dematia Method], Limiting Oxygen Index, Vertical Flame Test, Horizontal Burning Rate
- ✓ **AUTOMOTIVE TEXTILES**: Mass per square metre, Thickness, Abrasion Resistance: Taber H18 / CS10 [Automotive Std.] up to 300 cycles, Flammability at 45O, Horizontal Burning Rate, Pill (Methanamine) Test, Relaxation Shrinkage, Thermal Shrinkage, Odour Test, Tensile Strength [Automotive Std.], Tear Strength [Automotive Std.], Colour Fastness to Light (up to 6), Colour Fastness to Crocking, Colour Fastness to Shampooing, Colour Fastness to Resistance to Cold - 20°C for 2 hours, Pliability, Blocking Test, Gelling Test, Flexing Test [Dematia Method]

MEDICAL TEXTILES

- ✓ **COTTON WOOL PADS**: Acidity or Alkalinity [Methyl Orange / Phenolphthalein], pH at 26°C, Absorbency Sinking Time, Water Holding Capacity, Water Soluble Substance, Ether Soluble Substance, Sulphated Ash, Fluorescence, Bio burden Test (4 Organisms), Drying Rate [67 + 2% R.H. & 27 + 2^{O}C Temp.]

OTHER TECHNICAL TEXTILES

- ✓ **NARROW FABRIC**: Seat Belt Strength, Tape / Webbing Strength & Elongation, Hot Water Shrinkage of Webbing, Tensile Strength & Elongation, Belt for Lift
- ✓ **CONVEYOR BELT** upto 13 mm Thick (Dumbbel Shape): Tensile Strength [In-house Method]
- ✓ **NYLON ROPES** upto 12 mm: Tensile Strength, Diameter of Rope, Linear Density

COMPOSITES

- ➔ **Glass Composites**: Flexural Strength, Lap Shear Strength
- ➔ **Glass Composites / Mats**: Thermal Conductivity, Mass per square metre, Tensile Strength, Thickness, Density
- ➔ **Glass Roving / Fabrics**: Mass per square metre, Yarn Number, Thickness, Density, Breaking Strength & Elongation at Break, pH of Aqueous Extract, Glass Content

5.3 Special Testing

Apart from undertaking testing of fibres, yarns and fabrics (for physical as well as chemical properties), numerous special tests (that are most sought after) are conducted at BTRA. The same are widely availed by the industry. BTRA carried out 2927 tests under special testing. The type of tests conducted here as follows.

- ✓ Differential Scanning Calorimetry (DSC) Analysis
- ✓ Thermal Gravimetric Analysis (TGA)
- ✓ Gel Permeation Chromatography for Molecular Weight Distribution
- ✓ X-ray Diffraction Analysis (Mineral analysis / Chart diffraction / Fibre orientation angle / Material identification)
- ✓ FT-IR spectroscopy (Material & Finish identification)
- ✓ Scanning Electron Microscope
  - Longitudinal View of Fibres/Yarns
  - Cross-section View of Fibres/Yarns
  - Micrographs for Powder Sample
- ✓ Static Charge Measurement
  - Total Charge Developed and Half Decay Time [ASTM D:4238]
  - Surface Resistivity [ASTM D:257]
  - Volume Resistivity
- ✓ Melt Spinning Experiments
- ✓ Other special tests undertaken
  - UV Protection Factor [AATCC-183]
  - Surface Tension – drop volume method (or) contact angle method
  - EMI Shielding Effectiveness [ASTM D 4935]
  - Birefringence measurement by Polarising Microscope
  - Particle Size Analysis
  - Contact Angle
  - Total Organic Carbon (TOC) Analyser
  - Refractive Index of Liquids (Abbe's Refractometer)

- ✓ **Flammability Tests**

General Apparel

- ➔ Ease of ignition of vertically oriented specimen [BS EN ISO 6940]
- ➔ Flame spread properties of vertically oriented specimen [EN ISO 6941 / BS EN 1103]
- ➔ UK night wear safety regulation [BS 5438 / BS 5722 Test 1, 2 & 3]

Curtain, Drapes and Blinds

- ➔ Ignitability of vertically oriented specimen [BS EN 1101]
- ➔ Flame spread properties of vertically oriented specimen [BS EN 1102]

Personal Protective Clothing

- ➔ Limited flame spread [EN 532 / ISO 15025 / BS 5438: 1976 Tests 1, 2 & 3]
- ➔ Limiting Oxygen Index [IS:13501 / ASTM D 2863]
- ➔ Vertical Flammability [IS:11871 / BS:3119 / NFPA 1975 / NFPA 2112]
- ➔ Horizontal Flammability [IS:15061 / ASTM D:5132 / FMVSS / SUZUKI]
- ➔ 45°C Inclined Flammability [16 CFR 1610 / ASTM D:1230 / IS:11871(B)]
- ➔ Carpet Flammability [ASTM D:2863 / 16 CFR 1630 / ISO:6925 / BS : 6307]
- ➔ Vinyl Coated Fabric Flammability [IS:1259]

Flammability of plastics

- ➔ Vertical Burning Test [UL 94 (VO.V1.V2) / ASTM D:3801 / IEC 60695–11–10(B) / ISO:1210(A) / UL 94 (VTM) / ASTM D: 4804 / ISO:9773 (Non Rigid Sample) / UL 94 (5V) / ASTM 5048 / IEC 60695-11-20]
- ➔ Horizontal Burning Test (Wing Top Method) [ASTM D:4986 / ISO:3582 / ISO:9772]
- ➔ Horizontal Burning Test [UL94HB / ISO:1210(A) / ASTM D:635 / IEC:60695–11–10(A)]
- ➔ Determining deterioration of visibility due to smoke released on combustion of materials [using Smoke Visibility Tester] as per UIC 564.2 OR Appendix-15 method
- ➔ Determination of Toxicity Index [Fume Toxicity Tester] as per N.C.D. 1409 method

5.4 Eco-parameters Testing

The following types of tests are undertaken at BTRA.

- Formaldehyde Content in Auxiliaries as per GOTS
- Allergenic Disperse Dyes
- Glyoxal Content in Textiles
- Polycyclic Aromatic Hydrocarbons (PAH)
- Identification & Quantification of Uirgin / Recycled Polyester Fibre
- Free formaldehyde [ISO:14184 - part 1]
- Release formaldehyde [ISO:14184 - part 2]
- Chlorophenol - PCP / TECP / OPP
- Pesticides - Organo chlorine / Organo phosphorous / Others / Total pesticide residue
- Aryl amines
- Phthalates
- Chlorinated organic carriers
- Poly chlorinated biphenyls
- Hexachloro benzene
- Allergenic disperse dyes
- Organo tin
- Heavy metals
- Oekotex-100 [9 metals]
- Hexavalent chromium

- Spectro photometric evaluation of dyes/optical whitener - Water soluble / Solvent soluble
- Analysis of organic compounds by - GC-FID / GC-MS {NIST library search report}
- Perfumery analysis by GC-MS
- TLC analysis
- HPTLC analysis
- HPLC analysis
- Total organic carbon [TOC] of water samples
- Acid digestion of metals/dyes/polymer/textiles etc.
- Triclosan

... and many more

5.5 Microbiology Testing

Textiles, being an integral part of our every day life, have been involved in search of hygienic functional garments with application of anti-microbial finishes. BTRA carried out 418 tests under microbiology testing. The type of tests conducted at this laboratory is as follows.

- Antifungal activity, assessment on textile materials: Mildew and Rot resistance of Textile materials Test-II – Agar Plate, Chaetomium globosum [AATCC 30 Test 2]
- Antifungal activity, assessment on textile materials: Mildew and Rot resistance of Textile materials Test-III – Agar Plate, Aspergillus niger [AATCC 30 Test 3]
- Antifungal activity, assessment on textiles materials: Mildew and Rot Resistance of Textile materials Test –IV – Humidity Jar, Mixed spore suspension [AATCC 30 Test 4]
- Antibacterial Activity of Fabrics, Detection of: Agar Plate Method [AATCC 90]
- Assessment of Antibacterial Finishes on Textile Materials [AATCC:100]
- Antibacterial Activity of Fabrics, Assessment of Textile Materials – Parallel Streak Method [AATCC:147]
- Antimicrobial Activity Assessment of New Carpets - qualitative antibacterial assessment / quantitative antibacterial assessment / quantitative antifungal assessment. [AATCC 174 – Parts 1 to 3]
- Determination of a population of microorganisms on products [ISO 11737 – Pt I]
- Textile fabrics – Determination of antibacterial activity – Agar Diffusion Plate Test [ISO 20645]
- Textiles – Determination of antibacterial activity of antibacterial finished products [ISO 20743]
- Determination of the Antimicrobial Activity of Immobilized Antimicrobial Agents Under Dynamic Contact Conditions [ASTM E 2149]
- Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi [ASTM G 21]
- Test for antibacterial activity and efficacy on Textile Products [JIS L 1902]
- Antimicrobial products - Test for antimicrobial activity and efficacy for plastics and other antimicrobial coated hard surfaces. (Film Contact Test Method) [JIS Z 2801]
- Microbiological Examination of Water [IS 1622 & IS 5403]
- Methods for testing cotton fabrics for resistance to attack by microorganism by Humidity Chamber Method [IS 1389]

- Evaluation of Bacterial Filtration Efficiency of Medical Textiles [In-house Test Method]
- Aerobic Plate count & Yeast and Mold count [Bacteriological Analytical Manual]
- JIS Z 2801:2000 for Paints / Films

Other Services

BTRA continued the activity of supplying chemicals / gadgets, repairing / calibrating gauges / testing instruments and testing stores accessories for the mills. The details are given in Appendix-9.

Powerloom Service Centres (PSCs)

BTRA runs three Powerloom Service Centres (PSCs) [at Ichalkaranji, Solapur and Madhavnagar-Vita]. In order to improve the quality, operating efficiency and productivity of powerloom clusters, BTRA PSCs provide technical consultancy, testing services, training in loom working, loom maintenance, disseminating information through training programmes, workshops, demonstrations and discussions. Liaison visits are made by BTRA staff to have a first-hand view of the problems faced by the powerloom weavers/processors and on the spot suggestions are made. The activities of these centres are given in the following Table-2.

Table–2 : Activities of BTRA Powerloom Service Centres

Activities		Ichalkaranji	Solapur	Madhav-nagar-Vita
Total yarn and fabric samples tested for physical s & chemical properties		10189	3331	768
Number of technical assistance / trouble shooting / consultancy given		363	398	37
Total number of persons trained		234	304	98
Total number of trainee man-days		--	2528	1661
Total seminars / workshops conducted		16	9	09
Survey of closure of powerlooms	Units	432	408	334
	Looms	3812	6032	2784
Number of interactive workshops conducted for TUF scheme and Group Insurance scheme		--	--	09
Group insurance facilitations for powerloom workers [number of beneficiaries]		514	3193	422
Number of Advisory / PPCICC meetings conducted		1	1	2
Number of samples for design development [non-CAD] / Analysis		--	--	15

6. SPECIAL EVENTS

6.1 Talk on 'Disruptive Innovation and Textile's Future'

BTRA organised a talk on 'Disruptive Innovation and Textile's Future' at its premises on 23rd November 2017. Dr. Charles Brumlik spoke on 'Future of Textiles in India' and Mr. Sarkar spoke on 'Collaborative Innovation / Open Innovation'. In these speeches, the following topics were covered.

- Mega Trends in Textile Industry (both consumer as well as technical textile segment) in the areas of Market led Innovation, Fibre Innovation, Smart supply chain of tomorrow, Dyes and additives innovation, Digital innovation / transformation, etc.
- Leveraging external innovation capabilities to maximize internal R&D impact to business

7. INFORMATION DISSEMINATION / INDUSTRY INTERACTION

7.1 Papers Presented & Published

Many research papers of topical interest are presented in various meets and published in journals. The same are given in Appendices–3 and 4.

7.2 Training Programmes Conducted

BTRA organised many training programmes [at BTRA and at Unit level] during the year under review. Details are provided in Appendix-5.

7.3 BTRA Publications / Library

A list of BTRA publications, brought out during the period under review, is given in Appendix–7. BTRA library serves its users and textile units with 'Current Awareness Services' on a regular basis, through the publication of 'BTRA Scan (Quarterly)' and 'BTRA Bulletin (Monthly)'.

BTRA Library has added many specialized books especially in the areas of geotextiles, nonwovens, composites and nanotechnology. The details of additions to library are given in Appendix–9. It receives around 30 foreign and 35 Indian journals / magazines / newsletters regularly. As on 31st March, 2018, the library has 22,952 holdings. BTRA updates its website (www.btraindia.com) at regular intervals.

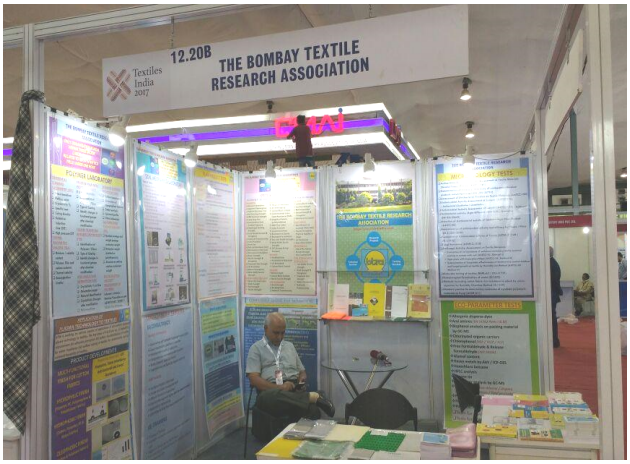
7.4 Academic Activities

BTRA offered internship to 45 students from 8 technical education institutes during the period under review.

8. EXHIBITIONS PARTICIPATION

BTRA participated in the following exhibitions and various research publications and posters depicting the research and consultancy activities of BTRA were displayed during the occasion.

- Technotex 2017 Exhibition, held between 12th and 14th April 2017 at Mumbai
- Nonwoven Tech Asia 2017 Exhibition, held between 8th and 10th June 2017 at Mumbai
- Textiles India 2017 Exhibition, held between 30th June to 2nd July 2017 at Gandhinagar
- Techtextil India 2017 Exhibition, held between 13th to 15th September 2017 at Mumbai
- Textile Research Conclave Exhibition cum Conference, held between 9th and 10th February 2018 at Tirupur



BTRA Stall view at Textiles India 2017 Exhibition held between 30th June to 2nd July 2017 at Gandhinagar

BTRA Stall view at Techtextil India 2017 Exhibition held between 13th to 15th September 2017 at Mumbai

BTRA Stall view at the Exhibition of Textile Research Conclave held between 9th and 10th February 2018 at Tirupur

Various research publications, samples of technical textiles and posters depicting the research, testing, training and consultancy activities of BTRA were displayed during the occasion. Visitors were given brochures related to testing, publications and training as promotional materials to the visitors.

Acknowledgements

The major portion of R & D work at BTRA is based on the financial assistance provided by the various sponsoring agencies. This is apart from various In-house projects that are being carried out. The generous support from the sponsors has also enabled BTRA to build a good and useful infrastructure, which efficiently supports the R & D work. Our in-depth gratitude goes to the Ministry of Textiles, Government of India for their generous support and to the Board of Research on Nuclear Science, under Department of Atomic Energy, Government of India and Defence Research & Development Organisation, under Ministry of Defence, Government of India. Thanks are also due to members of BTRA for giving constant encouragement and support to BTRA scientists / technologists to continue their work in uplifting the industry.

Appendix – 1

SPONSORED PROJECTS

On-going Projects

Ministry of Textiles, Government of India, New Delhi

- Studies on Radiation induced Modification of Textile Materials
- Atmospheric pressure plasma treatment for enhancing the conducting properties of textiles doped with intrinsic conductive polymers
- Studies on effect of plasma treatment for adhesion improvement of coated technical textiles
- Analysis of Eco-management in Indian Textile Processing Industry
- Development of electronic servo control drive industrial TFO twister for heavy denier filament yarn
- Development of cotton waste based oil absorbent for oil spill clean-up
- Nano-fibre application to enhance the anti-clogging properties of geotextiles
- Melt spinning of PVDF / ZnO nanostructure hybrid filament for wearable smart textile
- Development of test method for analysing hexavalent chromium content in dyes, pigments and textile auxiliaries
- Centre of Excellence for Geotech
- BTRA powerloom service centre – Ichalkaranji
- BTRA powerloom service centre – Solapur
- BTRA powerloom service centre – Madhavnagar

BRNS, Department of Atomic Energy, Government of India, New Delhi

- Studies on performance enhancement of textile effluent treatment plant by electron beam method

New Project Initiated

Defence Research & Development Organisation, Ministry of Defence, Government of India, New Delhi

- Preparation of nanofibre based protective clothing against chemical warfare agent

Appendix–2

PAPERS PRESENTED IN CONFERENCES / SEMINARS

Staff Name	Subject	Occasion/Venue/Date
Mr. V.K. Patil	Standardisation in Geotech Sector	3rd National Conclave on 'Standards for Technical Textiles' organised by FICCI at New Delhi on 3rd November 2017
Mr. V.K. Patil	Geosynthetics in Construction Industry	Awareness seminar on Geosynthetics organized by Regional Textile Commissioner Office, Navi Mumbai and PWD, Goa held at Goa on 5th December, 2017

Appendix–3

PAPERS PUBLISHED IN JOURNALS

Staff Name	Title	Journal Name
Mr. V.K. Patil	Environmental Geotechnique	Textile Value Chain, May 2017, p. 24-25
Mr. Vijay Shirole	An introduction to sustainable textile production (Part-1)	BTRA Scan, 47(2), June, 2017, p. 1–7
M/s. Tanaji Kadam & Pratik Joshi	An introduction to lean six sigma applications in the textile industry (Part-1)	BTRA Scan, 47(2), June, 2017, p. 8-14
Mr. Tanaji Kadam	An introduction to lean six sigma applications in the textile industry (Part-2)	BTRA Scan, 47(3), September, 2017, p. 1-9
Mr. Vijay Shirole	An introduction to sustainable textile production (Part-2)	BTRA Scan, 47(3), September, 2017, p. 10-19
Ms. Aruna Apte	Microbiological testing of textile materials and other products: Need of the hour	BTRA Scan, 47(4), December 2017, p. 1 - 6
M/s. V.K. Shinde & R.A. Shaikh	Importance of calibration of measuring instruments	BTRA Scan, 47(4), December, 2017, p. 7 - 9
M/s. Smita Deogaonkar, Pradnya Wakode & Kaushlesh P. Rawat	Electron beam pre-treatment for textile effluents	Textile Times, 45(7), February 2018, p. 28 - 29

Appendix – 4

TRAINING PROGRAMMES CONDUCTED

Subject	To Whom	Duration
	On-Site Training	
Good work practices	12 staff from M/s. Samtex Desinz, Noida	23rd June 2017
Technology, Upgradation, Quality Control and Value Addition	Sixty Participants of Solapur Chaddar Cluster at Solapur	17th to 19th July 2017
Size Application and Evaluation	Three staff of M/s. Jai Chemicals Limited, Ahmedabad	25th to 26th September 2017
Good Work Practices and Utility Conservation	15 staff from M/s. Skylark Dyeing, Delhi	28th November 2017
Good Work Practices and Utility Conservation	20 staff from M/s. RMP Fab Sourcing, Delhi	29th November 2017
Good Work Practices and Utility Conservation	15 staff from M/s. Gupta Exim, Delhi	30th November 2017
Fabric Inspection	60 staff of M/s. PeeVee Textiles, Vardha	For 5 days in February 2018
Good Work Practices and Utility Conservation	Twelve staff of M/s. Haryana texprint, Faridabad	14th February 2018
Good Work Practices and Utility Conservation	Ten staff of M/s. Shivam Devansh Fab Pvt. Ltd., Faridabad	17th February 2018
Good Work Practices and Utility Conservation	thirteen staff of M/s. Sunshine Dyeing, Ludhiana	20th February 2018
Good Work Practices and Utility Conservation	Eighteen staff of M/s. Eakta Dyeing, Ludhiana	22nd February 2018
Good Work Practices and Utility Conservation	Twelve staff of M/s. PI Cottex, Ludhiana	23rd February 2018
Cuprammonium fluidity test and its utility	6 staff of M/s. United Bleachers, Coimbatore	For 3 days in March 2018
	Training at BTRA	
Technical Textiles (Geotech)	Eight students from M/s. Veermata Jijabhai Technological Institute, Mumbai	For 5 days in May 2017
Technical Textiles (Geotech)	Four students from M/s. Institute of Chemical Technology, Mumbai & M/s. MLV Textile and Engineering College, Bhilwara	For 5 days in May 2017
Technical Textiles (Geotech)	Two students from M/s. Indian Institute of Carpet Technology, Bhadoi, UP	For 18 days in June 2017
Technical Textiles	Three students from M/s. Veermata Jijabhai Technological Institute, Mumbai	For 15 days in June 2017

Appendix – 4 (Contd.)

TRAINING PROGRAMMES CONDUCTED

Subject	To Whom	Duration
Technical Textiles	Three students from M/s. Veermata Jijabhai Technological Institute, Mumbai	For 10 days in June 2017
Technical Textiles (Geotech)	Two students of M/s. Indian Institute of Carpet Technology, Bhadoi, UP	For 7 days in July 2017
Technical Textiles	Six students from M/s. Veermata Jijabhai Technological Institute, Mumbai	For 7 days in July 2017
Technical Textiles	Two students from M/s. Anuradha Engineering College, Chikali	For 7 days in July 2017
Textile Terminology and Processing	Mr. Aman Agarwal from M/s. Bhavya Fabrics, Ahmedabad	For 7 days in November 2017
Yarn testing and sizing	Four staff from M/s. Kuraray India Pvt. Ltd.,	5th and 6th December 2017
Sizing and Testing	Two staff of M/s. Indofil Industries, Mumbai	For 3 days in January 2018
Mechanical and Chemical Testing	Ten staff of M/s. TRADC – Birla Cellulose, Surat	For 5 days in January 2018
General elements of textiles	One person from M/s. Viresh Naturals	For 4 days in January 2018

Appendix – 5

CONFERENCES / SEMINARS / TRAINING PROGRAMMES / WORKSHOPS ATTENDED BY BTRA STAFF

Name of Staff	Occasion	Place	Date
M/s. Tanaji Kadam, Vijay Gawde and Vijay Shirole	LAPF Confluence	Mumbai	21st April 2017
Mr. Akash Kanse	Training course on the subject 'Management of Workplace Hazards'	Central Labour Institute, Mumbai	For 3 days in July 2017
M/s. Chandrakala L.M. and Kumar Krishnanand	International Symposium on 'Advanced Structural Technical Textiles'	Organised by National Centre for Aerospace Innovations and Research (NCAIR) at IIT-Bombay, Mumbai	19th July, 2017
Ms. Chandrakala L Madichetty	Nine day training course on "Radiation Safety Aspects of Nucleonic Gauges"	Conducted by Indian Association for Radiation Protection at Mumbai	Between 4th and 12th September 2017
Mr. Vijay Gawde	Three day training course titled 'Training on Master Trainer'	Organised by National Skill Development Council (NSDC) at New Delhi	Between 7th and 9th September 2017
Mr. V.K. Patil	Annual General Meeting	Indian Technical Textiles Association (ITTA) at Mumbai	September 2017
M/s. Tanaji Kadam, Vijay Shirole and Akash Kanse	Exhibition on 'Water Recycling, Reuse and Treatment'	Organised by ITAF at Bombay Exhibition and Convention Centre, Mumbai	28th September 2017
M/s. Tanaji Kadam and Vijay Gawde	Conference on 'Achieving Sustainable Growth in Textile and Apparel Industry through Manufacturing Excellence'	Organised by Confederation of Indian Industry at Mumbai	6th October 2017
M/s. V.K. Patil and G.R. Mahajan	Meeting on 'Standardisation in Geosynthetics' on 27th.	Organised by Bureau of Indian Standards at Mumbai	27th October 2017
Mr. Akash Kanse	Attended and passed 'IRCA Certified ISO 9001:2015 Lead Auditor Training Course'	Conducted by BSI Training Academy at Andheri, Mumbai	26th and 30th October 2017
BTRA testing staff	Training on operational aspects of newly installed Multi Station Tensile Tester at Geotech Lab, BTRA	Mr. Daniel from M/s. Walter Bai, Switzerland was the trainer	October 2017

Appendix – 5 (Contd.)

CONFERENCES / SEMINARS / TRAINING PROGRAMMES / WORKSHOPS ATTENDED BY BTRA STAFF

Name of Staff	Occasion	Place	Date
Mr. V.K. Patil	3rd National Conclave on 'Standards for Technical Textiles'	Organised by FICCI at New Delhi	3rd November 2017
Ms. Pragati Kulkarni	4-day training course on 'Basic and Advance Statistics for Researchers'	Held at CIRCOT, Mumbai	7th and 10th November 2017
Mr. Vijay Gawde	12th meeting of Textile Machinery and Accessories Sectional Committee (TXD 14)	Bureau of Indian Standards at Mumbai	28th December 2017
Mr. V.K. Patil	Awareness seminar on 'Geosynthetics'	Jointly organized by Regional Textile Commissioner Office, Navi Mumbai and PWD, Goa held at Goa	5th December 2017
Mr. V.K. Patil	21st meeting of Geosynthetics Sectional Committee (TX-30) in joint session with 10th meeting of Industrial Fabrics Sectional Committee (TX-33)	Bureau of Indian Standards Office, Mumbai	9th January, 2018
Mr. V.K. Patil	Centre of Excellence Meeting	Textile Commissioner's Office, Mumbai	16th January, 2018
Mr. Tanaji Kadam	Meeting of Rajya sabha Standing Committee for a discussion on 'Impact of cheaper Chinese products on Indian Industry'	Mumbai	16th January, 2018
Mr. V.K. Patil	AMC meeting under the scheme for the promotion of Geosynthetics (Jute) in North East Region	Udyog Bhavan, New Delhi	30th January, 2018
Mr. Akash Kanse	Workshop on 'Environmental sustainability through science based tools and approaches'	IRMRA, Thane	For two days in February 2018

Appendix – 5 (Contd.)

CONFERENCES / SEMINARS / TRAINING PROGRAMMES / WORKSHOPS ATTENDED BY BTRA STAFF

Name of Staff	Occasion	Place	Date
Dr. Anjan K. Mukhopadhyay and Mr. Akash Kanse	Workshop on 'Crystallisation, Filteration and Drying'	Institute of Chemical Technology, Mumbai	For three days in February 2018
Mr. V.K. Patil	AMC meeting under the scheme for the promotion of Geosynthetics (Jute) in North East Region,	Udyog Bhavan, New Delhi	On 18th and 19th February 2018
Mr. Tanaji Kadam	Meeting on PAT-IV cycle benchmarking	Bureau of Energy Efficiency, New Delhi	7th March 2018
Mr. V.K. Shinde	Training program on 'ISO/IEC 17043:2010'	BTRA	7th March 2018
Mr. Tanaji Kadam	Workshop on 'Cotton conclave – 2018'	Indian Merchants Chamber, Mumbai	13th March 2018
M/s. Vijay Gawde and Vijay Shirole	9th Asian Textile Conference (ATEXCON)	organised by The Textile Association of India in Mumbai	14th March 2018
Mr. Tanaji Kadam	Purchase committee meeting for M/s. Cetcon Yarn Dyers	District Industry Centre, Pune	14th and 20th March 2018
Mr. V.K. Patil	Expert panel meeting of BIS on Geosynthetics (TX-30)	Office of Indian Technical Textiles Association, Mumbai	22nd March 2018
Dr. Anjan K. Mukhopadhyay and Mr. V.K. Patil	DGFT input review meeting	Textile Commissioner's Office, Mumbai	28th and 30th March 2018

Appendix – 6

PUBLICATIONS RELEASED BY BTRA

BTRA Scan	4 Issues [Quarterly]
BTRA Bulletin	12 Issues [Monthly]

Appendix – 7

OTHERS

PRODUCTS / CHEMICALS / INSTRUMENTS / GADGETS SOLD ON REIMBURSABLE BASIS	• Viscosity cups [19 no.] • Cuprammonium solution [28 litres] • Fluidity Tubes [28 no.] • Fluidity Wheel [2 no.] • Weight for drove test [1 no.] • Hook for drove test [1 no.]
INSTRUMENTS / GADGETS CALIBRATED	• Various instruments at BTRA Test Laboratories and at 3 BTRA PSCs are calibrated regularly
INSTRUMENTS SERVICED	• Servicing of several equipments / instruments at BTRA Test Laboratories

Appendix – 8

NEW ADDITIONS TO BTRA LIBRARY

- CHARACTERISATION AND TREATMENT OF TEXTILE WASTEWATER, Himanshu Patel & R.T. Vashi, Elseiver Inc., USA, 2015
- BIOLOGICAL WASTEWATER TREATMENT – 3rd Edition, C.P. Leslie Grady, et al., CRC Press, USA, 2011
- SOIL ENGINEERING IN THEORY AND PRACTICE – Vol. 2: Geotechnical Testing and Instrumentation [2nd Edition], Alam Singh & G.R. Chowdhary, CBS Publishers & Distributors P. Ltd., New Delhi, 2014
- SUSTAINABLE FIBRES AND TEXTILES – S.S. Muthu, Elsevier Ltd., UK, 2017
- FUNDAMENTALS OF YARN WINDING, Milind Koranne, Woodhead Publishing India Pvt. Ltd., New Delhi, 2013 / reprint 2017
- STATISTICS FOR TEXTILE ENGINEERS, J.R. Nagla, Woodhead Publishing India Pvt. Ltd., New Delhi, 2014
- SCIENCE IN CLOTHING COMFORT, Apurba Das & R. Alagirusamy, Woodhead Publishing India Pvt. Ltd., New Delhi, 2010 / Reprint 2016
- Energy Audit Manual – The Practitioner's Guide, R. Suryanarayanan, Energy Management Centre, Kerala and National Productivity Council, Chennai, 2017
- 2018 Technical Manual of AATCC, AATCC, USA, 2018
- CO_2 EMISSION MITIGATION THROUGH ENERGY CONSERVATION – A Practical Guide, Dr. T. Sambandam, Shanlax Publications, Madurai, 2017
- SUSTAINABILITY IN FASHION AND APPARELS – Challenges and Solutions, Dr. M. Parthiban, et al., Woodhead Publishing India Pvt. Ltd., New Delhi, 2017

CDs / Soft Copy Downloads

- **Latest International Standard Test Methods:** JIS L 1902:2015 [English version], JIS Z 2801 – 2010 + 2012 (Amendment 1), ASTM G21 – 2015, ASTM D3274 – 2009 (2013) , ASTM D3273 – 2016, DIN EN ISO 14362-1:2017, DIN EN ISO 14362-3:2017, DIN EN ISO 15025:2016, ISO 105-X12:2016 and ISO 3795:1989, DIN EN 16711-1:2015 and DIN EN 16711-2:2015

Appendix – 9

DIRECTOR'S ENGAGEMENTS

Month	Details
April, 2017	♣ Attended the PowerTex India at Bhiwandi on 1st April, 2017 ♣ Attended the Technotex 2017 conference on Technical Textiles in Mumbai on 12th April, 2017 ♣ Moderator of the session IV on 'Buyer's Perspective' in the Technotex conference on Technical Textiles in Mumbai on 13th April, 2017 ♣ Attended the curtain raiser of Textile India – 2017 in New Delhi on 18th April, 2017 ♣ Attended the Annual LAPF Confluence, organised by Birla Cellulose brand LIVA, in Mumbai on 21st April, 2017
May, 2017	♣ Attended the Industry Capacity Building Programme organised by the Textiles Committee at Mumbai on 18th May, 2017 ♣ Visited the Kristeel Shinwa Factory at Silvasa on 31st May, 2017
June, 2017	♣ Attended a meeting with Dr. G.H. Naik at the Research Center of Godrej Consumer Products Ltd., Vikhroli, Mumbai on 7th June, 2017 ♣ Visited Nonwoven Tech Asia 2017 Exhibition in Mumbai on 8th June, 2017 ♣ Attended the Road Show on Textiles India 2017 Exhibition in Mumbai on 12th June, 2017 ♣ Attended a meeting with Mr. Abhishek Choudhury, Director, Nanobiz India Pvt. Ltd. and Mr. Gajanan Nagrsekar, Kallows Engineering India Pvt. Ltd., in Pune on 14th June, 2017 ♣ Attended 6th meeting of PAMC in Mumbai on 21st June, 2017 ♣ Attended the Mega International Event 'Textiles India 2017' Exhibition at Gandhinagar, from 30th June to 2nd July, 2017
July, 2017	♣ Attended R&D and Technical Textiles meeting in New Delhi on 19th July, 2017
August, 2017	♣ nil
September, 2017	♣ Attended Techtextil India 2017 Exhibition on 14th September 2017 at Mumbai ♣ Attended 7th Annual General Meeting of Indian Technical Textiles Association on 15th September 2017 at Mumbai
October, 2017	♣ nil
November, 2017	♣ Attended PEC meeting organised by the Technology Development Board (TDB), Department of Science and Technology in Bangalore as an expert member on 10th and 11th November, 2017 ♣ Attended the Industry-Academia Interactive Meet at IIT Bombay on 18th November, 2017 ♣ Attended a meeting along with Mr. Sharad Saraf, Chairman, BTRA Governing Council, at the office of Cotton Corporation of India, Belapur on 28th November, 2017

Appendix – 9 (Contd.)

DIRECTOR'S ENGAGEMENTS

Month	Details
December, 2017	♣ Attended the first meeting of Steering Committee on Technotex 2018 'An International Exhibition and Conference on Technical Textiles' held under the Chairmanship of Secretary, Ministry of Textiles in New Delhi on 4th December, 2017 ♣ Attended the Indian Geotechnical Conference 2017 – Geo Nest at Indian Institute of Technology, Guwahati from 14th to 16th December, 2017 ♣ Attended the Memerber's Gala Dinner organised by the Cotton Association of India on 27th December, 2017
January 2018	♣ Attended the Comprehensive Textile Labelling Regulation meeting at Textile Commissioner's Office, Mumbai on 6th January, 2018 ♣ Attended the 21st meeting of Geosynthetics Sectional Committee (TX-30) in joint session with 10th meeting of Industrial Fabrics Sectional Committee (TX-33) in Mumbai on 9th January, 2018 ♣ Attended the meeting on review of progress of technical schemes at Textile Commissioner's Office, Mumbai on 13th January, 2018 ♣ Attended the meeting on scheme for R&D for the textiles industry including jute for five years (2014-15 to 2018-19) for components I & III at Textile Commissioner's Office, Mumbai on 13th January, 2018 ♣ Attended a meeting with the Secretary, Ministry of Textiles, New Delhi on 16th January, 2018
February 2018	♣ Chaired a session in the Textile Research Conclave organised by the Tirupur Exporters Association in Tirupur on 9th and 10th February, 2018 ♣ Attended the 12th WFCFD Crystallisation, Filteration and Drying at the Institute of Chemical Technology, Mumbai on 22nd February, 2018
March 2018	♣ Attended a meeting (regarding the curriculum for the Textile University to be set up in Maharashtra), under the Chairmanship of Secretary (Textiles), Government of Maharashtra, held at Mantralaya, Mumbai on 6th March, 2018 ♣ Attended the 8th meeting of the Project Approval & Monitoring Committee (PAMC) of R&D Scheme for the period 2014-15 to 2018-19, held at Textile Commissioner's Office, Mumbai on 12th March, 2018 ♣ Attended the 9th Asian Textile Conference (ATEXCON) titled 'Textile Industry moving beyond the conventional paradigms', held at Mumbai on 14th March, 2018 ♣ Attended a meeting on 'Centre of Excellence (CoE)' at Textile Commissioner's Office, Mumbai on 27th March, 2018

Appendix – 10

DISTINGUISHED VISITORS TO BTRA

Name of the Visitors	Company
Mr. Tridip Chatterjee, Managing Partner	Ajisha Health Centre, Navi Mumbai
Mr. Anirudha Kulkarni, Chief Consultant, Textile & Clusters Infra Consulting	MITCON Consultancy & Engg., Pune
Mr. Aniruddha Kadam, Executive Vice President, Clusters Infra, Textile and Market Research Consulting	MITCON Consultancy & Engg., Pune
Mr. D. Das Chowdhury, Whole-Time Director	Nagreeka Exports Ltd., Mumbai
Dr. Jan-Pleun Lens, V.P. Research & Application and Dr. Ulrich Girrbach, FR Fiber and Textiles	FRX Polymers, USA
Mr. Victor Bhattacharjee, Assistant Manager (Vocational Skills Certification Business), Talent	Mettl Management, Mumbai
Mr. Partha Chakraborty, General Manager	SAANS Analytical Instruments Pvt. Ltd. Thane
Dr. S.U. Kulkarni, General Manager – Technical	Entremonde Polycoaters Ltd.
Mr. Ranjit Dash, Business Head – Landfill & Lining (Geosynthetics Division)	Garware Wall Ropes Ltd.
Ms. Rajani Agarwal, Sales and Marketing Manager	Asia Pay
Mr. Pritesh Panchal, Joint Business Manager – Civil	AIMIL Ltd.
Mr. Rahul Dev Mal, Senior Manager – Manufacturing and Mr. Satyapriya Dash, Technical Advisor	Arvind Ltd.
Mr. Hari Shankar Prasad, Senior DGM (M&C)	RITES
Mr. Abhishek Mudafale, Principal Consultant, Investments	SIDBI Venture Capital Ltd.
Mr. Irfan Chikte	Konkan Technical Supplies Co., Mumbai
Mr. Kedar Chaudhari, Director R&D – Food & Beverage (APAC+MEA)	Diversey
Mr. Sanjay Shedge, Director – I&L Engineering	Diversey Care – Asia Pacific (APAC)
Mr. Alok Sharma	Bigphi Technologies
Mr. Gaurav Gupta, Senior Manager & RSM	Bank of India
Mr. Anil Upadhye, GM (QC & Business Development)	Technocraft Industries (India) Ltd. (Yarn Div.)
Mr. Sandeep R. Naik, AGM (P & QC - Rayon)	
Mr. Amit Vidulkar, Business Head (Woven Geotextiles & Reinforced Products)	Techfab India
Mr. D.S. Taware	Siddha-Kala & Associates
Mr. R.S. Jirage	Jirage Structural Consultant Pvt. Ltd.
Mr. V. Manoharan, Quality Assurance Manager	Technocraft Industries (India) Ltd.

Appendix – 10 (Contd.)

DISTINGUISHED VISITORS TO BTRA

Name of the Visitors	Company
Dr. Ayushi Mogra, Director	Ginnigold Cotton & Agro Industries Producer Company Ltd.
Mr. Paresh Trivedi, President (Industrial Chemicals)	Deepak Fertilisers & Petrochemicals Corporation Ltd.
Mr. Kishor B. Bhandary, Marketing Manager, PVA Resin Division	Kuraray India Pvt. Ltd.
Mr. Francis Stat Maria, Technical Sales Leader	Kuraray Asia Pacific PTE Ltd.
Mr. Jumpot Yuvaniyama, Technical Sales Manager	Kuraray (Thailand) Co. Ltd.
Mr. Sameer V. Shah, Chairman & Managing Director and Mr. Nirmal Shah, Managing Director	Chembond Chemicals Ltd.
Mr. G. Uthayasekaran, GM (QC) and Mr. Manish K. Sharma, Product Development (R&D),	Khosla Profil Pvt. Ltd.
Mr. Sameer Pai, Regional Service Manager-EO and Mr. Jyotiba Kokitkar, Assistant Manager-Customer Support	JEOL
Mr. Pritesh Panchal, Joint Business Manager-Civil	AIMIL Ltd.
Dr. R. Guruprasad, Scientist	Central Institute for Research on Cotton Technology
Ms. Seema Srivastava, Executive Director along with Mr. Michael Dalmet, Asst. Manager (Exhibitions)	India International Textile Machinery Exhibition Society
Dr. Mayuri Gandhi, Scientist	Centre for Research in Nanotechnology & Science (CRNTS), Sophisticated Analytical Instruments (SAIF), IIT-Bombay
Dr. Virendra Madyar, Lead R&D	Living Guard Technologies Pvt. Ltd.
Mr. Avinash Ramchandra Mali, Senior Business Manager-Civil	AIMIL Ltd.
Mr. Moyez Ansari, Project Engineering	Aircon India
Mr. Paresh N. Trivedi, Managing Director	Chembond Polymers & Materials Ltd.,
Mr. Santanu Sahu, Director	SAANS Analytical Instruments Pvt. Ltd.
Dr. A.S. Indulkar, Stewardship Development	FMC Agricultural Solutions, Cheminova India Ltd.
Mr. Vijay Patil, Head Sales – Key Account	L&L Products
Ms. Shubhada S. Jagtap	Geotechnical Consultant
Dr. Manasi Nath, Scientist	Kraton Polymers India Pvt. Ltd.
Mr. Shibu Mathews, Marketing Manager	Austro Chemicals & Bio-technologies Pvt. Ltd.
Mr. Amit Dayal, Vice President	Textile Research & Development Centre (TRADC)

Appendix – 11

OUTSTATION VISITS BY BTRA STAFF

- ✓ Adinath Dyeing & Printing, Ludhiana
- ✓ Akash Printers, Ahmedabad
- ✓ AKR (Rohini Dyeing), Perundurai
- ✓ Ankur Textiles, Ahmedabad
- ✓ Anupam Synthetics Pvt. Ltd., New Delhi
- ✓ Anupam Tex Processors Pvt. Ltd., Faridabad
- ✓ Bannari Amman Spg. Mills, Perundurai
- ✓ Bee K Bee Prints Pvt. Ltd., Faridabad
- ✓ Bhaskar Silk Mills, Surat
- ✓ Bhavin Textiles, Surat
- ✓ BTRA PSCs – Ichalkaranji / Solapur / Madhavnagar
- ✓ Bureau of Energy Efficiency, New Delhi
- ✓ Chandhok Textiles, New Delhi
- ✓ Chinko Silk Mills, Surat
- ✓ District Industry Centre, Pune
- ✓ Donear Industries Ltd., Surat
- ✓ Eakata Dyeing, Ludhiana
- ✓ Finlay Mills, Achalpur
- ✓ G.S. Settia & Sons, Sonipet
- ✓ Ganga Fashions Pvt. Ltd., Surat
- ✓ Garware Wall Ropes Ltd., Akurdi
- ✓ Garware Wall Ropes Ltd., Wai
- ✓ Geosource, Ahmedabad
- ✓ Gonawala & Sons, Surat
- ✓ Groundwater Survey and Development Agency, Nashik
- ✓ Gupta Exim, Delhi
- ✓ Haryana TexPrint, Faridabad
- ✓ ITI College, Akola
- ✓ ITI College, Amravati
- ✓ ITI College, Buldhana
- ✓ ITI College, Nanded
- ✓ Jai Chemicals Ltd., Ahmedabad
- ✓ Jayavishnu Tex Processors, Tiruppur
- ✓ Kolhapur DIC (Udyog Bhavan)
- ✓ Komal Texfab, Ahmedabad
- ✓ Krishna Dyeing & Printing Mills, Surat
- ✓ Krishna Textile Processors, Perundurai
- ✓ Kristeel Shinwa Factory, Silvasa
- ✓ Kunjubehari Processors, Faridabad
- ✓ Kusumgar Corporates, Vapi
- ✓ Maccaferri Environmental Solutions Pvt. Ltd., Gurgaon
- ✓ Minerva Syncot Pvt. Ltd., Perundurai
- ✓ Ministry of Textiles, New Delhi
- ✓ MITCON, Pune
- ✓ Mukesh Industries, Ahmedabad
- ✓ Nagreeka Exports, Kolhapur
- ✓ National Skill Development Corporation, New Delhi
- ✓ Nisan Exim, Ahmedabad
- ✓ Pee Vee Textiles, Jam, Hinganghat
- ✓ PeeVee Textiles, Vardha
- ✓ PI Cottex, Ludhiana
- ✓ Pune DIC (Udyog Bhavan)
- ✓ PVM Enterprises, Ludhiana
- ✓ Rinku Processor, Ahmedabad
- ✓ RK Exports, Cuddalore
- ✓ RMP Fab Sourcing, Delhi
- ✓ Roshnai Creation Pvt. Ltd., Surat
- ✓ RSR Mohota Spinning & Weaving Mills, Hinganghat
- ✓ S.P. Textile Mills, Erode
- ✓ Saachi Processors, Ludhiana
- ✓ Samtex Desinz, Noida
- ✓ Shahi Dyeing Pvt. Ltd., Palwal, Haryana
- ✓ Shivam Devansh Fab Pvt. Ltd., Faridabad
- ✓ Shree Bhavya Fabrics, Ahmedabad
- ✓ Shree Ramanuj Dyeing and Printing Mills, Surat
- ✓ Shruti Enterprises, Silvassa
- ✓ Silwester Textiles, Boisar
- ✓ Skylark Dyeing, Delhi
- ✓ Stuti Knit Processors, Surat
- ✓ SVG Fashions, Ankaleswar
- ✓ Swami Textiles, Ludhiana
- ✓ Technocraft India Pvt. Ltd., Murbad
- ✓ Tejoday Dyeing Pvt. Ltd., Surat
- ✓ Triniti Colour India, Perundurai
- ✓ Tulsi Syntex Pvt. Ltd., Surat
- ✓ Vallabh Fabrics, Ludhiana
- ✓ Visit to Solapur Chaddar Cluster

Appendix – 12

BIS MEMBERSHIP

BTRA staff involved in the following standard development committees of Bureau of Indian Standards.

Sectional Committees	Title
TXD 01	Physical methods of test
TXD 05	Chemical methods of test
TXD 07	Textile speciality chemicals and dyestuffs
TXD 12	Narrow fabrics, webbings and braids
TXD 14	Textile Machinery and Accessories
TXD 21	Dyeing, finishing & allied machinery
TXD 28	Silk and silk products
TXD 30	Geo-textiles and industrial fabrics
TXD 31	Man-made fibres, cotton and their products
TXD 32	Textiles protective clothing
TXD 33	Industrial fabrics
TXD 35	Technical textiles for Agrotech applications
TXD 36	Technical textiles for Meditech purposes

Appendix – 13

MEMBERS OF THE GENERAL ADVISORY COMMITTEE FOR RESEARCH AND LIAISON

[2018-2021]

1) Dr. P.R. Roy Chairman, Digital Consulting (India) B-509,Infinity Tower, Nr. SafalProfitare, Corporate Road, Pralhadnagar, Ahmedabad 380015	**2)** Dr. M. K. Talukdar, Kusumgar Corporates, 101/102, Manjushree Bldg., Hatkesh Co-op. Society, Corner of N.S.Road No.5, JVPD Scheme, Juhu, Mumbai 400 056	**3)** Mr. V. Kannan Vice President, Business Development, Reliance Corporate Park, Bldg. No. 8, 1st Floor, 'A' Wing, Thane Belapur Road, Ghansoli, Navi Mumbai 400701
4) Mr. K.L. Vidur Chartered Engineer B-401, NirmanVihar, Rajmata Jeejabai Road, Andheri (East), Mumbai 400093	**5)** Mr. Ullhas M. Nimkar, Row House No.25, Vasant Vihar Thane (West) Pin 400 601	**6)** Dr. Sanjiv Kamat Vice President Kothari Info Tech Ltd., B 1/ 04/05 Ground Floor, B Wing, Boomerang, Chandivali, Andheri (East), Mumbai 400072
7) Prof. R.R. Deshmukh Associate Professor, Physics Department, ICT , Matunga, Mumbai 400019	**8)** Dr. Milind Khandwe President Technology & Innovation, Hindoostan Technical Fabrics Limited. Sir Vithaldas Chambers, 16 Mumbai Samachar Marg, Fort, Mumbai 400 001	**9)** Dr. B.V.S. Viswanadham Dr.-Ing (Ruhr University, Bochum Germany), Dean (Infrastructure Planning & Support) and Professor of the Dept. of Civil Engg. Indian Institute of Technology Bombay,Powai, Mumbai 400 076
10) Dr. Vijay Ramkrishnan Sr. Vice President, Technical & New Businesses, Garware Wall Ropes Ltd., Plot No.11, Block No. D-1, MIDC, Chinchwad, Pune 411019	**11)** Dr. Asim Tewari Prof – in – Charge, National Centre for Aerospace Innovation Research, Indian Institute of Technology Bombay, Powai , Mumbai 400076	**12)** Dr. Mujeebur Rehman GM- R&D & QA, Atul Ltd., Colours Division, R& D Department, Valsad Pin 396020

Appendix – 13 (Contd.)

MEMBERS OF THE GENERAL ADVISORY COMMITTEE FOR RESEARCH AND LIAISON

[2018-2021]

13) Prof. Bhaskar Thorat Head, Department of Chemical Engineering, Institute of Chemical Technology, Nathalal Parekh Marg, Matunga, Mumbai 400019	**14)** Prof. Anirban Guha Associate Professor Dept. of Mechanical Engg. Indian Institute of Technology Bombay, Powai, Mumbai 400076	**15)** Dr. Harish Bisht Director, The Ahmedabad Textile Industry's Research Association, P.O. Ambawadi Vistar, Ahmedabad 380 015
16) Dr. Prakash Vasudevan, Director, The South India Textile Research Association, Coimbatore Aerodrome P.O., Coimbatore 641 014	**17)** Dr. A. Basu, Director General, The Northern India Textile Research Association, Sector 23, Rajnagar, Ghaziabad 201 002	**18)** Mr. Shahrokh Bagli, Chief Technology Officer, Strata Geosystems (India) Pvt. Ltd, Sabnam House, Plot No. A-15/16, Central Cross Road B MIDC, Andheri (E), Mumbai 400 093
19) Mr. K. Venkatarayan, 301, Tulsi, Near Building No. 17-A, Vrindavan Society, Thane (West) 400601	**20)** Prof. N.V. Bhat, 4/78, Palm View Society, Vidyavihar (East), Mumbai 400077	**21)** Dr. Anjan K. Mukhopadhyay, Director, The Bombay Textile Research Association, Lal Bahadur Shastri Marg, Ghatkopar (West), Mumbai 400 086

Appendix - 14

STAFF DETAILS

The total staff strength of BTRA as on 31st March 2018 was as follows:

Director	**1**
At BTRA	
◆ Scientific / Technical Officers	22
◆ Scientific / Technical Staff	25
◆ Skilled / Semi-skilled & Maintenance Staff	20
◆ Administrative Staff	15
Sub-total	**83**
At PSCs	
◆ Scientific / Technical Officers	1
◆ Scientific / Technical Staff	3
◆ Skilled / Semi-skilled & Maintenance Staff	4
◆ Administrative Staff	1
Sub-total	**9**
TOTAL	*92@*

@ - Including 20 contractual staff and 5 trainees

Director : Dr. Anjan K. Mukhopadhyay

Technical Services Division

Chief Textile Technologist : Mr. Tanaji I. Kadam
Senior Scientific Officer Grade-I : Mr. V. A. Gawde
Technical Services Executive : Mr. V. R. Shirole

Library, Information & Publication

Senior Textile Technologist : Mr. P. Rathakrishnan

Electronics

Senior Scientific Officer Grade-I : Mr. V.K. Shinde
Junior Scientific Officer : Mr. P.S. Ajgaonkar

Appendix – 14 (Contd.)

STAFF DETAILS

BTRA Test Laboratories

Senior Scientific Officer Grade-I : Mr. R.A. Shaikh

(i) Physical Testing Division

Junior Scientific Officer : Mr. D.R. Yadav

Scanning Electron Microscope

Senior Scientific Officer Grade-II : Mr. Amol G. Thite

Geotech Cell

Senior Scientific Officer Grade-II : Mr. R.R. Menon

Junior Scientific Officer : Mr. G.R. Mahajan

Research Officer (Soil Mechanics) : Mr. Prashant C. Muke

(ii) Chemical Testing Lab.

Senior Scientific Officer Grade-I : Mrs. S.P. Vairagi / Mr. M.P. Sathianarayanan / Mrs. Chandrakala L.M.

Senior Scientific Officer Grade-II : Ms. A.U. Shenoy / Ms. Smita C. Deogaonkar/ Ms. Tejaswini R. Ghadyale

Junior Scientific Officer : Mrs. M.P. D'Souza / Mrs. S.D. Mayekar

(iii) Microbiology Lab.

Senior Microbiologist : Mrs. Aruna D. Apte

(iv) Plasma Lab.

Senior Scientific Officer Grade-I : Dr. Prasanta Kumar N. Panda

Senior Scientific Officer Grade-II : Ms. S.S. Palaskar

Research Scholar : Ms. Archana Gangwar / Mr. Sachin R. Tambe

Textile Engineering Research & Development

Senior Scientific Officer Grade-II : Mr. J.A. Sawant

Engineering Services Section

Senior Scientific Officer Grade-I : Mr. D.H. Yadav

Administration

Accounts Officer – P. Gr.	:	Mrs. S.S. Surve
P.A. to Director	:	Mrs. Rohini B. Mangalore
Purchase Officer	:	Mr. M.H. Bondre
Junior Accounts Officer	:	Mrs. Mugdha M. Shinde
Junior Accounts Officer	:	Mrs. Veena A. Dwivedi
Junior Admin. Officer	:	Ms. Sanjori S. Sonawane

BTRA PSC, Ichalkaranji	Officer In-charge	:	Mr. V.G. Kulkarni
BTRA PSC, Solapur	Officer In-charge	:	Mr. A.V. Patil
BTRA PSC, Madhavnagar	Junior Scientific Officer	:	Mr. N.A. Chavan

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LIST OF MEMBERS

- Banswara Syntex Ltd. [Unit: BTM], Rajasthan
- BMD Pvt. Ltd., Banswara
- BSL Ltd., Bhilwara
- CTM Technical Textiles Ltd., Ahmedabad
- Diversey India Pvt. Ltd., Mumbai
- Donear Industries Ltd., Mumbai
- Eurotex Industries & Exports Ltd., Kolhapur
- Flexituff International Ltd., Mumbai
- Garware-Wall Ropes Limited, Pune
- Gokak Mills, Gokak Falls, Karnataka
- Hindoostan Mills Ltd., Karad
- Hindustan Unilever Ltd. (Biopolymer Unit), Pondicherry
- Indo Count Industries Ltd., Mumbai
- Jaya Shree Textiles & Industries, Rishra
- Jeevan Nonwovens, Navi Mumbai
- Kadri Wovens, Tamil Nadu
- Kusumgar Corporates, Mumbai
- Mangrul Mills Ltd., Nagpur
- Mirachem Industries, Mumbai
- Morarjee Textiles Ltd., Nagpur
- Nagreeka Exports Ltd., Kolhapur
- National Textile Corporation Ltd. (Western Region), Mumbai
- Pee Vee Textiles Ltd., Jam, Samudrapur, Wardha
- Purity Techtextile Pvt. Ltd., Navi Mumbai
- RSWM Ltd., Gulabpura, Bhilwara
- Raymond Ltd., Thane
- R.S.R. Mohota Spg. & Wvg. Mills Ltd., Hinganghat
- Reliance Industries Ltd., Mumbai
- Ridham Synthetics Pvt. Ltd., Mumbai
- Ruby Mills Ltd., Mumbai
- S.Kumars Limited, Dewas, MP
- Shri Ambika Polymers Pvt. Ltd., Gujarat
- Siyaram Silk Mills, Silvassa
- Spentex Industries Ltd., New Delhi
- Strata Geosystems (India) Pvt. Ltd., Daman
- Supreme Nonwoven Ind. Pvt. Ltd., Mumbai
- Techfab India, Mumbai
- Technocraft Industries (India) Ltd., Murbad
- United Bleachers Ltd., Tamil Nadu
- Visaka Industries Ltd., Nagpur
- Wellknown Polyesters Ltd., Mumbai
- Welspun India Ltd., Mumbai

THE BOMBAY TEXTILE RESEARCH ASSOCIATION
L. B. S. Marg, Ghatkopar (W), Mumbai - 400086
Tel. : (O) 022-25003651/2652 Fax: 022-25000459
Email : info@btraindia.com