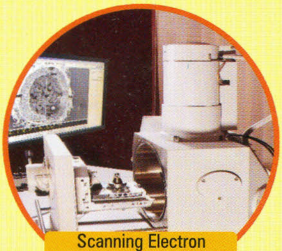
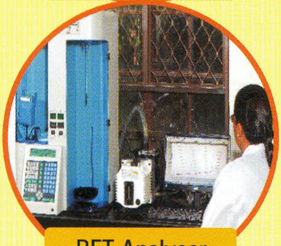
ICAR-CIRCOT leaflet no : 125

Electrospinning Facility

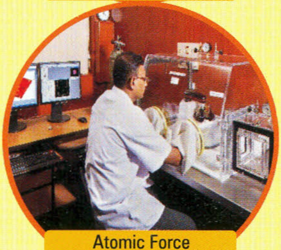
at ICAR-CIRCOT



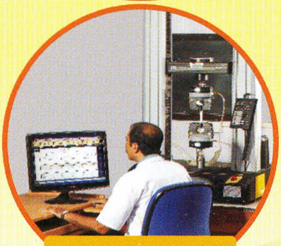
Scanning Electron Microscope(SEM)



BET Analyser



Atomic Force Microscope (AFM)



Tensile Tester

भाकृअनुप
ICAR

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Adenwala Road, Matunga, Mumbai 400019
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ISO 9001 : 2008

About ICAR-CIRCOT

The Central Institute for Research on Cotton Technology (CIRCOT) is a pioneering institute for research in cotton technology under the Indian Council of Agricultural Research (ICAR). It was established in the year 1924 with a mission to achieve self-sufficiency in cotton production through technological improvements in fibre, yarn and fabric quality of Indian cotton. The institute is now engaged in developing new technologies and machinery for better utilization of cotton and other natural fibres by carrying out basic, applied, strategic and anticipated research. CIRCOT, an ISO 9001: 2008 certified institute, is a renowned cotton testing laboratory. It also has the accreditation from National Accreditation Board for Testing and Calibration Laboratories (NABL), Ministry of Science and Technology, Government of India.

What is Electrospinning System?

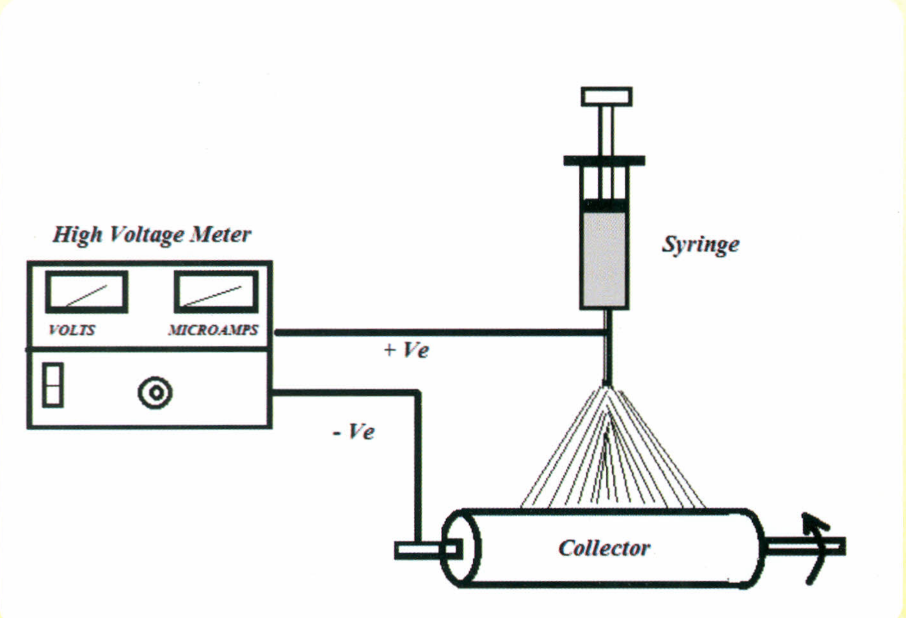


Figure 1. Schematic diagram of Electrospinning system

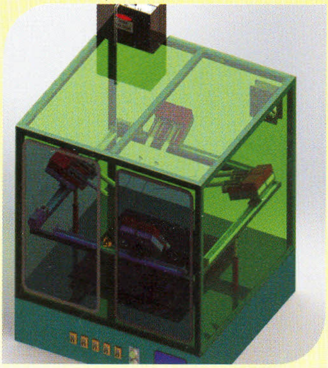
Electrospinning is one of the emerging research areas in the recent decades. The process of electrospinning was patented by J.F. Cooley in February 1902 (U.S. Patent 692,631) and by W.J. Morton in July 1902 (U.S. Patent 705,691). This method produces nanofibres from conducting polymers. A conducting polymer solution or a melt is fed through nozzle jets to form droplets (Fig.1) and subjected to a very high voltage (20-60 kV). Due to electrostatic forces generated as a consequence of the applied high voltage, the fibres are drawn towards the collector where the solvent evaporates or cooling occurs, resulting in formation of nano fibres. It is an alternate technique to the conventional mechanical force fibre forming process, which is used for producing Micro fibres. The use of electrospun nano fibres have been well-recognized in biomedical and filtration applications. In recent years, the use of this technique is being explored for agricultural and textile applications.

Electrospinning work at ICAR-CIRCOT

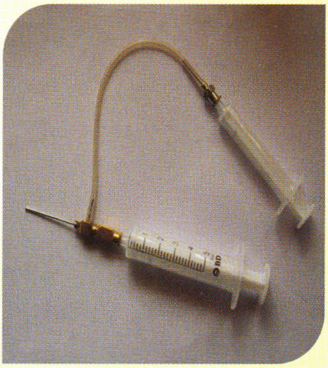
ICAR-CIRCOT is known for its decade-long research in the field of nanotechnology, particularly in nanomaterial formulation for different applications. Presently, CIRCOT is working on a project entitled "Biodegradable electrospun fibre mat for use in packaging of fresh perishable agricultural material" sponsored by ICAR under National fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA). The main objective of this project is to study the effects of multi-phase and multi-needle on the electrospinning mat production, the voltage deflection phenomenon in a multi-needle setup and to predict the process variables objectively, so as to improve reproducibility of the electrospinning process. Under the project, ICAR-CIRCOT has established an electrospinning facility including some nano fibre characterization instruments.

Other ongoing projects in the area of electrospinning are : (1) Design and Development of electro spraying setup for production of high performance cotton textiles and (2) Electrospinning Geometry Optimization for Preparation of Core-sheath Nanofibres and Conversion of Nanofibers into Yarns (Sponsored by DST, India).

Electrospinning unit



Multi-phase electrospinning



Co-axial needle

Production Facilities

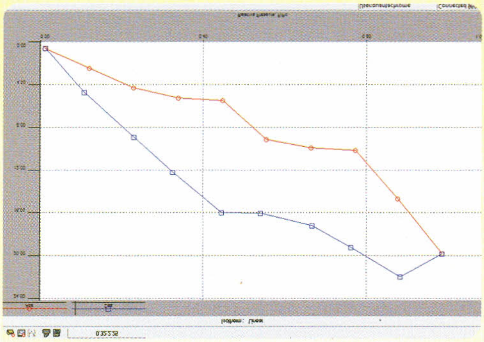
- Multi-axial syringe pump setup
- High voltage application up to 75 kV
- Co-axial fibre production arrangement
- Multi - needle spinning arrangement

Characterization Facilities

CIRCOT has basic as well as advanced characterisation equipment for nano material characterisation. The following instruments are available to characterise electrospun nano fibres :

BET Analyzer

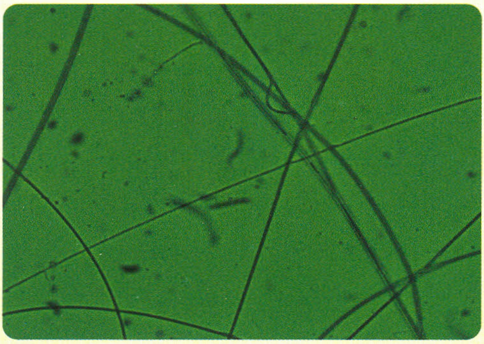
It is used to measure the specific surface area of nano materials by nitrogen multilayer adsorption, measured as a functional of relative pressure. The technique encompasses external area and pore area evaluation to determine the total specific surface area in m^2/g.



BET analysis graph

Optical Microscopy

It can be used to characterize geometric properties of nanofibers, such as fiber diameter, diameter distribution, fibre orientation and fibre morphology.



Microscopic image of coaxial fibres

Fourier Transform Infrared Spectroscopy (FTIR)

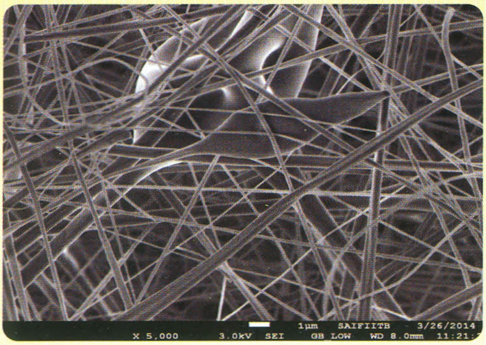
It can be used to investigate the chemical and the structural characteristics of the fibres and the constituent polymers as well as to find out the presence of solvent residues in the electrospun mat.

UV-Vis Spectroscopy

It can be used to study the optical properties of the functional nanofibers, based on the transmittance of UV-visible light.

Scanning Electron Microscopy (SEM)

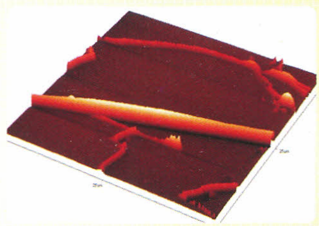
It can be used to understand the surface morphology and microstructure of the electrospun nanofibre and its nonwoven membranes under higher resolution.



SEM image of electrospun fibre mat

Atomic Force Microscopy (AFM)

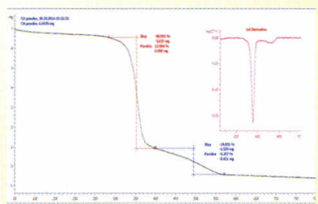
It can be used to study in detail the surface morphology by measuring fibre diameter, fibre surface roughness, mat thickness and chemical interactions between the constituent polymer molecules.



AFM image of Electrospun fibre

Thermogravimetric Analysis (TGA)

It can be used to study the thermal stability of the polymeric chains constituting the nanofiber and their thermal degradation pattern.



TGA graph of electrospun mat

Differential Scanning Calorimetry (DSC)

It can be used to understand thermal behaviour of nanofibres made from neat polymers, copolymers and polymer blends as well as to determine physical transformations; for example, glass transition temperature, crystallinity, melting point and chemical changes.

Tensile Tester (UTM)

It can be used to study the physical properties such as tensile strength and elongation of electrospun nanofibres.

Agriculture and Textile Applications of Electrospun mats

- Electrospun nanofibres incorporated with pheromone for plant protection can help in controlling the pest population by attracting the pests into the traps.
- Electrospun nanofibres incorporated fungicides can be used as a protective coating on seeds to insulate and regulate temperature reaching the seeds, and for control on environmental stimuli during seed germination.
- Fertilizer loaded electrospun membranes can be used for controlled release of fertilizer over a period of time, thereby reducing fertilizer loss and pollution causes by run-offs.
- Enzymes like laccase, immobilized on electrospun nanofibres can degrade and detoxify pesticide, fungicide, herbicide and fertilizer residues and reduce contamination of crops and pollution.
- Nitrogen fixing rhizobia immobilized on electrospun nanofibres and coated on seeds prior to germination can help to promote plant growth, while simultaneously improving the soil bacteria (rhizobia) survival rate against the environmental stress.
- Functional finishing of textiles like moisture management, antimicrobial finishing etc.
- When used in sensor aplications, higher specific surface of elecrospun nanofibres can provide higher sensitivity.
- To impart protective function to textiles and for medical applications such as nanofibre scaffolds for biomedical implant/transplants and wound care.
- Air and water filtration for the removal of fine dust and metal particles, thus improving air quality and avoiding hazardous emissions.
- Aligned metal oxide electrospun nano fibres can be used in solar cells fabrication enabling uniform dispersion of catalysts, and thus increasing electrocatalytic activity to obtain higher chemical–electric energy conversion efficiency.

Training & Consultancy Services

- Training on basics of electrospinning process and its applications
- Guidance to graduate and postgraduate students for their projects
- Consultancy for establishment of indigenous electrospinning machine and designing of collectors for various end use requirements
- Contract research for evaluation of nano fibre mat in various application
- Any other specific requirements of the industry

Published by

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November, 2014